

March 15, 1960

B. LONG

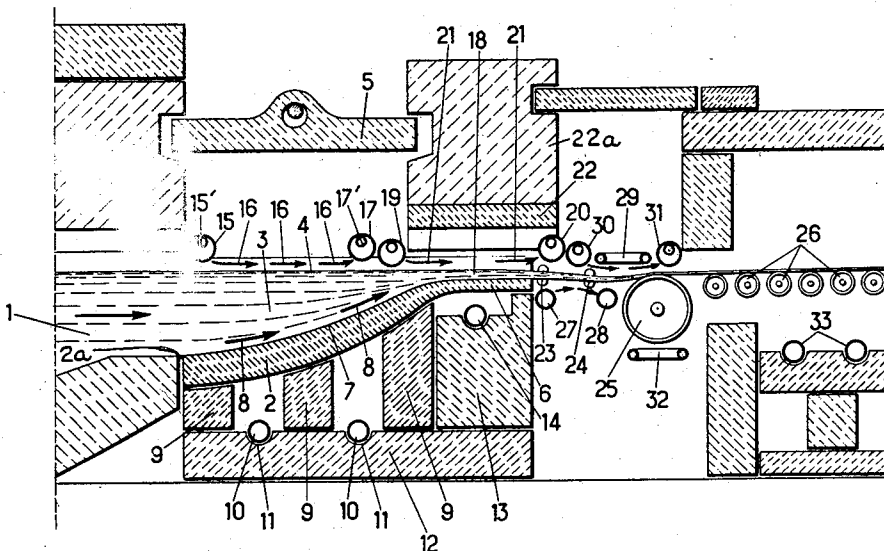
2,928,212

METHOD AND APPARATUS FOR CONTINUOUSLY DRAWING A GLASS SHEET

Filed Jan. 18, 1956

4 Sheets-Sheet 1

FIG. 1



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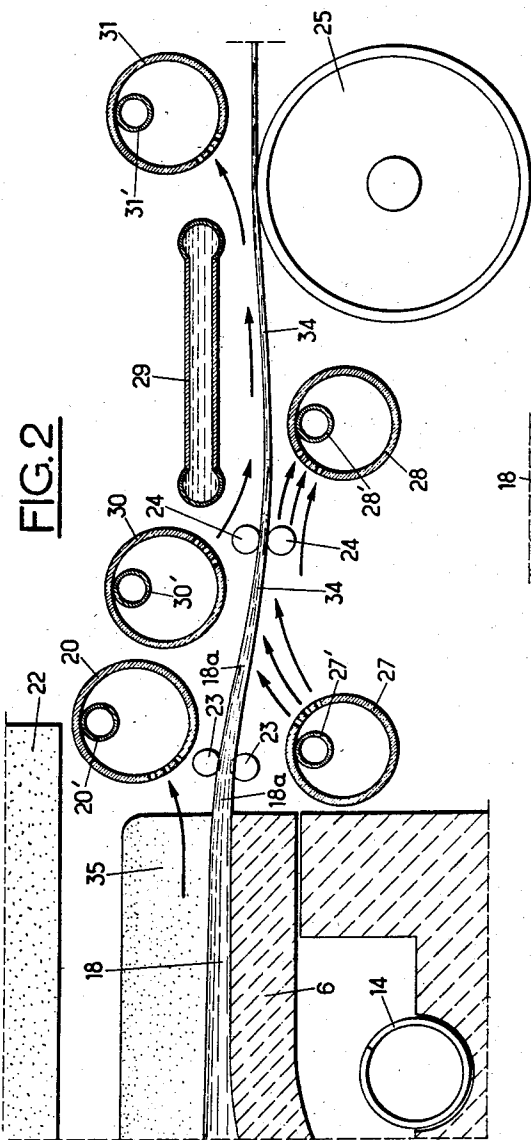
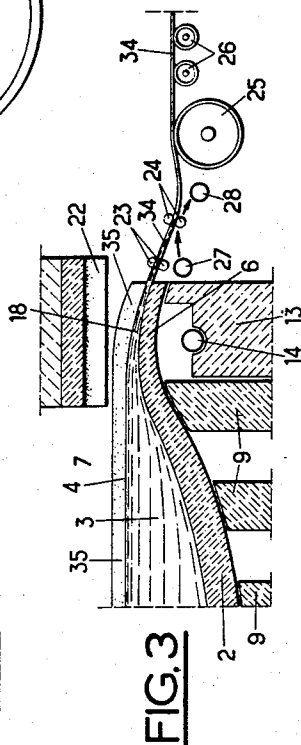
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METHOD AND APPARATUS FOR CONTINUOUSLY DRAWING A GLASS SHEET

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4 Sheets-Sheet 2



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METHOD AND APPARATUS FOR CONTINUOUSLY DRAWING A GLASS SHEET

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FIG. 4

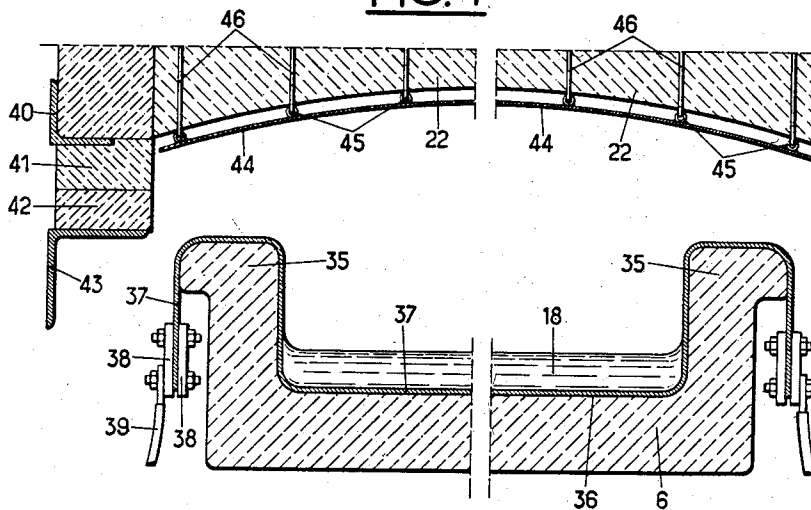


FIG. 5

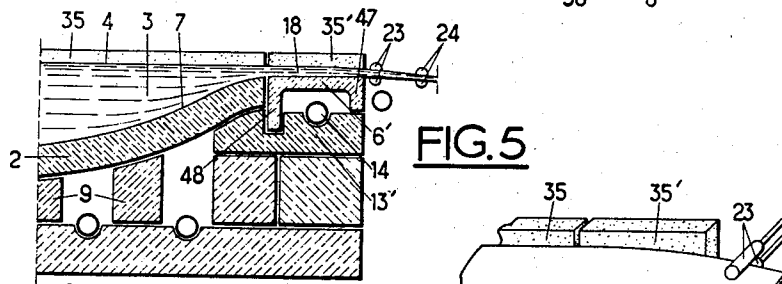
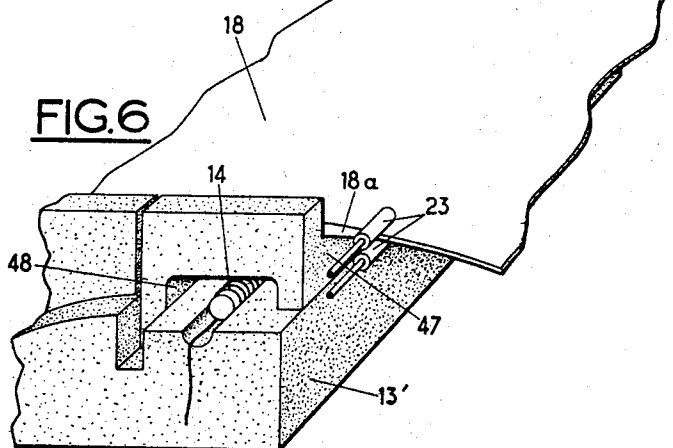


FIG. 6



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METHOD AND APPARATUS FOR CONTINUOUSLY DRAWING A GLASS SHEET

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FIG. 7

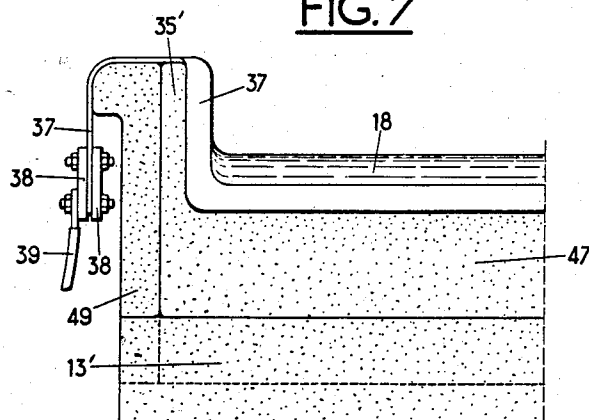


FIG. 8

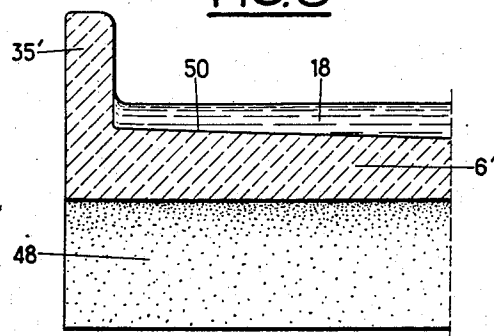
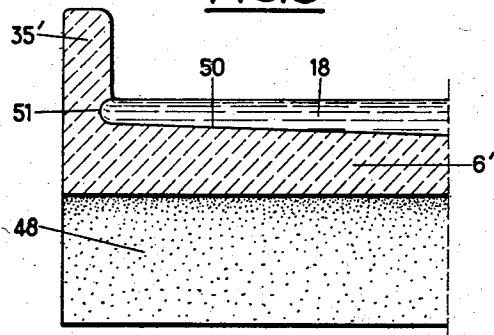


FIG. 9



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2,928,212

METHOD AND APPARATUS FOR CONTINUOUSLY DRAWING A GLASS SHEET

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Application January 18, 1956, Serial No. 559,998

Claims priority, application France January 24, 1955

5 Claims. (Cl. 49—17)

My invention relates to apparatus for the continuous drawing of a glass sheet from a shallow bath, and especially to an apparatus according to which the sheet is drawn in a horizontal or nearly horizontal direction.

It is well known that glass is ordinarily drawn from a shallow bath in a direction vertical to the surface of the bath, the sheet itself rising from a thickened portion at its base, known as its "foot," the two opposing faces of this foot curving gradually away from the plane of the sheet so as to merge into the horizontal surface of the bath.

It is also well known that after travelling a certain vertical distance the sheet is generally bent into a horizontal position over a bending roll and that it is then introduced into the annealing lehr while in a horizontal position.

This method of forming the sheet by drawing it vertically from the surface of the bath has certain disadvantages. Among these is the fact that a substantial drawing force is necessarily exerted on the "skin" of the foot of the sheet and of the sheet itself as it is hardening, since in addition to the internal friction and superficial forces, this drawing must overcome the relatively strong pull of gravity on the glass which has been lifted from the bath and is positioned between its surface and the bending roll.

As a consequence of the fact that this drawing force is strong, the "skin" in question is stretched and is therefore elongated while it is hardening.

Under these conditions the irregularities in temperature which affect this skin result in unevennesses or waves in the surface known as "batter" and "striae" which are even more marked, all other things being equal, when the "skin" is under the greatest tension.

In my copending application Serial No. 54,127, filed November 25, 1955, entitled "Improvements in the Continuous Drawing of Glass into Sheets," and now abandoned I claimed a process of drawing from a shallow bath which, for a given speed of drawing and a given thickness of the sheet, permits a substantial reduction in the magnitude of the unevennesses in its surface, especially by reducing the elongation of the "skin" of the "foot" of the sheet and the skin of the sheet itself during its hardening, but this process delivers sheets, the surfaces of which still leave something to be desired.

The principal object of the present invention is to provide an apparatus for continuously drawing a sheet from a shallow bath which, for a given drawing speed and a given thickness of the sheet, permits an even greater reduction in the magnitude of the unevennesses of the surface than does the aforementioned process.

Another object of the present invention is to eliminate those defects in the sheet which result from its bending over a bending roll.

With the apparatus constituting my invention, the following results are achieved:

(1) The drawing force need no longer lift the weight of the foot of the sheet and of the sheet itself up to the bending roll.

(2) The greater part of the thickness of the foot of

2

the sheet consists of glass having a relatively high viscosity, with the remainder consisting of glass having a low viscosity.

(3) The sheet itself is very rapidly hardened.

5 The process utilizing my invention begins with the formation of a skin on the surface of the draw bath, the viscosity and thickness of which are rapidly increased as the glass approaches the back end of the tank or draw pot, that is to say, the end from which the glass is drawn.

10 This end is so constructed that much less viscous glass is interposed between it and the skin before the sheet leaves the tank in a horizontal or nearly horizontal direction.

It will immediately be seen that the low viscosity glass 15 which flows underneath the relatively stiff skin at the surface of the bath serves to reduce the friction between this skin and the walls of the tank. Moreover, since the sheet leaves the tank in a horizontal or nearly horizontal direction, it will be readily understood that the following two important advantages result from the general construction hereinbefore described:

(1) The drawing force required for a given speed and thickness of the sheet is reduced as much as possible.

20 (2) This drawing force affects almost the entire thickness of the sheet.

The process utilizing my invention consists, in the first place, of the step of extending the back end of the drawing tank to form a thermal conditioning channel or spout for the foot of the sheet. This spout is horizontal or nearly so, and is constructed in such a manner that it radiates poorly towards the top and supports the foot 30 of the sheet for a considerable distance while the sheet is being drawn in a horizontal or nearly horizontal direction. The greater part of the thickness of the foot of the sheet is formed from the highly viscous skin which results from a substantial hardening of the surface of the bath, and the remainder of its thickness from warmer glass which has travelled along the bottom of the drawing tank, the temperature of which is increased as it passes 35 over the thermal conditioning channel or spout. My process comprises also on the other hand the step of rapidly stiffening the lower face of the sheet before placing it in a horizontal or nearly horizontal position on one or more conveyor rollers preceding a series of rollers which form a horizontal or nearly horizontal table designed to assure the overall smoothness of the sheet before it enters the annealing lehr.

The fundamental characteristic of my process is the production of a very long thin foot for the sheet which is supported throughout the greater part of its length by a thermal conditioning channel or spout hereinafter referred to as a "drawing spout." This foot has as high 40 a temperature gradient as possible between its highly viscous upper surface which is in contact with the atmosphere, and its much less viscous lower face which is in contact with the spout.

This gradient ensures that only a minimum drawing force will be required and that very little deformation will result from the bending and flowing of the free part of the foot of the sheet and of the sheet itself between the spout and the first conveyor roller. The gradient results from certain special arrangements. In the first place, the following points should be mentioned:

(1) The warmer glass which flows along the bottom of the tank or draw pot is led to the spout by progressively decreasing the depth of the tank from its front end to the entrance of the spout.

(2) The drawing spout is long enough to permit the required increase in the temperature of this warmer glass to be brought about by conduction.

70 But these two features would be completely inadequate if the drawing spout were not made of a refractory ma-

terial having a low overall emissivity in the range of temperatures between about 1000° C. and about 1100° C. This material may consist, for instance, of pure magnesia, alumina or silica, free from traces of iron, or even those silico-aluminous refractories manufactured from raw materials which contain only minimal quantities of highly absorbent impurities such as iron oxides.

The temperature gradient within a layer of glass lying, like the foot of the sheet in my process, on a very hot hearth made of a refractory material, is largely influenced by the emissivity of this hearth, an emissivity which is, in general, greater than that of the glass.

It would be absolutely hopeless to try to increase the temperature gradient in the layer of glass which rests on the drawing spout by heating the spout if it were made of an ordinary refractory material which, by reason of its own strong radiation, could not fail to substantially heat the upper part of the layer of glass.

In order that this concept may be clearly understood, it should be remembered that the overall emissivity of magnesia, alumina and silica, when free from ferruginous impurities, in the temperature range between about 1000° C. and about 1100° C., lies between 0.3 and 0.5, whereas that of the silico-aluminous materials ordinarily used in the construction of drawing tanks is greater than 0.7, running sometimes as high as 0.8 and sometimes 0.9.

The process utilizing my invention can thus be carried out only with a drawing spout which is, in the first place, long enough to permit a film of glass which glides over it to be sufficiently heated by conduction, and, in the second place, provided with walls which, where they contact the glass, have a low emissivity in the temperature range between 1000° C. and 1100° C.

An emissivity of 0.5 may be considered to be the upper limit when a clear glass having an iron oxide content (expressed as Fe_2O_3) no greater than 0.10% is being drawn.

If, however, the glass being drawn is more highly absorbent by reason of a higher percentage of iron oxides or because of the presence of other highly absorbent constituents, the upper limit of this overall emissivity for the spout may be raised to 0.7.

When the lower surface of the draw pot, which is made of a material having a low overall emissivity, is heated (by means of electrical resistances, flames, or the like) the glass which is in contact with its upper surface is given the low viscosity required by my process without materially reducing the high viscosity of the greater portion of the thickness of the foot of the sheet. But the requirement that the drawing spout radiate poorly in an upward direction may be even more strictly satisfied by lining its upper surface with a sheet of metal which does not oxidize readily and which is highly resistant to corrosion by the glass, such as platinum and certain of its alloys. This arrangement reduces the overall emissivity below 0.2, and also possesses the advantage of permitting the spout to be made of ordinary refractory materials.

Since the metal lining may be easily heated electrically by the Joule effect, it will readily be seen that the use of a spout having a metallic lining permits the glass forming the lower part of the foot of the sheet to be rendered highly fluid while the heating of its upper portion is held to a minimum, thus creating a particularly high temperature gradient between its upper and lower surfaces. This gradient generally exceeds 80° C. per centimeter.

This gradient may be further increased by placing a screen over the foot of the sheet which has the property of reflecting back a large portion of the energy which the said foot radiates upwardly.

Since the process utilizing my invention comprises the substantial hardening of the "skin" of the foot of the sheet, it will be appreciated that in the absence of this screen the foot of the sheet would exchange heat with the atmosphere and ambient objects by radiation not

only from its surface but also from its sub-adjacent layers. Such an exchange of heat would cause a reduction in the temperature gradient which gradient results from the convective cooling which is the basis of the substantial hardening previously mentioned.

The presence of the screen renders the loss of heat by radiation upwardly from the foot of the sheet negligible and consequently permits the temperature gradient through the sheet to be brought to a maximum value by means of vigorous convective action at its surface.

The screen in question may consist of a vault which reflects back a large portion of the energy radiated by the foot of the sheet and may be made, for example, of a highly absorbent refractory material surmounted by heat insulating brickwork.

The screen may also consist of a sheet of platinum suspended under a vault made of a refractory material which may be of any type, provided it will not harm the platinum where the metal is in contact with it. The sheet of platinum acts by means of its own high reflecting power.

Thus, as has already been pointed out, the drawing spout increases the length of the draw pot and must necessarily have a certain length, since the increase in the temperature of the film of glass along the bottom of the lower part of the foot of the sheet which is necessary in order to carry out the process utilizing my invention takes a certain amount of time.

This spout may be made an integral part of the draw pot, but for several reasons, especially its length, the facility of replacing it, and its particular construction, it is desirable to make it in the form of a separate piece which is positioned against the end of a pot having a relatively simple shape and made of an ordinary refractory material.

The drawing spout is, in general, horizontal, but it may be advantageous to incline it slightly away from the horizontal, especially in order to facilitate the delivery of the sheet.

The bottom of the spout may be flat, but, to facilitate the production of a sheet having a constant thickness throughout its width (with the exception of the edges), this bottom is slightly concave at its center so that the sheet of glass which covers it is slightly thicker there than in the vicinity of its edges.

When the foot of the sheet leaves the spout, its lower face is vigorously cooled, preferably by convection, by means of a homogeneous sheet of air which sweeps along it, in order that the sheet itself may come in contact with the first conveyor roller a short distance beyond the spout without any injurious effect on the polish of its surface.

Thus, the process utilizing my invention possesses over known processes in which the glass is first drawn vertically and then bent, the important advantage that the lower face of the sheet is not affected by imperfections in the surfaces of a bending roll.

If at the same time one or both faces are cooled by means of water coolers which still further increase the viscosity of the thick skin which has already been formed, the rigidity of the sheet will be so great that any longitudinal sagging due to bending and flowing between the spout and the first conveyor roller will be slight.

In the vicinity of the spout the two edges of the unsupported or "free" portion of the foot of the sheet are stiffened and supported by two pairs of small roller wheels of a known type. Additional pairs of small roller wheels may be positioned between these first rollers and the conveyor roller in order to support the edges of the sheet and thereby reduce the longitudinal and transverse sagging of the sheet as much as possible.

The conveyor roller corrects almost all of the transverse sagging. The longitudinal sagging and the residual transverse sagging are corrected by the series of rollers which follow the conveyor roller and form a table over

which the sheet passes before it enters the annealing lehr.

In order that the invention may be more clearly understood, several embodiments of my invention will now be described, purely by way of example and without in any way limiting the scope of the invention to the specific apparatus shown in the attached drawings; in which:

Figure 1 is a vertical longitudinal cross-section showing the assembly of a drawing machine which comprises a shallow tank or "pot" provided with a long thermal conditioning spout, the bottom of which is heated and carries the foot of the sheet, the cooling devices which form the "skin" of high viscosity in the foot of the sheet, and the members which support the sheet until it enters the annealing lehr;

Figure 2 is a vertical longitudinal cross-section, on a larger scale, showing the portion of the foot of the sheet which lies on the spout, the free portion of this foot, then the sheet itself between the second set of small roller wheels and the conveyor roller, and finally the means for stiffening the sheet before it comes in contact with this roller;

Figure 3 is a simplified vertical longitudinal cross-section showing a device for drawing the sheet in an approximately horizontal direction from a slightly inclined spout;

Figure 4 is a vertical cross-section taken in a plane transverse to the drawing direction and showing a spout provided with a platinum lining which is electrically heated by use of the Joule effect, and the platinum reflecting screen positioned above the spout;

Figure 5 is a vertical longitudinal cross-section showing a spoutless tank which holds the draw bath, together with a separate thermal conditioning spout fixed to its end;

Figure 6 is a partial perspective view on a larger scale showing a separate spout and the free end of the foot of the sheet, each of the edges of which is cooled and supported by a pair of small roller wheels;

Figure 7 is a partial vertical elevation taken from the side nearest the annealing lehr showing the left-hand half of a separate spout having a heated platinum lining; and

Figures 8 and 9 are transverse vertical cross-sections showing two embodiments of a separate spout having a bottom which is slightly concave at its center.

As shown in Figures 1 and 2, the stream of glass 1 which arrives at the thermal conditioning zone of a tank furnace travels from left to right, in the direction of the arrow, into the drawing tank or "pot" 2 and continuously replenishes the draw bath 3, the surface 4 of which is covered by the movable screen 5 made of a refractory material.

The drawing tank or chamber itself is elongated at the end opposite the point at which the glass enters, so as to form a fairly long thermal conditioning spout 6, which is the basic element necessary to carry out the process constituting my invention and which is also called the drawing spout.

The bottom 7 of the tank or chamber 2 rises progressively from the entrance 2a for the glass to the drawing spout so as to direct into as smooth a path as possible the current of warmer glass which flows near the bottom and which is indicated by the arrows 8.

The bottom of the tank or chamber rests on the bricks 9 and is heated by means of electrical resistances 10 positioned in the semi-cylindrical grooves 11 of a refractory insulating slab 12.

The drawing spout is supported at its end by the refractory member 13.

The blowing tube 15 is pierced along its lower right-hand side by a number of holes which are arranged in several rows and so spaced as to produce a substantially homogeneous sheet of air at a short distance from the surface of the tube.

This sheet of air is directed over the surface of the glass bath and sweeps along this surface as indicated by the arrows 16. It is then drawn in by the suction tube 17 which is provided with a number of holes distributed in several rows along its lower left-hand side.

The tubes 15 and 17 which extend all the way across the bath 3 are made of stainless steel. In order to protect them against overheating, each tube rests freely on a small tube support through which water circulates and which is designated by the same number as the tube, accompanied by a "prime" mark (').

The convective cooling of the surface of the bath which is accomplished by the cooperating blower and suction tubes 15 and 17 brings about a steep temperature gradient in the superficial layers. The surface of the bath becomes covered with a very stiff "skin" which rests on relatively mobile subjacent glass.

The layer of glass 18 which covers the spout and constitutes the longest part of the foot of the sheet is quite thin. It consists, at the top, of the "skin" formed by convective stiffening of the surface of the bath and, at the bottom, of only a thin film of warmer glass which has travelled in the line indicated by the arrows 8 along the bottom 7 of the tank 2.

The temperature gradient thus created would be scarcely sufficient to carry out the process utilizing my invention if other supplementary measures were not employed. In other words, the foot of the sheet must, while on the spout, be subjected to a special thermal conditioning, which is accomplished as follows:

(1) The blower tube 19 in cooperation with the suction tube 20 vigorously cools the upper part of the foot of the sheet by convection, the air circulating from the first-named tube to the second as shown by the arrows 21.

(2) The drawing spout is heated by the electrical resistance 14. If it is necessary to vary the heating of the spout transversely, the electrical resistance 14 is divided into several sections which are separately fed, or it may be sufficient to rely on the spacing of its coils, placing them close together where the most heat is required and spacing them further apart where less heat is needed.

(3) The drawing spout (and consequently the pot in the case of Figure 1) is made of a material such as pure alumina or pure magnesia, free from traces of iron, and thus having, as is well known, an overall emissivity less than 0.5 for temperatures of the order of 1100° C., to which the upper face of the draw spout is subjected.

Since the construction from pure alumina or magnesia of a one-piece "pot" having a spout is a difficult matter, silico-aluminous refractory materials made from selected raw materials from which the greater part of the absorbent impurities, such as iron oxide, have been eliminated by an appropriate treatment, are ordinarily employed.

It is certain that a convenient solution for the spouted pot problem consists in making the spout separately from somewhat exceptional materials and placing this spout along side of the pot itself as shown in Figure 5.

The cooling of the upper part of the foot of the sheet and the fact that a film having a relatively high mobility is formed at its bottom by heating the sole of the spout by means of the electrical resistance 14 cooperate to establish a steep temperature gradient which insures, on the one hand, very little deformation of the foot of the sheet and the sheet itself due to bending and flowing, and, on the other hand, only a minimum of friction between the foot of the sheet and the spout.

If necessary, the efficacy of the two above-described arrangements may be still further increased by the choice of a suitable material for the lower surface of the vault lintel 22 which extends over the upper surface of the foot of the sheet, the extrados 22a of this lintel being heat insulated.

By constructing this vault lintel with especially absorbent refractory materials due, for example, to a high percentage of iron oxides, it is assured that the vault

will act as a radiation reflecting means and return to the foot of the sheet the greater part of the energy radiated by the sheet to the vault. The conditions which are, as has already been explained, most favorable to an increase in the temperature gradient within the sheet, are thus brought about.

Bricks of magnesia or chrome-magnesia containing more than 5% of iron oxides constitute suitable highly absorbent refractories.

In connection with the description of Figure 4, another solution of the problem of the reflecting screen above the foot of the sheet is disclosed.

On leaving the spout, the edges of the free part of the foot of the sheet 18a (see Figure 2) are supported by two pairs of small roller wheels 23. It must be emphasized that this free part of the foot of the sheet is stretched only slightly since the greater part of its thickness has already been considerably stiffened. The true sheet having parallel surfaces thus begins at a relatively short distance from the spout.

However, this sheet has a tendency to droop after it leaves the spout and it is advisable to hold it as taut as possible between the two pairs of small roller wheels 24 before it reaches the conveyor roller 25 and the subsequent series of rollers 26 (Figure 1) the uppermost portions of which form a table on which the sheet acquires the desired smoothness.

The film of relatively low viscosity which is formed by contact with the heated spout is rapidly hardened by means of the sheet of air emanating from the blower tube 27 (Figure 2). This air is drawn up through the suction tube 28.

Above the sheet, the water cooler 29 serves to still further increase the rigidity of the sheet so that the contact of the lower face of the sheet with the conveyor roller 25 does not affect the polish of this face.

In order to avoid any irregular convective effect on the upper surface of the sheet by the air which has been cooled by contact with the cooler 29, which might give rise to a little batter, a light current of air is circulated between the cooler 29 and the sheet by means of the blower 30 and the suction tube 31.

A water cooler 32 may also be utilized to cool the conveyor roller 25.

The rollers 26, which form the table which smooths the sheet before it is annealed, are heated slightly by the electrical resistances 33 positioned beneath them.

Figure 2 shows more clearly the foot of the sheet 18 which rests on the sole of the spout 6 which is heated by the electrical resistance 14.

The side of the spout is designated by reference numeral 35.

The upper surface of the foot of the sheet is slightly inclined to the horizontal as a consequence of the drawing, but is not greatly attenuated, so that the sheet itself attains practically its final thickness at a short distance from the spout. Its lower face may be brought into contact with the conveyor roller 25 without any risk of damaging the quality of its polish.

On Figure 3, the pot is provided with a spout which inclines slightly downward. This arrangement takes advantage of the slight effect of gravity on the free part of the foot of the sheet. The drawing takes place at a slight angle to the horizontal and then the sheet, after being substantially hardened, is brought into a horizontal position. It is then smoothed on the rollers of the table 26, as in the case illustrated in Figure 1.

In Figure 4, the spout is, like the pot itself, made of an ordinary silico-aluminous material.

The upper surface or sole 36 of the spout 6 and its sides 35 are, throughout the length of the spout, covered by a sheet of platinum 37 (see Figure 4).

Each end of this sheet is gripped between two small bars 38 made of a metal which is a good conductor, the means for holding these two bars together being so dis-

posed as to also grip the ferrule at the end of the connecting cable 39.

The vault lintel above the spout is supported by two angle irons 40; the space between the sides of the spout and the summers of the vault is filled in with supporting bricks 41 and 42 which rest on the angle irons 43 (Figure 4).

The vault is characterized by the fact that its lower surface 22 is lined with a sheet of platinum 44 which carries the rings 45, and is suspended by means of the rods 46, the ends of which are hooked and engage in the rings 45.

This sheet of platinum constitutes a screen which reflects the radiation emitted upwardly by the foot of the sheet 18 which rests on the platinum resistance sheet 37 which is electrically heated by the Joule effect.

Since the resistance sheet is brought to a high temperature, for example, between 1000° C. and 1100° C., the lower face of the foot of the glass sheet 18 is given a relatively low viscosity even though the greater part of the thickness of the sheet, from the upper surface down, has a high viscosity.

The lateral edges of the foot of the sheet 18 are, like its lower face, rendered relatively mobile by the electrical heating of the resistance 37 and it will readily be appreciated that the sliding of the sheet over the spout requires a very small drawing force.

The foot of the sheet 18 may be compared to a plate of hardened glass which is lubricated on the three faces exposed to substantial friction.

In Figure 5, the "pot" itself is separate from the drawing spout 6', which is positioned against it in such a manner that its sole, which supports the foot of the sheet 18, is level with the edge of the inner surface 7.

The drawing spout 6' is supported through two feet 47, 48 by the refractory brick 13' which is provided with a notch in which the foot 48 is seated and a groove in which the heating coil 14 rests.

The drawing spout 6' is made of a material having a low overall emissivity such as pure alumina, magnesia or silica free from traces of iron oxides.

A separate drawing spout offers the advantage that it may be easily replaced in case of wear.

Figure 6 shows how the foot of the sheet 18 is supported by the spout and how the free part of the foot of the sheet is gripped at its edges by the two pairs of small roller wheels 23. The chamber beneath the sole of the spout which is heated by the electrical resistance 14 is closed at its lateral ends by two insulating bricks 49 which have been omitted from Figure 6 for the sake of clarity but which are shown on Figure 7.

The separate drawing spout shown on Figure 7 is provided with a platinum lining 37 which is bent back over the lateral sides 35' and foot 47 of the drawing spout, thereby forming a rim about the outlet of the spout.

A like rim is provided where the spout engages the pot itself since it is also desirable to provide a platinum lining at this point. Thus, while the foot of the sheet is heated on three surfaces by the platinum lining, it leaves the spout without having come in contact with anything other than platinum.

Alloys of platinum may be substituted for platinum. In this event, it may be advantageous, in order to prolong the life of the lining, to make use of alloys which the glass does not wet or which it wets only with difficulty, for example, those containing a certain percentage of precious metals such as ruthenium, gold, etc.

The spout of Figure 8 is provided with a sole 50 in contact with the glass which is slightly inclined from the edges towards the center so that the sheet 18 which rests on this sole increases slightly in thickness from its edges to its center.

This transverse cross-section for the sole facilitates the production of a sheet which is uniform in thickness throughout its width since the central zone has a tendency

to be warmer and consequently to be drawn a little thinner than the balance of the sheet.

The spout of Figure 9 is provided, in addition to the slightly concave sole, with a groove 51 at the base of each of the sides 35'. This has the effect of giving the edge of the sheet a smoother profile and accentuates the tendency of the edge to harden first.

What I claim is:

1. Apparatus for drawing glass into sheets comprising a drawing chamber having inlet and outlet ends, the bottom of said chamber sloping gradually upward from the former to the latter, and merging into an elongated spout at the outlet end of said chamber, both said chamber bottom and spout being made of a material having an emissivity less than .5 for temperatures between 1000° C. and 1100° C. and said spout being adapted to admit a stream of glass slightly deeper than the thickness of the sheet to be drawn, means for heating the lower surface of the glass conductively through said spout, convective cooling means above said spout for providing a flow of cooling gas in contact with the upper surface of said glass throughout substantially the entire length and breadth of the spout, and radiation reflecting means above said spout for reflecting back heat radiated by said glass, said radiation reflecting means comprising a heat insulating material surfaced with a refractory having an emissive power which is not less than the emissive power of a chrome-magnesia refractory containing at least 5% of iron oxides.

2. Apparatus as claimed in claim 1 in which the refractory material composing said spout is chosen from

the group consisting of silica, magnesia and alumina, and is substantially free from iron oxides.

3. Apparatus as claimed in claim 1 in which said last mentioned refractory is selected from the group consisting of magnesia and chrome-magnesia containing more than 5% of iron oxides.

4. Apparatus as claimed in claim 1 in which electrical resistance heating means are provided below the upper surface of said spout.

5. Apparatus as claimed in claim 1 comprising means for cooling the lower surface of the glass as it passes beyond the spout.

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