Dec. 23, 1930. J. R. SPEER ET AL 1,785,986

METHOD OF AND APPARATUS FOR ROLLING SHEET METAL

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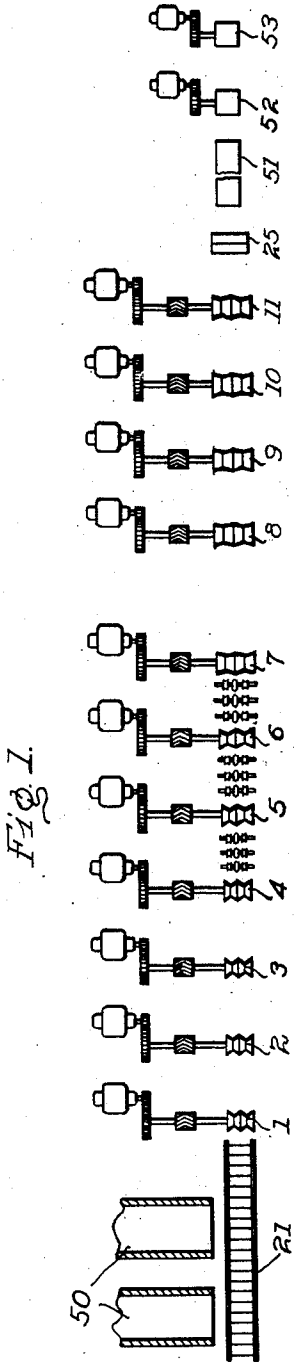

Fig. 1.

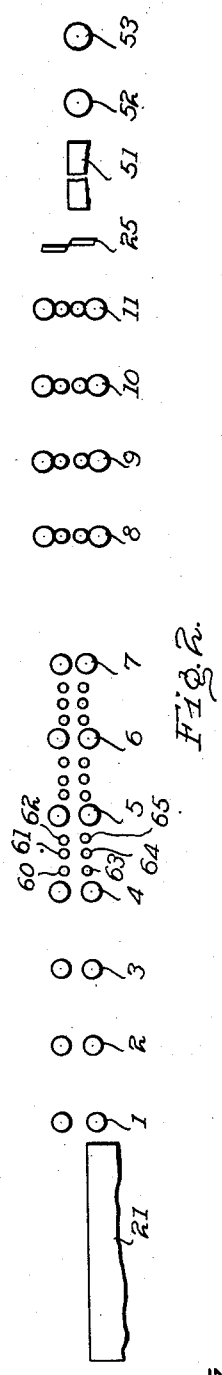

Fig. 2.

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METHOD OF AND APPARATUS FOR ROLLING SHEET METAL

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Fig. 3.

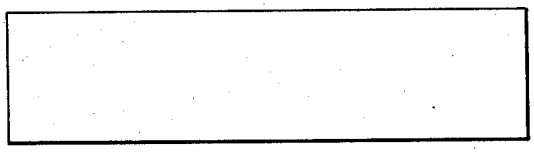


Fig. 4

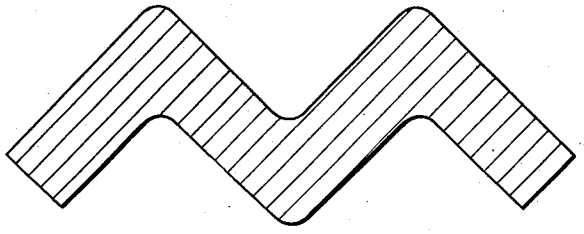


Fig. 5.

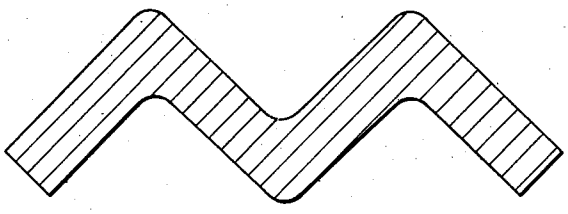


Fig. 6.

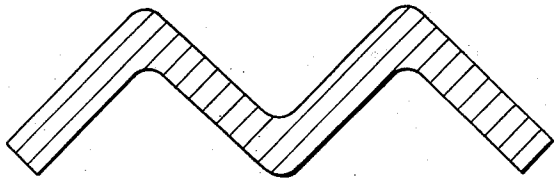


Fig. 7

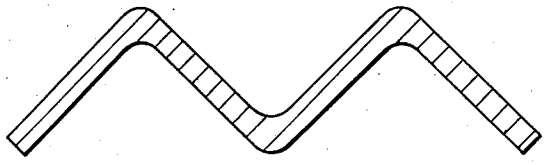
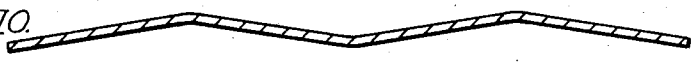


Fig. 8.

Fig. 9.

Fig. 10.



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METHOD OF AND APPARATUS FOR ROLLING SHEET METAL

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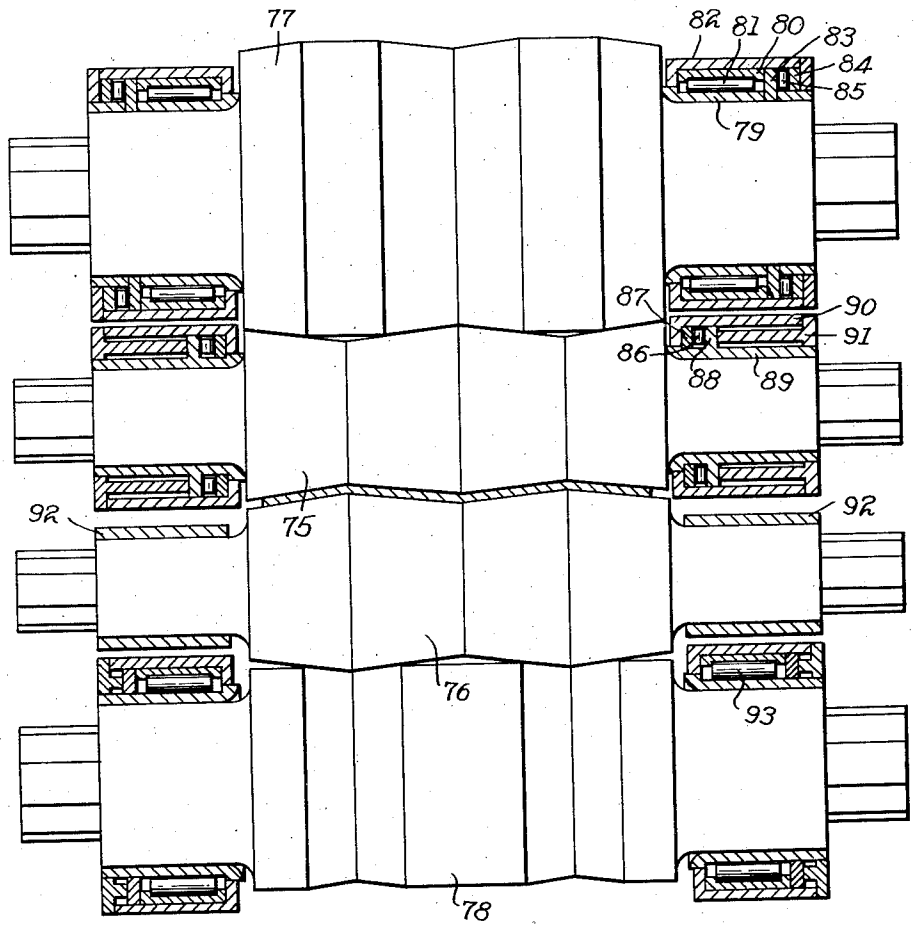
Fig. 11.



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METHOD OF AND APPARATUS FOR ROLLING SHEET METAL

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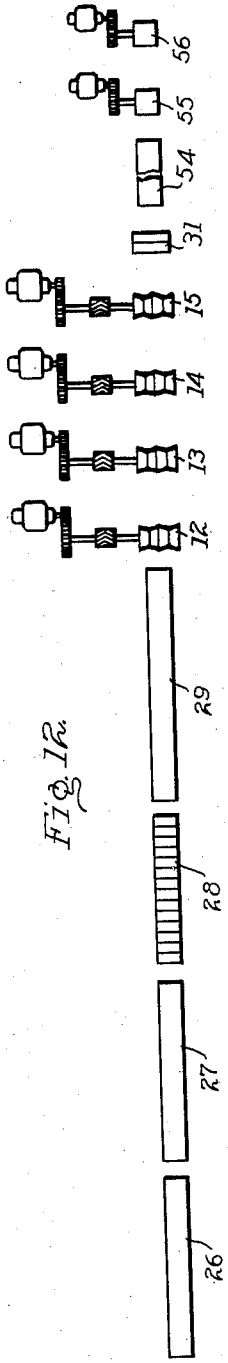

Fig. 12.

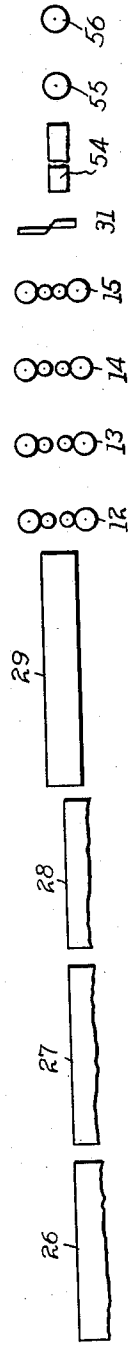

Fig. 13.

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METHOD OF AND APPARATUS FOR ROLLING SHEET METAL

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Fig. 14.

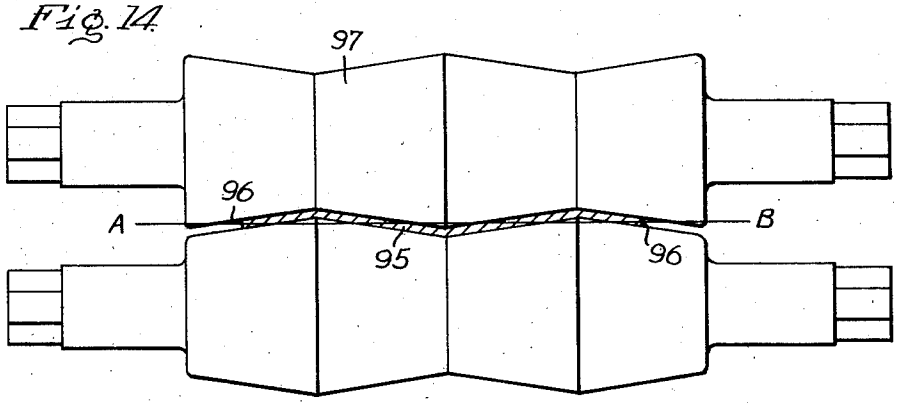


Fig. 15.

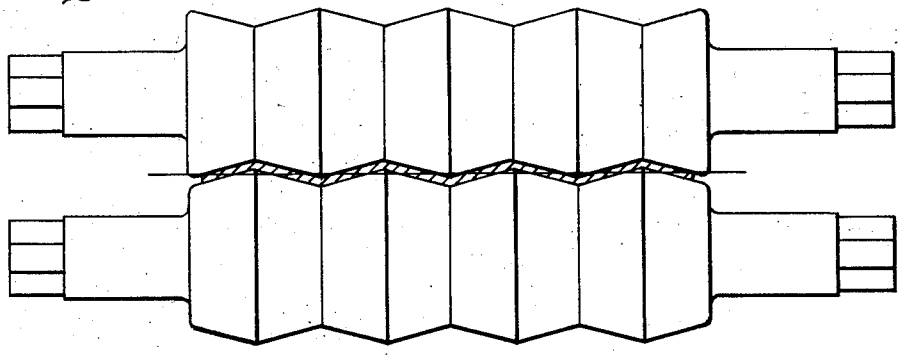
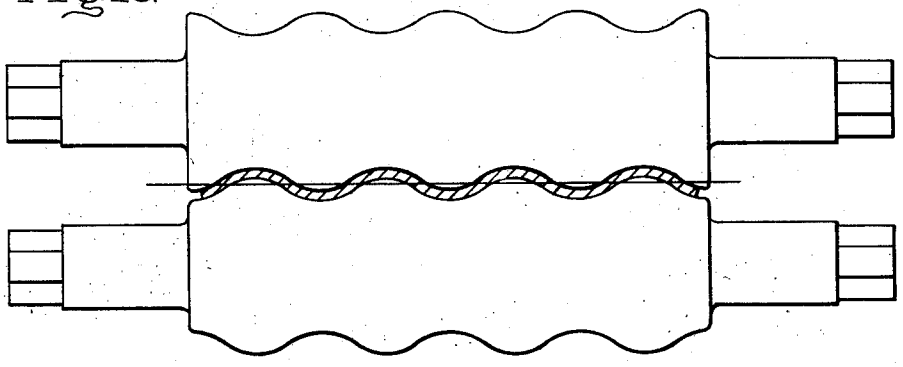


Fig. 16.



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METHOD OF AND APPARATUS FOR ROLLING SHEET METAL

Filed July 6, 1928 6 Sheets-Sheet 6

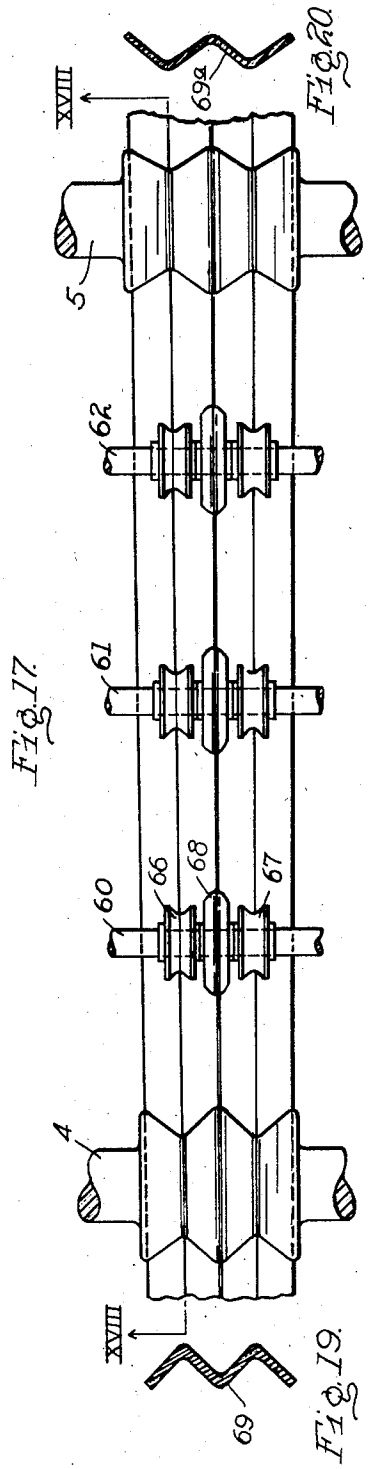

Fig. 17.

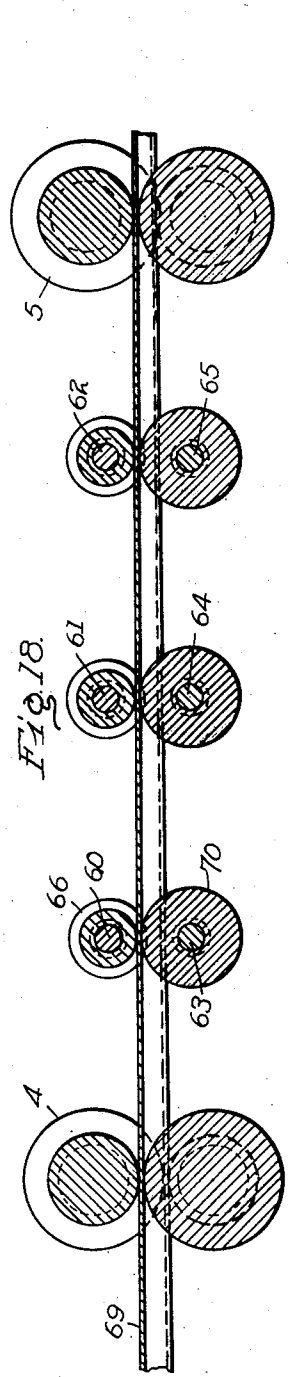

Fig. 18.

Fig. 19.

Fig. 20.

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Patented Dec. 2, 1930

1,785,986

UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR ROLLING SHEET METAL

Application filed July 6, 1928. Serial No. 290,734.

Our invention relates to the rolling of metal into wide thin sheets.

In the earlier rolling of thin metal sheets it has been the customary practice to pass sheet bars or tin bars, as they are commonly called, between pairs of substantially cylindrically shaped working rolls whereby the bars are reduced to the desired thinness. In mills of the latest development for continuous rolling of sheet strip the working rolls employed are made slightly concave in shape, and the degree of concavity at each succeeding set of rolls is slightly reduced until the last set of rolls in the line of operation is reached in which the contacting surfaces of the cooperating rolls are made substantially parallel across their entire width. Consequently, when preliminary blank is started through the mill its central portion becomes somewhat thicker than its edge portion, and the difference in thickness across the width of the blank or bar is gradually reduced as it is passed through the successive sets of rolls to reduce its thickness or gage. The purpose for making the rolls with a concave shape is to provide a means for holding the strip metal sheets centrally aligned in the working rolls, the alignment of the sheets in the rolls being accomplished by the uneven working of the metal across its width effected in the sheets as they pass through the rolls. Hence metal sheets rolled in accordance with such a procedure do not have a uniformly worked structure across their entire width, and therefore do not contain a uniform grain structure.

In rolling metal sheets in accordance with the above described practice it is a difficult problem to prevent the sheets from wrinkling and curling along their edge portions as they are rolled. This is especially true where very thin sheets are being produced. It is also a considerable problem to properly remove the scale adhering to the exterior surfaces of bars and sheets in preparing them for rolling into sheet form. As is well known in the art, it is very essential to the production of high grade sheets that the scale be entirely removed from the stock, so that it cannot in any way injure the finished sheet.

The object of our invention, generally stated, is to provide an improved method of and apparatus for rolling thin metal sheets whereby sheets free from adhering scale and having substantially uniformly worked structures are produced at a greater speed and in a more effective and efficient manner than accomplished by any of the present practiced methods.

A more special object of our invention is to provide for automatically maintaining a piece of metal centralized in each successive set of rolls of a continuous mill as it is being rolled, and at the same time maintaining the thickness of the sheet substantially uniform across its width.

Another object of the invention is to provide for rolling thin metal sheets in such a way that the scale adhering to the exterior portions of the metal is effectively removed during the early operations upon the stock in the process of reducing it into thin sheet form.

In accordance with the invention a substantially thick hot slab of metal is first passed through a reversing mill or a series of sets of rolls in which the cooperating contacting surfaces of the working rolls in each stand or mill are provided with a corrugated contour affording corrugated roll passes, the distance between the rolls, or in other words the thickness of the roll pass, being maintained substantially uniform across the width of the rolls, accordingly producing a longitudinally corrugated sheet of uniform thickness. In the reversing mill or the first few stands of reducing rolls, depending upon which is employed, and which may be referred to as the breaking down rolls, the corrugations in the rolls are made substantially deep, and the width and depth of the corrugations are maintained substantially the same in each succeeding set of these rolls.

When a slab is passed through these rolls the resulting blank is formed with longitudinal corrugations conforming to the shape of the rolls. The tongue and groove of corresponding corrugations across the face of the rolls work together and produce a corrugated slab or section, the linear distance across the surface of the corrugated section being much

greater than the original surface of the slab. This surface elongation across the width of the blank is, in effect, a stretching and deforming of the surface, the action of which is to loosen and remove scale from the surface of the blank.

Inasmuch as the diameter of each increment of each roll varies in accordance with the contour of its corrugated working face, the peripheral speed at different points along its transverse surface will vary, and due to these different speeds and the effect they have upon the material passing through the rolls a differential slippage between the cooperating contacting surfaces of the roll is set up and any scale adhering to the surface of the metal stock is very effectively removed. Further, it will be realized that due to this differential slippage which has an equalizing effect in opposite transverse directions between corrugations in the rolls, the metal blanks are maintained centralized as they pass through each set of rolls.

Following the breaking down rolls, a series of sets of successively operating reducing rolls may be employed for operating upon the metal being worked, these being so arranged that the metal in passing therethrough may or may not be acted upon by more than one set of rolls at the same time. The type of stands used for the reducing operation may, as in the breaking down operations, be of the well known two-high type. The corrugations in the contour of the rolls are maintained in number in each of these stands the same as in the breaking down rolls, but each succeeding set of rolls in the series of reducing stands may have the depth of the corrugations therein slightly reduced and the distance between the corrugations correspondingly increased, thereby reducing and widening the stock as it passes therethrough. In order to so pass the material from one set of these stands to the next, means are provided for successively flattening out the stock as it issues from one set of rolls, and for guiding it into the following set of rolls. Following the reducing or primary sets of rolls the metal may be acted upon by a series of stands of finishing or secondary sets of rolls, preferably of either the four-high or cluster type, having small diameter working rolls and large diameter backing up rolls, and in the rolls employed in these stands as in the preceding rolls the corrugated contour of the cooperating contacting surfaces is maintained, the depth of corrugations, however, being slightly decreased in each succeeding set of rolls with corresponding widening of sheet.

If it is desired to ultimately produce from the last set of finishing rolls flat sheet of the gage obtainable at this stage of the process, corrugated rolls in that stand may be omitted and cylindrical rolls substituted for flattening out the corrugated sheet to a perfectly flat sheet. It is possible to reduce single sheets in this way to comparatively thin gages, such for instance as standard U. S. gages 16 to 20. However, to reduce sheets to thinner gages than 16 to 20, it is necessary to roll the sheets in corrugated pack formation in a further operation as described.

With the sheets formed with longitudinal corrugations as provided in accordance with the succeeding steps of this invention, they may be nicely nested in pack formation for such finer reduction; and, to further increase the ease of handling the sheets where they are so reduced, means may be provided after the last set of rolls in the finishing stands for cutting the sheets into predetermined length. The sheets then may be conveniently piled into pack formation and the resulting packs passed through a second set of finishing rolls which conform in mechanical details to those of the first set of finishing stands, the number of corrugations being maintained throughout this last set of finishing stands for the same purpose and in the same manner as in the preceding rolls. If it is desired to produce a flat sheet from this second finishing unit, the last stand may be provided with cylindrical rolls having working surfaces disposed in parallel relation. It is evident that this procedure may be repeated in still another set of finishing rolls if it is desired to further reduce the sheets to a still thinner gage. It is also evident that the thinness to which the sheets may be reduced may be varied by varying the number of sheets in each pack as it is passed through a finishing operation.

It may be desirable in the practice of this invention to provide means between different sets of rolls or sections of the mill for preheating the stock so that it may be more readily worked. Also, before the sheets are formed in packs they may be passed through a charcoal and water bath, commonly referred to as a charcoal dip, to prevent the sheets from sticking together as they are being rolled in pack formation, or other means to this end may be employed. In some instances it may be desirable to place a pickling unit or bath between the roughing or breaking down rolls and the reducing rolls to completely remove any possible scale that may remain on the metal before it is rolled into the thinner gages.

Where four-high or cluster mills are employed, as is preferable in the finishing stands, the contour of the backing up rolls may be so formed that only portions of their surfaces bear upon the working rolls, this being for the purpose of minimizing slippage between the surfaces of the rolls which tends to cause excessive heating and distortion in the rolls as well as consequent wear-

ing away of the contacting surfaces of the rolls.

To automatically and effectively roll the sheets to a uniform thickness, one of the working rolls in each stand may be mounted in a bearing in such a way that it cannot move transversely in the mill, and in order to do this without effecting excessive heating in the roll neck and shoulder an anti-friction and thrust bearing, or bearings may be employed. The other working roll, preferably the lower, is mounted in a bearing with a limited space between it and the roll proper so that the roll is free to move longitudinally a limited amount. Consequently, if any unequal or ununiform portion appears in the sheet being rolled it will cause an unequal pressure at different points along the length of the rolls and the lower roll will automatically seek a position equalizing the pressure whereby a sheet of uniform thickness is produced.

As referred to hereinbefore, the corrugated contour of the rolls causes a slippage to occur between the contacting surfaces of the rolls and the material being rolled, varying in accordance with the difference in peripheral speeds of the rolls, the slippage tending to slightly elongate the metal between the different corrugations. In view of this the depth of the corrugations in the rolls is preferably reduced in each succeeding stand so that as the sheet becomes thinner the slippage and its effect becomes less.

The invention will be further explained in connection with the accompanying drawings forming a part of this specification, and in which Fig. 1 is a diagrammatic plan view of a mill embodying the invention; Fig. 2 a side elevation of the mill of Fig. 1; Fig. 3 an end view of a slab of such relative proportions as may be rolled in the mill; Figs. 4, 5, 6 and 7 transverse sectional views showing the blank as corrugated and successively reduced by the first four stands of rolls; Figs. 8, 9 and 10 transverse sectional views of the blank as further reduced in the succeeding stands of rolls of Figs. 1 and 2; Fig. 11 a face view of any one of the last three or four stands of Figs. 1 and 2; Fig. 12 a diagrammatic plan of a series of rolls and other apparatus forming a finishing unit; Fig. 13 a side view of Fig. 12; Fig. 14 a face view of a pair of rolls with a sheet between them so positioned that its edges are operated upon at a point where the diameters of the two rolls are substantially the same; Fig. 15 a similar view of a pair of rolls having a greater number of corrugations; Fig. 16 a similar view of a pair of rolls having arcuate corrugations; Fig. 17 an enlarged plan view of one of the spreading devices shown between the stands in Fig. 1 and 2; Fig. 18 a vertical sectional view taken on the line XVIII—XVIII, Fig. 17; Fig. 19 a transverse sectional view of a blank as it enters the spreader of Figs. 17 and 18; and Fig. 20 a view similar to Fig. 19 showing the blank as it leaves the spreader.

Referring to Figs. 1 and 2, the mill there shown comprises a feeding roll table 21 arranged adjacent to heating furnaces 50, and a series of breaking down or reducing roll stands 1, 2, 3 and 4 having their working faces provided with corrugations of the same or substantially the same depth, and in which a piece of material is reduced in thickness, elongated in length, and maintained at substantially the same width, and in which, due to the change in the form of a blank and to the excessive differential slippage between the metal and the contacting surface of the rolls, scale adhering to the metal is effectively loosened and removed therefrom. In Fig. 3 there is shown a slab of such relative cross sectional dimensions as may advantageously enter the first of the break down rolls or roll passes, and Figs. 4, 5, 6 and 7 show the blank in its corrugated reduced form as it emerges from the successive roll passes of stands 1, 2, 3 and 4.

Following stand 4 there are a series of stands 5, 6 and 7 having their rolls provided with corrugations conforming in numbers to those employed in the preceding breaking down rolls, but of reduced depth in each succeeding set of rolls. Also, the length of the rolls are preferably correspondingly increased in each succeeding stand. For flattening out the corrugations in the sheets of material as they issue from one set of rolls, and for so guiding them as they pass into the next set of rolls that they will properly enter them, flattening and spreading devices are placed between stands 4 and 5, 5 and 6, and 6 and 7, respectively. These devices may take different forms, but are indicated here as a set of rollers arranged as shown in Figs. 17 and 18. Three sets of idle rollers are shown as being mounted for rotation upon upper shafts 60, 61 and 62, and on lower shafts 63, 64 and 65, extending transversely of and above and below the line or plane of pass between adjacent stands of rolls, as for example stands 4 and 5. On shaft 60 there are a pair of grooved idle rollers 66 and 67 between which there is an idle roller 68 having a projection adapted to engage the central valley of a blank 69 (Fig. 19) after it emerges from rolls 4. On shaft 63 the idle rollers are reversed, a grooved roller being at the center of the shaft, and projection rollers 70 being arranged opposite to rollers 66 and 67. On shafts 61 and 64 there are similar sets of idle rollers spaced laterally from each other at greater intervals than the rollers on shafts 60 and 63, and provided with shallower grooves and smaller projections to spread the blank and flatten its corrugations. In a similar way, shafts 62 and 65 are provided with three pairs of rollers spaced still farther apart than the pairs of

rollers on shafts 61 and 64, and having still shallower grooves and shorter projections to further spread blank 69 so that it may properly enter the working rolls 5. By such an arrangement of guidin spreading and flattening rollers, a blank between any successive pairs of rolls may have the depth of its corrugations diminished, and its width increased, and may also be properly guided. The spreading and flattening action of these rollers is illustrated by comparing blank 69 (Fig. 19) with the same blank 69*a* (Fig. 20) as it emerges from rolls 5, and also by comparing Figs. 8, 9 and 10 which show the blank as it emerges from rolls 5, 6 and 7.

Following the breaking down stands 1, 2, 3 and 4, and the reducing stands 5, 6 and 7, which are preferably all of the two-high type, there are a series of finishing stands 8, 9, 10 and 11. As illustrated, these stands may be of the four-high type in which the working rolls have smaller diameters than the backing up rolls. The working rolls in these stands are also of corrugated contour whereby metal in passing through them will keep in alignment and be rolled to uniform thickness. The longitudinal corrugated contour of the finished strip may be maintained uniform in depth and spread throughout this entire set of finishing stands. If it is desired to produce a flat sheet at the end of these finishing rolls, the working rolls of stand 11 may be provided with cylindrical faces. Immediately following stand 11 of the finishing rolls there is a flying shear 25 which may be used for cutting the strips into any predetermined lengths as they pass out onto a table 51 following the shear. If the rolled sheets issuing from stand 11 are not sheared they may be passed over table 51 to a coiler, two of which are indicated at 52 and 53 at the end of this table.

While it is possible to roll single sheets in the first set of finishing stands 8, 9, 10 and 11 to a thickness comparable to the U. S. standard gages 16 to 20, in order to effect a reduction to the thinner gages, such as U. S. standard gages 28 to 30 or thinner, a second set of finishing stands may be provided such as is illustrated in Figs. 12 and 13. The faces of the working rolls of these stands are corrugated for the purposes above set forth, the corrugations preferably being the same in depth and spread as those shown and described in connection with stands 8, 9, 10 and 11. When a strip issues from finishing stand 11 and is cut into predetermined lengths, it may be passed through a pickling vat 26 disposed immediately after table 51 or after coilers 52 and 53. From the pickling vat where scale is removed, the sheets may be passed into a vat 27 containing charcoal-water or other suitable material to prevent them from sticking together when later rolled in pack formation. As the strips or sheets issue from vat 27 they may be arranged in packs on a table or pack-forming device 28 with their corrugations nesting within each other. The pack may then be heated to a proper temperature for rerolling, the heating preferably being effected in a continuous heating furnace 29 arranged as illustrated immediately after the pack piling device, and just preceding the first of the pack rolling and finishing stands 12, 13, 14, and 15.

To again cut the sheets into suitable lengths, another flying shear 31 may be arranged immediately after the stand 15, the cut sheets being then placed on a table 54. If the sheets are not sheared, they may, if desired, be coiled on coilers 55 and 56 at the end of table 54. As stated in connection with the other set of finishing stands, if it is desired to flatten the sheets as they issue from stand 15, such stand may be provided with working rolls having cylindrical surfaces. Should it be desired to retain the corrugations in the sheets, the working rolls of stand 15 will, of course, be corrugated, as they will also preferbaly be in case it is desired to further roll the sheets in larger corrugated packs to gages thinner than may be rolled in finishing stands 12—15. Such rolling to very thin gages may be effected by rerolling larger corrugated packs in stands 12—15, or by providing an additional set of stands. Sheets may be thus rolled to sheet mill, to tin plate and even foil gages.

As explained above, it is preferred to so shape the surfaces of the backing rolls in the four-high or cluster mills that only portions of their surfaces bear upon the working rolls, the purpose being to minimize slippage between the surfaces of the rolls, and the consequent heating and wear. It has also been explained that it is preferred to provide one or the other of the working rolls and its backing roll or rolls with end thrust bearings to hold such rolls against longitudinal movements, and to so mount the other working roll and its backing roll or rolls that they may move longitudinally to maintain uniform working pressure upon a blank to cause it to be rolled uniformly. These features of our invention are illustrated in Fig. 11 which shows somewhat diagrammatically a face view of a stand of four-high rolls including upper and lower working rolls 75 and 76, and upper and lower backing rolls 77 and 78. It will be observed that the backing rolls contact only with the outer portions of the corrugated projections formed on the surfaces of the working rolls, and that by reason of this the slippage between the surfaces of the working and backing rolls is materially reduced. This reduction in slippage lessens the frictional heat and reduces the wear which might otherwise occur.

Preferably, as shown in Fig. 11, it is the upper working and backing rolls that are

provided with end thrust bearings, and it is the lower working and backing rolls that are mounted to permit of their longitudinal movements. Both the upper and lower backing rolls are also preferably mounted in roller or other suitable anti-friction bearings. Each end of upper backing roll 77 is provided with a collar 79, between which and a ring 80 roller bearings 81 are arranged. The inner end of collar 79 bears against the shoulder of the roll, and ring 80 is enclosed in a casing 82. At the outer end of ring 80 there is a radially disposed ring 83 between which and a second radially disposed ring 84 there are a series of thrust roller bearings 85, which are suitably backed so that they act through ring 83 and collar 79 to hold backing roll 77 against longitudinal movements.

In a similar way, upper working roll 75 is provided with thrust bearings in the form of rollers 86 arranged between a radially disposed ring 87 and a radial flange 88 projecting outwardly from a collar 89 on the neck of roll 75. Ring 87 is enclosed in a casing 90 which bears against the shoulder of roll 75, and the flange 88 of collar 89 is backed by a ring 91 so that roll 75 is held against longitudinal movements.

The necks of lower roll 76 are mounted in ordinary bearing rings 92 with sufficient clearance between the ends of the rings and the shoulders of the roll to permit the roll to move longitudinally. Also, in such a way as to permit lower backing roll 78 to move longitudinally its necks are provided with roller bearings 93 caged similarly to the roller bearings 81 on backing rolls 77. Thus the lower working and backing rolls may move longitudinally to automatically maintain a working pass of uniform thickness, the rolls being caused to move endwise by such variations as there may be in the pressure upon the corrugated faces of the working rolls when rolling a blank.

In the several figures of the drawings to which reference has thus far been particularly made, the rolls are illustrated as being provided with two complete corrugations of angular form. While two corrugations are sufficient for most purposes, the number of corrugations may be increased as illustrated in Fig. 15, and they may be of curved form as shown in Fig. 16. When rolling corrugated sheet metal directly from heated slabs, a still larger number of corrugations may be provided on the surface of all of the working rolls.

In the present day continuous rolling of sheet metal considerable difficulty is encountered in preventing wrinkling or curling of the edges of thin sheets. In the practice of our invention such wrinkling and curling may be avoided by so regulating the width of the blank that its edges lie on, or substantially on, the pitch line of the corrugations of the working rolls. This is illustrated in Fig. 14 which shows a blank 95 having its edges 96 lying on the pitch line A—B of working rolls 97. On the pitch line of the working rolls there is no differential slippage between the surfaces of the rolls, and therefore with a roll pass of uniform thickness from edge to edge there is no tendency to so elongate the edges of the blank as to cause it to wrinkle or curl.

In the operation of our invention a relatively thick heated slab, such as that indicated in Fig. 3 is first roughed down in corrugated roll passes such as those formed by the rolls of stands 1, 2, 3 and 4, in which the blank is not only elongated and reduced in thickness, but its surface is laterally distended and its width increased. A double advantage of thus roughing down a slab is to descale it, and to prepare it for entering subsequent corrugated passes, the first of which are formed by the break down rolls of stands 5, 6 and 7. Between stands 4 and 5, 5 and 6, and 6 and 7, the blank is spread laterally and the depths of its corrugations are diminished by a series of guide and spreading rollers such as illustrated in Figs. 17 and 18, the blank as it issues from the roll stand 7 having corrugations such as illustrated in Fig. 10, or corrugations of less depth than there shown.

The corrugated blank is then passed through a series of continuous roll passes formed by the rolls of stands 8, 9, 10 and 11 which are sufficient in number to reduce the blank to such thinness as practical working conditions permit, for example to from 16 to 20 gage. Thereafter, the blank may be sheared by shears 23 (Figs. 1 and 2), the sheared blanks being piled upon table 51, or it may be coiled by coils 52 or 53. For the production of thinner gage sheet metal, sheared lengths of blanks emerging from roll stand 11 may be passed through a pickling vat 26 and a charcoal coating bath 27 to a table or stacking device 28, on or by which they are arranged in nested packs for subsequent pack-rolling in stands 12, 13, 14 and 15, the packs having first been passed through a continuous furnace 29. This operation may be repeated as many times as required to produce sheets of any desired thinness.

By rolling the sheet metal in corrugated roll passes either singly or in nested packs, there are eliminated the centering difficulties heretofore encountered in continuous sheet rolling mills, and the sheet metal is uniformly worked from edge to edge. While it is preferred to maintain the corrugated roll passes of uniform thickness throughout, it will be understood that the invention may also be practiced in mills having corrugated roll passes thicker at their centers than at their edges. In all cases the centering of the blanks is facilitated, as is also the uniformity of working of the metal, by holding one of each

pair of working rolls and its backing roll or rolls against longitudinal movements, while mounting the other of each pair of working rolls and its backing roll or rolls for longitudinal movements as illustrated in and explained in connection with Fig. 11.

According to the provisions of the patent statutes, we have explained the principle and mode of operation of our invention, and have illustrated and specifically described the preferred mechanism for and manner of practicing it. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim as our invention:

1. In a rolling mill for rolling sheet metal, the combination of a plurality of sets of reducing rolls arranged in tandem formation, the cooperating surfaces of said rolls being corrugated to form a corrugated sheet of uniform thickness, the depth of corrugations being diminished in succeeding set of rolls, and rollers above and below the line of pass between the sets of reducing rolls for spreading the sheet and diminishing the depth of its corrugations as it passes from one to another of the sets of rolls.

2. A mill for rolling thin gage sheet metal, comprising a pair of working rolls having their faces provided with cooperating annular corrugations for reducing the metal to substantially uniform thickness, one of said rolls being mounted to permit it to move longitudinally, and means for holding the other of said rolls against longitudinal movement.

3. A mill for rolling thin gage sheet metal, comprising a pair of working rolls having their faces provided with cooperating annular corrugations for reducing the metal to substantially uniform thickness, one of said rolls being mounted to permit it to move longitudinally, and end thrust bearings for holding the other of said rolls against longitudinal movement.

4. A mill for rolling thin gage sheet metal, comprising a pair of working rolls having their faces provided with cooperating annular corrugations for reducing the metal to substantially uniform thickness, and backing rolls for the working rolls provided with corrugations meshing with but of less depth than those of the working rolls, thereby reducing the frictional contact between the backing and working rolls.

5. A mill for rolling thin gage sheet metal, comprising a pair of working rolls having their faces provided with cooperating annular corrugations for reducing the metal to substantially uniform thickness, backing rolls for the working rolls provided with corrugations meshing with those of the working rolls, one of the working rolls and its backing roll being mounted to permit them to move longitudinally, and means for holding the other working roll against longitudinal movements.

6. A mill for rolling thin gage sheet metal, comprising a pair of working rolls having their faces provided with cooperating annular corrugations for reducing the metal to substantially uniform thickness, backing rolls for the working rolls provided with corrugations meshing with those of the working rolls, one of the working rolls and its backing roll being mounted to permit them to move longitudinally, and means for holding the other working roll and its backing roll against longitudinal movements.

7. The continuous method of rolling sheet metal, comprising reducing a blank in a series of continuous roll passes each having a plurality of corrugations the same in number, and maintaining the blank in alignment in the continuous passes by the engagement of the corrugations of the blank with those of the passes.

8. The continuous method of uniformly rolling sheet metal, comprising reducing a blank in a series of continuous roll passes each having a plurality of corrugations the same in number, and each roll pass being of uniform thickness from side to side, and maintaining the blank in alignment in the continuous passes by the engagement of the corrugations of the blank with those of the passes.

9. The continuous method of rolling sheet metal, comprising reducing a blank in a series of continuous roll passes each having a plurality of corrugations the same in number but successively less depth and greater spread, spreading the blank between successive continuous roll passes to cause its corrugations to correspond in spread with those of the pass it enters, and maintaining the blank in alignment in the continuous passes by the engagement of the corugations of the blank with those of the passes.

10. The continuous method of uniformly rolling sheet metal, comprising reducing a blank in a series of continuous roll passes each having a plurality of corrugations the same in number but of successively less depth and greater spread, and each roll pass being of uniform thickness from side to side, spreading the blank between successive continuous roll passes to cause its corrugations to correspond in spread with those of the pass it enters, and maintaining the blank in alignment in the continuous passes by the engagement of the corrugations of the blank with those of the passes.

11. The method of rolling sheet metal, comprising breaking down and simultaneously descaling a slab in corrugated roll passes of uniform spread to form a longitudinally corrugated blank, and thereafter reducing said blank in a series of continuous roll passes each corrugated to correspond with the cor-

rugations of the blank, and maintaining the blank in alignment in the continuous passes by the engagement of the corrugations of the blank with those of the passes.

12. The method of rolling sheet metal, comprising breaking down and simultaneously descaling a slab in corrugated roll passes of uniform spread to form a longitudinally corrugated blank, thereafter reducing the blank in a series of continuous roll passes having corrugations the same in number but of successively less depth and greater spread than those of the blank to maintain the blank in alignment in the continuous roll passes, and spreading the blank between successive continuous roll passes to cause its corrugations to correspond in spread with those of the pass it enters.

13. The continuous method of rolling sheet metal, comprising reducing a blank singly in a series of continuous roll passes each having a plurality of corrugations the same in number, matching a plurality of such blanks in a nested pack, reducing the matched pack in a series of continuous roll passes each having the same number of corrugations as the first-mentioned passes, and maintaining the single blank and pack in alignment in the continuous passes by the engagement of the corrugations of the blank and pack with those of the passes.

14. The continuous method of uniformly rolling sheet metal, comprising reducing a blank singly in a series of continuous roll passes each having a plurality of corrugations the same in number, and each roll pass being of uniform thickness from side to side, matching a plurality of such blanks in a nested pack, reducing the matched pack in a series of continuous roll passes each having the same number of corrugations as the first-mentioned passes and each being of uniform thickness from side to side, and maintaining the single blank and pack in alignment in the continuous passes by engagement of the corrugations of the blank and pack with those of the passes.

15. The continuous method of rolling sheet metal, comprising reducing a blank singly in a series of continuous roll passes each having a plurality of corrugations the same in number but of successively less depth and greater spread, spreading the blank between said successive continuous roll passes to cause its corrugations to correspond in spread with those of the pass it enters, matching a plurality of such blanks in a nested pack, reducing the matched pack in a series of continuous roll passes each having the same number of corrugations as the first-mentioned passes, and maintaining the single blank and pack in alignment in the continuous roll passes by engagement of the corrugations of the blank and pack with those of the passes.

16. The continuous method of uniformly rolling sheet metal, comprising reducing a blank singly in a series of continuous roll passes each having a plurality of corrugations the same in number but of successively less depth and spread, and each of said roll passes being of uniform thickness from side to side, spreading the blank between said successive continuous roll passes to cause its corrugations to correspond in spread with those of the pass it enters, matching a plurality of such blanks in a nested pack, reducing the matched pack in a series of continuous roll passes each having the same number of corrugations as the first-mentioned passes and each being of uniform thickness from side to side, and maintaining the single blank and pack in alignment in the continuous passes by the engagement of the corrugations of the blank and pack with those of the passes.

17. The continuous method of rolling sheet metal, comprising reducing a blank in a series of continuous roll passes each having a plurality of corrugations the same in number, maintaining the blank in alignment in the continuous passes by the engagement of the corrugations of the blank with those of the passes, and finally flattening the blank.

18. In a continuous rolling mill for rolling sheet metal, the combination of a plurality of sets of reducing rolls arranged in tandem formation, the cooperating surfaces of said rolls being provided with a plurality of annular corrugations to form a longitudinally corrugated sheet of uniform thickness, the depth of corrugations being diminished and their widths spread in succeeding sets of rolls, and means located between adjacent sets of rolls for spreading the sheet as it passes from one set of rolls to another to cause its corrugations to correspond with those of the rolls it enters.

In testimony whereof, we hereunto sign our names.

JAMES RAMSEY SPEER.
FREDELLIA H. MOYER.