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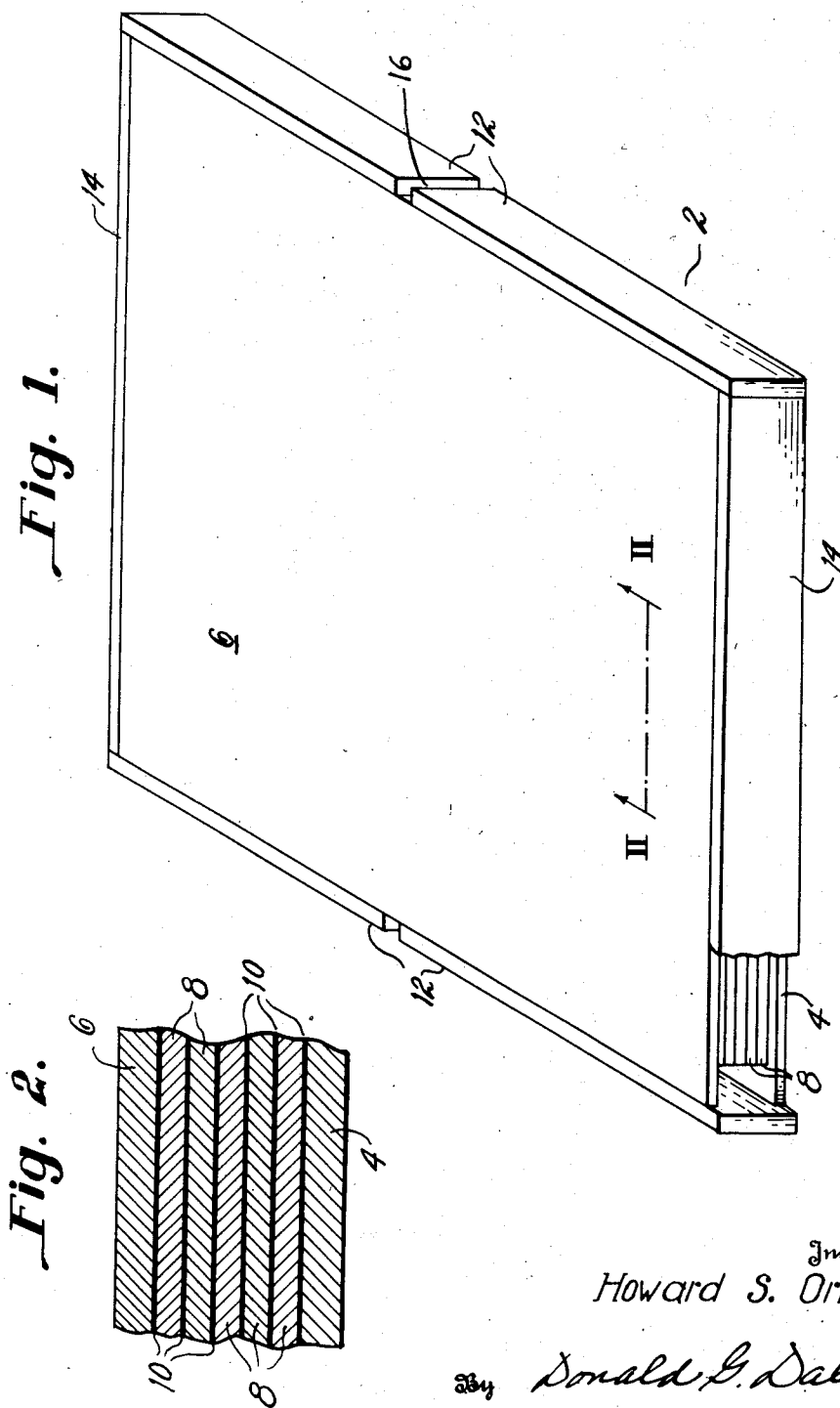
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2,645,842

MULTIPLE ROLLING OF STRIP

Filed Feb. 28, 1947

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3a.

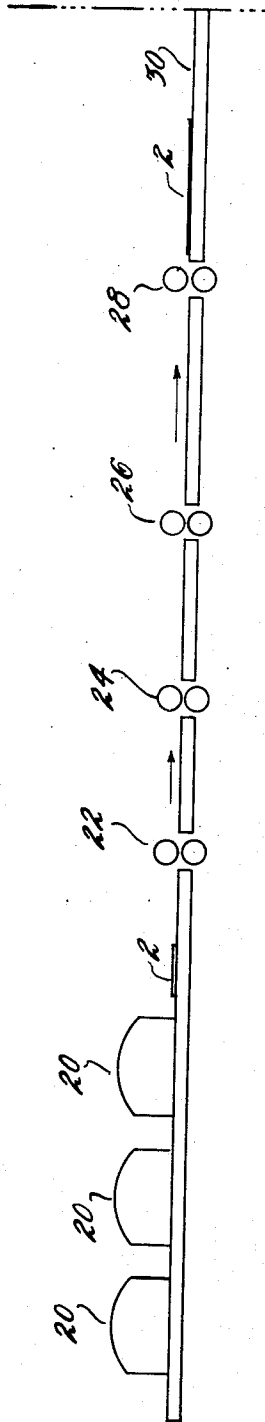
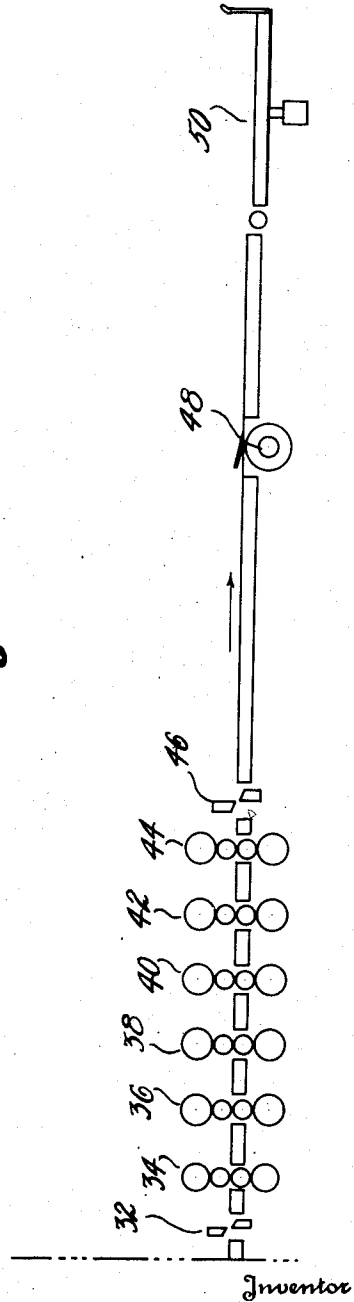


Fig. 3b.



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MULTIPLE ROLLING OF STRIP

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3 Claims. (Cl. 29-19)

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This invention relates to a method of hot rolling strip metal in a plurality of layers or plies. The invention relates more particularly to the rolling of difficultly rollable metals, such as alloy steels of which high silicon electrical steel and stainless steel are typical.

The invention has among its objects the provision of a method whereby difficultly rollable metals may be hot reduced to relatively thin gauges quickly and easily.

The invention has as a further object the provision of a method of hot rolling such metals whereby strip with an excellent surface results without the necessity of performing any special finishing step thereon.

In the rolling of strip metal in single ply in a continuous mill, the ratio of the width to the thickness of the finished product very rarely exceeds 1000:1, and in fact the cost of rolling strip in this manner mounts rapidly when the width to thickness ratio of the finished product exceeds 200:1. The higher costs of production are a result of greater power consumption, roll deterioration, damage to equipment on account of excessive torque loads, and the necessity for precision control of slab heating and rolling temperatures. The practical limitations in the single ply hot rolling of typical steels on modern continuous hot strip mills are shown by the table below, in which the strip thicknesses given are the minimum thicknesses of strip which it is practical to produce by such method in commercial production. In the table, "W" is the width of the strip in inches, "T" is the thickness of the strip in inches, and "W/T" is the width to thickness ratio.

Table I

W	Mild Carbon		Low Alloy		Austenitic Stainless	
	T	W/T	T	W/T	T	W/T
30"	0.038	790	0.060	500	0.070	428
40"	0.038	1,050	0.070	570	0.100	400
50"	0.048	1,040	0.075	667	0.130	384
60"	0.058	1,032	0.080	750	(1)	(1)
70"	0.068	1,030	0.100	700	(1)	(1)
80"	0.078	1,025	0.100	800	(1)	(1)

1 Cannot be rolled economically.

In addition to the very definite limitations in the W/T ratio of the strip produced by single ply continuous hot rolling, this method has the further disadvantage that the surface produced is far from perfect, due to the oxide and scale rolled thereinto. It has been necessary, therefore, to give the rolled strip a further finishing treatment to remove the scale and to smooth the surface.

I have invented a method which makes pos-

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sible the multiple rolling of difficultly rollable metals in continuous hot strip mills and may be utilized, if desired, to produce finished strip or sheets in which the W/T ratio is as great as 10,000:1 with a consequent elongation of the composite slab of as great as 50:1 without subjecting the mill stands and other mill equipment to any more wear and strain than they must withstand in producing strips of the thickness given in the table above by the single ply rolling method. In addition, my improved method permits the production of hot rolled strips with surfaces which are almost free from scale or other defects. Thus after annealing and pickling of the hot strip the surface finish is such that the product is suitable for many applications, while if the material is subjected further to a light cold reducing pass followed by annealing, pickling, and skin rolling the resulting strip has a commercial finish equivalent to most products now on the market produced by the hitherto known laborious and costly methods.

The invention will be more readily understood by reference to the accompanying drawings in which:

Figure 1 is a view in perspective of a pack of plates forming a composite slab for rolling in accordance with the invention;

Figure 2 is a partial cross section therethrough taken along the line II-II in Figure 1; and

Figures 3a and 3b, taken together, constitute a schematic view in side elevation of the rolling mill stands and associated means which may be employed in practicing the invention.

The composite pack shown in Figures 1 and 2 is indicated generally by the reference character 2. It consists of a top plate or sheet 6 and a bottom plate or sheet 4 of easily hot rollable metal, such as mild steel. Enclosed between such top and bottom plates or sheets are a plurality of stacked plates or sheets 8 of difficultly rollable metal. In the embodiment of the slab shown, plates 8 are made with their lengths and widths somewhat less than those of the top and bottom plates 6 and 4, so that the inner plates are overlapped by and afforded a limited amount of freedom within the slab covers. Inner plates 8 are spaced from each other and from the top and bottom plates 6 and 4 by the interposed layers 10 of separating material, which is of such character as to prevent the welding of adjacent sheets together during the heating and hot rolling operations. The composite slab 2 is completed by the side bars 14 and the end bars 12 which are welded to the outer edges of sheets 4 and 6, accomplished preferably by a welding operation which lays down a bead between the exposed outer edges of the top and bottom plates and of the side and end bars. It is preferred that the interior of

the pack or composite slab have free access to the atmosphere while still maintaining the rigidity and strength of the slab. This purpose may be accomplished by using multiple end bars 12 which are spaced, as at 16, to provide an opening or openings from the atmosphere into the slab. It is possible, however, to employ a completely sealed composite slab if oxidation of the components after assembly is not relied upon in forming separator layers 10.

It is preferred that the slab 2 be of substantially the same dimensions as integral slabs made of a single metal employed as starting products in the single ply rolling of strip. When the composite slab is so dimensioned it may be readily heated and rolled in existing mill equipment for the hot rolling of strip. In the usual practice of the invention the ratio of the total thickness of the inner plates 8 to the total thickness of the softer cover plates 4 and 6 lies between 1:1 and 2:1, although admirable results have been obtained with such ratio having a value of as much as 5:1.

The weld preventing separating layers 10 may be of a variety of compositions and may be provided in a variety of ways. Thus, it is possible simply to employ those layers on sheets 8 and that layer on sheets 4 and 6 which are formed thereon as a result of their previous heating and rolling, in other words, the natural oxide or the scale on the plates. Alternatively it is possible to provide them by heating the assembled composite slab, initially at least, in an oxidizing atmosphere, the interior of the slab having access to such atmosphere, as shown. The layers 10 are usually formed, however, of finely divided refractory material such as magnesia applied to the surfaces of the components, preferably as a suspension or slurry in water. One such material which has given good results is that known as Lumnite cement, which is a calcium aluminate cement manufactured and sold by the Universal Atlas Cement Company. Best results have been yielded, however, when the weld preventing layers are formed by lightly swabbing the components before assembling them into packs with an approximately 15% aqueous solution of chromium sesqui-oxide, Cr_2O_3 , followed by a layer of a slurry of magnesia in water applied by means of a spray gun. The last named separating layer is particularly to be preferred in cases where the ratio of total thickness of the hard difficultly rollable components to the total thickness of the soft steel covers is large, thus requiring a rather high coefficient of friction between components to prevent appreciable slippage thereof. It will be apparent that the layer 10 need be applied to but one side of each of plates 8 if the plates are assembled so that a layer 10 lies between each pair adjacent plates 8.

In the rolling of a composite slab in which the inner plates 8 are made of "18-8" stainless steel,

the slab, after assembly in the manner indicated, is reduced in the apparatus indicated in Figures 3a and 3b in the following manner. It is to be understood that such method is given by way of example only and that the invention is not limited thereto. The composite slab 2 is heated, to the proper rolling temperature for the inner components, in one of several furnaces 20, being subjected to a normal four-hour heating cycle with an ultimate temperature of 2250° F. The heated slab 2, after discharge from the furnace, then progresses through a succession of 2-high roughing mills 22, 24, 26, and 28, spaced progressively longer distances apart so that the lengthening slab is at no time engaged simultaneously by two roughing stands. After delivery from the final roughing stand 28 the elongated slab may be held if desired on delivery table 30 following which it is presented to the continuous strip finishing mill employing a plurality of 4-high stands 34, 36, 38, 40, 42, and 44. There is provided a crop shear 32 in advance of stand 34 of such finishing mill, but ordinarily the composite slab is not sheared at this point since it is desired that the components be held together by side and end elements 12 and 14 which still remain welded to the top and bottom cover plates or sheets. The 4-high finishing mills are so spaced that the composite slab, after engagement of its entering end with the second mill 26, is always in engagement with two or more mill stands. The mill stands are operated at progressively higher speeds that the composite pack is subjected to substantial tension between stands. Such tension may, for instance, be on the order of from 10 to 50% of the tensile strength of the reduced composite slab at that point.

Upon emerging from the hot strip finishing mill the hot reduced composite slab, which now has a gauge comparable to that of a single ply strip similarly hot rolled, may be cut by flying shear 46 into desired lengths, following which the composite sheets may be delivered to the piler 50. Alternatively, the flying shear 46 may remain idle, the composite strip being collected in a continuous coil by coiler 48. Separation of the components of the composite strip, whether such strip is sheared and piled as composite sheets or is coiled as a continuous composite strip, may readily be accomplished by shearing off the welded edges of the composite product and then running it through a roller leveller, which operation causes the components to shift and slide on one another and thus readily to fall apart.

The following Table II gives the salient facts, such as composition, the starting width, length, and thickness in inches of the starting components of a typical composite slab in accordance with the invention, and the final thickness in inches of each component, together with the W/T ratio of the finished hot rolled components, and the reduction ratio thereof.

Table II

Plate	Material	Dimension in inches	Thickness		W/T	Reduction Ratio
			Original	Final		
Cover	.08% C Steel	37×103½	1.250	.076	486	16.4
First	17% Cr	34¾×100¾	.250	.016	2,120	15.6
Second	18% Cr, 8% Ni	34¼×100	.490	.031	1,095	15.8
Third	18% Cr, 8% Ni	34¼×100	.190	.012	2,830	15.8
Fourth	18% Cr, 8% Ni	34¼×100	.078	.005	6,800	15.6
Fifth	17% Cr	34¾×100¾	.250	.016	2,120	15.6
Bottom	.08% C Steel	37×103½	1.250	.076	486	16.4
Composite			3.758	.232	160	16.2

It can be seen by reference to the fourth inner component of the composite slab that a strip was produced in this instance, by use of the invention, in which the ratio W/T was 6800. Such value is not to be taken as the maximum obtainable, however, since as above stated it is feasible to produce strip by my method in which this ratio is as high as 10,000.

The hot rolling of the composite slab both in the roughing mill and in the hot continuous strip finishing mill, even when the slab includes the difficultly rollable inner components set out in Table II, imposes very little more load or strain upon the mill than when it is rolling an integral mild steel slab of identical dimensions. The following Table III shows the current consumed by each of the mill driving motors of the six finishing stands in the rolling of the composite slab of Table II and a slab of mild rimming steel 4" thick and of substantially identical length and width. The two slabs were heated and rolled in substantially the same manner, the percentage reduction given one slab by any particular mill stand being substantially the same as that given the other slab by that stand.

Table III

Mill Stand	34	36	38	40	42	44
Rimmed Steel Slab....	4,000	4,600	4,000	2,200	3,800	2,200
Composite Slab.....	4,200	5,200	4,400	2,200	4,400	2,300

Having thus fully described and illustrated preferred embodiments of the novel method of multiple hot strip rolling of the invention, I desire to claim as new the following.

I claim:

1. The method of hot rolling difficultly rollable alloy steel strips which comprises forming a pile of plates of such alloy steel or steels, providing top and bottom mild steel cover plates on the pile, the cover plates marginally overhanging the pile on its side and end edges, substantially enclosing said pile to form a composite slab by welding side and end bars to the edges of the cover plates, the side and end members being spaced somewhat from the edges of the pile, providing at least one opening through a side edge or end edge of the composite slab large enough to allow free communication between the pile and the atmosphere, providing separating layers of weld preventing material between adjacent members of the pile and between the cover members and the pile by applying to at least one of the two confronting surfaces of adjacent members of the

composite slab before their assembly a slurry of finely divided refractory material in water, heating the composite slab to the hot rolling temperature for the components in the pile, hot rolling the heated composite slab in a roughing mill to plate gauge, thereafter on the same heat reducing such composite rough rolled product on a continuous hot finishing mill wherein the composite product is engaged simultaneously in two or more mill stands of the train, the composite product being rolled being subjected to appreciable tension between the stands of the hot finishing mill, shearing the edges from such finished hot rolled composite product and separating the plies thereof.

2. In a method of hot rolling difficultly rollable steel such as alloys of silicon or nickel, into strip having a ratio of width to thickness in the neighborhood of 500 or more, the steps including piling a plurality of plates of said steel with a layer of refractory weld-preventing material between adjacent plates, applying mild steel sheathing plates to the top and bottom of the pile with layers of said material between the pile and said sheathing plates, said sheathing plates marginally overhanging the edges of the pile, closing the edges of the pile substantially throughout, by welding mild steel bars to the edges of the sheathing plates, heating the resulting composite slab to a temperature suitable for hot-rolling, hot-rolling the slab to strip by passing it through a plurality of roughing mills then through a multiple-stand finishing mill while maintaining tension on the resulting strip between stands, shearing off the edges of the strip, removing the mild steel sheathing layers, and separating the several plies formed from said first-mentioned plates.

3. The method defined by claim 2 characterized by at least two bars being secured to the edges of the sheathing plates on one side of the slab, said last-mentioned bars having their ends in spaced relation providing an air vent therebetween.

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