

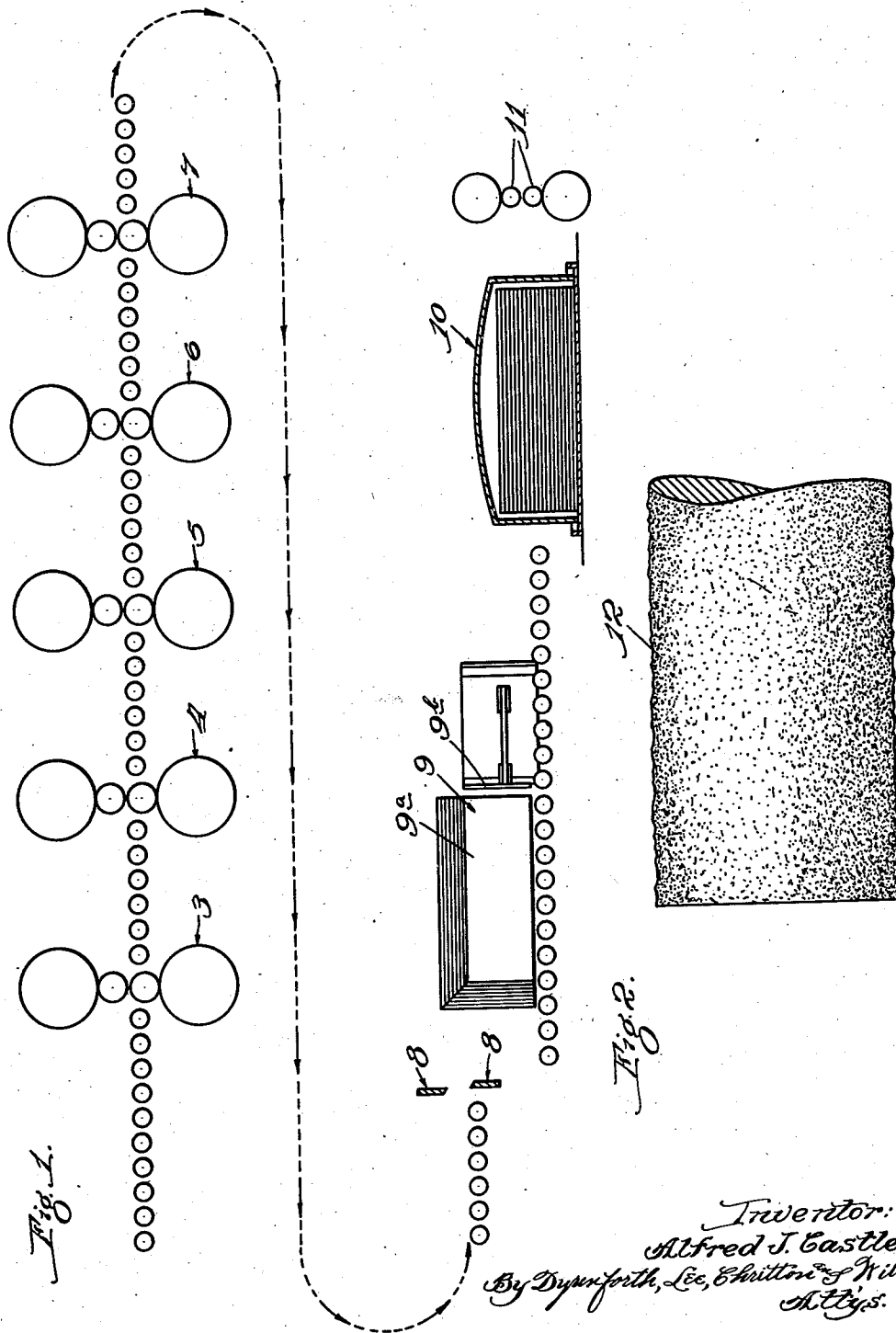
Jan. 18, 1938.

A. J. CASTLE

2,105,969

METHOD OF AND APPARATUS FOR PRODUCING FERROUS SHEET METAL

Filed Aug. 7, 1935



UNITED STATES PATENT OFFICE

2,105,969

METHOD OF AND APPARATUS FOR PRODUCING FERROUS SHEET METAL

Alfred J. Castle, Chicago, Ill., assignor to Inland Steel Company, Chicago, Ill., a corporation of Delaware

Application August 7, 1935, Serial No. 35,185

30 Claims. (Cl. 23—18)

My invention relates to the production of cold reduced ferrous sheet material and more especially to the finishing of such material to the end of causing the material to present the physical characteristics requisite to meet the requirements of deep draws, as in the case of the production of automobile fenders, and the like, and, where required, the surface characteristics rendering it suitable for the desired adhesion thereto of coatings, such as paint and lacquer films, vitreous enamel and metallic coatings, the present application being a continuation, in part, of my application for United States Letters Patent Serial No. 738,544, filed August 4, 1934.

Sheet material suitable for deep drawing operations must present a uniformly fine grain structure and a degree of softness and ductility proportionate to the deepness of the draw to be performed.

It is well known in the manufacture of cold reduced ferrous material that the desired fine grain structure can be obtained by suitable cold reduction, such as is commonly practiced in the art, followed by box annealing, the fine grain thus produced being comparable to a normalized structure; and that the higher the temperature at which the material is annealed the greater the degree of softness and ductility of the material.

In accordance with prior practice two procedures have been followed in the production of cold reduced sheets; one which consisted in box annealing the cold reduced sheet material with the surfaces of the material smooth and glossy, and the other in pickling the cold reduced sheet material prior to box annealing to cause the surfaces thereof to be roughened.

In the case of the first-referred-to practice which is the usual and well established one, it is not commercially feasible to anneal the sheets at a temperature higher than approximately 1200° F., a temperature too low to produce the necessary softness and ductility of the sheets for extremely deep drawing operations, because of the sticking together of adjacent ones of the sheets when heated above approximately 1200° F. due to their glossy and smooth surface characteristics.

In the case of the second-referred-to practice while it is possible, by reason of the roughened surfaces produced on the sheets in the pickling operation, to utilize a higher annealing temperature, namely, approximately 1300° F., without objectionable adhesion of adjacent sheets, such procedure is very costly in that it requires

the extra operation of pickling as above referred to, and furthermore, necessitates an objectionable departure from the regular desirable practice of cold rolling (tandem rolling) in oil because if oil is used it would require removal thereof from the sheets, as by the use of an alkali solution before pickling, thus necessitating the use, in place of the oil, of another liquid, such as water, to obtain the desired reduction of the strip sheet during the cold rolling thereof, resulting in material reduction of the possible production in this operation, by reason of the enforced relatively slow rolling of the material and resultant higher costs.

One of my objects is to provide for the so surfacing of the sheets prior to the annealing thereof that they may be annealed at a temperature as high as, and even higher than, that at which the sheets may be annealed when pickled before annealing as above referred to, without the sticking of the sheets together and without requiring such pickling operation and permitting oil to be used in the cold reduction of the sheets, the resultant sheets being of higher ductility and softer in regard to Rockwell hardness than any cold reduced sheets hitherto produced and thus presenting superior drawing qualities.

Another object is to provide for the so conditioning of the surfaces of the sheets, which after annealing are subjected to a skin-rolling operation to put them in the proper condition to withstand the deepest drawing operations and at the same time not to develop local over-draws or "stretcher strains", as to insure the desired adhesion, to the sheets, of coatings such as paint and lacquer films, vitreous enamel and metallic coatings; and other objects as will be manifest from the following description.

Referring to the accompanying drawing:

Figure 1 is a view in side elevation, and in the nature of a diagram, of a portion of an apparatus embodying my invention and providing for producing cold reduced sheets in accordance with my invention and involving a cold reducing mill and a box annealer; and

Figure 2, a broken face view of a dull or mat surfaced roll forming a part of the apparatus.

My invention as to the phase thereof relating to the so surfacing of the sheets prior to annealing that the annealing thereof may be performed at the high temperature referred to, without the adhering together of adjacent sheets consists, generally stated, in subjecting surfaces of certain of the sheets in at least the final cold rolling thereof, preceding the annealing opera-

tion, to the rolling action under pressure of rolls (which may constitute the last stand of the cold reducing apparatus) at least one of which has a dull or mat working face, to thereby produce
 5 dull or mat surfaced sheets, in which condition they are stacked in a pile so that as to each pair of contacting surfaces at least one thereof is a mat surface, and in such surfaced and stacked condition subjected to the higher annealing temperatures referred to in the box annealer.
 10

A specific example of the use of my invention is in connection with the general practice of cold reducing sheet material wherein the hot rolled sheet material is continuously pickled to remove
 15 the scale produced in the hot rolling thereof, then tandem cold rolled with oil, as for example in the mill comprising the stands 3, 4, 5, 6 and 7 of rolls of which the stand 7 is the last stand; the sheet material thus produced cut to length as by the shearing mechanism illustrated diagrammatically at 8; the sheets, sheared to length, automatically stacked by the stacking means represented generally at 9 and of a common and well known form of construction and operating
 20 to line up these sheets as they drop flatwise in succession from the shearing mechanism 8 upon the sheets previously discharged from this mechanism to the support below; the stacking mechanism comprising generally substantially vertical side and end boards 9^a and 9^b, respectively, arranged at substantially a right angle to each other above a support to which the sheets are to be delivered and serving to receive at the interior angle thus provided, the adjacent corners of
 25 the sheets to thus stack them in a substantially vertical pile; the stack being then transferred to a box annealer such as that represented generally at 10 wherein the stack of sheets is annealed, preferably under deoxidizing condition to preserve an unoxidized surface, and then skin rolled as by the skin rolls represented at 11 and shown as comprising smaller rolls of the skin roll stand shown as of the 4-high type.
 30

In accordance with my invention at least one of the sheet-engaging rolls in one or more of the stands of the tandem mill, including the last stand 7 instead of presenting smooth, glossy, work faces as hitherto provided in practice, would present a dull or a mat working face generally
 35 as indicated at 12, for causing the sheets passed therethrough to present the desired dull or mat surfaced condition. Either one or both of the sheet-engaging rolls of stand 7 may be provided with the desired dull or mat face. When both of these rolls are dull or mat surfaced both surfaces of the sheets operated thereon will be dull or mat surfaced and in the automatic stacking thereof by the mechanism 9 both of the contacting surfaces of each pair thereof will be mat
 40 surfaces. When one only of the sheet-engaging rolls of stand 7 is dull or mat surfaced one surface only of a sheet operated thereon will be dull or mat surfaced and in the automatic stacking thereof by the stacking mechanism 9 one only of the contacting surfaces of each pair thereof will be a mat surface, the other thereof being relatively smooth and glossy.
 45

An essential factor being that of providing for at least one of each pair of contacting surfaces as a mat surface, this may be provided for in
 50 other ways, if desired. Thus, by way of example, the sheets to comprise the stack may consist in whole or in part of sheets both surfaces of which are smooth and sheets both surfaces of which are dull or mat surfaced, these two kinds of
 55

sheets being arranged in alternation, whereby each pair of contacting surfaces comprise a mat surface. Such sheets could be produced in any desirable way, as for example by the use of two mills for rolling, respectively, the two kinds of
 60 sheets, or one mill by changing the rolls to roll both kinds of sheets, in both of which cases the sheets would be arranged in alternation as stated in any desirable way, as for example by hand labor.
 65

The stacking of the sheets with each pair of contacting surfaces thereof comprising at least one rolled mat surface as above stated, permits the sheets to be annealed, without sticking together, at temperatures from approximately
 70 1350° F. to approximately 1400° F.

When it is desired that the finished sheets present suitable dull or mat surfaces, as for example to aid in the deep drawing operations, or to render the sheets especially adapted for the adhesion thereto of coatings as above stated, the skin rolling operation, after annealing, is performed by the use of sheet-engaging rolls one or both of which, as desired, has a dull or mat work face
 75 suitable for insuring the finishing of such surfaces of the sheets as it is desired be provided with the desired dull or mat surfaces.

The skin rolling, to insure the desired dull or mat surfacing of the sheets, may be, and preferably is, produced by a single pass rolling, as for example on a mill of the 4-high type as shown having a dull or mat surfaced roll, or rolls, depending on whether both surfaces of the sheets or only one thereof are to be mat finished, but may be produced on a multiple pass mill, as for example of the 2-high type, though this last-referred-to procedure is not so desirable because of the extra expense involved.
 80

The character of surface required for the dull or mat surfaced roll or rolls used to prepare the sheets for annealing, as above stated, is substantially that which is produced by the abrading of a steel roll as by blasting with a suitable abrasive material of about the order of 60 mesh, as for example sand, or a metal abrasive such as crushed chilled steel shot, either with or without a subsequent chemical etching of the abraded surfaces with any suitable acid, as for example an approximately 10% nitric acid aqueous solution, the roll by way of example, being of substantially
 85 the character set forth in my pending application for U. S. Patent Serial No. 695,721, filed October 28, 1933, preferably of a scleroscope hardness over 70.

I have demonstrated in practice that sheets produced in accordance with my method present much greater ductility and are much softer than sheets made by the only one of the two above referred to prior methods comparable from an economical standpoint and involving the use of
 90 opposed smooth glossy rolls for rolling the sheets which are stacked with their smooth surfaces in contact; sheets of 20 gage produced by my method, involving annealing at from approximately 1350° F. to approximately 1400° F., presenting a Rockwell value of approximately B-40 and an Olsen value of approximately 410-435 as compared with sheets produced by the above referred to method involving the annealing of sheets with their glossy surfaces in mutual contact at about
 95 1200° F. which present a Rockwell value of approximately B-50 and an Olsen value of approximately 385-400.

Sheets produced by my method present even greater ductility and are softer than sheets pro-
 100

duced by the other referred to, much more expensive, method of the art involving annealing at about 1300° F. after pickling, resulting in sheets having much superior qualities for deep drawing and adherence of coatings thereto.

material the surfaces of which are relatively smooth so that as to each pair of contacting surfaces one thereof is a mat surface, and in such surfaced and stacked condition annealing the sheets.

6. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls at least one of which is of a scleroscope hardness over 70 and has a dull or mat working face to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, and in such surfaced and stacked condition annealing the sheets.

7. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting the surfaces of the sheet material to the rolling action under pressure of rolls of a scleroscope hardness over 70 and having dull or mat working faces to produce dull or mat surfaces on the sheet material, and in such surfaced condition annealing the sheets.

8. The method of producing cold rolled sheets by tandem mill operation and involving the annealing of the cold reduced sheets in stacks, which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls at least one of which has a dull or mat working face in at least the last stand of the tandem mill to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, and in such surfaced and stacked condition annealing the sheets.

9. The method of producing cold reduced sheets by tandem mill operation and involving the annealing of the cold reduced sheets in stacks, which comprises subjecting the surfaces of the sheet material to the rolling action under pressure of rolls of a scleroscope hardness over 70, and having dull or mat working faces in at least the last stand of the tandem mill to produce dull or mat surfaces on the sheet material, and in such surfaced condition annealing the sheets.

10. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls the surface characteristics of at least one of which are of the order produced by blasting a roll with abrasive material of the order of about 60 mesh to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, and in such surfaced and stacked condition annealing the sheets.

11. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls at least one of which is of a scleroscope hardness over 70 with surface characteristics of the order produced by blasting a roll with abrasive material of the order of about 60 mesh to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, and in such surfaced and stacked condition annealing the sheets.

12. The method of producing cold reduced

Where it is desired the finished sheets present a dull or mat surface on one or both sides thereof not possible if skin rolled by opposed smooth, glossy rolls, the skin roll or rolls as the case may be, for producing the dull or mat surface or surfaces may, by way of example, be of the character and scleroscope hardness, and treated, as explained in my said pending application for patent Serial No. 695,721, and if desired, in the case of the abraded roll, the working face thereof chemically etched by acid, such as by an approximately 10% nitric acid aqueous solution, after the abrasion of the rolls, as for example by the blasting operation.

While I have illustrated certain procedures in the practicing of my novel method, I do not wish to be understood as intending to limit it thereto, as the procedures described, as also the apparatus disclosed, may be varied without departing from the spirit of my invention.

What I claim as new, and desire to secure by Letters Patent, is:

1. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls at least one of which has a dull or mat working face to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, and in such surfaced and stacked condition annealing the sheets.

2. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting the surfaces of the sheet material to the rolling action under pressure of rolls at least one of which has a dull or mat working face to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface and in such surfaced and stacked condition annealing the sheets.

3. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting the surfaces of the sheet material to the rolling action under pressure of rolls having dull or mat working faces to produce dull or mat surfaces on the sheet material, and in such surfaced condition annealing the sheets.

4. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting the surfaces of the sheet material to the rolling action under pressure of rolls one of which has a dull or mat working face to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces one thereof is a mat surface, and in such surfaced and stacked condition annealing the sheets.

5. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls having dull or mat working faces to produce dull or mat surfaces on the sheet material, stacking such surfaced sheets in alternation with other of the sheet

5 sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting the surfaces of the sheet material to the rolling action under pressure of rolls of a scleroscope hardness over 70 and the surface characteristics of which are of the order produced by blasting the rolls with abrasive material of the order of about 60 mesh to produce dull or mat surfaces on the sheet material, and in such surfaced condition
10 annealing the sheets.

13. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls at least one of which has a dull or mat working face to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, in
15 such surfaced and stacked condition annealing the sheets, and thereafter subjecting the mat-surfaced sheets to a skin rolling operation with rolls at least one of which has a dull or mat working face to further establish the desired dull or mat surfaces on the sheets.
20

14. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting the surfaces of the sheet material to the rolling action under pressure of rolls having dull or mat working faces to produce dull or mat surfaces on the sheet material, annealing the sheets in such surfaced condition and thereafter subjecting the sheets to a skin rolling operation with rolls having
25 dull or mat working faces to further establish the desired dull or mat surfaces on the sheets.

15. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls at least one of which is of a scleroscope hardness over 70 and has a dull or mat working face to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, in
30 such surfaced and stacked condition annealing the sheets, and thereafter subjecting the mat-surfaced sheets to a skin rolling operation with rolls at least one of which has a dull or mat working face to further establish the desired dull or mat surfaces on the sheets.
35

16. The method of producing cold rolled sheets by tandem mill operation and involving the annealing of the cold reduced sheets in stacks, which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls at least one of which has a dull or mat working face in at least the last stand of the tandem mill to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, in such surfaced and stacked condition annealing the sheets, and thereafter subjecting the mat-surfaced sheets to a skin rolling operation with rolls at least one of which has a dull or mat working face to further establish the desired dull or mat surfaces on the sheets.
40
45
50
55
60
65

17. The method of producing cold reduced sheets by tandem mill operation and involving the annealing of the cold reduced sheets in stacks, which consists in subjecting the surfaces of the sheet material to the rolling action under pressure of rolls having dull or mat working faces in at least the last stand of the tandem mill
70
75

to produce dull or mat surfaces on the sheet material, annealing the sheets in such surfaced condition and thereafter subjecting the sheets to a skin rolling operation with rolls having dull or mat working faces to further establish the desired dull or mat surfaces on the sheets.
5

18. The method of producing cold reduced sheets involving the annealing of the cold reduced sheets in stacks which comprises subjecting surfaces of certain of the sheet material to the rolling action under pressure of rolls the surface characteristics of at least one of which are of the order produced by blasting a roll with abrasive material of the order of about 60 mesh to produce dull or mat surfaced sheet material, stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface, in such surfaced and stacked condition annealing the sheets, and thereafter subjecting the mat-surfaced sheets to a skin rolling operation with rolls at least one of which has a dull or mat working face to further establish the desired dull or mat surfaces on the sheets.
10
15
20

19. Apparatus for producing cold reduced sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, at least one of the sheet-engaging rolls of the final pass of said mill having a dull or mat working face for producing dull or mat-surfaced sheet material, and an annealer into which the sheets, stacked so that as to each pair of contacting surfaces at least one thereof is a mat surface, are introduced.
25
30

20. Apparatus for producing cold reduced sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, at least one of the sheet-engaging rolls of the final pass of said mill having a dull or a mat working face for producing dull or mat-surfaced sheet material, means for stacking the sheets for annealing so that as to each pair of contacting surfaces at least one thereof is a mat surface and an annealer into which the sheets so stacked are introduced.
35
40

21. Apparatus for producing cold reduced sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, both of the sheet-engaging rolls of the final pass of the mill having a dull or mat working face for producing dull or mat surfaced sheet material, and an annealer, into which the sheets in stacked condition, are introduced.
45
50

22. Apparatus for producing cold reduced sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, one of the sheet-engaging rolls of the final pass of the mill having a dull or mat working face for producing sheet material dull or mat surfaced on one face only, means for stacking the sheets so that as to each pair of contacting surfaces at least one thereof is a mat surface and an annealer into which the sheets so stacked are introduced.
55
60

23. Apparatus for producing cold reduced sheets comprising a tandem, cold reducing, mill in which the sheet material is rolled before annealing, at least one of the sheet-engaging rolls of one or more of the stands of said mill, including the last stand, having a dull or mat working face for producing dull or mat-surfaced sheet material, and an annealer into which the sheets, stacked so that as to each pair of contacting surfaces at least one thereof is a mat surface, are introduced.
65
70

24. Apparatus for producing cold reduced
75

5 sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, at least one of the sheet-engaging rolls of the final pass of said mill having a dull or mat working face of the order produced by blasting a roll with
10 abrasive material of the order of about 60 mesh for producing dull or mat-surfaced sheet material, and an annealer into which the sheets, stacked so that as to each pair of contacting surfaces at least one thereof is a mat surface, are introduced.

15 25. Apparatus for producing cold reduced sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, at least one of the sheet-engaging rolls of the final pass of said mill being of a scleroscope hardness over 70 and having a dull or mat working face for producing dull or mat-surfaced sheet material, and an annealer into which the sheets,
20 stacked so that as to each pair of contacting surfaces at least one thereof is a mat surface, are introduced.

26. Apparatus for producing cold reduced sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, the sheet-engaging rolls of the final pass of said mill being of a scleroscope hardness over 70 and having dull or mat working faces to produce dull or mat-surfaced sheet material and an annealer
30 into which the sheets in stacked condition are introduced.

27. Apparatus for producing cold reduced sheets comprising a tandem, cold reducing, mill in which the sheet material is rolled before
35 annealing, at least one of the sheet-engaging rolls of one or more of the stands of said mill, including the last stand, being of a scleroscope hardness over 70 and having a dull or mat working face for producing dull or mat-surfaced sheet material, and an annealer into which the sheets,
40 stacked so that as to each pair of contacting

surfaces at least one thereof is a mat-surface, are introduced.

28. Apparatus for producing cold reduced sheets comprising a cold reducing mill in which the sheet material is rolled before annealing, at least one of the sheet-engaging rolls of the final pass of said mill being of a scleroscope hardness over 70 and having a dull or mat working face of the order produced by blasting the roll with abrasive material of the order of about 60 mesh
10 for producing dull or mat-surfaced sheet material, and an annealer into which the sheets stacked so that as to each pair of contacting surfaces at least one thereof is a mat surface, are introduced.
15

29. Apparatus for producing cold reduced sheets comprising a cold reducing mill, an annealer for the stack annealing of the cold reduced sheets, and skin rolls for rolling the annealed sheets, at least one of the sheet-engaging rolls of the final pass of said mill and at least one of said skin rolls having a dull or mat working face, said dull or mat faces operating, respectively, to produce dull or mat surfaced sheet material to be annealed and to insure the
20 desired dull or mat surfaced condition of the annealed skin rolled sheets.
25

30. Apparatus for producing cold reduced sheets comprising a cold reducing mill, an annealer for the stack annealing of the cold reduced sheets, and skin rolls for rolling the annealed sheets, the sheet-engaging rolls of the final pass of said mill and said skin rolls having dull or mat working faces, the dull or mat faces of said mill operating to produce sheet material
30 to be annealed having dull or mat surfaces and the dull or mat skin rolls operating to insure the desired dull or mat surfaces on the annealed skin rolled sheets.
35

ALFRED J. CASTLE. 40