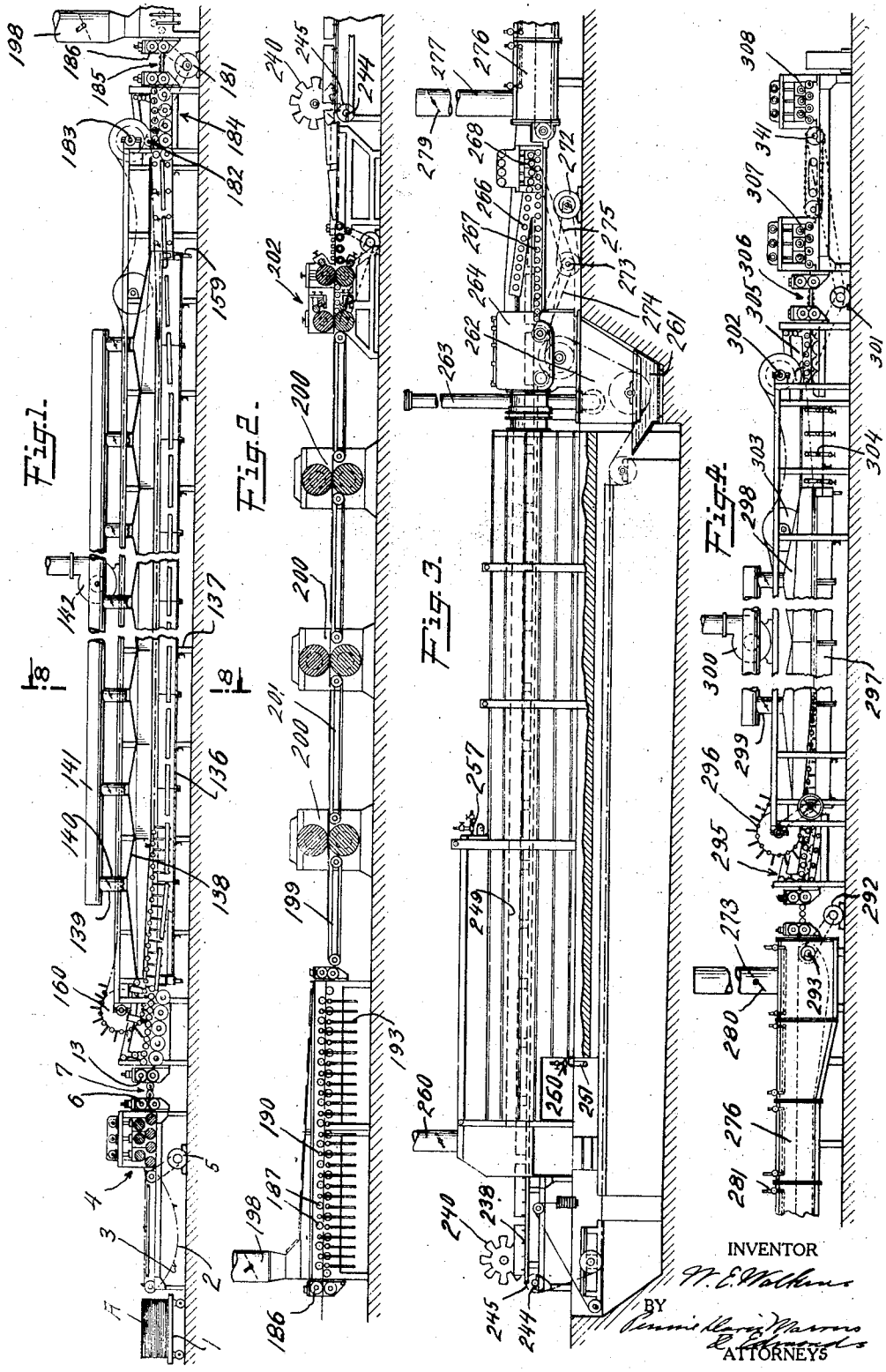
Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 1



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PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 2

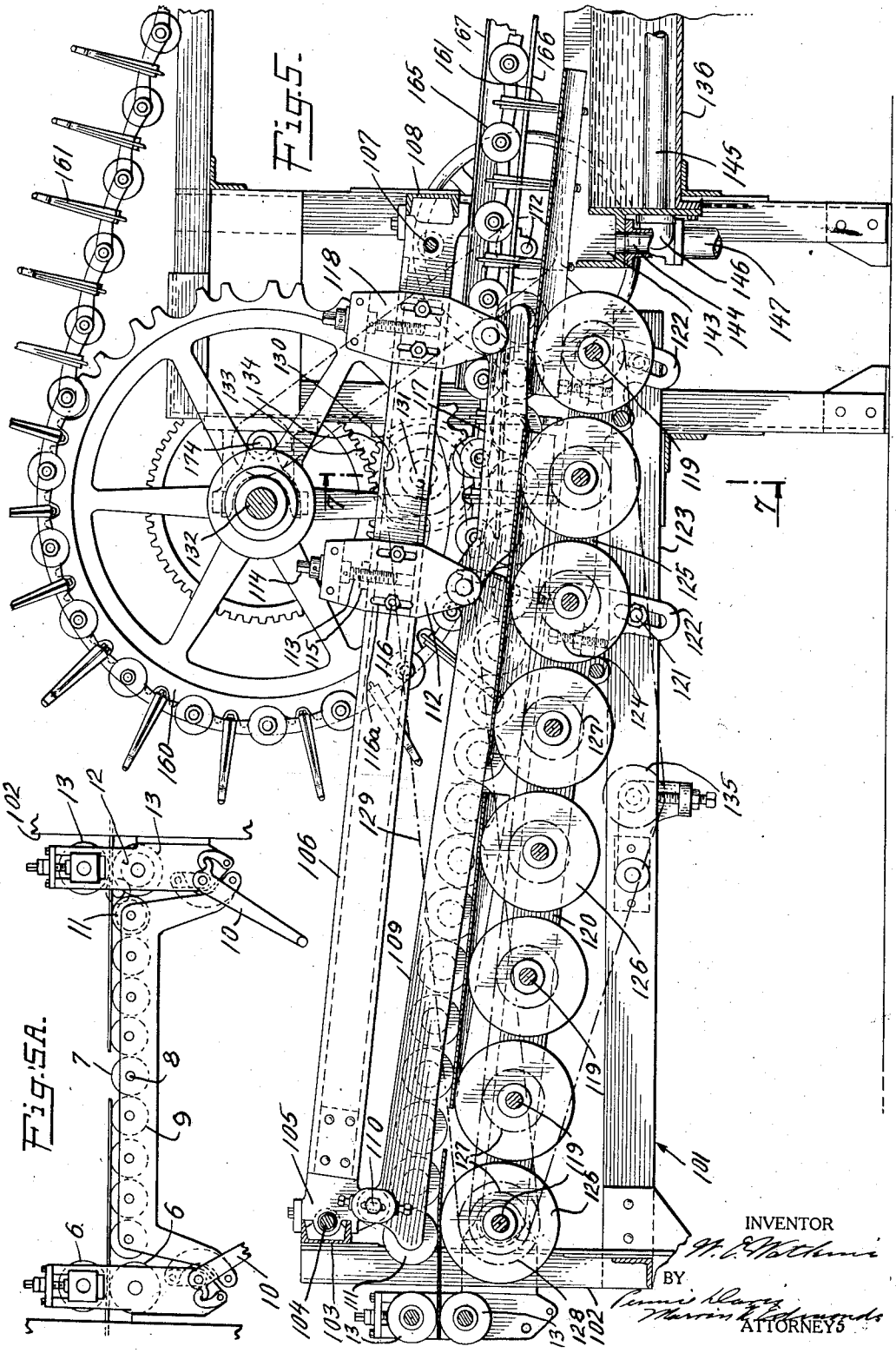


Fig. 5.

Fig. 5A.

INVENTOR
W. E. Watkins
BY
Munn, Mason & Alexander
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 3

Fig. 7.

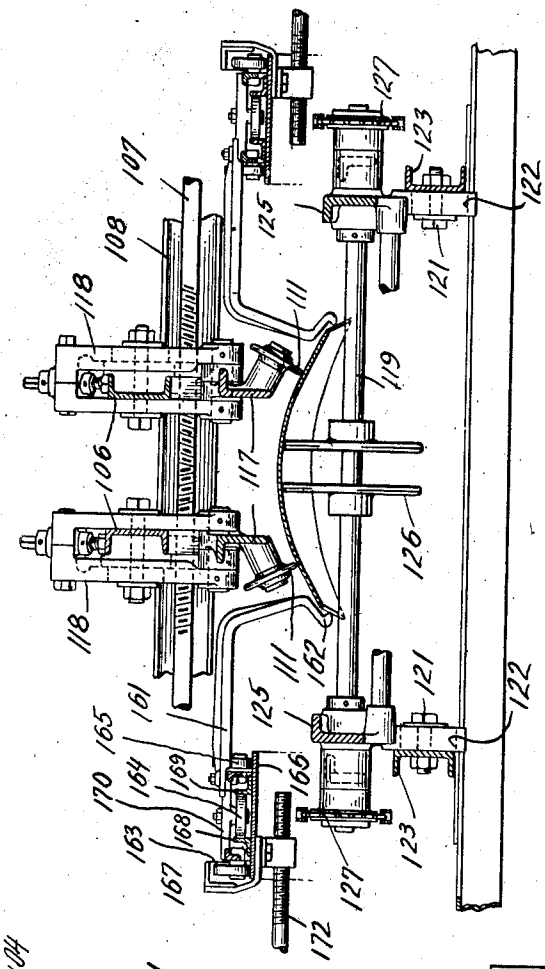


Fig. 5C.

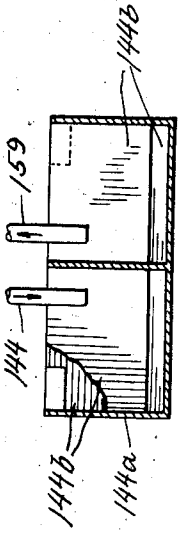


Fig. 6.

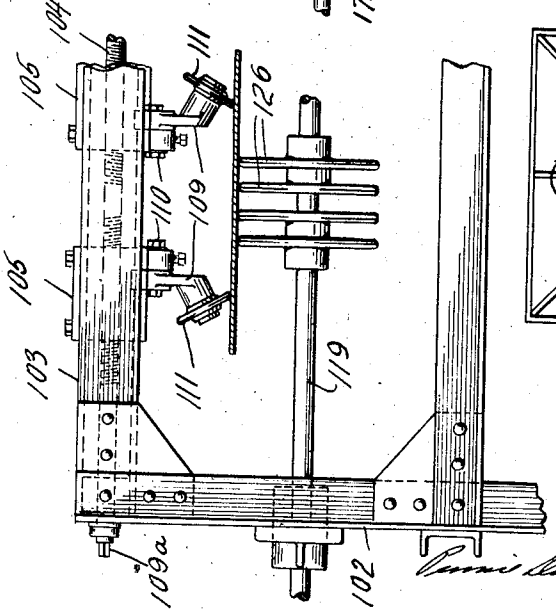
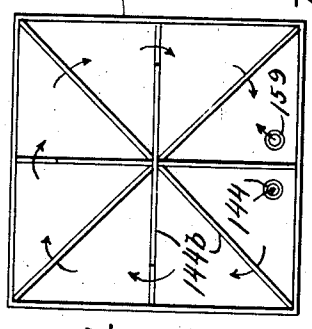


Fig. 5B.



5C

5C

INVENTOR
W. E. Watkins
BY
Parris Davis Warwick & Edmonds
ATTORNEYS

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PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 4

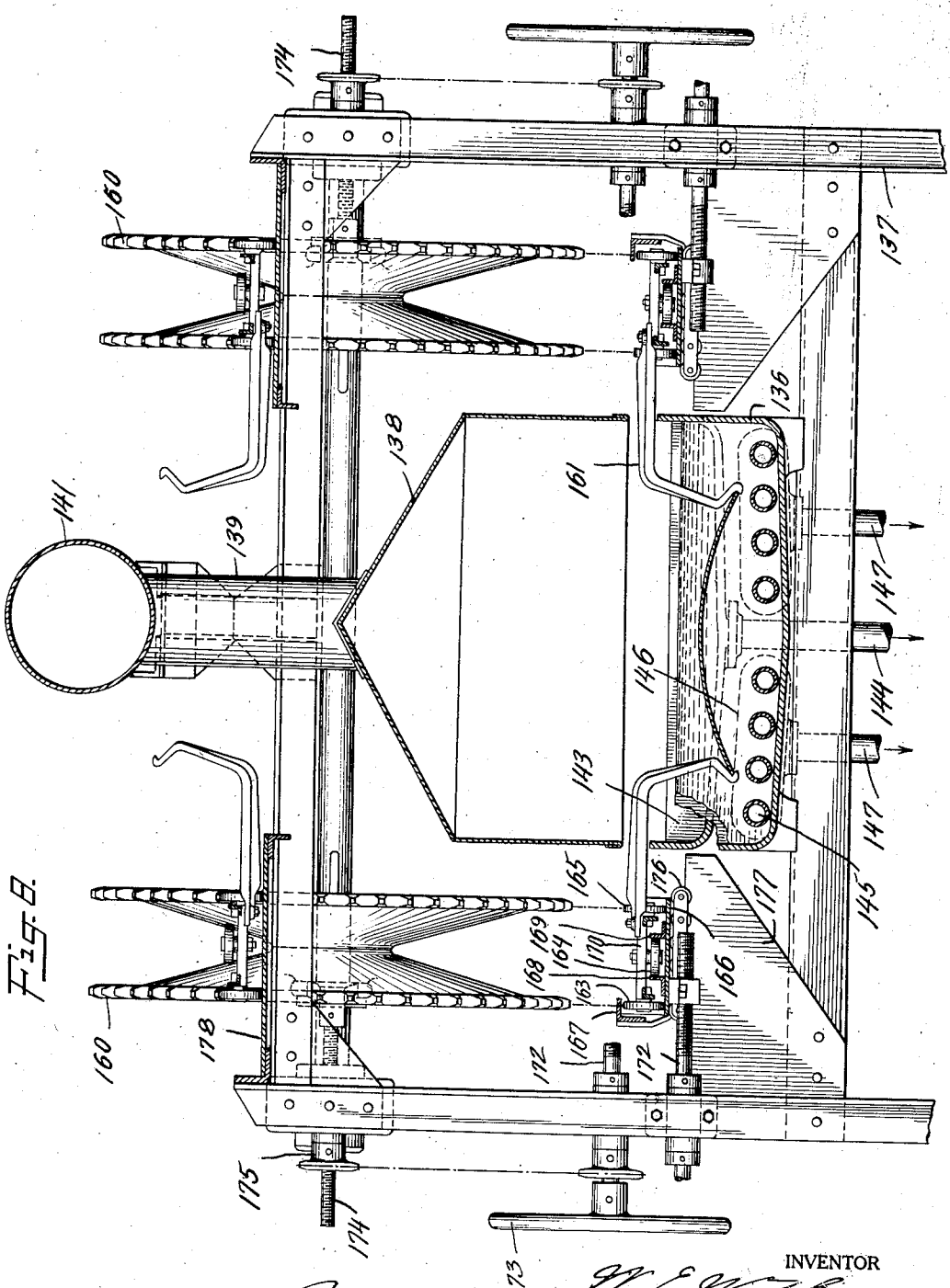


Fig. 8.

INVENTOR
W. E. Watkins
BY
Dennis Davis Marmon & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 5

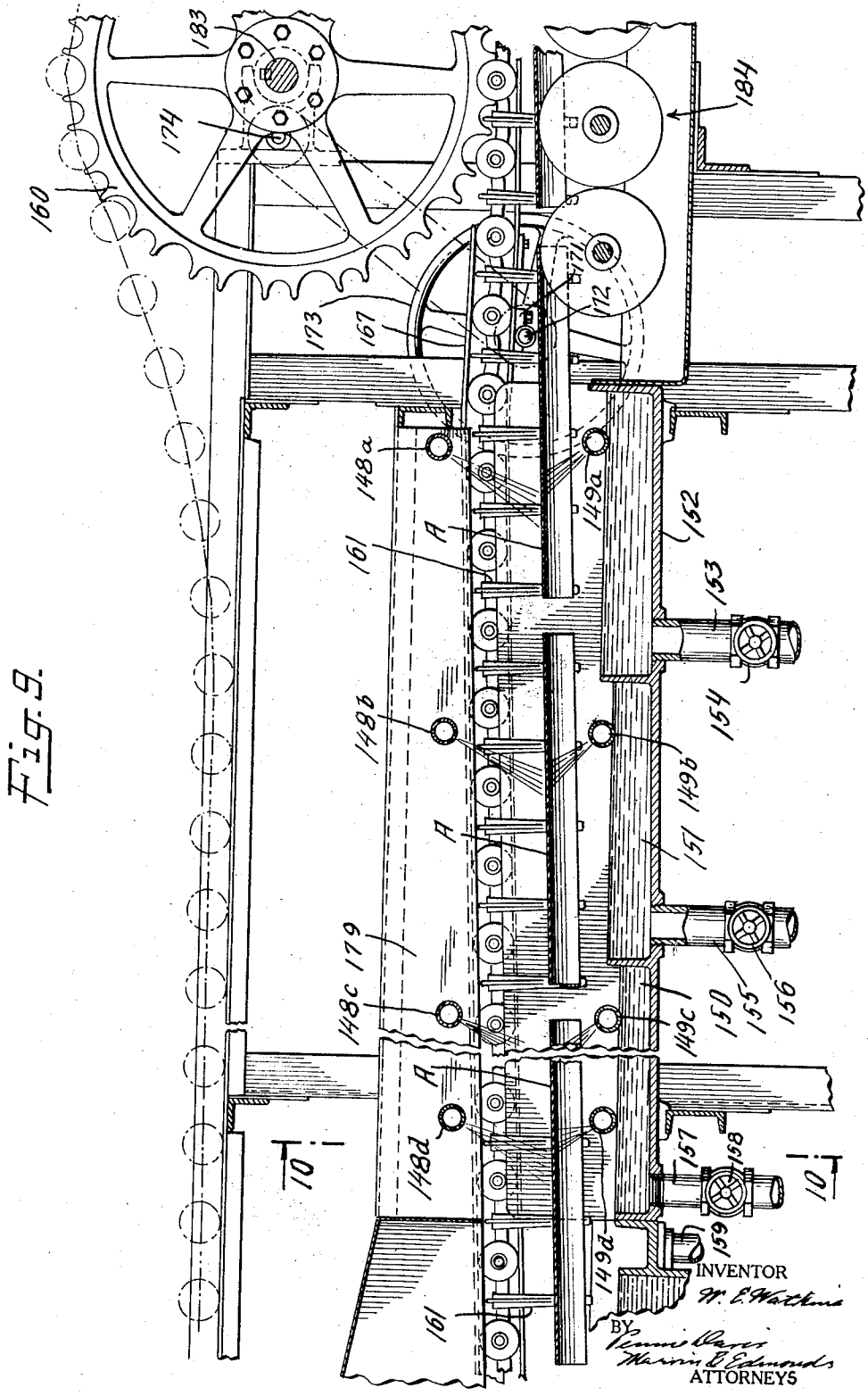


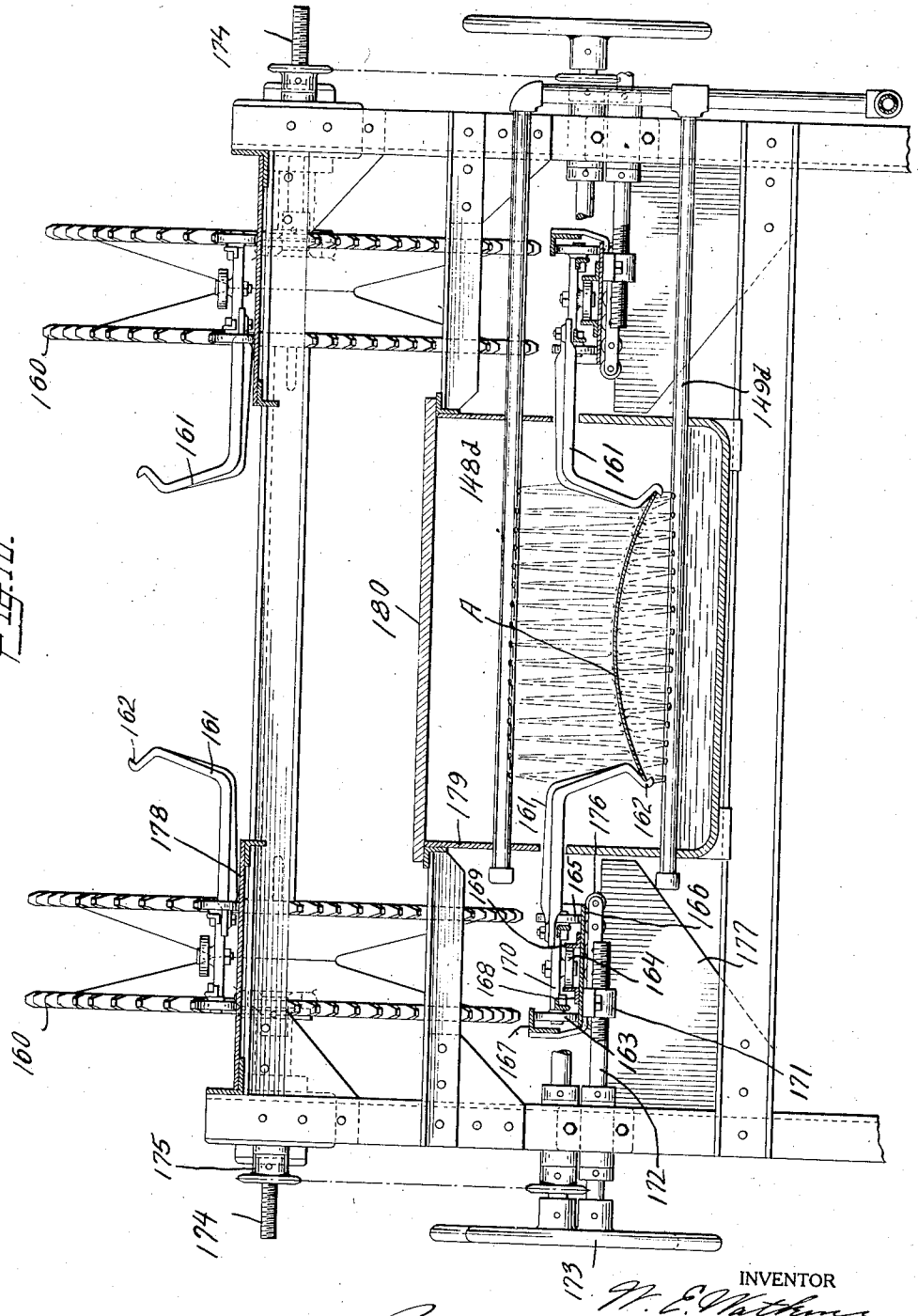
Fig. 9.

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PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 6

Fig. 10.

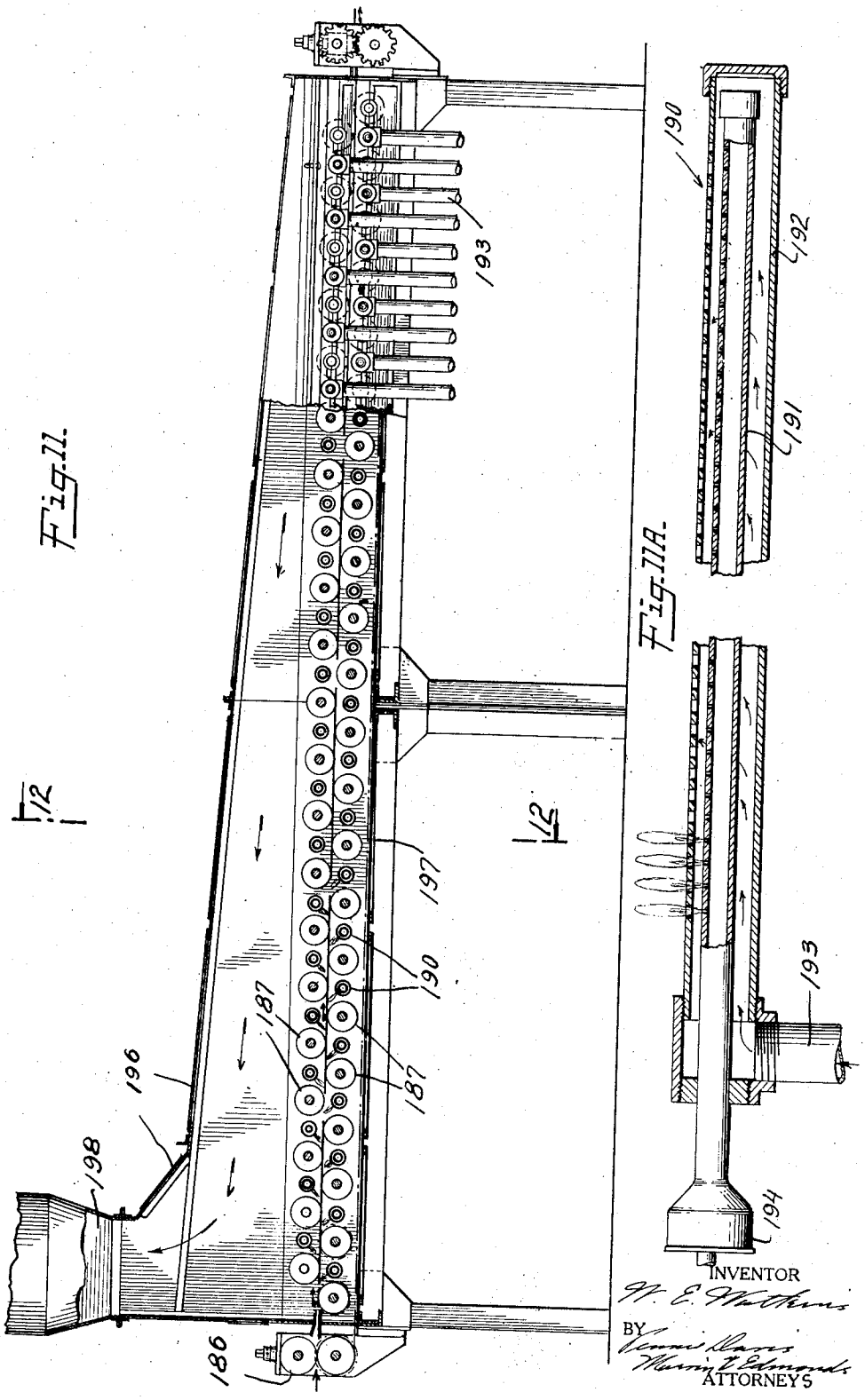


INVENTOR
W. E. Watkins
BY
Connolly, Bame, Morris & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 7



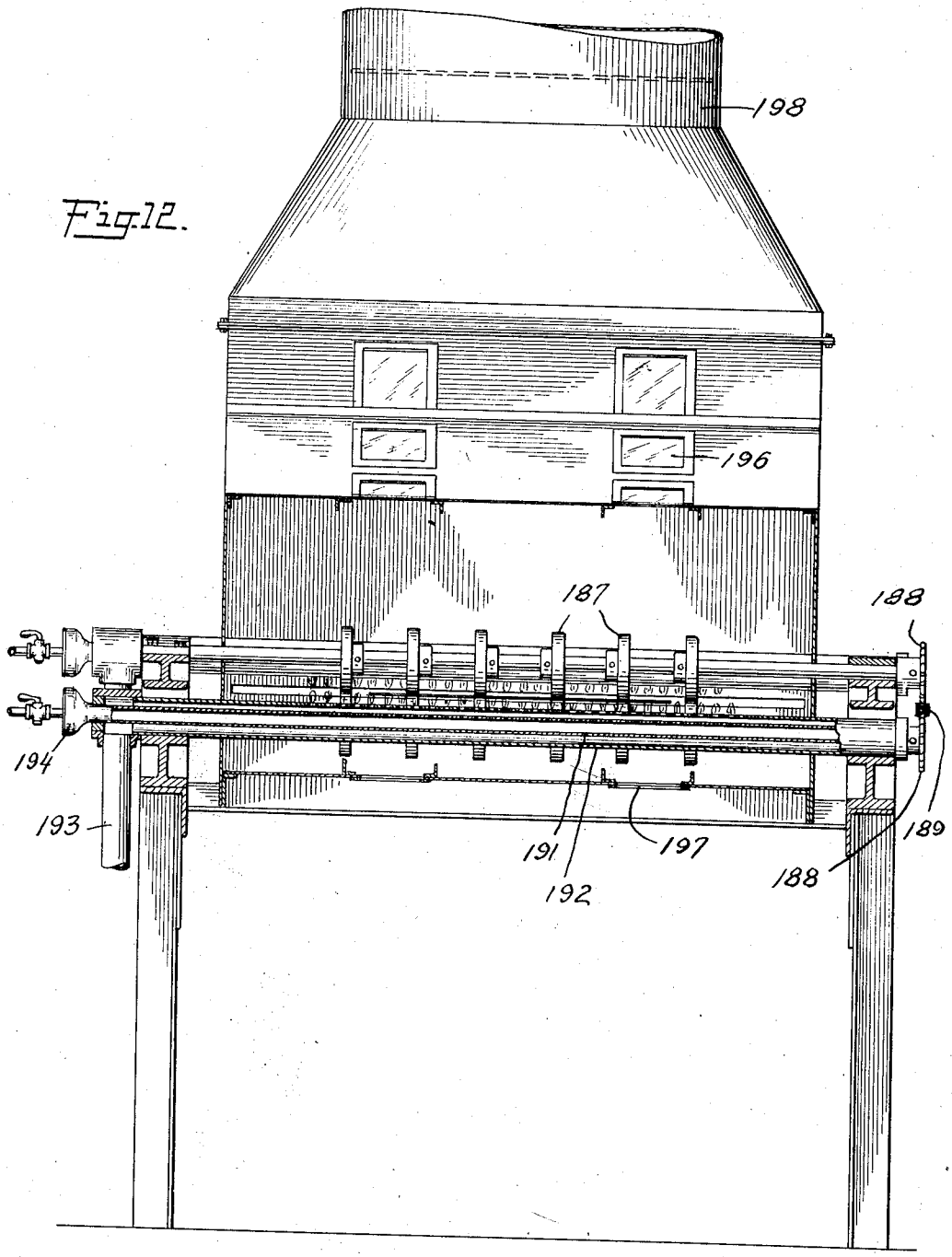
INVENTOR
W. E. Watkins
BY
Dennis Lacey
Murray E. Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 8

Fig. 12.



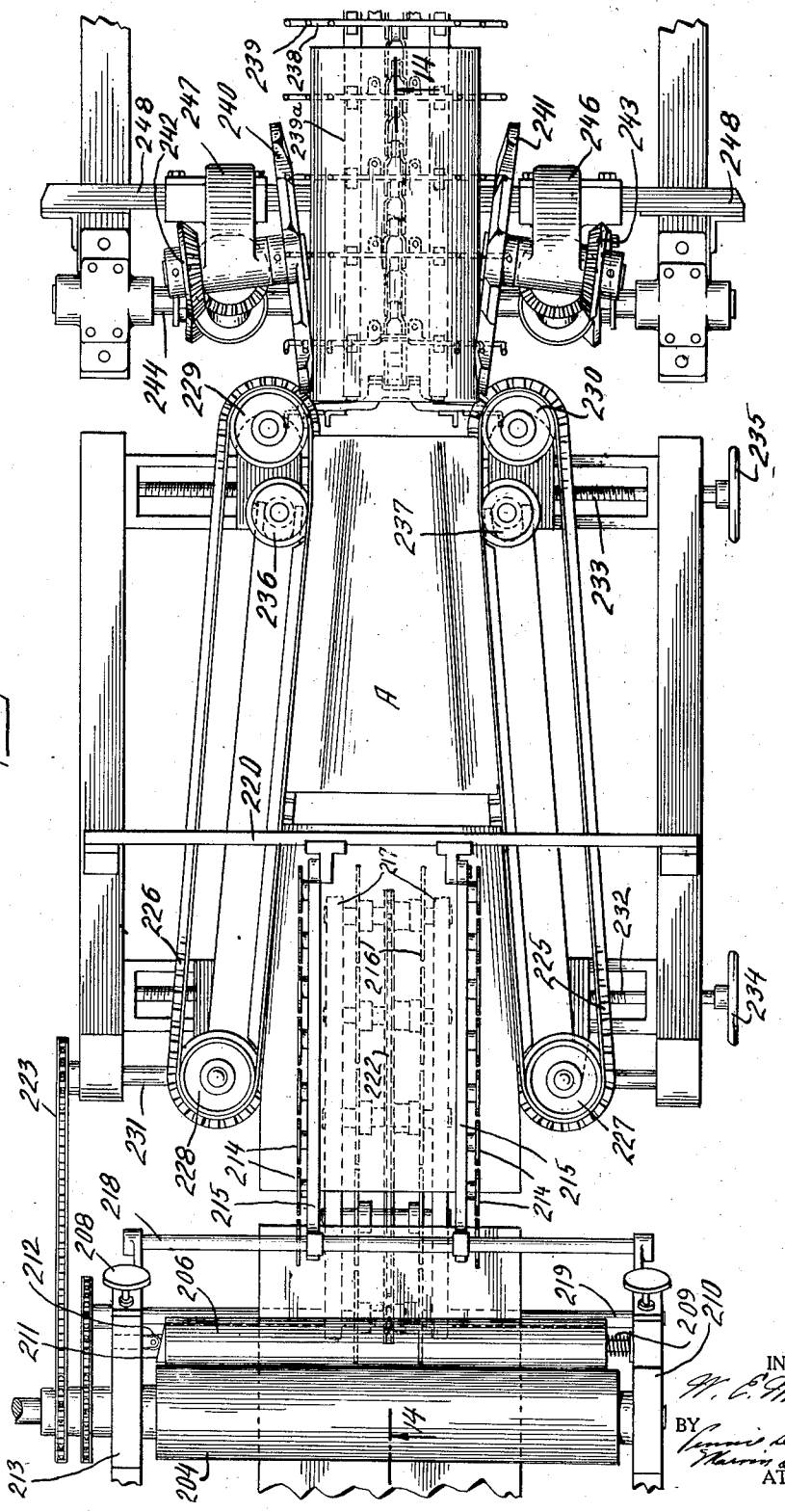
INVENTOR
W. E. Watkins
BY
Dennis Davis Warren & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 9

Fig. 13.



INVENTOR
W. E. Watkins
BY
Lewis, Davis, Munn & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 10

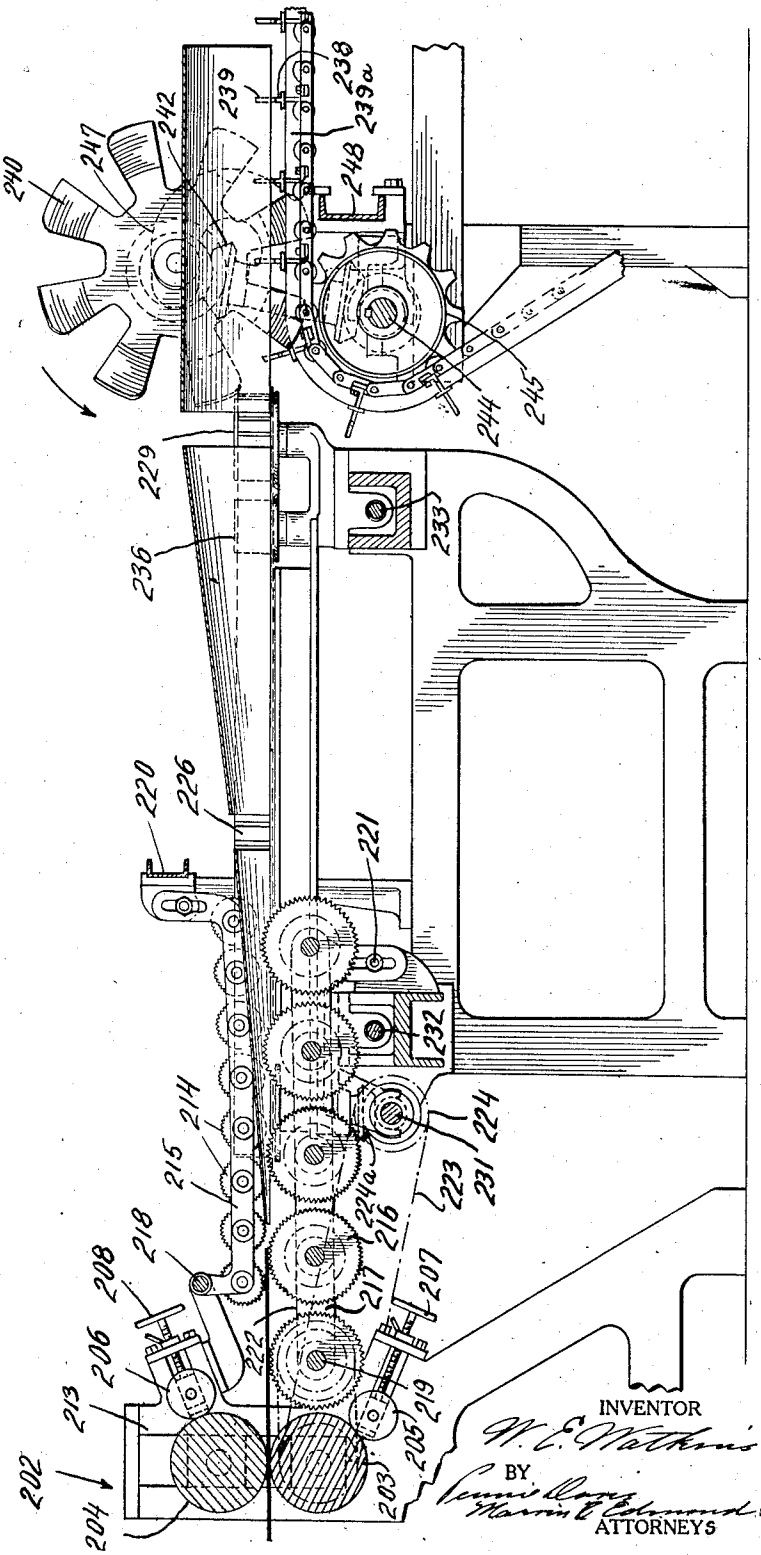


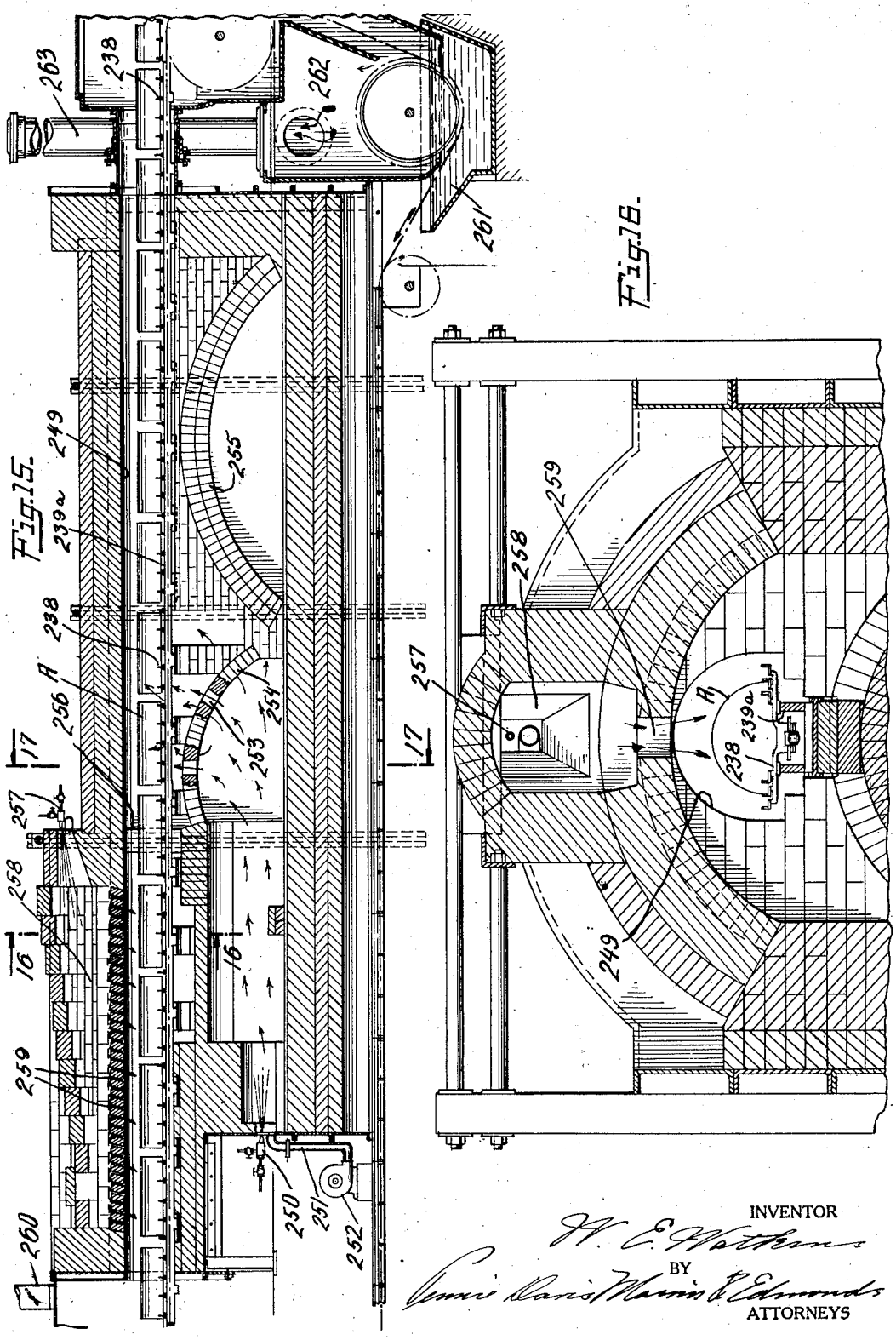
Fig. 14.

INVENTOR
W. E. Watkins
BY
Dennis Lane & Harris & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 11



INVENTOR
W. E. Watkins
BY
Dennis Davis Mann & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 12

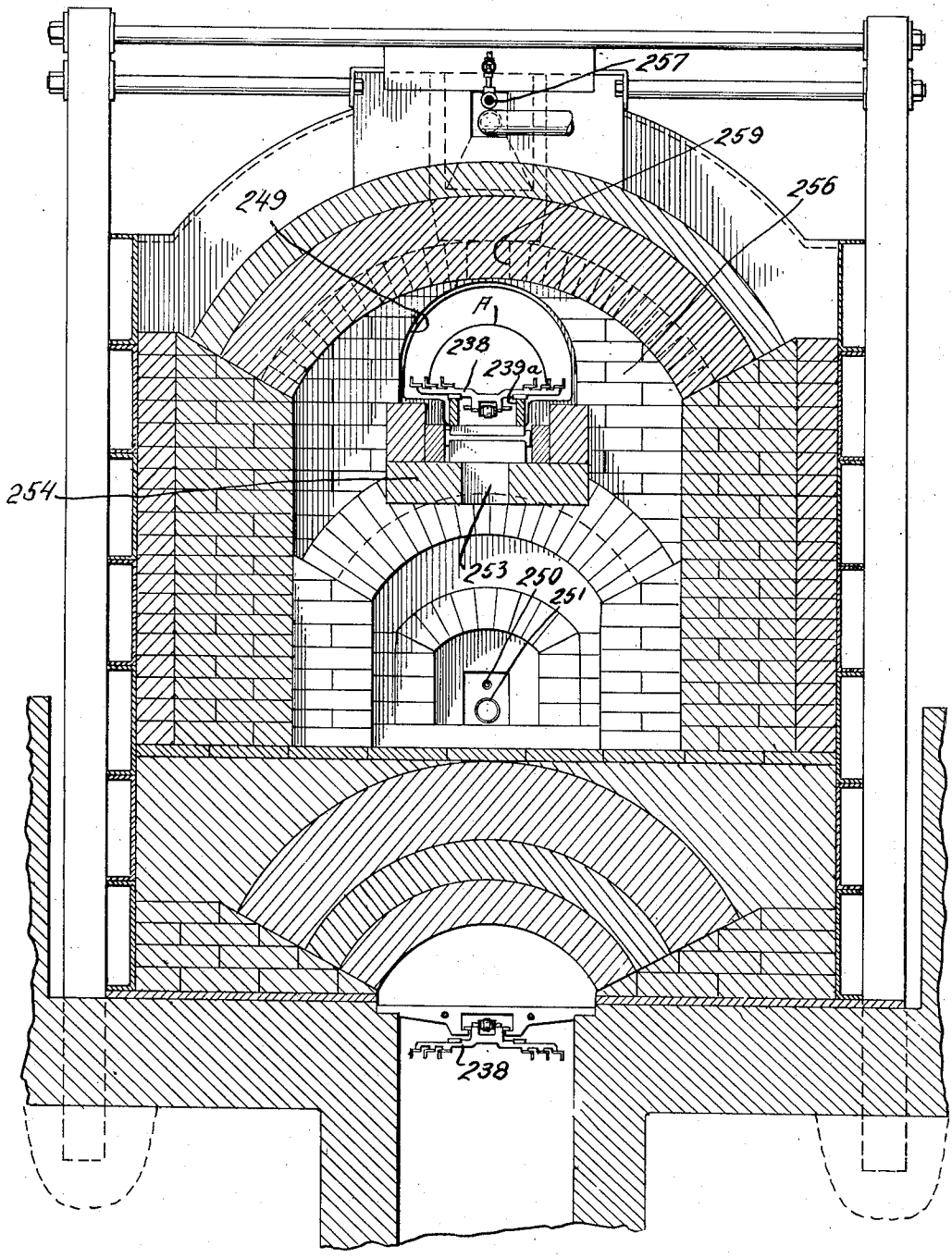


Fig. 17.

INVENTOR

W. E. Watkins

BY

Dennis Harris Morris & Edmonds

ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 13

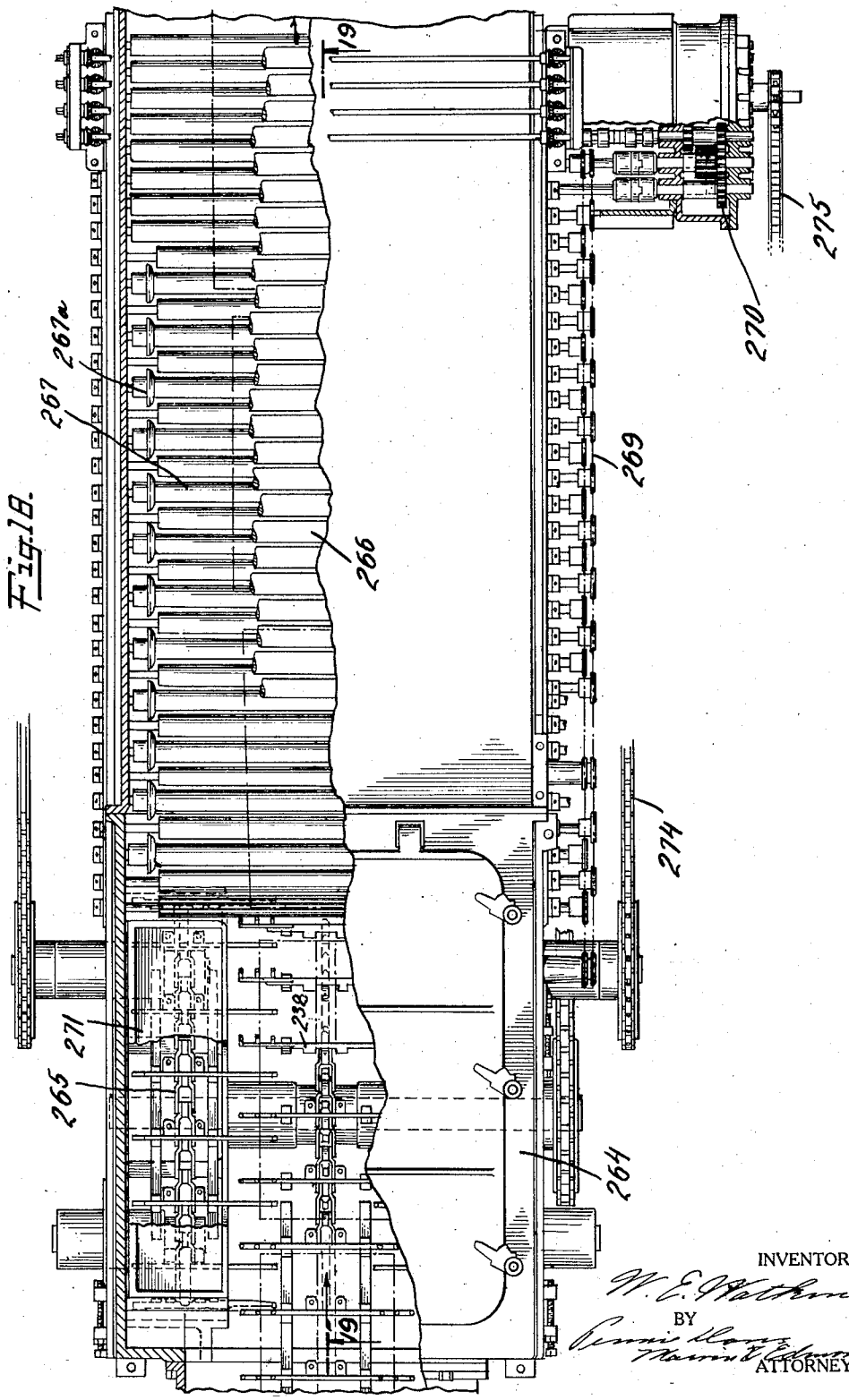


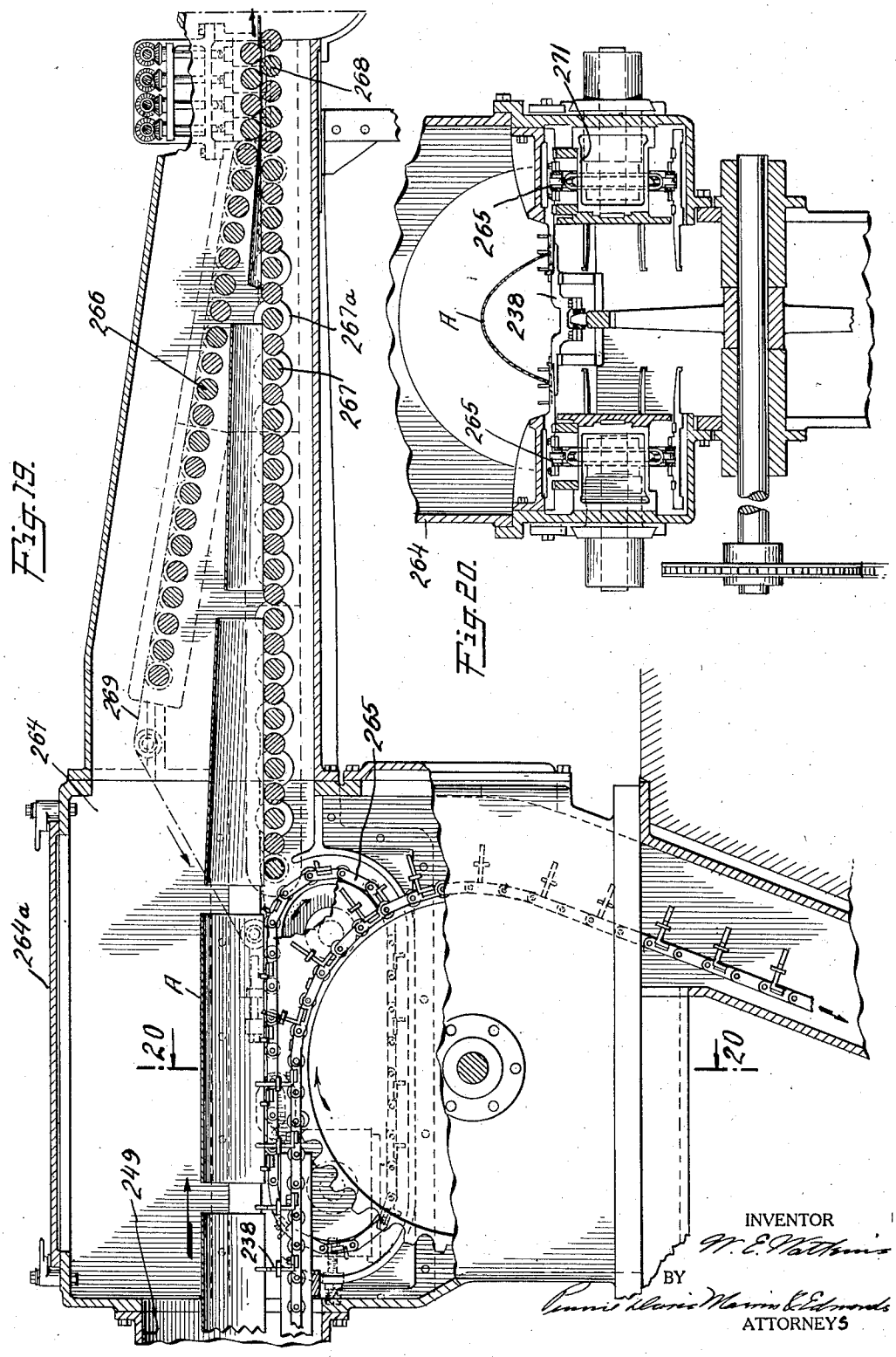
Fig. 18.

INVENTOR
W. E. Watkins
BY
Cummings & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

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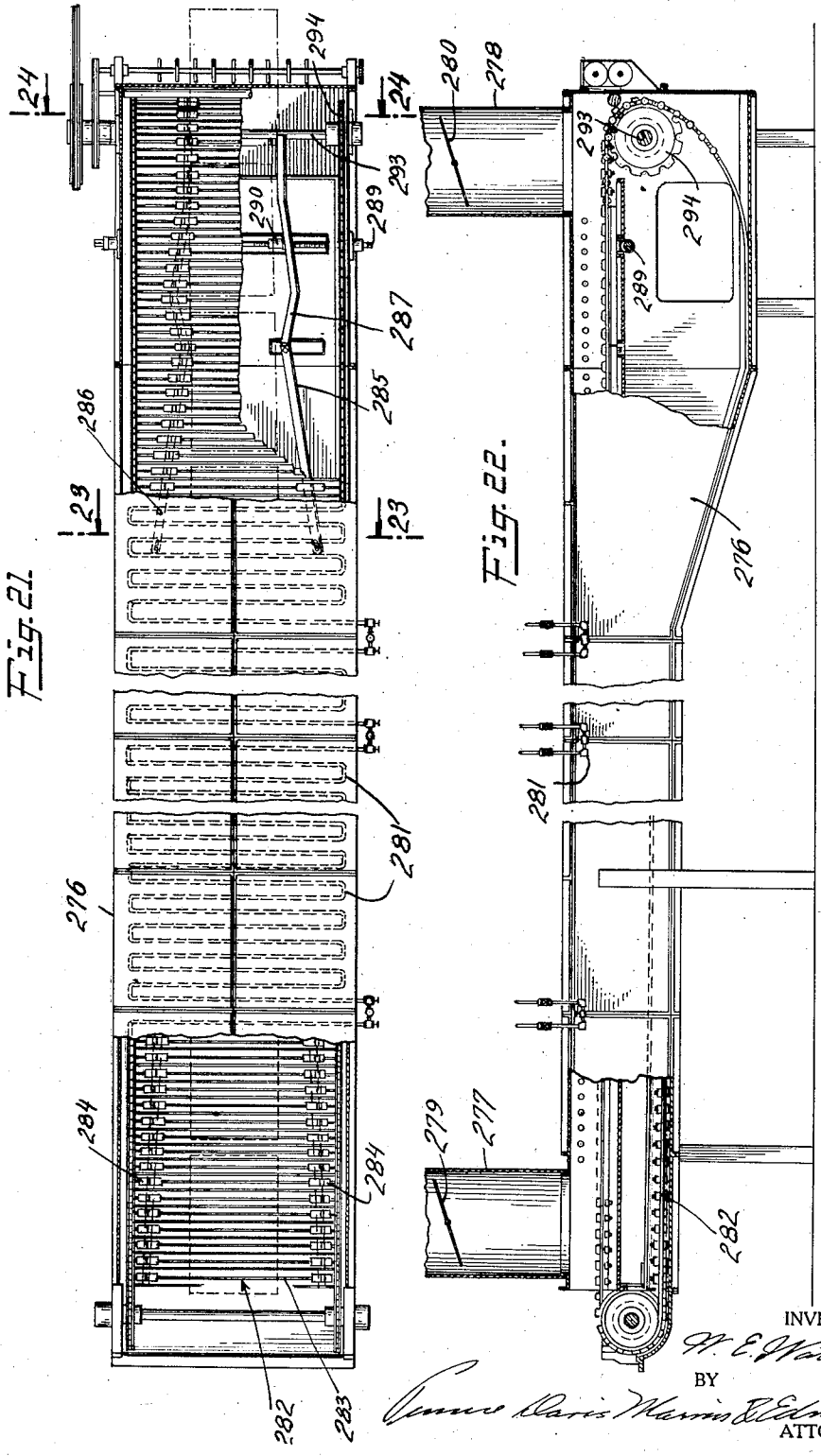


Fig. 21.

Fig. 22.

INVENTOR
W. E. Watkins
BY
Connolly Davis Morris & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 16

Fig. 23.

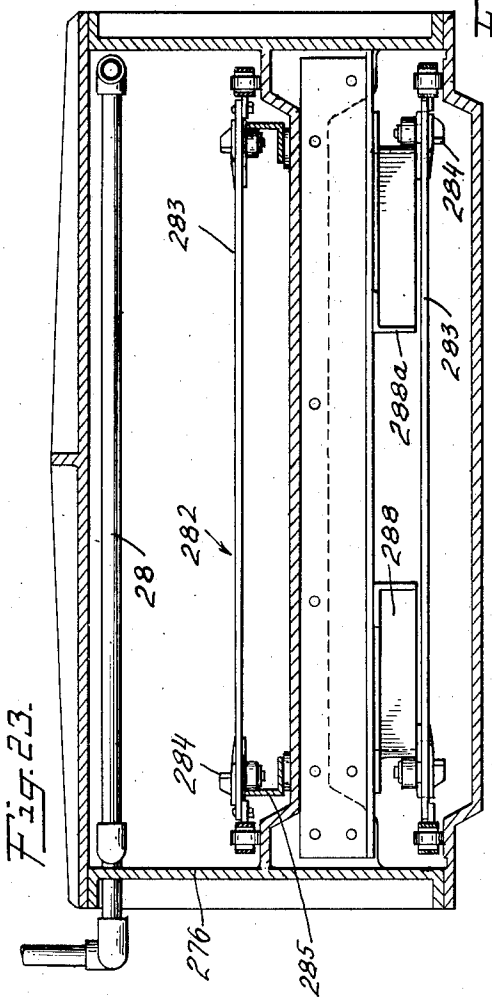


Fig. 24.

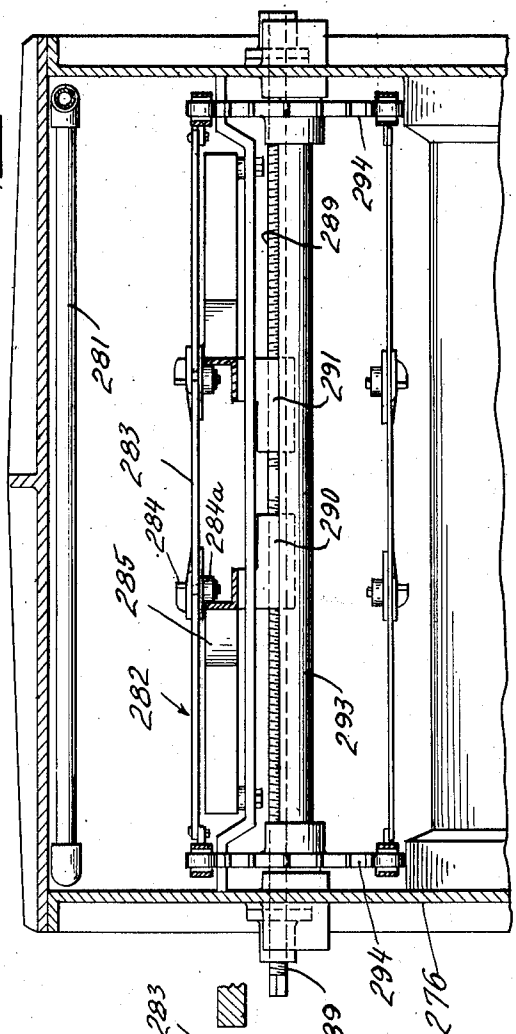
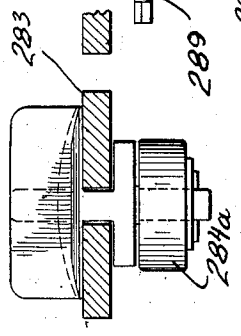


Fig. 24A.



INVENTOR
W. E. Watkins
BY
Dennis Davis Warren & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 17

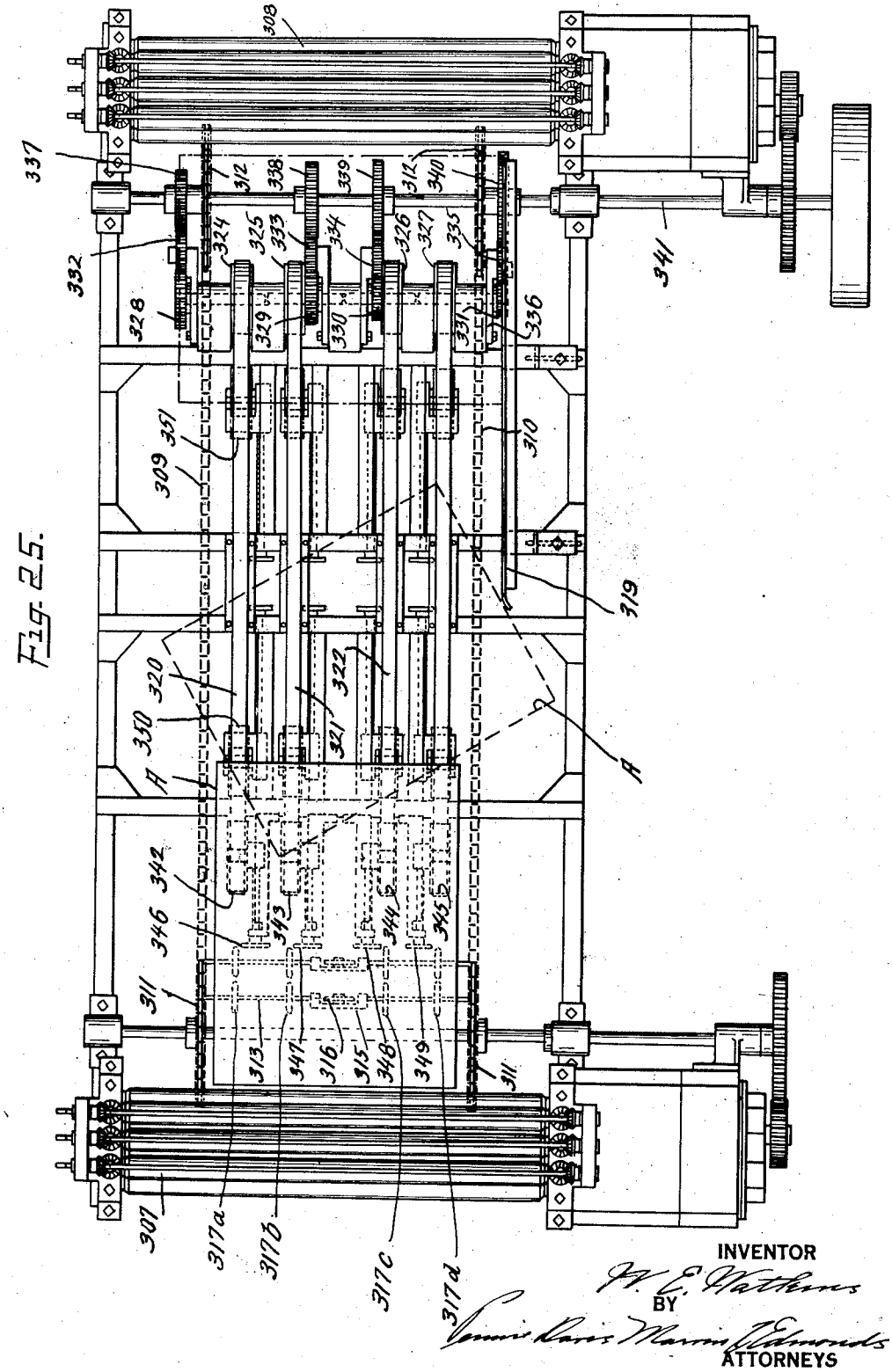


Fig. 25.

INVENTOR
W. E. Watkins
BY
Dennis Davis Marvin & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 18

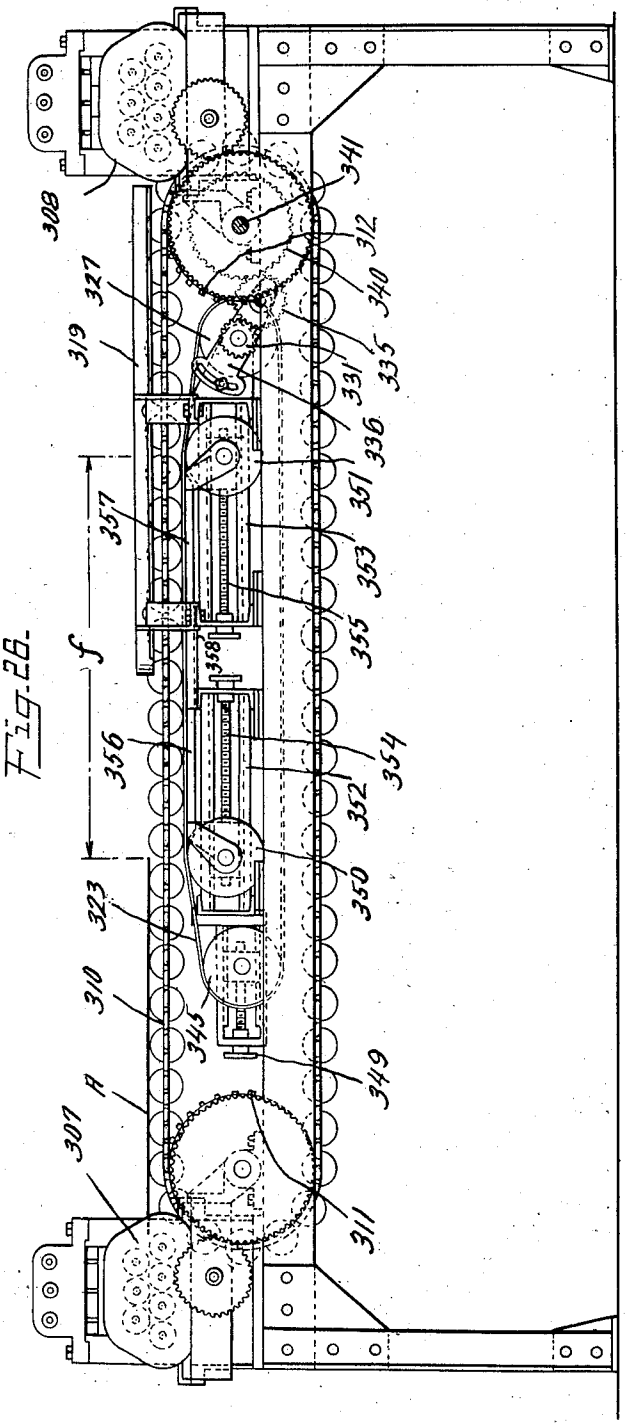


Fig. 28.

INVENTOR
W. E. Watkins
BY
Dennis Davis Marvin & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 19

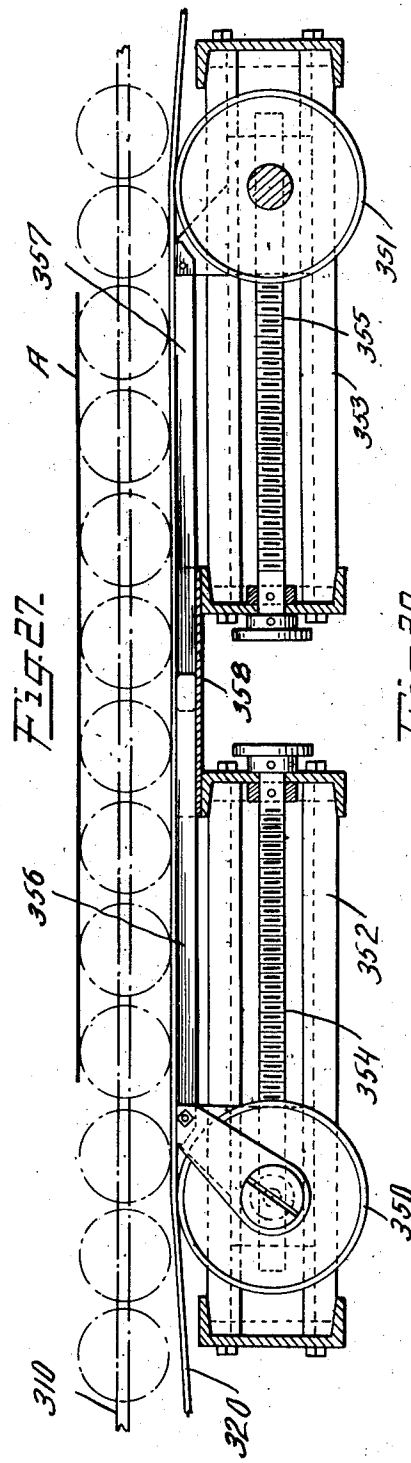


Fig. 27.

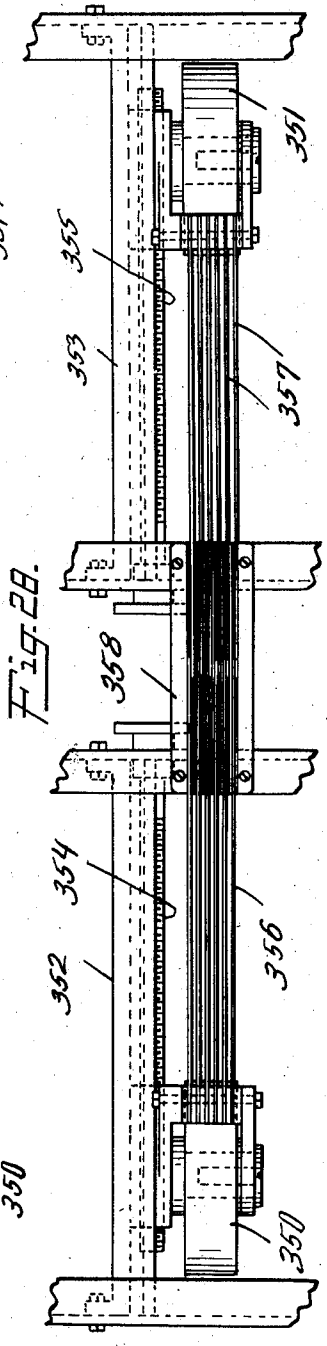


Fig. 28.

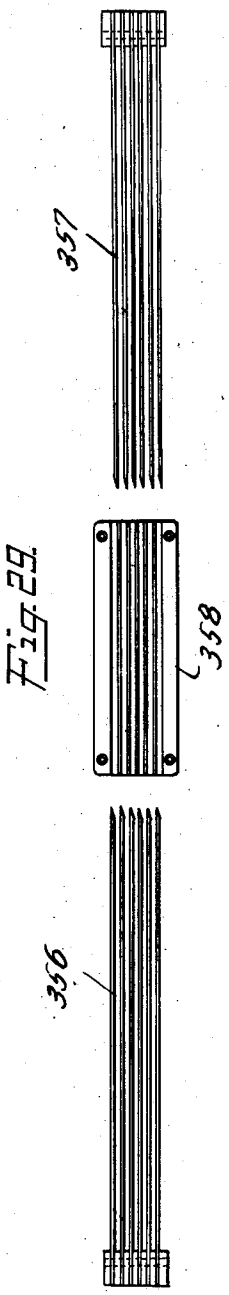


Fig. 29.

INVENTOR
W. E. Watkins
BY
Dennis Davis Marvin & Edmonds
ATTORNEYS

Jan. 20, 1931. W. E. WATKINS 1,789,853

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Filed June 16, 1926 20 Sheets-Sheet 20

Fig. 30.

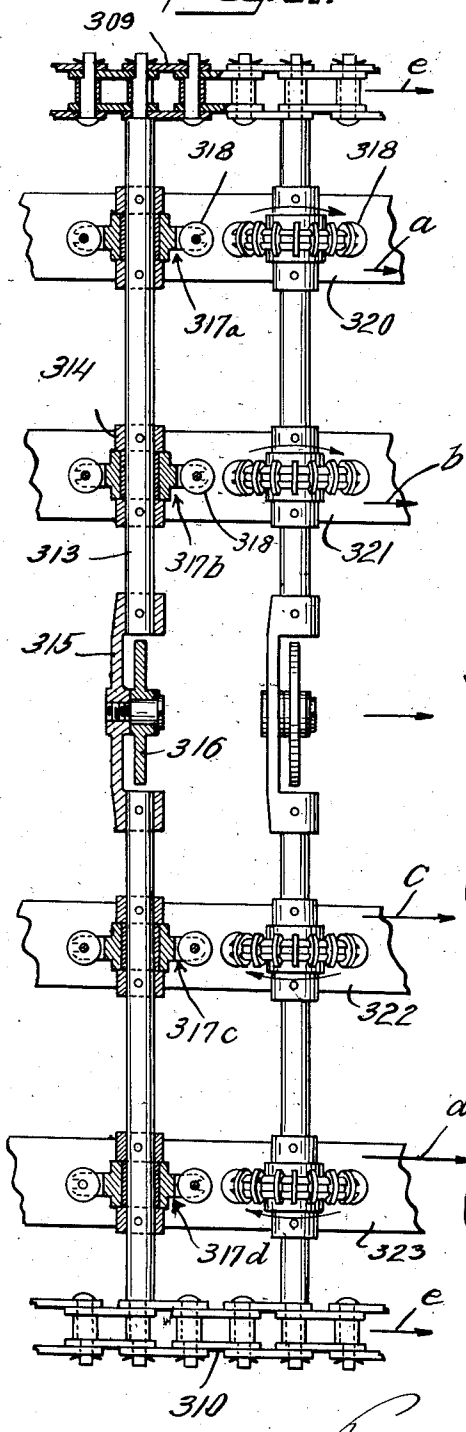


Fig. 31.

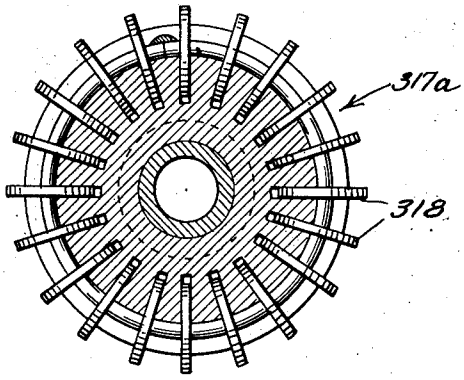
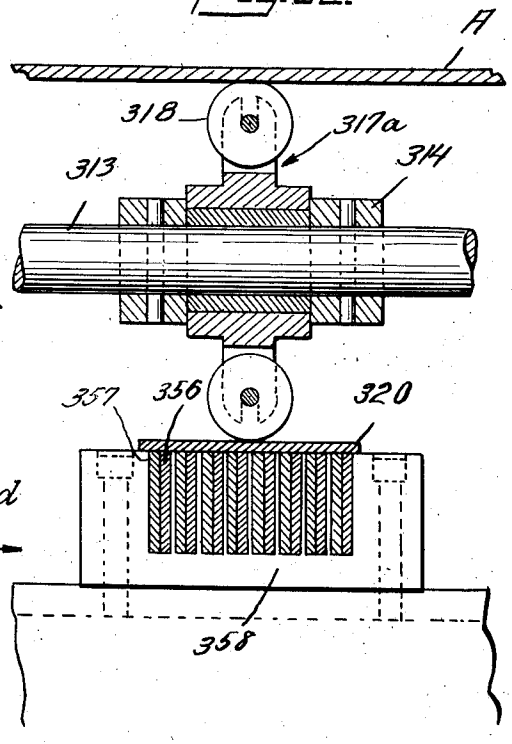


Fig. 32.



INVENTOR

W. E. Watkins

BY

Dennis Davis Morris & Edmonds

ATTORNEYS

Patented Jan. 20, 1931 1,789,853

UNITED STATES PATENT OFFICE

WILLIAM E. WATKINS, OF NEW YORK, N. Y., ASSIGNOR TO COPPER PLATE SHEET & TUBE COMPANY, A CORPORATION OF NEW JERSEY

PROCESS AND APPARATUS FOR TREATING SHEET METAL

Application filed June 16, 1926. Serial No. 116,486.

This invention relates to a process and apparatus for treating sheet metal, such as ferrous plates. This invention comprises certain improvements in the art of handling sheet metal plates, and treating such plates for the purpose of improving their physical characteristics.

The improved apparatus comprises an assembly of various mechanisms, each of which contributes to the common end, and all of which cooperate in the production of the desired ultimate result, and some of which, in sub-combination and alone, present features of novelty.

I shall describe my invention as applied to the handling and treating of hot rolled ferrous plates. According to the usual practice, sheet bars are rolled to form metal sheets of the desired size and thickness, the sheet bars being first heated to give them the degree of ductility necessary for the rolling operation. While the bars are still hot, they are repeatedly passed between heavy metal rollers under considerable pressure; the heating and rolling are repeated until a product of desired length, width and thickness is obtained. The product of this so-called "hot mill work" is too hard and brittle for fabrication purposes, and accordingly the product requires annealing before it can be of use for most purposes. Furthermore, the hot rolling operations are performed in the presence of atmospheric air, with the result that the surfaces of the product become more or less oxidized.

According to the particular embodiment of the invention herein described, ferrous plates which have been previously hot rolled are conveyed one at a time in continuous succession through an acid bath for the purpose of removing the oxide adhering to the surfaces of the plates. The individual sheets are conveyed through this acid pickling bath in arched form, then washed free of acid and subjected to the action of a dryer. The plates are then fed between rolling mills to impart to the plates the desired cold rolling effect. After passing through these rolling mills, the individual sheets are each prepared for the subsequent annealing operation. The flat plates coming from the rolling mills are crowned or arched for passage through an annealing furnace. The plates may be coated, prior to the crowning operation, with a layer of liquid such as asphaltic base hydrocarbon oil.

In order that the arched sheets may retain their shape while passing through the annealing furnace, I have provided means for first heating the crown of each of the sheets before subjecting the edges thereof to high temperatures. This relieves the tension in each of the plates promptly after it enters the annealing furnace, and the subsequent uniform heating of the plates up to the desired annealing temperature can then be carried out without any danger of having the plates become warped or in any way distorted from their initial arched form.

Upon leaving the annealing furnace, the plates are flattened out and then passed through a cooling chamber. Apparatus is provided for then subjecting the plates, in succession, to the action of dilute acid for removing any oxides formed during the preceding annealing operation. Upon leaving the acid bath, the plates are washed, passed through straightening rolls, rotated 90°, and passed through a second set of straightening rolls.

The details of one embodiment of this invention are set forth in the following description, which is to be considered in conjunction with the accompanying drawings. It is to be understood that these details may be varied in many ways, and that some of the elements described and illustrated may be replaced by equivalents or omitted entirely without sacrificing all of the advantages of my invention. It will therefore be understood that in illustrating and describing this one embodiment of the invention, I do not limit myself thereto, but contemplate the employment of such other like devices in the several combinations and sub-combinations set forth, as fairly fall within the scope of the appended claims. In the accompanying drawings,

Figures 1 to 4 inclusive, placed end to end, constitute a sectional elevation of the complete apparatus.

Figure 5 is a vertical section view of the arching mechanism for preparing the sheets to pass through the black pickling bath.

Figure 5A is an elevation of one of the bridges.

Figure 5B is a plan view of the acid settling tank.

Figure 5C is a vertical section view of the tank shown in Figure 5B, portions being cut away to show details of construction.

Figure 6 is a fragmentary elevation of part of the crowning mechanism shown in Figure 5.

Figure 7 is a fragmentary transverse section view taken on line 7 of Figure 5, showing details of the arching mechanism.

Figure 8 is a transverse section view of the black pickling apparatus taken on line 8—8 of Figure 1.

Figure 9 is a longitudinal section view of the washing apparatus associated with the black pickling apparatus.

Figure 10 is a transverse section view of the washing apparatus taken on line 10 of Figure 9.

Figure 11 is a longitudinal section view of the dryer.

Figure 11A is an enlarged longitudinal section view of one of the burners shown in Figure 11.

Figure 12 is a transverse section view of the dryer taken on line 12—12 of Figure 11.

Figure 13 is a plan view of the arching mechanism for arching the cold rolled sheets.

Figure 14 is a longitudinal section view of the arching mechanism taken on line 14—14 of Figure 13.

Figure 15 is a longitudinal section view of the annealing furnace.

Figure 16 is a fragmentary transverse section view of the annealing furnace taken on line 16 of Figure 15.

Figure 17 is a transverse section view of the annealing furnace taken on line 17—17 of Figure 15.

Figure 18 is a partially cut away plan view of the decrowning mechanism associated with the annealing furnace.

Figure 19 is a longitudinal section view of the decrowning mechanism taken on line 19—19 of Figure 18.

Figure 20 is a transverse section view taken on line 20—20 of Figure 19, showing details of construction.

Figure 21 is a partially cut away plan view of the cooling chamber arranged to receive the hot plates from the annealing furnace.

Figure 22 is a partially cut away longitudinal elevation of the cooling chamber shown in Figure 21.

Figure 23 is a transverse section view of the cooling chamber taken on line 23—23 of Figure 21.

Figure 24 is a transverse section view of the cooling chamber taken on line 24—24 of Figure 21.

Figure 24A is a sectional detail view of one of the guide rollers within the cooling chamber.

Figure 25 is a plan view of the straightening rollers and the mechanism for rotating the metal sheets.

Figure 26 is a side elevation of the apparatus shown in Figure 25.

Figure 27 is a fragmentary longitudinal section view of part of the mechanism shown in Figures 25 and 26.

Figures 28 and 29 are plan views of parts of the apparatus shown in Figures 25 and 26.

Figures 30 and 31 are plan views, partly in section, of portions of the apparatus shown in Figures 25 and 26.

Figure 32 is an enlarged vertical section view of certain details shown in Figures 30 and 31.

The apparatus of the present invention can be used in varying ways for treating sheet metal, such as iron or steel; and while it is not possible to herein set forth in detail the permissible variations in methods, I shall indicate some of these variations in describing the apparatus illustrated in the accompanying drawings.

The apparatus shown in Figure 1 comprises a power driven conveyor for supplying individual sheets of metal to straightening rollers. From these rollers the sheets are delivered to an arching mechanism. A conveyor picks up the arched sheets and carries them through an acid bath and then through water sprays that wash the plates free of acid. The plates are then flattened out, passed through a dryer, and then between a plurality of heavy rollers. The dryer and rolling mills are shown in Figure 2. Upon leaving the last rolling mill, the sheets may be passed through apparatus adapted to apply a film of liquid to one or both surfaces of each sheet.

A coating machine suitable for applying the layer of liquid to one or both faces of each sheet is described in my Patent No. 1,295,820. Such a coating machine can be used for applying to the sheets a layer of any desired liquid. For example, I have found that certain beneficial results can be obtained by applying to the sheets a layer of oil, such as asphaltic base hydrocarbon oil. This oil volatilizes within the annealing furnace, but before the film of oil disappears it serves to distribute the heat being supplied to the sheets, thus preventing local overheating. The oil vapor forms a reducing atmosphere within the furnace.

After the plates have been coated as above described, they are then delivered to an arching mechanism and transferred through a furnace heated to a temperature sufficient to anneal the plates. For low carbon steel,

this critical temperature is in the neighborhood of 1620° F. Ferrous plates heated to this temperature are relatively soft and in order to prevent the sheets from warping or becoming in any way distorted while passing through the annealing furnace, I prefer to treat each of the sheets so as to relieve the tension in the sheet and thus reduce the force exerted on the edges of the sheet by the furnace conveyor. I have found that this can be accomplished by heating the upper portion or crown of each of the arched sheets to a fairly high temperature before subjecting the edges of the sheet to high temperatures. My improved furnace is illustrated in Figure 3. Figure 3 also shows the flattening or decrowning mechanism associated with the delivery end of the furnace conveyor. The annealed sheets are passed through a cooling chamber such as that illustrated in Figure 4, and then through an acid bath, and ultimately through straightening rollers which serve to straighten the sheets. This last mentioned mechanism is preferably constructed so that the sheets can be passed through one set of straightening rollers, then automatically rotated 90°, and passed through another set of straightening rollers.

Referring again to Figure 1, I have illustrated a truck 1, carrying a stack of ferrous sheets A. These sheets are the product of what is known as "hot metal work"; they have been made by passing hot sheet bars through rolling mills until the desired dimensions have been obtained, and then passing them through an annealing furnace. The sheets A are placed one at a time by hand on a conveyor 2 having projecting fingers 3, which engage the individual sheets and force them toward the trimmer 4, which is of ordinary construction. The conveyor 2 is driven by a motor 5, and the conveyor is made up of detachable links which may be removed or inserted as desired for the purpose of varying the distance between the fingers 3, thus enabling the conveyor to be used for handling sheets of different lengths. A pair of delivery rollers 6 deliver the sheets from the trimmer to conveyor rollers 7, each loosely mounted on a power driven shaft 8. The bearings for each of these shafts are carried by a bridge 9 (see Fig. 5A) and each shaft is driven at the speed of the delivery rollers 6. This bridge is provided with latching devices 10 adapted to hold it in the position shown in Figure 1. By releasing these devices, the bridge can be dropped to a lower level so as to disengage the gear 11 from the driving gear 12. When this is done, the sheets passing through the delivery rolls 6 simply pile up on the bridge rollers, thus permitting continued operation of the conveyor 2 and the trimmer 4, even though the arching mechanism is shut down.

The arching mechanism (Figures 1, 5, 6 and 7)

When the bridge 9 occupies its normal position, the sheets are fed across the bridge in succession and picked up by the delivery rollers or disks 13 (see Fig. 5).

The arching mechanism comprises two cooperating sets of wheels or disks, one set being arranged above the other, and the two sets being adapted to force the center of each sheet upward as it progresses, while holding the side edges of the sheet down. These sets of disks serve to deliver each sheet in arched form to a conveyor adapted to carry the sheets through the acid bath.

In Figure 5, I have illustrated a framework 101 having front upright portions 102 carrying an upper cross-beam 103. A screw-threaded adjusting rod 104 extends parallel to the beam 103 and is journaled at the ends of this beam. Two blocks 105 each have screw-threaded engagement with the adjusting rod 104. These blocks are each connected to an upper supporting beam 106. The two supporting beams, each designated by the numeral 106, are supported at their rear ends by a second adjusting rod 107 extending parallel with a second cross-beam 108. Each of the adjusting rods 104 and 107 is provided with right and left hand screw-threads so that when either of these rods is turned, as by applying a crank to a squared end such as that shown at 109*a* in Figure 6, the adjacent ends of the supporting beams 106 are brought closer together or spread further apart, depending upon the direction of rotation of the adjusting rod.

Upper front bearing beams 109 are pivoted to each of the upper supporting beams 106, as shown at 110. Each of the two beams 109 carries a plurality of stub shafts, each carrying a wheel or disk 11. These disks are inclined at an angle to the vertical, as shown in Figures 6 and 7, and serve to engage the upper surface of each of the sheets passed through the arching mechanism, so as to hold the edges of the sheets down while the center is being forced up by the lower set of arching disks hereinafter described. The rear end of each of the upper bearing beams 109 is journaled in a bearing block 112, adjustably mounted on a corresponding supporting beam 106. The position of each bearing beam with respect to the corresponding supporting beam can be varied by adjusting the screw 113 having a squared end 114 and a lock nut 115. It will be understood that a bearing block and an adjusting screw are provided for each of the bearing beams 109, as shown in Figure 7. The blocks 112 can be fixed to the supporting beams 106 in any adjusted position by tightening nuts 116 on bolts passing through slots

116*a* in the bearing blocks. This provides independent adjustment of the rear ends of the two bearing beams 109.

A pair of upper rear bearing beams 117, each carrying four or five wheels or disks 111, is arranged with the forward end of each bearing beam journaled to the corresponding bearing block 112, and with the rear end of each beam journaled to a rear bearing block 118. Each of the rear bearing blocks may be identical with the bearing blocks 112, and may be provided with the same adjusting and clamping devices. The rear bearing blocks 118 may be adjusted for the purpose of adjusting each of the rear bearing beams 117 independently of each other and of the front bearing beams 109. The disks 111 carried by the upper front and rear bearing beams are not power driven; they are simply rotatably mounted on stub shafts carried by the bearing beams.

The lower set of disks (shown at 126) adapted to cooperate with the upper set of disks just described, comprises a plurality of wheels or disks of a diameter preferably larger than that of the disks 111 and each mounted on a shaft extending at right angles to the direction of travel of the sheets through the arching mechanism. In Figure 5, I have shown eight of these shafts, the forward six, designated by the numeral 119, being journaled in front bearing beams 120. Each of the two lower front bearing beams 120 is pivoted about the axis of the first shaft 119 and the rear end of each of these beams is detachably connected, as by means of a bolt 121 projecting through a slot in an integral extension 122 of the bearing beam and secured to a lower supporting beam 123. An adjusting screw 124 can be used as a means for adjusting the position of the rear end of each lower bearing beam 120 with respect to the corresponding supporting beam 123. The two rear transverse shafts 119 are journaled in separate lower bearing beams 125, each having its forward end journaled on an axis concentric with the axis of the last transverse shaft 119 carried by the front bearing beams 120. The rear end of each of the lower rear bearing beams 125 is detachably and adjustably connected to the lower supporting beam 123 in a manner similar to that of the rear end of each front bearing beam 120, thus permitting independent adjustment of each of the lower rear bearing beams.

The disks 126 carried by the shafts 119 are somewhat larger than the disks 111 carried by the stub shafts on the upper bearing beams 109. Referring to Figure 6, I have illustrated four disks 126 carried by the first shaft 119. These disks are arranged so that the horizontal plane including the upper edges of the disks 126 coincides at least approximately with the horizontal plane including the lower edges of the upper disks 111. The first two or three shafts 119 may each carry four disks 126 arranged substantially as shown in Figure 6; the remaining shafts 119 preferably carry only two disks, as shown in Figure 7. Where only two disks are provided they are arranged closer together than the outside disks on the shafts carrying four disks apiece. All of the disks on the shafts 119 are preferably of the same diameter. The rear ends of each upper front bearing beam and the corresponding lower front bearing beam are closer together than the front ends of these members, and accordingly the centers of the lower disks near the rear are closer to the centers of the upper disks 111. Accordingly, as the sheets pass through the arching mechanism, the center of each sheet is forced upward, while the edges are held down, and in this way the sheets are delivered in arched form to the conveyor for transfer through the acid bath.

Each of the lower disks 126 is power driven. The ends of the shafts 119 are provided with sprocket wheels 127 and adjacent sprocket wheels are connected by a sprocket chain passing over all of the sprocket wheels. The front sprocket 128 is driven by means of a chain 129 connected to a sprocket wheel 130 on a counter shaft 131 driven from the conveyor shaft 132 by means of gears 133 and 134. An adjustable idler sprocket wheel 135 is mounted on the lower supporting beam 123 and serves to take up the slack in the sprocket chain passing over the sprocket wheels on the shafts 119.

Black pickling and washing apparatus (Figures 1, 5, 5B, 5C, 8, 9 and 10)

After the plates have been subjected to the action of the arching mechanism shown in Figures 1, 5, 6 and 7, they are picked up by a conveyor and carried through the black pickling acid bath. The sheets are then washed free from acid and delivered to a dryer.

In Figure 1, I have illustrated a longitudinal section view of the black pickling apparatus, which includes a long trough or rectangular container 136, made up of a plurality of sections of metal carried by suitable supports 137. This acid receptacle is covered by a plurality of hoods 138, each communicating with a take-off pipe 139 having a damper or valve 140 therein. The take-off pipes 139 communicate with a header 141 and the acid vapors are drawn off from the header by means of a blower 142. The dampers 140 in the several take-off pipes 139 can be independently adjusted so as to regulate the manner in which the acid fumes are withdrawn from the several hoods; for example, if it is found that acid vapors are collecting in certain of the hoods, the passages leading to the remaining hoods can be closed off and the blower 142 used solely for the purpose of re-

moving the acid vapors from the particular hoods containing excess vapors.

Referring to Figure 5, I have illustrated a collecting trough 143 at the intake end of the acid bath arranged so as to receive the acid drawn off from the acid container 136. The acid overflows from the container into the trough 143 and is then taken off by means of a pipe 144. The pipe 144 leads to a settling tank 144*a* shown somewhat in detail in Figures 5B and 5C. The acid, in flowing through the settling tank, is caused to flow over and under a plurality of partitions 144*b* which cause the velocity of the acid to alternately increase and decrease a number of times before it is drawn off and again supplied to the acid container 136. The acid within the container 136 is heated by a plurality of steam pipes 145 connected to a header 146 communicating with drain pipes 147.

At the discharge or delivery end of the acid bath, I have provided means for washing the sheets free from acid. Referring to Figure 9, I have illustrated a plurality of water spray pipes 148*a*, 148*b*, 148*c* and 148*d*, arranged above the advancing sheets A, and a corresponding group of spray pipes 149*a*, 149*b*, 149*c* and 149*d*, arranged below the sheets. I have illustrated three trays 150, 151 and 152, arranged so as to collect the wash water as it drips from the advancing sheets. Wash water can be supplied to the spray pipes 148*a* and 149*a* by means of a pump which may get its source of supply from a tank which is kept filled with water from any suitable source. The wash water collecting within the tray 152 can be drawn off by means of a pipe 153 and returned to the supply tank mentioned above. A valve 154 is provided for regulating the flow of wash water through pipe 153. This valve can be regulated so as to control the amount of water passing over from tray 152 to tray 151. The wash water may be supplied to spray pipes 148*b* and 149*b* by a pump which may get its supply from the supply tank above mentioned, or from the drain pipe 155 connected with the tray 151. A valve 156 controls the flow of wash water through a pipe 155. A spray pump can be employed for supplying wash water to spray pipes 148*c*, 148*d*, 149*c* and 149*d*, this pump getting its supply from the drain pipe 157, having a valve 158 therein. The water in tray 151 contains more acid than the water in tray 152, and the water in tray 150 contains more acid than the water in tray 151. By regulating the valves 154, 156 and 158, the acidity of the liquid in each of the three trays can be regulated. The valve 158 can be adjusted so as to draw off less liquid than the amount supplied to tray 150, in which event the liquid flows over into the main acid bath 136, previously described. A supply pipe 159 is shown in Figure 9 as a suitable means for returning to the main acid tank 136 the acid which has been drawn off from the forward end of the acid tank and passed through the separating tank.

The conveyor which serves to carry the individual sheets through the acid bath in arched form is preferably constructed so that only the conveyor fingers which engage the edges of the sheets pass through the acid. The sheets are engaged along their edges only, thus insuring adequate exposure of all portions of the sheet surfaces to the action of the acid and to the subsequent action of the washing apparatus. The conveyor illustrated in the accompanying drawings is made in two sections, one for engaging each side of each of the sheets as it is delivered from the arching mechanism. Each section of the conveyor is carried by double sprocket wheels mounted on a suitable supporting structure. In Figure 5, I have illustrated one of the sprocket wheels 160, mounted on the shaft 132 and carrying one section of the conveyor. Each conveyor section is made up of a number of links best illustrated in Figure 10. As shown in this figure, each link includes a bent arm 161, having a rearwardly projecting bent finger 162 adapted to engage the edge of a sheet A. The opposed conveyor arms 161 on the two conveyor sections are formed in such a manner that they are adapted to engage the edges of each sheet as it is delivered from the arching mechanism. The sheets expand slightly as they are being delivered from the arching mechanism until they engage the conveyor arms.

Each of the conveyor arms 161 is carried by a small truck consisting of three wheels 163, 164 and 165. The wheels 163 and 165 are arranged in vertical planes and are adapted to roll along a horizontal track 166. An auxiliary upper track 167 is provided against which the wheels 163 may bear in the event that the arms 161 are for any reason forced downwardly so as to pivot about the wheels 165. The track 167 thus limits such displacement of the arms 161 without interfering with the normal operation of the conveyor. The wheels 164 are arranged in a horizontal plane and are adapted to engage vertical tracks 168 and 169. The wheels 164 and their cooperating tracks 168 and 169 prevent lateral displacement of the conveyor links. All of the wheels 163, 164 and 165 are suitably journaled on a support 170. A screw-threaded block 171 is fixed with respect to the above mentioned tracks and is engaged by an adjusting screw 172 connected to a hand wheel 173. By turning this hand wheel, the position of the tracks with respect to the acid container can be varied to suit the requirements for sheets of various widths. This adjusting mechanism is provided for each of the conveyor sections.

Whenever the positions of the conveyor

tracks are changed, it is necessary to change the positions of the sprocket wheels in a corresponding manner. I have illustrated these sprocket wheels as being splined to their supporting shafts, and I have illustrated screw-threaded adjusting rods 174 connected to the sprocket wheels in such a manner that by rotating the screw-threaded members 175, the positions of the sprocket wheels can be changed. The members 175 can be connected to the hand wheels 173 so that by merely turning the hand wheels, the conveyor tracks and the sprocket wheels can be simultaneously adjusted.

The tracks 166 are supported on grooved rollers 176, and these rollers are adapted to travel along supporting plates 177 carried by the framework of the apparatus. When the tracks are adjusted toward or away from the acid container, they simply move along on the rollers 176. Tracks 178 are arranged so as to support the conveyor links while they travel from the rear end of the acid bath to the forward end of the same.

It is desirable to have the sheets carried through the acid bath while in arched form, because the sheets can then be carried by means engaging the edges of the sheets only. It is desirable to retain the sheets in arched form during the washing operation, because the washing action is more effective than it would be if the sheets were all horizontal; the water readily drains off from the curved sheets, and as the sheets come into close proximity with the successive spray pipes, the acid is effectively removed. Depending aprons 179 and a cover plate 180 serve to enclose the washing apparatus.

Referring to Figure 1, I have illustrated a motor 181 adapted to supply power to a shaft 182 geared to the conveyor shaft 183 to supply power to the conveyor.

As the sheets leave the washing apparatus, they are delivered to a double set of disks indicated at 184 in Figure 1. This disk mechanism is fundamentally the same as the arching mechanism located at the forward end of the conveyor and it operates in exactly the same manner except that it serves to decrown or flatten the sheets instead of to convert flat sheets into arched form. As soon as the sheets have been flattened, they are delivered to the drying apparatus.

The drying apparatus (Figures 1, 2, 11, 11A and 12)

After passing through the decrowning mechanism illustrated at 184 in Figure 1, the sheets are fed by a set of rubber rollers onto a bridge 185 similar in all respects to that provided in front of the arching mechanism above described. (See Fig. 5A.) A pair of feed rollers 186 picks up the sheets from the bridge and passes them into the drying apparatus.

In Figure 11, I have illustrated an air excluding container or chamber through which the flat sheets are passed in succession between conveyor rollers 187. These rollers are mounted on shafts provided at one end with sprocket wheels 188 cooperating with a chain 189 which interconnects all of the sprocket wheels. Power is supplied to the feed rolls 186 and to the conveyor chain by the motor 181, as illustrated in Figure 1.

I have provided a plurality of gas burners 190 (best shown in Figure 11A), these burners being arranged between the shafts carrying the conveyor rollers 187 and in close proximity to the sheets being carried through the drying chamber. Each of the burners comprises a perforated gas pipe 191 arranged within a larger pipe 192 provided with perforations registering with those in the gas pipe. Air under controlled pressure is supplied to the pipe 192 by means of a pipe 193. In this way the burner is supplied with the secondary air necessary to complete the combustion. Primary air is admitted to the pipe 191 through the head 194 of ordinary construction. The burners are arranged so that the gas flames impinge directly upon the wet sheets and the moisture is quickly and effectively removed from the sheets by virtue of the heat generated within the drying chamber and also as a result of what may be termed the explosive action of the flames on the wet surfaces. Both the upper and lower surfaces of each sheet are subjected to the action of the flames from the burners, and the sheets are thoroughly dried before leaving the drying apparatus.

The upper portion of the drying chamber is covered over so as to exclude air; suitable windows 196 are provided for observing the action of the flames on the upper surfaces of the sheets. Glass windows 197 are provided in the bottom surface of the drying chamber to permit inspection of the lower surfaces of the plates and of the lower burners. The roof of the drying chamber is preferably inclined so as to cause the combustion gases to flow toward one end, as indicated by the arrows in Figure 11. These gases are drawn off through a suitable flue or pipe 198.

The surfacing rollers and coating mechanism (Figures 2, 13 and 14)

As the sheets pass out of the drying apparatus above described, they are fed onto a conveyor shown at 199 in Figure 2. The sheets then pass one at a time between a plurality of surfacing rollers of the usual construction. In Figure 2, I have illustrated several of these roller mills at 200, and it will be understood that as many of these roller mills can be provided as may be desired, suitable conveyors of the type illustrated at 199 and 201 being provided for the purpose of conveying the sheets to and from the sur-

facing rollers. After the sheets have been passed between the desired number of surfacing rollers, they are passed through the coating mechanism shown at 202 in Figure 2. This coating mechanism, which may be of the type shown in my Patent No. 1,295,820, can be used for the purpose of applying to one or both surfaces of each sheet, a layer or film of a liquid such as oil. The sheets may be thus coated with a liquid which will prepare the sheets for the heat treatment within the annealing furnace. It will be understood that it is not necessary to apply a liquid of any kind to the sheets prior to introducing them into the annealing furnace, but I have found that certain beneficial results can be obtained by so doing. For example, the coating mechanism can be used for the purpose of applying to both surfaces of each of the sheets a film of asphaltic base oil, which has the effect of distributing the heat supplied to the sheets within the annealing furnace and preventing local over-heating of the sheets.

In order to insure proper distribution of the liquid film on the surfaces of the sheets after they have passed through the coating mechanism, I prefer to employ distributing apparatus of the type shown in Figures 13 and 14. This apparatus comprises a pair of rollers 203 and 204, adapted to engage the lower and upper surfaces, respectively, of each sheet. Auxiliary rollers 205 and 206 bear against the rollers 203 and 204, respectively. Adjusting means 207 is provided for the purpose of varying the contact pressure between the roll 205 and the roll 203, and a similar adjusting means 208 is provided for varying the contact pressure between rolls 206 and 204. The auxiliary rolls 205 and 206 are mounted so that they may oscillate back and forth with respect to the main rollers 203 and 204. Springs 209 tend to force the rolls 205 and 206 away from the bearing support 210. The opposite ends of these rolls are provided with cam surfaces 211 bearing against rollers 212 carried by the bearing support 213. As the rolls 205 and 206 revolve, they are caused to oscillate by virtue of the cooperation between the cams 211 and the cam followers or rollers 212. This oscillating movement serves to distribute the film of oil which has collected on the main rollers 203 and 204, and as a result, these rollers serve to effect an even distribution of the liquid film on the upper and lower surfaces of the metal sheets passing between the rollers.

The furnace arching mechanism (Figures 2, 13 and 14)

Preparatory to passing the sheets through the annealing furnace, I prefer to convert them into arched form so that they can be carried through the annealing furnace by a conveyor which comes in contact with the sheets only at their edges. The apparatus which I have illustrated in the accompanying drawings as being suitable for this purpose includes two sets of sharp-toothed disks that co-operate in a manner similar to that described in connection with the arching mechanism arranged in front of the black pickling bath. I prefer to have these disks provided with sharp teeth in order that the disks may perform their necessary function of arching the sheets without injuring the film of liquid. Of course, where no liquid has been applied to the sheets, it is entirely satisfactory to employ arching disks having smooth peripheries.

Referring to Figures 13 and 14, I have shown two sets of disks 214 carried by stub shafts mounted on yokes or supporting beams 215. These disks 214 are not power driven. Their function is to hold the edges of the sheets down while the center is being forced up by the larger toothed disks 216 carried by the lower supporting beam 217. The forward ends of the upper supporting beams 215 are journaled on the transverse shaft 218 and the corresponding end of the lower supporting beam 217 is journaled about the transverse shaft 219. The rear ends of the upper supporting beams 215 are adjustably mounted on a transverse beam 220. A similar adjustment indicated at 221 is provided for the lower supporting beam 217. The shafts carrying the lower disks 216 are interconnected by a driving chain 222 and power for driving these disks is supplied from the shaft of the distributing roll 203 by means of the chain 223 and gearing shown at 224 and 224*a*.

After the sheets have been arched by the action of the toothed disks 214 and 216, they are delivered to the converging guide conveyors 225 and 226 (see Fig. 13). These link or chain conveyors pass around pulleys 227, 228, 229 and 230. Power is supplied to the pulleys 227 and 228 from the shaft 231 driven by the chain 223. These converging conveyors serve to bring the edges of the arched sheets closer together so that the sheets can be delivered in proper form to the furnace conveyor. Screw-threaded adjusting rods 232 and 233, connected to hand wheels 234 and 235 respectively, constitute means for adjusting the distance between the ends of the converging conveyors 225 and 226 to accommodate sheets of various widths. If it is desired to have the delivery end of each of the converging conveyors extend substantially parallel with the direction of travel of the sheets, then guide rollers 236 and 237 can be arranged as shown in Figure 13. Satisfactory results can be obtained without employing these auxiliary rollers.

The furnace conveyor constitutes a series of inter-connected links, each provided with a cross-arm 238, having a number of upwardly projecting fingers 239 on each end

thereof. Each arm is provided with a number of these projections 239, in order that the conveyor may be suitable for handling sheets of different widths.

I prefer to provide some means for positively feeding the sheets from the converging conveyors 225 and 226 onto the furnace conveyor. A satisfactory device for accomplishing this result comprises a pair of wheels 240 and 241, inclined at an angle to the direction of travel, as illustrated in Figure 13. These wheels are provided with blades, and the inclined surfaces of these blades are so formed that straight-line contact is established between the blades and the edges of the advancing sheets. These wheels 240 and 241 are rotated in the direction indicated by the arrow in Figure 14, and serve to simultaneously press down the edges of the advancing sheets and urge the sheets forward. Power is supplied to these wheels through the systems of gearing illustrated at 242 and 243. These gear systems or trains are connected to the shaft 244, which carries the furnace conveyor sprocket wheel 245. The shaft 244 is driven by the furnace conveyor. The inclined guide wheels 240 and 241 are journaled in mounting pieces 246 and 247, secured to a cross-beam 248.

The annealing furnace (Figures 3, 15, 16 and 17)

The improved annealing furnace, as illustrated in Figures 3, 15, 16 and 17, comprises a structure of refractory material having a longitudinal chamber or passage 249, through which the arched sheets are carried by the furnace conveyor, the links of which are illustrated at 238. This conveyor is supported throughout its travel within the furnace, upon tracks 239*a*. A suitable lubricant can be supplied to the conveyor links through openings in the tracks at the intake end of the furnace and the lubricant can be applied to the conveyor links as they return to the intake end of the annealing furnace.

The main burner of the furnace is illustrated at 250, air being supplied through a pipe 251 by means of a blower 252. The hot combustion gases pass through openings 253 in the refractory arch 254, and then come in contact with the advancing sheets A. The hot gases also pass under the arch 255 and come up around the edges of the advancing sheets in the rearward part of the furnace. The forward end of the furnace chamber 249 is separated from the rearward portion by an apron wall of refractory material shown at 256. Within this forward portion of the chamber, the arched sheets are given a preliminary heat treatment for the purpose of reducing the tension within the sheets. This is accomplished by providing an auxiliary oil burner 257 in the upper forward part of the furnace structure, and adapted to supply hot combustion gases to the upper portion or crown of each of the advancing sheets. The crowns are thus heated to a high temperature before the edges of the sheets are brought to a high temperature. As a result, the center portion of each sheet becomes somewhat soft and the force exerted by the conveyor fingers against the edges of the sheets is accordingly diminished. This prevents the conveyor fingers from distorting the edges of the sheets while they pass through the furnace. It will be observed that the combustion gases supplied by the auxiliary burner 257 pass through a combustion chamber 258 and then downward through relatively narrow openings 259 into contact with the crown or upper portion of each of the sheets. These hot gases are drawn off through a stack 260 at the forward end of the furnace. The metal sheets, while being passed continuously and in succession through the annealing furnace, are brought up to the proper annealing temperature, in the neighborhood of 1620° F.

The furnace conveyor, after delivering the sheets to a decrowning apparatus hereinafter described, returns through a water seal 261, which serves as a means for preventing air from getting into the furnace chamber and oxidizing the sheets. This water seal is covered by a hood 262 communicating with a vertical condenser pipe 263 which is closed at its upper end and serves merely as a means for cooling and condensing the water vapors which form within the sealing chamber. The water vapor which has condensed within the pipe 263 drips back into the water receptacle.

The furnace delivery and decrowning mechanism (Figures 3, 18, 19 and 20)

The furnace conveyor carries the annealed sheets into a delivery casing shown at 264, in Figure 19. This casing encloses an auxiliary conveyor shown at 265, which serves to pick the sheets off from the furnace conveyor and deliver them to the decrowning mechanism. The delivery chamber 264 and the decrowning mechanism are all in open communication with the furnace chamber 249. The chamber 264 is provided with a lid 264*a*, which can be removed for the purpose of observing the operation of the furnace conveyor and the auxiliary conveyor 265 and making any necessary adjustments or repairs.

The decrowning mechanism comprises two sets of rollers shown at 266 and 267. The sheets are carried forward by the rollers 267 and are spread out flat as they come in contact with the upper set of rollers 266. The rollers 267 are provided near their ends with collars 267*a*, best shown in Figure 18, which prevent the sheets from traveling too much to either side. The decrowning or flattening rollers deliver the plates to the straightening rollers indicated at 268. The two sets

of rollers 266 and 267 are interconnected by means of sprocket wheels and a chain 269, power being supplied to these rollers through gearing illustrated at 270 in Figure 18.

Referring again to the auxiliary conveyor 265, I prefer to construct the track supports for this conveyor in such a manner that the conveyor can be adequately cooled. In Figure 20, I have illustrated a track structure at 271, forming a hollow chamber through which water can be circulated for cooling the conveyor elements as they pass along the track.

At 272 in Figure 3, I have illustrated a motor for supplying power to the furnace conveyor, to the decrowning mechanism, and to the straightening rolls 268. I have illustrated the motor connected to a driving countershaft 273, which is in turn connected to the several parts of the apparatus by suitable means, such as the chains illustrated at 274 and 275.

The cooling chamber (Figures 3, 4, 21, 22, 23, 24 and 24A)

Upon leaving the straightening rollers 268, the sheets are fed one at a time into the cooling chamber, where the temperature of the plates is reduced to a value such that when the sheets are exposed to the air, they will not oxidize readily. This cooling chamber comprises a long, rectangular, closed container 276, provided with a furnace exhaust gas stack 277 at the intake end and a similar stack 278 at the discharge end. It will be observed that the furnace gases are carried along through the annealing furnace, the discharge chamber associated with the rear end of the furnace, the decrowning mechanism, the chamber enclosing the straightening rolls, and into the cooling chamber, where the gases are drawn off through the stacks 277 and 278. Accordingly, the plates are maintained in a reducing chamber throughout their movement through these several parts of the apparatus. The stacks 277 and 278 are provided with dampers 279 and 280 respectively, by means of which the rate of discharge of the gases can be controlled. I prefer to provide cooling pipes 281 in the upper portion of the cooling chamber, through which water can be circulated for the purpose of reducing the temperature of the chamber and of the sheets passing through the same.

I have provided an improved conveyor 282 within the cooling chamber, this conveyor being contained entirely within the enclosed space, thus avoiding the hazard of introducing air into the cooling chamber. This conveyor is provided with side chains carrying a large number of cross-rods 283 which support the sheets as they advance through the cooling chamber. Each of these cross rods carries a pair of guide members 284. These guide members are carried in slots extending lengthwise of each of the rods. The sheets delivered to the cooling chamber from the straightening rolls are carried along between the guide members 284, and when the sheets reach the rear portion of the cooling chamber, the guide members come in contact with metal angle members 285 and 286, which serve to bring the sheets into proper alignment for delivery to the adjacent part of the apparatus. These angle members are formed in the manner illustrated in Figure 21, and serve to bring each of the sheets into a position parallel with the direction of travel and into alignment with the center line of the apparatus. Each of the angle members is provided with a bent portion 287, which permits the sheets to travel forward for a short distance, even though they are not in exact alignment. This feature has been found to be of importance because it lessens the tendency of the sheets to become lodged within the cooling chamber. The small guide members 284, carried by the cross-rods 283, are each provided with rollers 284A, which follow the angle members 285 and 286. Thus, as the conveyor advances, the small guide members are brought relatively close together, and during the reverse travel of the conveyor, these guide members come in contact with cam surfaces 288 and 288*a*, which return these members to their initial positions near the ends of the cross-rods 283, as illustrated in Figure 23. The angle members 285 and 286 can be brought close together or moved further apart by turning the adjusting rod 289, which is provided with right and left hand screw-threads and passes through blocks 290 and 291, secured to the angle members.

In Figure 4, I have illustrated a motor 292, adapted to supply power to the shaft 293, which carries the conveyor sprocket wheels 294.

The white pickling apparatus (Figure 4)

The sheets, in passing through the annealing furnace above described, are given the treatment commonly known as white annealing. This serves to alter the physical characteristics of the sheet metal so as to render the sheets suitable for fabrication purposes. The sheets, in passing through the surfacing rollers illustrated in Figure 2, become hard and brittle, and it is necessary to give them the so-called white annealing treatment in order to make the sheets softer and suitable for industrial purposes. After the sheets have passed through the white annealing process, they are to some extent oxidized, and it is necessary to pass the sheets through a white pickling bath in order to remove the oxides which have formed on the surfaces of the sheets. In Figure 4, I

have illustrated a white pickling apparatus which is identical, so far as its essential features are concerned, with the black pickling apparatus illustrated in Figure 1. This apparatus of Figure 4 includes an arching mechanism 295, which may be identical with that provided at the forward end of the black pickling apparatus. After passing through the arching mechanism, the sheets are picked up by a conveyor 296, which may be identical with the black pickling conveyor. The sheets are then carried through the acid receptacle 297, which is covered over with hoods 298, provided with take-off pipes 299 and a blower 300, similar to the corresponding parts of the black pickling apparatus. A motor 301 supplies power to one of the conveyor sprocket wheel shafts 302. An idler sprocket wheel 303 takes up the slack in the conveyor and insures proper tension of the conveyor. Further adjustment of the conveyor tension can be effected by taking out or inserting links, as may be desired.

The sheets, in passing out of the white pickling bath, are subjected to the action of washing sprays 304, which may be identical with those provided in the black pickling apparatus, above described. The sheets then pass through a decrowning mechanism 305, which may be identical with the decrowning mechanism 184 associated with the black pickling apparatus. The sheets are then fed onto a bridge 306, which is preferably of the same construction as that illustrated in Figure 5A. The bridges employed can be dropped so as to disconnect the bridge rollers from their source of power and permit the sheets to pile up on the bridges, thus making it possible to operate parts of the apparatus while other parts are shut down. This is highly desirable because of the necessity of keeping the annealing furnace conveyor in motion to avoid overheating of the conveyor.

Sheet rotating and straightening apparatus (Figures 25 to 32 inclusive)

After the sheets leave the white washing apparatus and the decrowning mechanism associated therewith, they are fed between straightening rollers of the usual type, illustrated at 307 in Figures 4, 25 and 26. This serves to straighten the sheets in the direction of travel.

In order that the sheets may be straightened laterally, I prefer to employ an apparatus for rotating each sheet 90° and then passing the sheet forward through a second set of straightening rolls. I have illustrated such a second set of straightening rolls at 308.

The improved rotating mechanism includes a conveyor having chains 309 and 310 at each side thereof arranged to pass over sprocket wheels 311 and 312, located near the straightening rolls 307 and 308 respectively. The chains 309 and 310 carry transverse rods 313 (see Fig. 30), each provided with a plurality of collars 314. Each of the rods 313 is formed in two pieces interconnected at the center with a mounting piece 315 which carries a rotatably mounted wheel 316 having its axis at right angles to the rod. Between each set of collars 314 I have provided a bearing wheel mounted so as to be free to rotate about the rod and provided around its periphery with a plurality of small rotatably mounted disks 318 adapted to rotate about axes at right angles to the rods 313. The wheels mounted between the collars 314 are shown at 317*a*, 317*b*, 317*c* and 317*d*. These wheels, with their disks 318, constitute what may be termed universal bearing members for supporting the sheets delivered to the conveyor by the straightening rollers 307.

It will be understood that as the conveyor moves forward in the direction indicated by the arrows *e* and *e'* of Figure 30, the sheets are carried forward on the conveyor. Each sheet can be rotated on the conveyor by causing the wheels 317*a* and 317*b* to rotate in the directions indicated by the curved arrows shown near these wheels in Figure 30, and by causing the wheels 317*c* and 317*d* to rotate in the opposite direction, as indicated by the curved arrows located close to these wheels in Figure 30. The sheets then pivot about the central wheels 316 and rotate through the desired angle, depending upon the adjustment of the apparatus. After the sheet has been rotated through a predetermined angle, one edge of the sheet strikes the guide member 319 and the sheet is carried forward in proper alignment with the straightening rollers 308. After the sheets pass through these straightening rollers, they are ready for shipment.

The apparatus I prefer to employ for the purpose of causing the wheels 317*a*, 317*b*, 317*c* and 317*d* to rotate as above described, includes four belts, 320, 321, 322 and 323. These belts are arranged so that they pass under the shafts 313 and engage the wheels carried by these shafts. These belts are driven by pulleys 324, 325, 326 and 327. Each pulley is mounted on a stub shaft connected to a gear, the gears being shown at 328, 329, 330 and 331. These gears are driven by intermediate gears 332, 333, 334 and 335, carried by adjustable yokes, one of which is illustrated at 336 in Figure 26. These intermediate gears mesh with gears 337, 338, 339 and 340, mounted on a drive shaft 341. By properly selecting the intermediate gears, the belts 320, 321, 322 and 323 can be driven at the desired differential speeds. For example, these gears can be chosen so that the belt 320 will travel forward at half the speed of the chain 309. I have illustrated this fact by showing an arrow *a*, close to the belt 320, this arrow being half as long as the arrow *e'*, which represents the speed of the chain 309.

In like manner, the belt 321 can be driven at a speed equal to ¾ of the speed of the chain 309, this being represented by the arrow *b*. Since the belts 320 and 321 move at a slower rate than the conveyor chain 309, the wheels 317*a* and 317*b*, which come in contact with these belts, are caused to rotate as indicated by the curved arrows shown near these wheels in Figure 30.

In like manner, the belt 322 can be caused to move forward at a speed equal to 1¼ times that of the conveyor chains, and accordingly I have shown the arrow *c* of a length equal to 1¼ times that of the arrows *e* and *e'*. The belt 323 can be caused to move forward at a speed equal to 1½ times that of the conveyor chains, as illustrated by the arrow *d*. Since the belts 322 and 323 move forward at a higher speed than the conveyor chains, the wheels 317*c* and 317*d* are caused to rotate in the reverse direction, as indicated by the curved arrows shown close to these wheels.

The belts 320, 321, 322 and 323 pass over pulleys 342, 343, 344 and 345, each carried by an adjusting block, the position of which can be changed by turning the hand wheels 346, 347, 348 and 349. The tension of the belts can be adjusted by turning these hand wheels. Two similar sets of pulleys are shown at 350 and 351, these pulleys having their centers located somewhat above the center line of the pulleys just described. These pulleys are mounted on blocks arranged so as to slide on tracks 352 and 353. Adjusting screws 354 and 355 can be turned for the purpose of bringing these two sets of pulleys closer together or separating them further apart, as may be desired. By adjusting the positions of these pulleys, it is possible to determine the number of shafts 313, the wheels of which are brought into engagement with the traveling belts. This active portion of the conveyor system is shown at *f* in Figure 26.

In order that each of the belts may be firmly supported throughout the period of contact with the conveyor wheels, I have provided the apparatus which is shown in detail in Figures 27, 28 and 29. Secured to each of the blocks carrying the pulleys 350 and 351, I have provided a set of blades shown at 356 and 357. Each set of blades is firmly held at one end by the pulley block associated therewith, and the free ends of adjacent sets of blades can be adjusted toward and away from each other by adjusting the positions of the pulley blocks, as described above. These free ends are supported within guide blocks shown at 358, each of which is provided with channels or passages adapted to receive the plates, as illustrated in Figure 28.

The foregoing description sets forth in considerable detail apparatus adapted to convey individual sheets, one at a time, through the black pickling bath, washing sprays, drying apparatus, annealing furnace and cooling chamber, the sheets being carried in arched form through the pickling bath and through the annealing furnace. The improved furnace is adapted to relieve the tension within each sheet by preheating the crown of each sheet before the edges are brought up to a high temperature. The products of combustion are carried along with the material being heated and cooled, under sufficient pressure to prevent ingress of air into the heat treating or cooling chamber. The sheets may be coated with a protective covering preliminary to passing them through the annealing furnace.

The foregoing description sets forth in considerable detail the apparatus as actually constructed without attempting to define the permissible variations in the equipment as a whole, or in the details of its several machines and mechanisms. I am, however, aware that the apparatus may be changed in many particulars without departing from the spirit of my invention as defined by the appended claims.

I claim:

1. The process which comprises arching metal sheets, passing the arched sheets into a furnace, preheating the crown of each sheet to relieve the tension within the sheet, and then heating each sheet uniformly throughout.

2. The process which comprises arching metal sheets, passing the arched sheets into an annealing furnace, preheating the crown of each sheet to relieve the tension within the sheet, and then heating each sheet uniformly throughout up to approximately 1620° F.

3. An apparatus for treating metal sheets comprising an annealing furnace, means for arching the sheets, means for conveying the sheets in arched form through the furnace, and means for preheating the crown of each arched sheet to relieve the tension in the sheet

4. An apparatus for treating metal sheets comprising an annealing furnace, means for arching the sheets, means for conveying the sheets in arched form through the furnace, and means within the furnace for preheating the crown of each arched sheet to relieve the tension in the sheet.

5. An apparatus for treating metal sheets comprising an annealing furnace, means for arching the sheets, means for conveying the sheets in arched form through the furnace, means within the furnace for first supplying heat to a restricted area of each sheet, and means for then heating the sheets uniformly throughout to an annealing temperature.

6. An apparatus for treating metal sheets comprising an annealing furnace, means for arching the sheets, means for conveying the

sheets in arched form through the furnace, a burner near the forward end of the furnace arranged so as to supply hot combustion gases directly to the center portion of each sheet, and means for thereafter heating the sheets uniformly throughout to an annealing temperature.

7. An apparatus for treating metal sheets comprising an annealing furnace, means for arching the sheets, means for conveying the sheets in arched form through the furnace, a burner near the forward end of the furnace, a combustion chamber therefor having restricted flues for conducting the combustion gases into contact with the central section of each sheet, and means for thereafter heating the sheets uniformly throughout to an annealing temperature.

In testimony whereof I affix my signature.

WILLIAM E. WATKINS.