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SHEET GLASS BENDING ROLL

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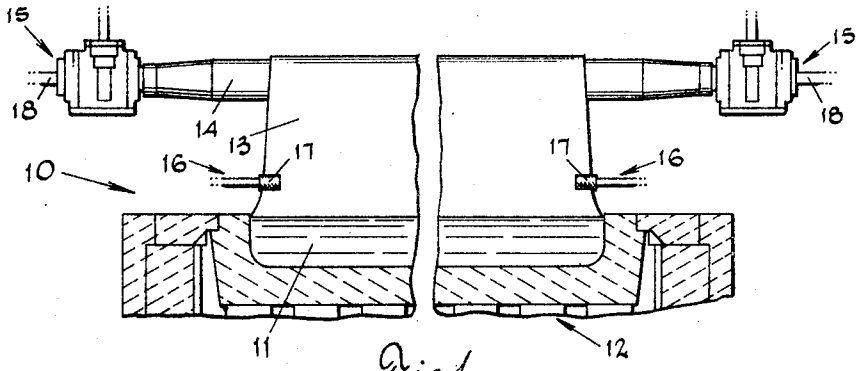


Fig. 1.

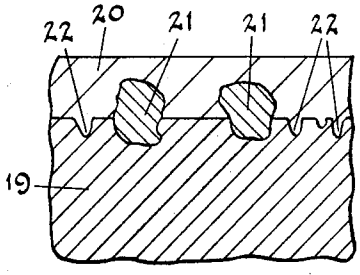


Fig. 2.

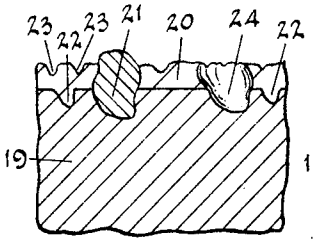


Fig. 3.

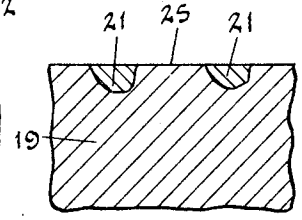


Fig. 4.

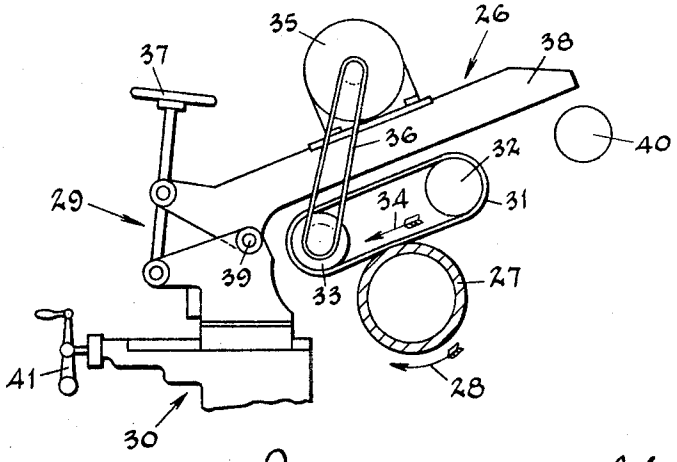


Fig. 5.

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SHEET GLASS BENDING ROLL

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The present invention relates generally to the manufacture of sheet or window glass and more particularly to improving the quality of such glass by providing an improved surface finish on the roll about which a newly formed glass sheet travels as it is continuously drawn upwardly from a bath of molten glass.

In the commercial production of window glass according to conventional processes, glass making materials are charged into one end of a continuous tank furnace where they are melted and integrated into a molten mass, and the molten mass thereafter flows progressively through refining and cooling areas and into a working receptacle. A sheet or ribbon is continuously drawn vertically upward from the surface of the molten bath in the working receptacle and, according to the so-called Colburn process with which the present invention is particularly concerned, after the sheet has travelled a short distance upwardly, it is deflected about a bending roll into a substantially horizontal plane. Thereafter, the sheet travels through a lehr wherein it is suitably annealed and cooled prior to cutting into individual blanks of the desired size.

At the point where the sheet is engaged by the bending roll, it is still in a semi-plastic condition although substantially set in its final sheet form, so that its original fire polished surface is very easily affected by contact with a hard surface. Thus, any irregularities in the surface of the bending roll will be printed on the surface of the sheet and have an adverse effect on its viewing quality.

It is therefore an object of the present invention to provide an improved surface finish for bending rolls used in the production of sheet glass.

Another object of the invention is to provide a bending roll surface wherein the layer of amorphous or so-called smear metal is minimized if not entirely eliminated.

Another object of the invention is to provide a bending roll which does not develop surface imperfections during extended use thereof in a window glass machine.

Yet another object is to provide a bending roll having a smooth sheet-contacting surface comprised essentially of undisturbed base metal by finishing the roll with an abrasive whose hardness is substantially greater than any of the components of the roll, whereby the roll surface is abraded uniformly and the material is cleanly removed regardless of differences in hardness of the roll components.

Still another object is to provide a bending roll having a smooth base metal finish free from surface irregularities caused by the finishing instruments.

Other objects and advantages of the invention will become more apparent during the course of the following description when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

FIG. 1 is an elevational view, partially in section, of a sheet glass drawing mechanism illustrating the use of a bending roll;

FIG. 2 is an enlarged fragmentary sectional view showing a portion of a bending roll finished according to conventional practice and ready for installation in a window glass machine;

FIG. 3 is an enlarged fragmentary sectional view showing the bending roll portion of FIG. 3 after it has been in use for a period of time;

FIG. 4 is an enlarged fragmentary sectional view showing a portion of a bending roll finished according to the present invention and ready for installation in a window glass machine; and

FIG. 5 is an end elevational view of one form of grinding apparatus for finishing bending rolls according to the present invention.

With reference now to the drawings and in particular to FIG. 1 thereof, there is shown generally at **10** a sheet or window glass drawing apparatus of the Colburn type wherein a bath of molten glass **11** is contained within a draw pot or working receptacle **12**. A sheet **13** is continuously drawn upwardly from the surface of the molten bath and deflected about a bending roll **14** into a substantially horizontal plane for movement through an annealing lehr (not shown). The bending roll is supported and driven by conventional drive means, shown generally at **15** and the details of which do not constitute a part of the invention, such that normally its peripheral speed equals the rate of draw of the sheet or, in other words, with no relative movement between the roll and sheet. In order to periodically clean the roll surface in a manner to be hereinafter more fully discussed, provision is generally made in the drive means **15** to operate the roll at a peripheral speed greater than the rate of draw, that is, to spin the roll relative to the sheet. Conventional width maintainers **16** having pairs of knurled rolls **17** engaging the opposite edges of the sheet counteract its natural tendency to narrow to a thread and hold the sheet at the desired width.

Due to the elevated temperature of the sheet as it contacts the bending roll, the roll tends to absorb heat and, unless cooled, will soon reach a temperature which will cause the sheet to adhere thereto. For this purpose, a heat absorbing medium, either liquid or gaseous, is generally circulated through the hollow interior of the bending roll, the interior of the roll being connected to the source of heat absorbing fluid in a conventional manner by conduits **18**.

Although cooling of the sheet begins immediately after formation, it is still at a temperature in the neighborhood of 1300° F. as it passes over the bending roll and is therefore in a highly plastic, softened condition. It will thus be apparent that any relief features on the surface of the roll will be imprinted on the lower surface of the sheet as it passes over the roll in contact therewith.

In an effort to prevent such damage to the newly formed sheet, it has been customary to provide the bending roll with a smooth, highly polished surface prior to assembly in the drawing apparatus. Despite the apparent high quality of the roll finish achieved by methods used heretofore, it has been found that after a relatively short period of use, defects began to appear in the sheet which were directly attributable to contact of the sheet with the bending roll. Consequently, it was necessary to either accept the glass of reduced quality or frequently replace the bending roll with a previously refinished roll held in reserve. Either alternative is costly, the latter involving an interruption of several hours in production while the roll is replaced. Until recently, this condition was thought to be an inherent feature which necessarily increased the cost and reduced the quality of glass produced according to this method, and thus it was tolerated. The fact that the condition was tolerated is believed to be due in large part to the fact that the underlying cause was not understood. According to the present invention, however, deterioration of the surface finish of the bending roll during use can be substantially if not entire-

ly eliminated so that the roll will produce glass of consistently high quality for an extended period of time.

Present day bending rolls are generally made of stainless steel due to its properties of strength, heat transmission and corrosion resistance. The cylindrical rolls are hollow and about nine inches in diameter and have a wall thickness on the order of one inch or less. The rolls may be cast according to any of several conventional methods and, regardless of the casting method, their external surface must subsequently be machined to achieve the degree of smoothness necessary. To produce the final finish, the rolls are generally first turned on a lathe to establish a true cylindrical surface and produce a preliminary finish. According to conventional roll finishing techniques, the surface of the roll is then ground with silicon carbide grinding wheels or silicon carbide impregnated belts, after which the final finish is achieved by spinning the roll in contact with a brass lapping tool to which is supplied a grinding compound containing finely divided aluminum oxide. Although by this technique a satisfactory finish is originally obtained, as was previously pointed out it has not been found to be durable and soon deteriorates when subjected to contact with the hot glass ribbon.

Stainless steel of the type used in casting the bending rolls contains extremely hard carbide particles imbedded in a relatively soft matrix. The base or matrix metal has a hardness of about 412 on the Knoop scale, while the carbide particles have a hardness of about 1800. It has been learned that the silicon carbide abrasives used heretofore in finishing rolls, which have a Knoop hardness of about 2500, become dulled and covered over with abraded metal in a short time and thereafter do not cut through these carbide particles, but instead disturb the softer matrix metal around them and either leave the carbide particles standing in relief or cause them to be dislodged, in which event they may scratch or gouge the roll surface. There is thus created a burnishing action and the softer matrix metal which is disturbed is not cleanly removed, but instead part or all of it is spread over the roll surface by the silicon carbide grinding wheel or belt to create an amorphous layer, or so-called layer of smear metal on the surface of the roll. The amorphous layer is relatively porous and has a hardness on the Knoop scale of 412 or less. There is shown in FIG. 2 an enlarged segment of a roll finished by conventional techniques showing the resulting surface conditions. The undisturbed base or matrix material is illustrated at 19, and an amorphous layer 20 of smear metal forms the actual finished surface. Carbide particles 21 are partially imbedded in the base metal 19, and grooves 22 may be formed therein during the lathe turning or grinding of the roll. It will thus be apparent that the layer 20 of smear metal covers over the carbide particles 21 and gouges 22 and when finished by lapping with a brass lapping instrument and aluminum oxide compound forms a smooth outer surface.

The layer 20 of smear metal is rather porous and loosely adhered to the base metal 19 so that when subjected to the hot atmosphere of sheet glass drawing apparatus and contact with the hot sheet, it will absorb gases, resulting in oxidation and the formation of sodium sulfate deposits on the roll surface. Contact with the hot tacky glass sheet also pulls fragments of the smear metal loose from the roll. Periodic spinning of the roll relative to the sheet is thus necessitated in order to clean and smooth the roll surface, that is, to distribute the sodium sulfate deposits and remove the loosened metallic particles. As shown in FIG. 3, the spinning tends to remove some of the layer 20 of smear metal leaving portions of the carbide particles 21 exposed and forming holes 23 in the surface where the smear metal particles are pulled out. Spinning the roll against the sheet may also tear out certain of the carbide particles leaving cavities 24, the particles 21 ploughing metal ahead of them as they are torn loose so as to form severe gouges in the finish. If the spinning is repeated a sufficient number of times, substantially all of the smear metal will be removed and the grooves 22 or other irregularities in the base metal 19 will be exposed. The relief features on the roll surface as shown in FIG. 3, although they are minute, imprint on the surface of the sheet and adversely affect its quality so that eventually the roll must be replaced.

According to the present invention, following turning of the roll on the lathe or other preparatory finishing, its surface is subjected to the abrasive action of a novel diamond impregnated grinding belt. The belt is used with conventional grinding apparatus such as is shown in FIG. 5, and includes a solid flexible backing material to which the diamonds are adhered by a suitable bonding agent. Due to the extreme relative hardness of the diamonds, their hardness being about 8000 on the Knoop scale, both the base metal and the carbide particles are cleanly abraded to produce the smooth surface finish 25 illustrated in FIG. 4, and the diamonds do not become dulled and covered with abraded metal. Thus, the carbide particles 21 are cut off along with the upper layer of the base or matrix material to remove any imperfections in the surface which may have existed due to prior treatment, such as the grooves 22 illlustrated in FIGS. 2 and 3, and create the smooth finish 25 free of the amorphous or smear metal layer 20 created by heretofore conventional finishing techniques.

Illustrated generally at 26 in FIG. 5 is one form of apparatus suitable for finishing bending rolls according to the invention. A roll 27 is placed in a lathe and rotated about its longitudinal axis in the direction of the arrow indicated at 28. A belt grinder indicated at 29 is mounted on the carriage 30 of the lathe so as to be capable of traversing the length of the roll. The diamond impregnated grinding belt 31, which is trained over an idler pulley 32 and a drive pulley 33, is driven in the direction indicated by arrow 34 by a motor 35 and drive belt 36. A control wheel 37 is used to move the grinding belt into and out of grinding position and to regulate its pressure upon the roll 27 by pivoting the arm 38 on which the pulleys 32 and 33 are carried about an axis 39. An additional pulley 40 is carried by the arm 38 for a purpose to be later described, and adjustment of the grinder 29 toward and away from the roll is provided by conventional adjusting mechanism operated through a handle 41.

In grinding bending rolls according to conventional practice, it may be desirable to use the so-called "contact wheel" position due to the limited cutting action of the silicon carbide belt. Since the hardness of the silicon carbide abrasive is not substantially greater than that of the bending roll, particularly the carbide particles therein, pressure must be applied to the belt to maximize its cutting action. Thus, the grinder is positioned so that the point of contact between the grinding belt and bending roll is opposite the surface of the drive pulley 33. Pressure can thus be applied through the pulley 33. The application of pressure causes additional heat to be produced at the grinding point, however, and this heat further accentuates the burnishing action and causes the formation of the amorphous or smear metal layer on the roll surface. Running of the pulley 33 directly opposite the roll 27 also introduces vibration into the pulley and as a result, areas of uneven grinding, or so-called chatter marks, are formed on the surface of the roll. These chatter marks may eventually be covered over by smear metal during subsequent grinding and lapping, but will be uncovered as the smear metal is lost during use of the roll and will be printed on the surface of the glass sheet.

Due to the extreme relative hardness and the clean cutting action of the diamond abrasives on the belt 31 of

the invention, very little pressure need to applied to the belt, so that the grinder can be operated in the so-called "slack-belt" position as shown in FIG. 5. According to the invention, the grinder **29** is generally left to pivot about axis **39** and float freely with the belt in contact with the roll **27** so as to allow for any slight warping in the roll. With the grinder in the floating slack-belt position and very little pressure on the belt, a minimum of heat is produced and no vibration or chatter marks are formed on the roll. The roll surface **25** thus formed is smooth and free from gouges and holes and is composed of parent metal which has not been distorted due to heat or caused to smear by the burnishing action.

Another important feature of the invention is that due to the durability and long life of the diamond impregnated belt relative to conventional grinding belts, its length, and consequently its cost, can be considerably reduced. Thus, conventional belts are of a length so as to run over the pulleys **33** and **40** of FIG. 5. Due to the pressure which must be applied in grinding with those belts, a rubber backup or traction belt comparable to the belt **31** is generally placed beneath the grinding belt and around the pulleys **32** and **33** to prevent slipping. For example, a conventional belt running over the pulleys **33** and **40** may be 106 inches long while the belt **31** of the invention is only 66 inches long.

The optimum grit size of the belt **31** will, of course, be determined by a number of factors such as the type of material from which the roll is made, the amount of surface material which it is necessary to remove, and the permissible deviation in the finished surface. It has been found that, a belt having a standard grit size of 400 will produce a very fine finish. However, the length of time required for grinding, while less than by conventional methods, is longer than believed necessary. It is preferred to first rough grind with a belt of about 100 grit size and then smooth the roll with a belt of about 300 grit size. This procedure has been determined to produce an excellent roll surface and reduce the roll finishing time by 30 to 50 percent over conventional procedures.

Reviewing briefly the invention, the bending roll whose surface is to be ground, be it a new roll whose surface has been previously machined or a used roll to be refinished, is placed in the lathe as shown in FIG. 5. The roll is turned in the direction of arrow **28** at a speed of about 40 r.p.m. and the diamond impregnated belt **31**, running in the direction of arrow **34** at a surface speed of about 7300 feet per minute, is placed against the turning roll. The carriage **30**, on which the grinder **29** is mounted, is moved slowly back and forth across the length of the roll until the desired surface finish is obtained. Preferably, the roll is first ground with a 100 grit belt, and then a 300 grit belt is placed on the grinder and the operation repeated to produce the final surface. There is thus produced a surface **25** free of smear metal wherein the imbedded carbide particles **31** are abraded down to the surface of the parent metal **19** and are not loosened by removal of the parent metal from around them.

Since a roll finished according to the present invention does not have a porous surface layer of smear metal, but instead has a relatively dense surface of the parent metal, there is much less tendency for the surface to corrode due to the action of the hot gases in the forming chamber. Consequently, it is not necessary to spin the roll to clean its surface as frequently as has been necessary in the past. However when spinning does become necessary, fragments of the metal are not pulled out by the hot tacky glass nor are the carbide particles torn loose to gouge the roll surface. Thus, when refinishing of the roll ultimately becomes desirable, its surface is not deeply scratched or pitted so that the refinishing time is minimized.

It will be appreciated that the present invention is important not only in the treatment of sheet glass bending rolls, but will also have important applications in other fields such as, for example, in the production of bearings, where the formation of a smooth surface free from an amorphous or smear metal layer will prevent chafing which may cause bearing failure.

It is to be understood that the form of the invention herewith shown and described is to be taken as an illustrative embodiment only of the same, and that various changes in the shape, size and arrangement of parts, as well as various procedural changes may be resorted to without departing from the spirit of the invention.

We claim:

1. A method of surface finishing a cylindrical sheet glass bending roll including hard carbide particles imbedded in a matrix of relatively soft material with an endless abrasive belt trained over a pair of spaced pulleys and having diamonds adhered thereto to form an abrasive surface substantially harder than said carbide particles comprising, rotating the bending roll about its longitudinal axis, driving said endless abrasive belt in contact with said bending roll with the region of contact being between said spaced pulleys so as to uniformly cut through said carbide particles and matrix metal and cleanly remove the abraded material, and shifting said belt back and forth across the length of said roll to form on said roll a relatively smooth surface of undisturbed material free from an amorphous layer.

2. A method of surface finishing a cylindrical sheet glass bending roll as claimed in claim 1, wherein said carbide particles have a Knoop hardness of about 1820, said matrix material has a Knoop hardness of about 412, and said abrasive surface has a Knoop hardness of at least 6000.

3. A method of surface finishing a cylindrical sheet glass bending roll as claimed in claim **3**, wherein said bending roll its first contacted by an abrasive belt having a standard grit size of 100, and thereafter by an abrasive belt having a standard grit size of 300 to form said relatively smooth surface of undisturbed metal.

References Cited by the Examiner

UNITED STATES PATENTS

2,241,568	5/1941	Yetter	51—142
2,819,572	1/1958	Lewis	51—289
3,056,243	10/1962	Flanders	51—289
3,101,577	8/1963	Skugghall	51—289
3,136,096	6/1964	Hine	51—142
3,136,097	6/1964	Liard	51—142
3,157,968	11/1964	Kurtz	51—289 X

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