

Feb. 18, 1969

R. A. G. CAPE

3,427,699

OPEN WEB STEEL JOIST PRODUCTION LINE

Filed Sept. 29, 1966

Sheet 1 of 6

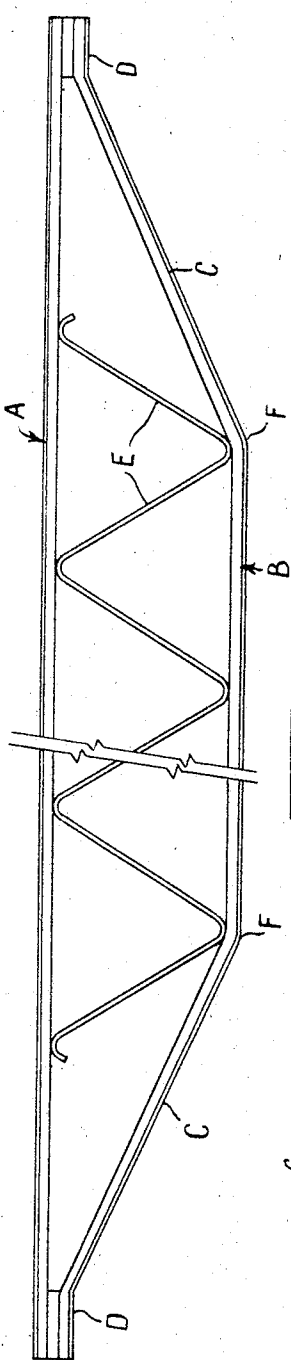


Fig. 1

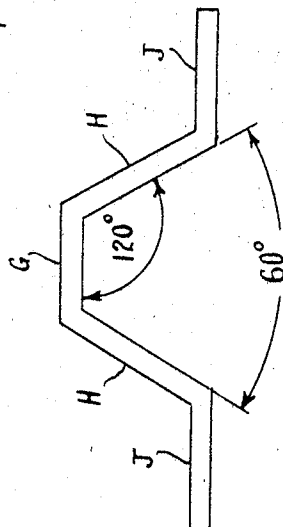


Fig. 2

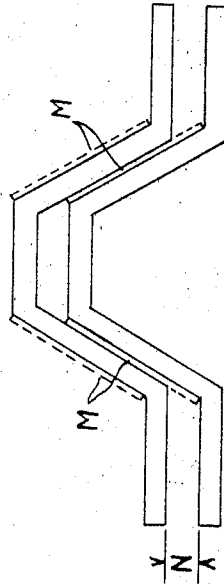


Fig. 3

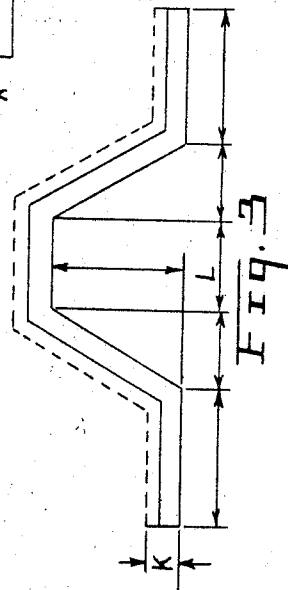


Fig. 4

INVENTOR

R.A.G. CAPE

Fetherstonhaugh & Co.
ATTORNEYS

Feb. 18, 1969

R. A. G. CAPE

3,427,699

OPEN WEB STEEL JOIST PRODUCTION LINE

Filed Sept. 29, 1966

Sheet 2 of 6

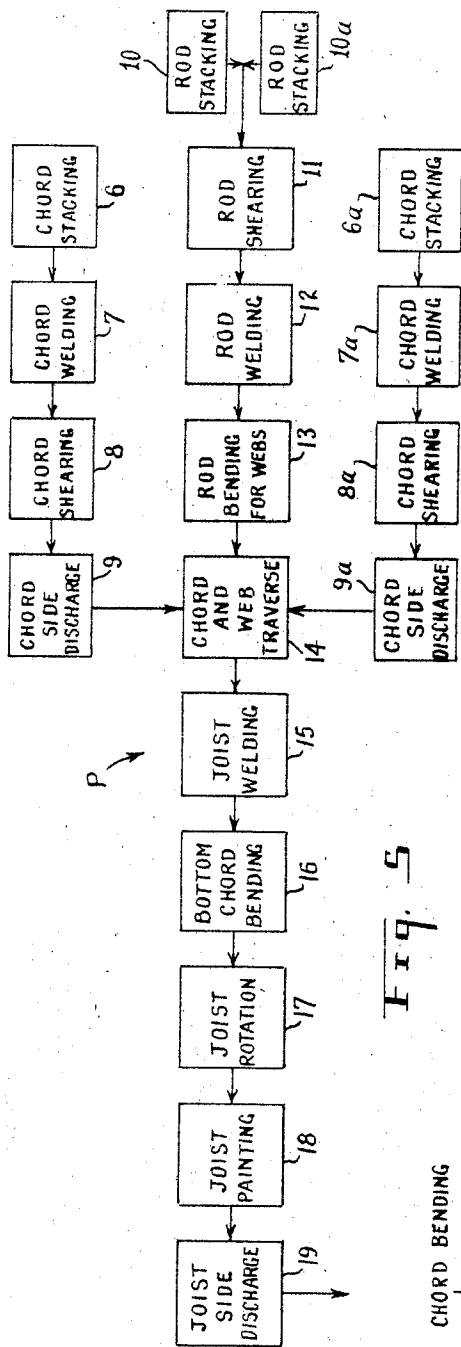


Fig. 5

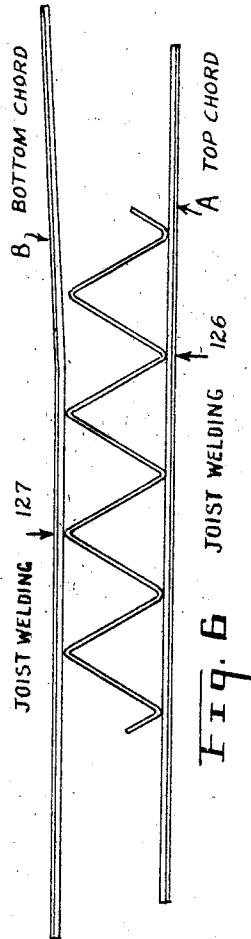


Fig. 6

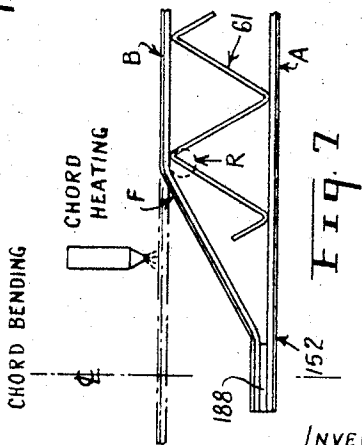


Fig. 7

INVENTOR

R. A. G. CAPE

Fetherstonhaugh & Co. ATTORNEYS

Feb. 18, 1969

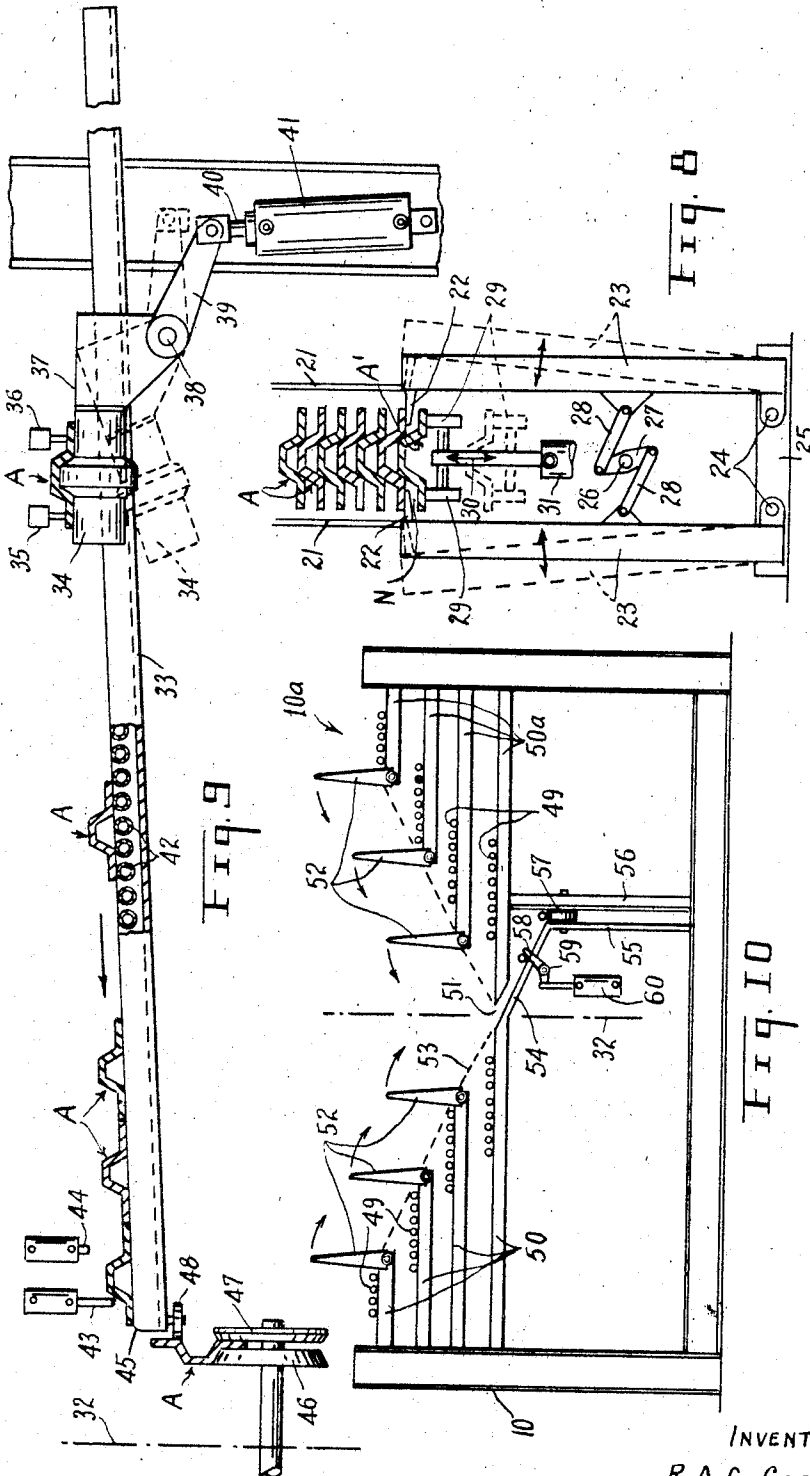
R. A. G. CAPE

3,427,699

OPEN WEB STEEL JOIST PRODUCTION LINE

Filed Sept. 29, 1966

Sheet 3 of 6



INVENTOR

R. A. G. CAPE

Fetters & Haugh & Co.
ATTORNEYS

Feb. 18, 1969

R. A. G. CAPE

3,427,699

OPEN WEB STEEL JOIST PRODUCTION LINE

Filed Sept. 29, 1966

Sheet 4 of 6

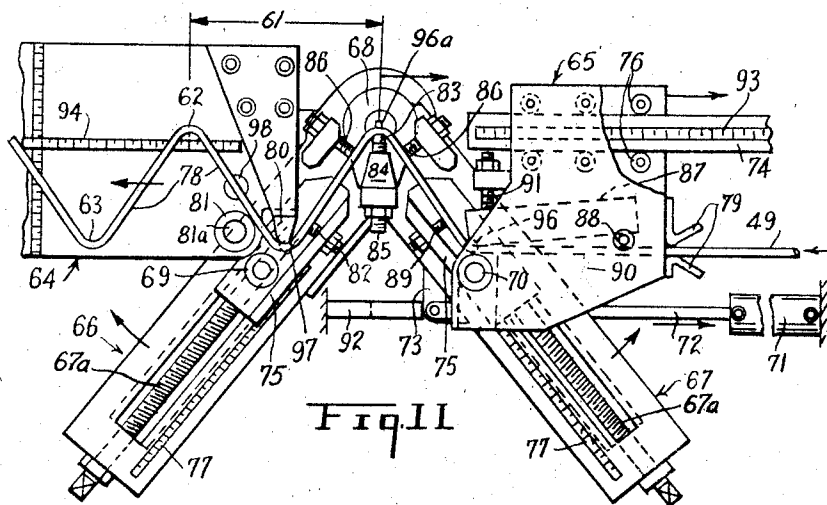


Fig. 11

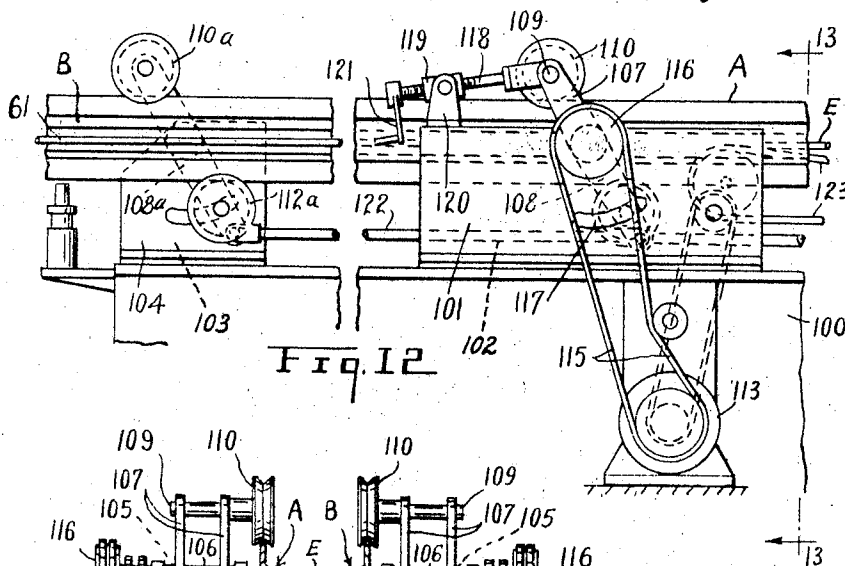


Fig. 12

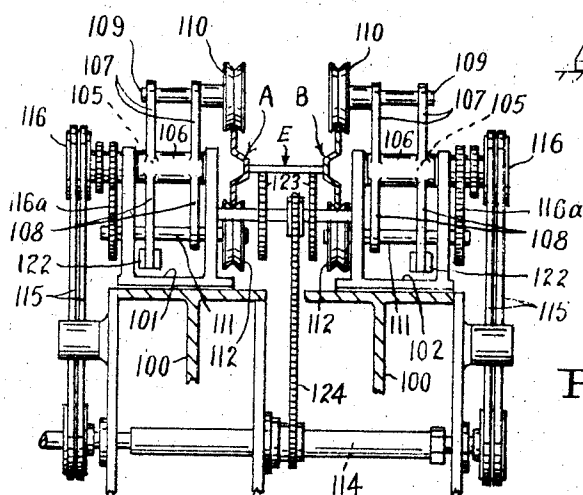


Fig. 13

INVENTOR

R. A. G. CAPE

Setterson & Co.
ATTORNEYS

Feb. 18, 1969

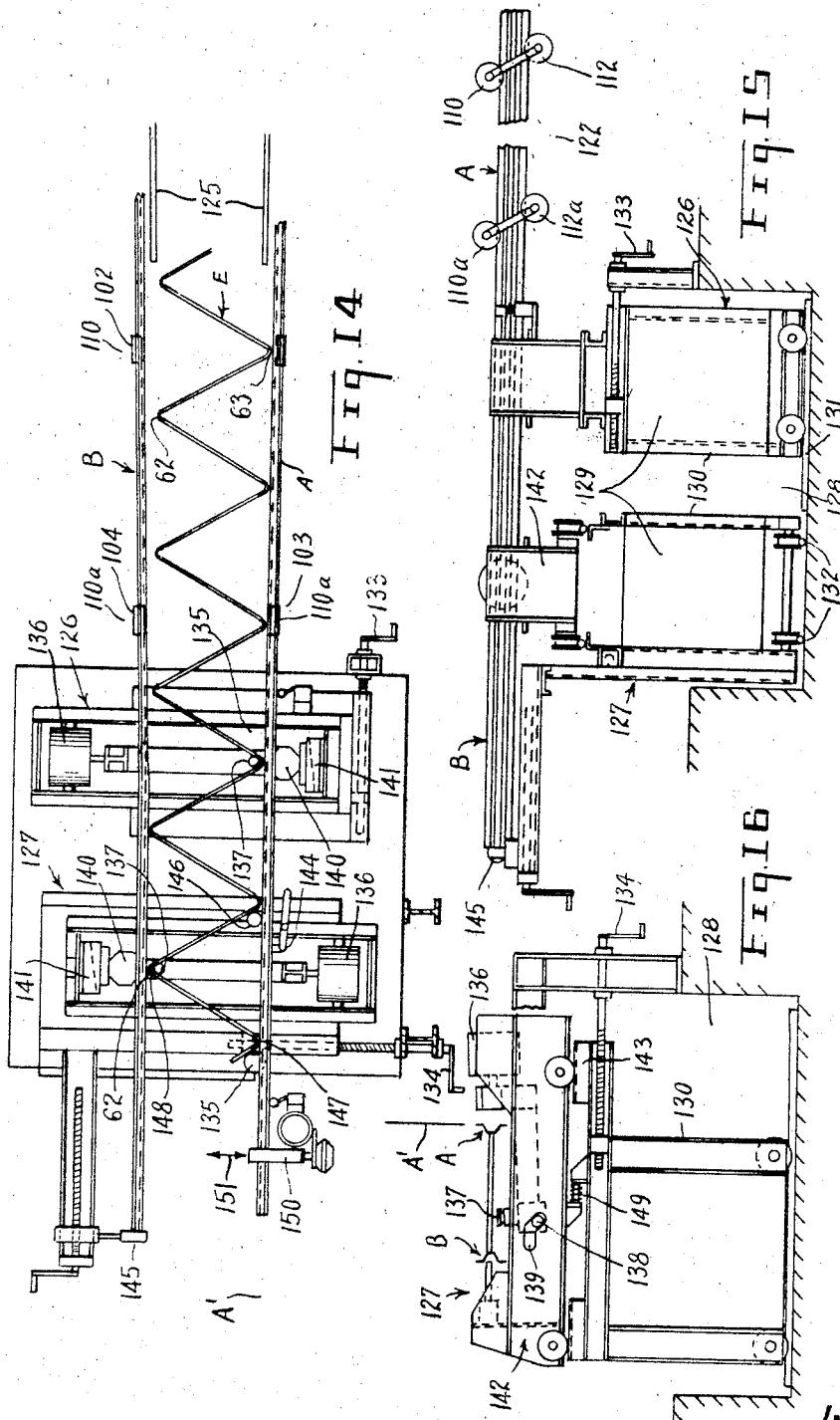
R. A. G. CAPE

3,427,699

OPEN WEB STEEL JOIST PRODUCTION LINE

Filed Sept. 29, 1966

Sheet 5 of 6



INVENTOR
R.A.G. CAPE
Fetters & Co.
ATTORNEYS

Feb. 18, 1969

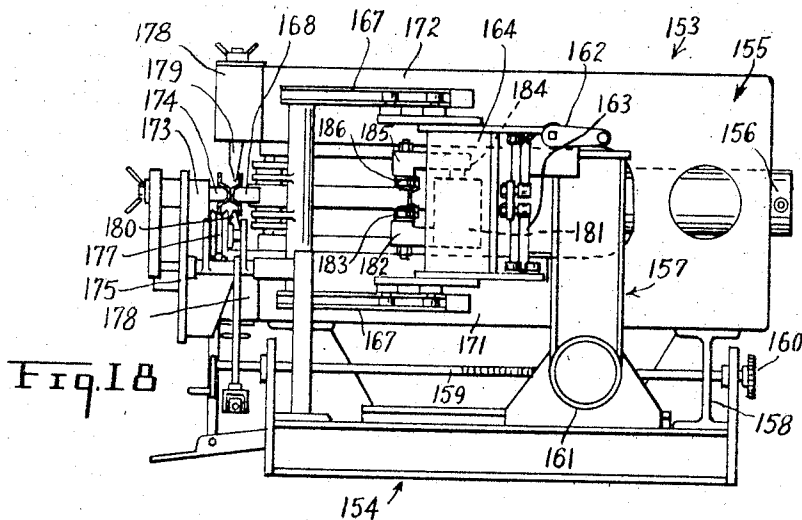
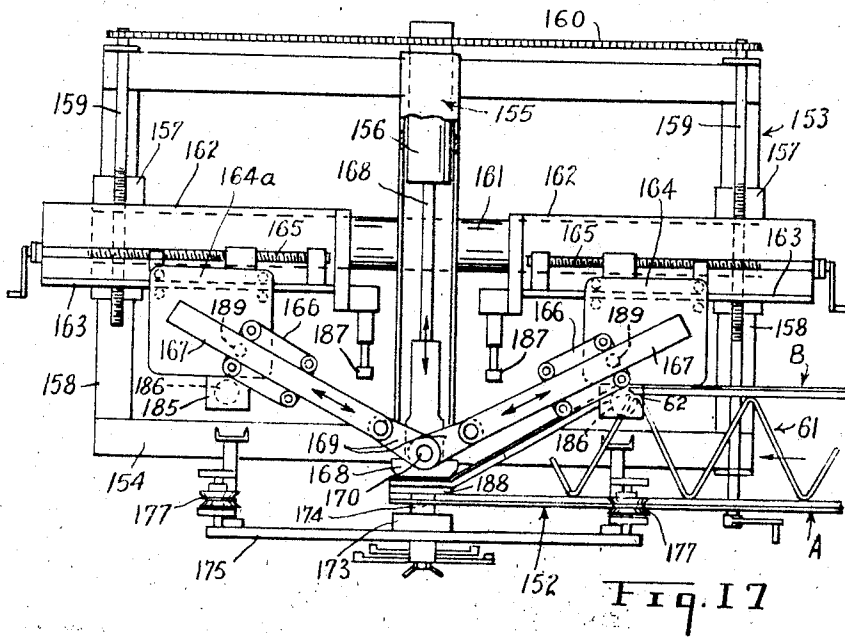
R. A. G. CAPE

3,427,699

OPEN WEB STEEL JOIST PRODUCTION LINE

Filed Sept. 29, 1966

Sheet 6 of 6



INVENTOR

R. A. G. CAPE

Fetthustonkaugh & Co.
ATTORNEYS

1

3,427,699

OPEN WEB STEEL JOIST PRODUCTION LINE
Richard Allan Gordon Cape, Lachine, Quebec, Canada,
assignor to Dominion Bridge Company Limited, Mon-
treau, Quebec, Canada

Filed Sept. 29, 1966, Ser. No. 582,884

U.S. Cl. 29—155

12 Claims

Int. Cl. B23k 9/12, 31/02; E04c 3/02

This invention relates to the production of open web steel joists and particularly the more or less automatic production of such joists whereby top and bottom chords are cut to length and the webs are formed, and all brought together in proper sequence and welded and shaped to form a complete joist ready for use in a building structure.

The invention consists essentially of a production line operation in which chords of a predetermined cross section referred to herein as top and bottom chords are stacked in two separated but parallel piles and the chords are individually fed forward from the bottom of the pile, sheared to length and discharged inwardly sideways to be aligned with a web profiled from steel rod; the chords and web are fed forwardly together in contiguous alignment and welded together after which the chord, which is to be the bottom chord of the joist is bent sideways into contact with the chord which is to be the top chord, of the finished joint after which the contacting portions of the top and bottom chords are welded together. The fabricated joist is then painted before being discharged from the production.

The various stages in the production line, particularly involving the rod bending to form the web panel, the bringing together of the top and bottom chords with the web panel, joist welding and bottom chord bending must be carried out with a definite time sequence and each of these operations involve a work procedure which will ensure that the chords will be of the proper length and be brought into contact with the formed web panel in a manner which will permit the chords to be welded to the web panel at a precise interrelationship which will further ensure that the welding of the chords to the web panel and subsequent bending of the lower chord and the welding of the chords at the ends of the joist, will be carried out in such manner that the finished joist will have a camber predetermined for the subsequent loading of the joint, in a building structure to ensure a level floor.

The chords used in the production line hereinafter described in detail are similar in profile but are not identical in the sizes of the elements comprising the chord. A range of sizes having varied thickness, depth and width are made. The profile of the chords is such that regardless of the varieties in size of certain elements, they will be accommodated in the various elements or stages in the production line and will be maintained in proper alignment with the web panel and with the forming and welding components of the production line.

The primary object of the present invention is to provide means whereby open web type joists can be fabricated at high speed and with a minimum of material and labour.

A further object of the invention is to fabricate open web steel joists in a sequenced production line.

A further object of the invention is to provide joists with a high degree of dimensional accuracy and uniformity.

A further object of the invention is to provide an open web steel joist having a built-in camber predetermined by the load to be imposed on the joist whereby the joist will become substantially flat when fully loaded.

These and other objects of the invention will be apparent from the following detailed specification and the accompanying drawings, in which:

2

FIG. 1 is a side elevation of an open web steel joist fabricated in accordance with the present invention.

FIG. 2 is an end view of a chord of the joist shown in FIG. 1 showing an angle of the sloping legs.

FIG. 3 is an end view similar to FIG. 2 but showing the dimensional features of the chords.

FIG. 4 is an end view of a pair of chords in modified form permitting an increase of spacing of the chords when stacked one above the other.

FIG. 5 is a block diagram showing the various stages of the joist production line.

FIG. 6 is a diagram showing the manner in which the top and bottom chords and the open web are brought together for the two stage welding of the chords to the web.

FIG. 7 is a diagram showing the operation of bending of the bottom chord to bring it into contact with the top chord to form the end portions of the joist.

FIG. 8 is a partial vertical elevation showing in outline the method of stacking the chords and the means whereby the lower chord of the stack is released for transfer longitudinally in the joist production line.

FIG. 9 is a partial side elevation showing in outline the means for side discharge of the chords and for turning them into a vertical position for further travel longitudinally in the joist production line.

FIG. 10 is a partial vertical elevation of the rod storage racks and the means for selectively transferring the rods into the joist production line.

FIG. 11 is a partial plan view of the mechanism for bending the rods to form the open web of the joist.

FIG. 12 is a partial longitudinal front elevation of the chord and web traverse section of the joist production line.

FIG. 13 is a vertical transverse section taken on the line 13—13 of FIG. 12.

FIG. 14 is a plan view of the two stage welding section of the joist production line.

FIG. 15 is a front elevation of the welding mechanism shown in FIG. 14.

FIG. 16 is a transverse vertical section taken on the line 16—16 of FIG. 14.

FIG. 17 is a plan view of the bottom chord bending machine showing the joist and in the fully bent position.

FIG. 18 is an end elevation of the machine shown in FIG. 17.

Referring to the drawings, and particularly to FIGS. 1 to 4, the joist 5 consists of a top chord section A and a bottom chord section B, resistance welded to a continuous V configuration web. The bottom chord B is bent upwards near each end at F to meet and run parallel with the top chord A for a short distance to form a bearing seat D where the two chords are welded together. The web configuration is in a series of equal V-shaped panels E extending between the inner bends of the bottom chord and half a panel beyond its attachment to the top chord A at both ends.

The chords A and B may be continuously cold formed from strip then cut into desirable finished lengths, or hot rolled at the mill in 60 foot lengths with square cut ends and shipped bundled in stacks of about 12 chords of a similar size held together with steel strapping.

The chords A and B for both top and bottom members of a joist are of similar profile. This profile may be described as a flanged channel composed of five elements—a middle web G, two sloping legs H at an angle of 120° with the web G and 60° between the legs H, and two outer portions J parallel with the middle web G (see FIG. 2).

The chords A and B although similar in profile are not necessarily identical in sizes of elements comprising the chord. A range of sizes having varied thickness, depth

and width are made. For reasons of economy the chords are grouped, each chord in a group has all dimensions similar except thickness. By changing the thickness K in pre-arranged increments, specified areas (sizes) can be obtained. One dimension is common to all chords, i.e. the inside width L of the web G of the chord is maintained at $\frac{3}{4}$ " (see FIG. 3). Thus in producing these chords, four only steel mill roll profiles are needed to produce 9 sizes since for each profile a change in spacing of forming will produce differing areas of cross section.

The thickness of the outer portions J and web G will vary directly with the gap between forming rolls whereas the change in thickness of the sloping webs H will vary by $\frac{1}{2}$ of the change in gap. It is of importance to realize that the sloping legs H of the chords will permit stacking or nesting of the chords. Also chords of a common size, when stacked provided a space N between successive outer portions or flanges J in the stack. This space, as a minimum, is $\frac{1}{8}$ ". For reasons to be described later, it is of advantage to increase the spacing between the flanges J in the stack. This is done by cutting small radial grooves about $\frac{1}{4}$ " wide x $\frac{3}{32}$ " deep in the final forming rolls in the portion of the rolls corresponding to the outside of the sloping legs H of the chords. This produces opposing raised ridges M on the chords at intervals of about 4 feet, which locally increase the leg thickness about $\frac{1}{32}$ " or the amount of reduction in the last pass of the chord through the forming rolls. These ridges M then increase the space N between the flanges J in a stack of chords from $\frac{1}{8}$ " to $\frac{3}{16}$ ", i.e. by two times the raised height of the ridges M (see FIG. 4).

The web members E of the joists are hot rolled rods; a range of rod diameters are shown in FIG. 10 to make the most economical use of chord sections. The web rods are sheared to about 60 feet in length at the steel mill and are steel strapped in bundles of approximately 9" diameter weighing in the order of 6 tons per bundle.

Joists are fabricated on the production line P in a succession of operations which take place at specified locations in a straight line extending a total of approximately 340 feet in length and in a width not exceeding 12 feet at the widest portion. The various stages in the joist production line P are shown in the block diagram FIG. 5 and are identified as follows: chord stacking 6 and 6a; chord welding 7 and 7a; chord shearing 8 and 8a; chord side discharge 9 and 9a; rod stacking 10 and 10a; rod shearing 11; rod welding 12; rod bending for webs 13; chord and web traverse 14; joist welding 15; bottom chord bending 16; joist rotation 17; joist painting 18; and joist side discharge 19.

For illustrative purposes the stations 6, 7, 8 and 9 are considered to handle the bottom chords B while the stations 6a, 7a, 8a and 9a are considered to handle the top chords A.

The mechanism and its operation at the various stages in the production line P will now be described in detail.

Chord stacking

In FIG. 8 there is shown in outline a cross section of the essential elements of the mechanism for stacking the chords A and B. As will be seen in FIG. 5 blocks 6 and 6a are located on either side of the longitudinal centerline of the production line and are located about 10 feet apart. The stacking mechanism shown in outline each consists of a pair of spaced apart side members 20 forming a slot 21, disposed parallel to the centerline of the production, into which the top and bottom chords A and B are separately stacked. The stacked chords A and B are supported in the slot 21 by a pair of fingers 22 projecting inwardly from the top of the levers 23 which are pivoted at their lower ends on the pins 24 on the fixed member 25. A centrally disposed shaft 26 has secured thereon a double ended lever 27 which, in turn, is connected to the levers 23 by the links 28. Below the slot 21 and between the levers 23 there is located a pair of rollers 29 which

are caused to be moved up and down as indicated by the arrow 30.

In operation, with the rollers 29 in the raised position, as shown in solid lines, the levers 23 are pivoted outwards by rotation of the shaft 26; until the fingers 22 clear the stack of chords, the stack of chords is then lowered in the direction of arrow 30 by the cylinder and piston device 31 until the space N between the two bottom chords is aligned with fingers 22, at this time the fingers 22 move inwardly to support all but the bottom chord; the rollers 29 continue their downward motion just beyond the point at which the bottom chord rests on power driven rollers, not shown. The chord A or B can then be moved along the production line on power driven rollers to the chord welding station 7 or 7a. As soon as the chord A or B is moved out of the way the rollers 29 are raised and the cycle of lowering and carrying the next lower chords is repeated. It will be understood that there will be sufficient groups of rollers 29 positioned under the stack of chords to support the whole length of the chords and that the rollers can be raised and lowered by means of hydraulic cylinder and piston devices, not shown, in well known manner. The rollers can be operated on a signal from the machine operator, or alternately automatically by over-run of a previous chord. At the top of the upward movement of the idler rollers 29, an automatic limit switch, not shown, causes the pair of levers 23 to pivot outwards and at a preset position in the downward motion of the rollers 29 a second automatic limit switch, not shown, causes the levers 23 to pivot inwards and their fingers to engage under the second from the bottom chord in the stack. The power driven rollers have, by this time, received a signal to cause the chords A or B to be driven forward in the production line into the chord welding stations 7 or 7a.

Chord welding

If a chord described above is following another chord, the trailing end of the leading chord overruns a limit switch, not shown, at the welding stations 7 or 7a. This stops further progression of this chord and instigates the signal for the chord movements described above. When this trailing chord hits the limit switch it also comes to a standstill by stopping the rotation of the power operated rollers.

The operator will now adjust by means of a push button the adjacent ends of the two chords in the welding stations 7 and 7a, as required, after which the joint will be welded using the CO₂ solid wire semi-automatic welding process. The welding stations consist of a small frame which holds three carbon blocks which are adjustable to suit each size of chord. In addition, air activated overhead clamps are used to clamp the two chord ends into alignment with a small space between the ends. The weld is completed for the full section on chord thickness under $\frac{3}{16}$ ", but greater thicknesses require back welding or reinforcing of the joint in the final stages of fabrication.

Due to the end to end welding of successive chords there is no scrap loss. On completion of welding, a push button will start the feed motor of the next-in-line operation which is a descaler, where scale is removed from the chords in well known fashion.

Chord shearing

The chord shear carried out at 8 and 8a is performed by a commercial hydraulic shear mounted on a carriage supported on four idler wheels running over a track. The shear is powered by a hydraulic pump delivering pressurized oil to the shear through flexible hoses. The shear, with a capacity of 50 tons, is capable of shearing through the heaviest chord section. Fixed and movable shear blades are readily interchangeable on the machine since four sets are necessary to cover the four ranges of chord profiles. The blade contours accurately match the chord profiles.

The shear carriage normally rests against a stop and it is maintained in this position by means of pulleys and counter-weights. The chord may then be drawn through the shear between the two blades by means of the preceding chord drive. When the leading edge of the chord strikes a limit switch which has been preset for shearing chords to a predetermined length, an electrical signal causes the upper shear blade to descend and simultaneously a powerful fast acting pneumatic clamp drives chisel pointed grips into contact with the chord, the shear and carriage are then driven forward by the power driven chord. The forward motion of the carriage continues until the shear blade after reaching the bottom of its stroke returns upwards. When the clamping blade releases the chord, the shear and carriage are then returned freely by the counterweight. The chord traverse continues unchanged. The process of shearing will repeat itself continuously so long as the sheared portion of the chord is cleared off the track.

Side discharge

The side discharge of the sheared chords carried out at 9 and 9a is shown diagrammatically in FIG. 9 and is the area of the production line in which the sheared lengths of chords are transferred from the in-line arrangement of the preceding equipment transversely towards the centerline of the whole line. In FIG. 9 only one side transfer station is shown, corresponding to station 9. A similar side transfer station 9a is located on the opposite side of the centerline 32.

The side discharge units 9 and 9a each consist of a frame 33 suitably supported to have a slightly downwards inclination towards the centerline 32 and are adapted to support the chords over their entire length. As the chords are moved forward from the chord shearing station 8 or 8a they slide on to a series of dumping rollers 34 at an elevation slightly above the top surface of the frame 33.

As the chord is driven forward onto the dumping rollers 34 its leading end will strike two limit switches 35 and 36 in succession. The shear limit switch 35 controls the length of the chord to be sheared, while the dumping limit switch 36 controls the dumping of the sheared chord onto the side discharge frame 33. The dumping rollers 34 are mounted on a bracket 37 mounted on the shaft 38. A lever 39 integral with the bracket 37 is connected to the piston rod 40 of the double acting hydraulic cylinder 41. As the leading edge of the chord strikes the dumping limit switch 36 the cylinder 41 is activated to effect rotation of the bracket 37 and its dumping roller 34 into the position shown in dotted lines in FIG. 9, thus permitting the chord to be dumped on to the rollers 42 set transversely on the frame 33. The inclination of the frame 33 is such that, the chords, by their own weight, will slide downwards on the rollers 42 until they meet the pneumatically operated stop 43. A succession of chords can be accommodated on the frame 33. At a touch of a button by the Resistance Welder Operator, the normally withdrawn piston of the stop 44 is extended downwards into the space between the bulbs of the two lowermost chords on the frame 33 while, at the same time, the piston of the stop 43 is withdrawn upwards permitting the lowermost chord to slide over the end 45 of the frame 33 where it will rotate through 90° and take up a vertical position with one flange supported between the pair of guide rolls 46 and 47. The guide roll 46 has its periphery bevelled to the same angle of the adjacent side H of the chords in order to support the chord in a vertical position. Guide rollers 48 located under the end of the frame 33 support the opposite side of the chords.

Release of the push button by the Resistance Welder Operator will reverse the pistons of the stops 43-44 allowing the chords on the frame 33 to slide further down and take up the position shown in FIG. 9.

The rollers 46-47 form part of the Resistance Welder Feed-Runway to be described later.

It must be understood that the above description of the operations and feed of one chord applies identically to the other chord of the joist and is completed at the chord side discharge stations 9 and 9a as seen in FIG. 5.

Referring back to FIG. 5 and to the stages 10 to 14 inclusive and, the first operation involved is the formation of the webs of the joist.

Rod storage

For efficient operation of the production line it is of advantage to be able to draw quickly on different diameters of rods. As previously stated rod diameters are selected to make the most economical use of the chord sections and joist depths.

Referring particularly to FIG. 10. The various diameter of rods 49 are stored on four cantilever arms 50 and 50a placed at four elevations on both sides of the centerline 32 of the production line and correspond to the stations 10 and 10a in FIG. 5. The adjacent ends of the lower arms 50 and 50a form a slot 51 two inches wide at the centerline 32 of the production line. Arms 50 and 50a at the higher elevations become progressively shorter.

On the inner ends of each of the six uppermost arms 50 and 50a, hinged members 52 are located. These members 52 are normally held in a vertical position by means of a suitable stop bolt, not shown, and can be rotated inwardly and downwardly to lie against the arm immediately below as shown in dotted lines to form ramps 53 over which rods 49 from an upper arm can be rolled down towards the central slot 51. As will be seen, eight bundles of different diameter rods 49 can be stored simultaneously and by rotating various hinged members 52 downwards it is possible to select a certain size of rod to move down the formed ramp 53 towards the central slot 51.

The central slot 51 is disposed at an angle by undercutting the end of the lowest arm 50 on one side of the centerline 32, at an angle and providing an extension surface 54 from the adjacent end of the arm 50a on the opposite side of the centerline. The surface 54 lies on the same plane as the adjacent hinged members 52 when the hinged members are rotated down into the ramp 53 forming position as shown in dotted lines in FIG. 10. The lower end of the extension surface 54 terminates at the vertical member 55 which, with the vertical member 56 supports the guide rollers 57. The top peripheral surface of the rollers 57 are level with the lower edge of the extension surface 54. Intermediate the length of the extension surfaces 54 there is provided a gate 58 which is in the form of a pivoted lever mounted on the shaft 59 located below the surface 54. The gate 58 passes through a slot in the surface 54 and acts to hold back rods 49 which have been delivered down the ramp surface 53. Rotation of the gate 58 into the dotted position shown is by pneumatically operated or other means 60 and permits one rod at a time to drop further down on to the rollers 57.

It will be understood that the arrangement shown in FIG. 10 will be repeated at intervals to support the full length of the rods 49 and that the gates 52 will prevent accidental discharge of the rods to the slots 51. After a rod has been delivered to rest on the rollers 57 it can be pulled forward by the operator who can then cause the gate 58 to be rotated to allow another rod to drop on to the rollers 57.

As the rods 49 are pulled out of the rod stacking stations 10 and 10a they are cut to length at station 11. As the rods received from the mill and stored in the rod stacking stations 10 and 10a are usually 60 feet long, they must either be cut to the length for a complete web or be butt welded to a succeeding rod before being cut to length in the rod shearing station 11. The shear used is

7

a commercial type of 20 ton capacity and is mounted on a carriage at an angle of 11° to the vertical and therefore has specially designed shear blades. The two shear blades have three holes in one blade and three slots in the other to accept the full range of rod sizes stacked in the rod stacking stations. The cutting edges of the holes and slots in the shear blades are horizontal i.e. 79° to the surface of the blades. This avoids deforming the rod ends in cutting. The 11° shear angle on the rod ends is for the purpose of butt welding to be described later.

The carriage supporting the shear is adjustable in increments of 1" from a fixed position of the web bender at the web bending station 13. From this fixed position, the shear location is predetermined for the total length of rod necessary to make four to six complete bends plus 4" additional beyond the final bend apex. Thus, if a joist requires say twelve panels, the web bender is operated to complete seven panels and then the rod is sheared to leave sufficient material for five more panels. A counter on the web bender will automatically cause the shear to operate after seven bends, or the operation may be performed by a push button.

The cutting of the rod to produce the required length of web will, of course, be done at an angle of 11° . This rather flat bevel is not objectionable. The cutting of a succeeding 60 foot length of rod produces a bevel of the same slope. This succeeding rod is then rotated through 180° and advanced into the rod welding station 12.

Whenever sufficient rod remains to complete the full bending of a web, the rod is free to move through the welding station 12. Where more rod length is required, the trailing end of a rod and the leading end of the next 60 ft. length must be halted in the welding station 12 for butt welding into a continuous length. This station 12 is part of the carriage supporting the shear in station 11. Being movable it is possible to adjust the welding station after shearing without additional bending of the rod. The welding station 12 is essentially a clamp composed of a fixed bottom and two adjustable side members which together form a U-shaped trough in which the bar ends are clamped for welding.

Welding of the rod ends is preformed using the metal inert gas process which, by reason of a small electrode and high current penetrates to the bottom of the narrow V butt joint. The resulting weld in an axial view is approximately square. In particular, the weld must not be wider horizontally than the diameter of the rod to avoid binding while passing through the next station 13.

Rod bending for webs

This machine, shown in FIG. 11, has been designed to produce an infinite variety of webs within the limits of the joist dimensions to be produced on the production line. It thus permits maximum efficiency in design of the web system for any joist. Excepting for the first and last bends on each web until, each cycle of motion of the web bender produces a complete panel 61, i.e. simultaneously top and bottom bends 62-63. The completed angles of the bends 62 and 63 at top and bottom of the panel 61 are the same.

The means whereby bending of the rod is accomplished is dependent on several principal parts—a fixed table 64, a movable carriage 65 and two movable arms 66 and 67 hinged together at 68 at adjoining ends and to the table 64 at 69 and to the carriage 65 at 70. The hinges 69 and 70 are disposed vertically and permit rotation of their respective arms 66 and 67 in a horizontal plane and the amount of rotation is dependent on the approach of the two hinges 69 and 70. At maximum spacing of the hinges 69 and 70, all three hinges 68, 69, and 70 will lie in a straight line. Forward motion of the carriage 65 is controlled by the cylinder and piston device 71 whose piston rod 72 is connected to the bracket 73 on the hinge 70. The carriage 65 is mounted on the fixed guide beam 74 for travel longitudinally of the production line in the

8

direction of the arrows and is guided by the guide rollers 76. By regulating the approach of the carriage 65 to the table 64 it is possible to secure any desired angle included between the three hinge points 68, 69, and 70. The movement of the carriage 65 on the guide beam 74 is controlled by the hydraulic cylinder 71 whose piston rod 72 is connected to the bracket 73 on the hinge 70. The eccentricity of the bracket or lever 73 with respect to the hinge 70 when the arms 66 and 67 are in a straight line is such that, when the cylinder 71 is activated, the necessary moment is provided for instigating the beginning of each bend.

The two outer hinges 69 and 70 at their top terminate in guideways 74 and 75 which are adjustable within slots in arms 66 and 67. By means of a screw 67a on each arm 66 and 67 and guides 75 and 76, it is possible to adjust and lock the spacing between the hinge 68 and hinges 69 and 70. Thus the spacing between hinges can be preset. Each arm 66 and 67 has mounted thereon a measuring tape 77 which reads directly the spacing between adjacent hinges.

If now the spacing between adjacent hinges could be assumed as the length of the diagonal 78 in a formed web, it is reasonable that for any position of approach of the carriage 65 towards the table 64, the distance between the two hinges 69 and 70 becomes the web panel spacing and the normal height of the middle hinge, compared with the other hinges 69 and 70, becomes the approximate height of the web. These conditions are with reference to the center of the hinges.

To produce a web panel from the straight rod 49, fed into the carriage 65 between the guide fingers 79 from the previous station 12, it is then essential that each of the hinges must support load points to produce bends in the rod. It is not sufficient to apply one load point only at each hinge since the resulting bends would be made with a radius too large for acceptance while the diagonal between bends would be curved in the form of a shallow S. Therefore, instead of one load point at each hinge there are three. At the hinge 69 there is a bending mandrel 80, an anvil 81 in the form of an annular ring concentric with the post 81a, hinge 69 and an adjustable anvil pin 82; at the hinge 68 there is a bending mandrel 83 adjustable in the block 84 by means of the screw 85 and a pair of adjustable anvil pins 86; and at the hinge 70, there is a bending mandrel 87 pivoted on the carriage 65 at 88, and an adjustable anvil pin 89 and an anvil block 90. The bending mandrel 87 is held in contact with the rod 49 by the adjustable screw 91.

When the arms 66 and 67 are in straight alignment with each other, i.e. with the hinges 69, 68, and 70 in a common line, the normal distance between the bending mandrels 80, 83 and 87 and their associated anvil pins is such that the rod 49 can be inserted between them. When the carriage 65 is moved towards the table 64, the arms 66 and 67 will be rotated about the central hinge 68. The distance of travel of the carriage 65 is controlled by the adjustable stop 92. With movement of the arms 66 and 67 three bends are simultaneously produced on the rod 49. The two outer bends formed at the bending mandrels 80 and 87 will, however, be half the angle of the bend produced at the center bending mandrel 83.

The position of the carriage either fully advanced against the stop 92 or retracted may be read on a tape 93 on ways which support both the carriage 65 and table 64. Thus, with the carriage 65 fully retracted the tape reading is equal to the combined length of the two diagonals of the desired web panel. When the carriage is fully advanced, the tape reading indicates the panel spacing, although a sample deduction must be made for spring back of the rod being bent.

In practice, after pre-setting the arm length and carriage advance, a straight rod 49 is fed into the machine so that the leading end is about 4" past the first hinge center 70. The carriage 65 is then advanced and retracted by

activating the cylinder 71 to form a half bend. The rod is then advanced until the bent end fits into the slot formed by the table mandrel 80 and the anvils 81 and 82. Cyclic motion of the carriage 65 then produces the first bent panel. Successive bends are created in the same way. The last bend is produced at the table hinge 69.

When the first panel is made and advanced into position for the second bend, it rests on the table 64. Here two measuring tapes 94 and 95 on the table top permit checking of the panel for spacing and height. If the spacing and height of the panel are incorrect, slight adjustment to arm length and carriage travel will rectify the defect. Any panel may be checked when in this location.

In order to advance the formed web, plungers indicated at 96 and 97, one on the carriage and the other on the table, are activated by suitable mechanism, not shown, to raise the formed web up out from between the mandrels and anvils. The formed web can then be drawn forward by an operator and reseat between mandrels and anvils for the next cycle of bend forming.

A high lift cylinder 98 located above the table 64 adjacent the hinge 69 provides, automatically, clamping and release of the formed web. Clamping of the formed web at this stage of the operation is essential to ensure that no twist occurs in the bent web.

A suitable conveyor, carries the formed web beyond the table 64 towards and through the next stage 14 as shown in FIGS. 5 and 6, where the formed web meets up with the top and bottom chords, delivered from the chord side discharge stations 9 and 9a. The apparatus for bringing the top and bottom chords and the formed web together is shown in FIGS. 12 and 13. This apparatus consists of a base 100 supporting transversely spaced apart support brackets 101 and 102 and a further pair of spaced apart support brackets 103 and 104.

Each of the brackets 101, 102, and 103 and 104 support a shaft 105 on which is rotatably mounted a sleeve 106. Pairs of levers 107 and 108 project from diametrically opposite sides of the sleeves 106.

A shaft 109 on each of the pairs of levers 107 carries a guide roller 110 at their inward opposing ends in spaced apart relationship as shown in FIG. 13. A similar shaft 111 on each of the pairs of levers 108 carries a guide roller 112 at their inward opposing ends. The guide rollers 110 and 112 are in vertical alignment with each other and support between them the top and bottom chords A and B. The guide rollers 110 rotate freely on their shafts 109 while the guide rollers 112 are power driven. The drive to the guide rollers is from the motor 113 to the shaft 114 via the belts 115 to the pulleys 116 on the shaft 105. Chain drives 116a extends the drive to the shafts 111. The shafts 111 extend through arcuate slots 117 in the vertical walls of the brackets 101, 102, 103 and 104 to permit the guide rollers 110 and 112 to be moved away from or into contact with the top and bottom chords A and B. The guide rollers 110 and 112 are rotated about the shaft 105 by means of the threaded rods 118 threaded through the pivoted nuts 119 mounted on the brackets 120. One end of the threaded rods 118 is rotatably connected to the clevis mounted on the shafts 109 while a handle 121 secured to the opposite ends of the rods 118 serves to rotate the shafts 118. One or more similar sets of guide rollers 110a and 112a are mounted on brackets 103 and 104 and their mounting levers 108a are connected with the levers 108 by means of the rods 122. The guide rollers 110a and 112a are not driven but merely clamp on the chords A and B with sufficient pressure to hold the chords in straight alignment while permitting the chords to move forward under the drive of the guide rollers 112.

As will be seen in FIGS. 12 and 13 the guide rollers 110, 110a, 112, and 112a associated with the brackets 101 and 103 guide the top chord A in a straight line from station 14 to station 15 in the production line whereas

the guide rollers associated with the brackets 102 and 103 guide the bottom chord B inwards at a slight angle towards the chord A for a reason which will be explained later during a discussion of the joist welding.

The rollers 110, 112, 110a and 112a are adjustable in elevation by the threaded screw 118 as described above. Since the top and bottom chords A and B of a joist are often dissimilar in size and therefore in width, the rollers supporting the top chord A are separately adjusted in elevation from the rollers supporting the bottom chord B. Suitable gauges can be stencilled on the sides of the machine to correspond with different chord sizes.

Reverting back to FIGS. 12 and 13 the completely formed web E as it enters station 14 rests on and is driven forward by two power driven endless chains 123 by means of the chain drive 124 from the shaft 114. The endless chains 123 may be operated continuously during all phases of web bender operation. On either side of the chains 123 there is provided plates 125 which act as dividers between the web E and the chords A and B and prevent the web from wandering off line. These plates 125 also act as guides for the chords A and B which are now standing on edge after being discharged from the stations 9 and 9a.

The formed web E as it is driven forward on the chains 123 lies in the horizontal plane passing through the axis of the shafts 105 and approximately central with the vertical height of the chords A and B.

The inner face A' of the chord A is used as a Reference Line. This reference line runs through the resistance welding station 15 and bottom chord bending station 16 and is a most important reference for securing straightness and/or cambering of the finished joist.

Joist welding

Reference is not made to station 15 and FIGS. 14, 15 and 16. The finished web panel E and the chords A and B are delivered into the resistance welding machine 126 and 127. The most unique feature is the fact that resistance welding is performed on both chords A and B simultaneously in a single station.

The welding machines 126 and 127 are located side by side in a pit 128 and each include a transformer 129 mounted on cages 130, the machine 126 being movable on the tracks 131 and the machine 127 is movable on the tracks 132. Machine 126 at the entry side of the station is adjustable on its tracks 131 by means of the screw device 133, while the machine 127 is adjustable on its tracks 132 by means of the screw device 134. Machine 126 is adjustable to suit panel spacing 61 and is fixed in relation to the reference line A'. The machine 126 may be adjusted to anywhere between 16 and 40 inches ($1\frac{1}{2}$ or $2\frac{1}{2}$ panel) from machine 127. Machine 127 is adjustable from the reference line A' to suit joist depth. Suitable measuring tapes, not shown, are mounted on each machine 126 and 127 to measure for the required setting.

The top chord A is held rigid in position in respect to the reference line A' by the guide rollers 135.

The welding equipment on each machine is that required for resistance welding and include a forging air cylinder 136, retracting electrodes 137 retracting electrode guide rollers 138 movable in the cam slots 139, fixed electrodes 140 and fixed electrode supporting wedges 141. The welding equipment on the machine 126 is rigidly fastened to the cage 130 supporting it, while the welding equipment on the machine 127 is mounted on a carriage 142 movable on the traverse tracks 143.

In the operation of welding the chords A and B to the web E, the two chords A and B are power driven against stops 144 and 145. The stop 144 is operated manually while the stop 145 is air operated. An air operated web stop 146 positions the first bend joint 147 in relation to the chord A for welding. After the web E has been positioned to bring the bend joint 147 in line with

the retracting electrode 137 in the machine 126, a foot pedal, not shown, is depressed to make the first weld of the web joint 147 to the top chord A. On retraction of the electrode 137 on machine 126 the top chord A and web E automatically move forward together until arrested by the web stop 146. Pre-setting of the web stop 146 automatically positions the web and chord for the welding of the next in line bend point to the chord A. The sequence of welding is repeated until the first bend point 148 adjacent the bottom chord B arrives in the welding machine 127. The foot pedal, not shown, is again depressed, and, this time, both welding machines 126 and 127 are energized to effect welding of the web bend points 62 and 63 to their adjacent chords A and B.

It will be noted in FIGS. 6 and 14 that, while the top chord A is directed in a straight line A', into the welding machines and the adjacent bend points of the web E are also maintained in a straight line close to the chord A, welding of the web to the chord A ensures that the web is held rigid. As the chord B approaching the welding station is spaced apart from the adjacent bend points of the web the chord B, offers no restriction to longitudinal movement of the web and the chord A in machine 126. It is only after the web E is aligned with electrode 137 in machine 127 that the chord B is moved against the adjacent bend points of the web. This movement of the chord B is effected by transverse movement of the carriage 142 during the welding operation. After welding of the web to the chord B the carriage 142 is retracted by the spring 149.

It is axiomatic that if the panel spacing of the web E on the top and bottom chords A and B is identical, a straight joist must result. In practice, a controlled camber is essential, the camber depending on the length of the finished joist and the loading to which the joist will be subjected to, for this reason, the panel spacings of the bottom chord B must be very slightly smaller than those of the top chord A. The top chord clamp 150, offset manually in the direction of the arrow 151 from the reference line A', automatically clamps the top chord A in position prior to movement of the carriage 142 in the welding machine 127. This reduces the panel spacing of the bottom chord B and results in the controlled camber needed for all joists.

After simultaneous welding pairs of web points to the chords A and B in both machines 126 and 127, the joists elements are moved forward until each successive pairs of web points are welded. Machine 126 will then discontinue welding while machine 127 finishes the last one or two welds on the bottom chord B.

Suitable relays, not shown, control both welding machines 126 and 127 so that none will operate unless web and chords are in position for welding.

As the welded joist leaves station 15 (FIG. 5) it is fed into station 16.

Bottom chord bending

Referring now to FIGS. 7, 17 and 18 the welded joist 152 is fed into the bottom chord bending machine 153. This machine consists essentially of base 154 on which is mounted a fixed C-frame 155 mounted midway of the base 154 in the longitudinal direction of the production and transversely thereof. The C-frame 155 supports a horizontally disposed hydraulic ram 156. A pair of brackets 157 mounted on the end members 158 of the base 154 are adjustable transversely of the machine by means of the threaded rods 159 and chain drive 160, to accommodate welded joists 152 of varying depth, being fabricated in the production line. The brackets 157 are tied together by the tubular member 161.

Each bracket 157 supports a longitudinally disposed frame 162 having upper and lower guide rails 163 on which carriages 164 and 164a are mounted and are adjustable thereon by means of the threaded rods 165. A guide member 166 is mounted on a pivot 189 on each of the carriages 164 and 164a and supports a sliding arm 167.

A bending anvil 168 is secured to the end of the rod 168 of the hydraulic ram 156 and is profiled to fit into the bulb of the bottom chord B.

The adjacent ends 169 of the sliding arms 167 are pivotally connected to the bending anvil 168 at 170.

The lower arm 171 of the C-frame 155 extends beyond the upper arm 172 and has an upturned member 173 which supports the fixed anvil 174. The fixed anvil 174 is contoured to fit into the bulb of the upper chord A. A panel 175, mounted on the front of the upturned member 173, is fitted with levers, not shown which control the extent of insertion of the joist into the machine, and rollers 177 which support the upper chord A.

The upper and lower arms 171 and 172 of the C-frame 155 each have a boss 178 in which profiled blocks 179 and 180 are fitted to engage with and hold vertical the vertically oriented flanges of the lower chord B at the end of the stroke of the hydraulic ram 156.

Each of the carriages 164 and 164a are provided with a floating cylinder arrangement 181, the cylinder of which is provided with an arm 182 on which is mounted a bending anvil 183, while the piston 184 associated with the cylinder is provided with an arm 185 on which is mounted a bending anvil 186.

An oxygen-gas torch 187 is mounted on each of the frames 162.

In the operation of the bottom chord bending machine, the two side brackets 157, frames 162 and carriages 164 and 164a are adjusted transversely of the machine with reference to the fixed anvil 174, to suit the depth of the joist being worked upon.

The cylinder arrangement 181 on the carriages 164 and 164a are individually activated to move the bending anvils 183 and 186 upwards and downwards away from each other to permit the joist to enter the machine. The cylinder 181 on the carriage 164 is then activated to bring the anvils 183 and 186 closer together to engage with the inward facing surfaces of the vertically oriented flanges of the bottom chord B as shown in FIG. 18. The anvils 183 and 186 are shaped to fit along the sloping legs and outer flanges of the chord.

A joist entering the machine is first stopped in a preliminary position where two operations are simultaneously conducted. The operator presses a button which causes the oxygen-gas torches 187 to ignite and heat the bottom chord B for a timed interval at the point where the seat bend will be made. In the meantime the operator assembles and tacks a filler 188 to the top chord A. After heating and tacking the filler, the joist is released to move forward into the bending position.

Immediately the bottom chord anvils 183 and 186 clamp around the chord at a point one inch ahead of the terminal web point 62 seen in FIG. 17. Simultaneously the hydraulic ram 156 is activated to move the anvil 168 in the direction of the fixed anvil 174; this causes the arms 167 to rotate the guide members 166 about their pivot connection 189 on the carriages 164 and 164a and effect bending of the bottom chord B about the anvils 183 and 186.

As the bottom chord B bends about the anvils 183 and 186 the extreme end of the chord strikes the filler 188 tacked to the upper chord A and a second bend (at the portion of the chord B heated by the torch 187 adjacent the carriage 164) then commences. Both bends then proceed simultaneously until the hydraulic ram 156 can move no further ahead.

The length of bottom chord B from its extremity to the first bend forms the end seat D (FIG. 1) of the joist. It is necessary that the flanges of the bottom chord seat are normal to the plane of the joist web. To achieve this, two profile blocks 179 and 180 attached respectively to the top and bottom arms of the C-frame 155 square the bottom chord while the hot bend is being made.

While under load of the hydraulic ram 156, both top and bottom chords A and B are accurately located. If

released, the spring back of the cold bend at the anvils 183 and 186 and the cooling of the hot seat D bend would cause undesirable separation of the chords. Therefore, while under load of the ram 156 the bottom chord B is tacked to the filler 188 previously welded to the top chord A. When released, the end profile remains.

On completion of bending and tacking of the leading end of a joist; the bottom chord anvils 183 and 186 are opened, the ram 156 is retracted, the joist stops are withdrawn and the joist may now be moved freely through the machine. The motor drive of the machine runway is reversible so that the trailing end of the joist may be backed up into the machine for a repetition of the operations conducted on the leading end.

In FIG. 17 it will be noted that the bending action on the lower chord B takes place at the right hand side of the hydraulic ram 156, i.e., the bending takes place about the anvils 183 and 186 associated with carriage 164. In contrast, the bending of the trailing end of the joist will take place on the left hand side of the machine on anvils 183 and 186 associated with the carriage 164a.

When both ends of the joist are finished, the joist is allowed to continue forward at the same time as a following joist enters the chord bending machine 153. The completed joist will then strike end on against a stop containing a limit switch which automatically operates the next sequence.

Joist 90° rotation section

Station 17 (FIG. 5)

Between the rollers of the runway beyond the chord bender, a series of arms cantilevered from a torque tube normally lie in a horizontal plane at an elevation just below the level of the rollers. When the last limit switch mentioned is actuated by a joist, the arms rotate through 90° lifting the joist clear of the chord bender runway and depositing it on a parallel runway composed of narrow rollers power operated.

When full 90° rotation of the arms is completed, they automatically return into their horizontal position. Simultaneously the final runway is activated and the joist moves forward while resting on its top chord A. The motor drive of this last runway has a variable speed output to regulate the travel rate of the joist through the paint booth.

Paint booth

Station 19 (FIG. 5)

The paint booth is a rectangular chamber with flap doors front and back to allow through travel of a joist. In the chamber are situated eight or more nozzles judiciously positioned for spraying all portions of any joist regardless of depth. These nozzles all operate simultaneously as the joist enters the chamber and are cut off automatically as the joist leaves.

The main additional feature of the spray booth is the method of atomization of the paint. Air is not used for this purpose since it would carry fine paint particles throughout the shop area. Instead the paint is subjected to a very high pressure and ejected through very fine nozzles. Little paint loss by air currents is evidenced. Paint fumes are not objectionable in the vicinity.

The thickness of coating is controlled by the rate of travel as predetermined by means of the variable speed drive.

Paint drying skids

Station 19 (FIG. 5)

Joists having passed through the paint booth are arrested in forward motion by running into an end plate. Here a limit switch de-energizes the runway and at the same time opens a valve to cause two horizontal hydraulic cylinders to push the joist sideways off the runway onto two skids at right angles. The hydraulic cylinders are sufficiently powerful that twenty or more joists are moved

together. By the time the drying skids are loaded, the leading joists are sufficiently dry to permit further work.

Special joist features

Most joists require certain special features such as the addition of wood nailer strips, bridging clips, seat plates, ceiling extensions, etc. These are then added by manual assembly and welding. In so handling the joist, the seat bends which were tacked only in the bottom chord bender are now welded for strength. In addition, any chord butt welds occurring in the middle third of the bottom tension chord are backwelded if necessary (depending on chord thickness) and reinforced by the addition of a splice plate in the bulb of the chord to cover the butt weld.

What I claim is:

1. A method for the continuous fabrication of individual metal joists comprising successively feeding web members of predetermined length to an assembly station, where the web member for each joist is brought into contact assembly with top and bottom chord members of predetermined length greater than the length of the web member and in such manner that the ends of the chord members extend beyond the ends of the web member, passing the contacting assembled web and chord members of each joist to a welding station and there joining said members by welding at the contacting surfaces thereof, passing the welded web and chord members of each joist to a chord bending and welding station where the extended ends of one chord member are bent into contact with and welded to the extended ends of the other chord member.

2. A method as set forth in claim 1 in which the top and bottom chord members are separately stacked on either side of the line of fabrication of the joists and the chords are taken singly from the stacks and fed into alignment with the web member.

3. A method as set forth in claim 1 in which the web member is formed from rod into an open wave form and the top chord member is fed forwardly on edge in parallel alignment with the adjacent crests of the wave form web member while the bottom chord member is fed forwardly on edge at a slight angle to the adjacent crests of the wave form web member.

4. A method as set forth in claim 3 in which the top chord member is first welded to at least two of the adjacent crests of the leading end of the web member and thereafter the top and bottom chord members are successively welded to the next following crests of the web member.

5. A method as set forth in claim 1 in which the top chord member is pressed inwardly a predetermined distance in the direction of the bottom chord member to impart a camber to the finished joist while the chord members are being welded to the web member.

6. A method as set forth in claim 1 in which the bottom chords are longer than the top chords and the leading end of the bottom chord is first bent into contact with and welded to the leading end of the top chord and, thereafter, the trailing end of the bottom chord is bent into contact with and welded to the trailing end of the top chord.

7. A production line for the fabrication of individual metal joists having a web member and top and bottom chord members comprising web bending means, the said web bending means adapted to bend a metal rod of predetermined length to form a web member having a wave form of uniform depth and spacing with the sides of the wave form being maintained straight between bends, a pair of chord advancing means, one each being located on either side of said web bending means, the said chord advancing means separately advancing each of the top and bottom chord members into contacting relationship with the bends on opposite lateral edges of the said formed web member, the said chords having their leading and trailing ends extending beyond the leading and trailing ends of the web member, means to advance the web member and top and bottom chord members uni-

formly into a welding station, the said station including a pair of welding machines, one of which is operable to weld the top chord to the adjacent bends of the web member and the other operable to weld the bottom chord to the adjacent bends of the web member, means to advance the welded joist into a bottom chord bending station, the said bottom chord bending station including a fixed die in a contact with the top chord of the joist, a hydraulic ram, a bending anvil secured to said ram adapted to make contact first with the leading edge of the bottom chord and secondly bend the bottom chord about a point close to an adjacent bend of the web member and into contact with the leading end of the top chord, means to advance the joist through the bottom chord bending station to bring the trailing end of the bottom chord into line with said connected die and hydraulic ram and secondly bend the trailing end of the bottom chord about a point close to an adjacent bend of the web member and into contact with the trailing end of the top chord, and means to weld the contacting surfaces of the top and bottom chords on completion of the separate bending operations at the leading and trailing ends of the joist to form joist and seats.

8. A production line as set forth in claim 7 in which the said web bending means includes a fixed table and a carriage movable with respect to the said fixed table, a rod bending mandrel and anvil on said table and on said carriage, a pair of arms pivotally mounted together at one end, one of said arms being pivotally mounted on said table while the other arm is pivotally mounted on said carriage, means to adjust the location of the pivotal mounting of the said arms on said table and carriage relative to the pivotal connection of the arms with each other to establish a predetermined depth of web to be bent, stop means to limit the distance of approach of the said carriage to said table to establish a predetermined longitudinal spacing between bends in the web, drive means for moving the said carriage, the said drive means in one position aligning the said arms in a straight line longitudinally of the production line and on movement against said stop forcing the arms into an angular position relative to each other to form the rod about said mandrels and anvils into a wave form, the said anvils maintaining the side of the wave form of the web straight between bends, and means to advance a rod into the said carriage and the formed web along the said table.

9. A production line as set forth in claim 7 in which the said pair of chord advancing means includes on one side of the said web bending means a top chord stacking means and on the other side a bottom chord stacking means, the said top and bottom chord stacking means each including a pair of side members forming a slot within which the chords are stacked one above the other, roller means supporting the stacked chords in said slot, a pair of pivoted finger members adapted to enter between the two lowermost chords in the stack to support the stack of chords above, means to lower the said roller means and the chord immediately supported thereby, means to advance the chord supported on said roller means and means to transfer the advanced chord transversely of the production line and to turn the chord on edge into alignment with the formed web advancing out of said web bending means.

10. A production line as set forth in claim 7 in which a first of said pair of welding machines is mounted for movement in the longitudinal direction of the production line and the second of said pair of welding machines is

mounted for movement transversely of the production, means to guide the top chord and formed web through the welding machines with the top chord continuously in contact with the adjacent bends of the formed web, and means to guide the bottom chord into contact with the adjacent bends of the formed web at a position trailing at least two web bends already welded to the top chord, control means whereby the first welding machine is operated to weld in succession a first leading bend and then a second bend of the formed web to the top chord and then to successively weld in pairs bends of the formed web to both top and bottom chords until all contact points between the web and top and bottom chords are welded.

11. A production line as set forth in claim 10 in which pressure means located ahead of the pair of welding machines applies pressure to the top chord to move the top chord a predetermined distance in the direction of the bottom chord, the applied pressure exerting a force on the formed web tending to shorten the distance between the bends of the formed web adjacent the bottom chord relative to the distance between bends adjacent to the top chord and thereby apply a predetermined camber to the welded joist.

12. A production line as set forth in claim 7 in which the said bottom chord bending station includes a pair of carriages adjustable in the longitudinal direction of the production line with respect to the said hydraulic ram and also transversely of the production line with respect to a fixed datum line coincident with the line of travel of the top chord of the joist, a guide member pivotally mounted on each of said carriages, a bending anvil on each of said carriages, the said latter bending anvils adapted to engage with the inward facing surfaces of the said bottom chord, the said guide members adapted to make contact with the outer facing surfaces of the said bottom chord, and a pair of arms pivotally mounted together at one end of said hydraulic ram adjacent the bending anvil attached thereto, the free ends of the said pair of arms being slidably mounted in the said guide members, the said arms, on movement of the said hydraulic ram and bending anvil against the said bottom chord, causing the guide member adjacent the bottom chord of either the leading end or the trailing end of the joist to bend the bottom chord about the adjacent bending anvil simultaneous with the bending of the bottom chord by the bending anvil attached to the said hydraulic ram into contact with the top chord to form a joist seat.

References Cited

UNITED STATES PATENTS

2,256,812	9/1941	Miller	29—155
2,624,430	1/1953	Macomber	52—694
2,662,272	12/1953	Macomber	29—155
2,722,735	11/1955	Beamish	282—5 X
3,158,731	11/1964	Cape	219—79
3,162,942	12/1964	Christman	29—471.1 X
3,199,175	8/1965	Wogerbauer	29—155
3,288,977	11/1966	Keller	219—79
3,362,056	1/1968	Preller et al.	29—430 X

THOMAS H. EAGER, *Primary Examiner.*

U.S. CI. X.R.

29—208, 430, 471.1; 52—694; 228—5; 219—79