No. 860,528. PATENTED JULY 16, 1907.

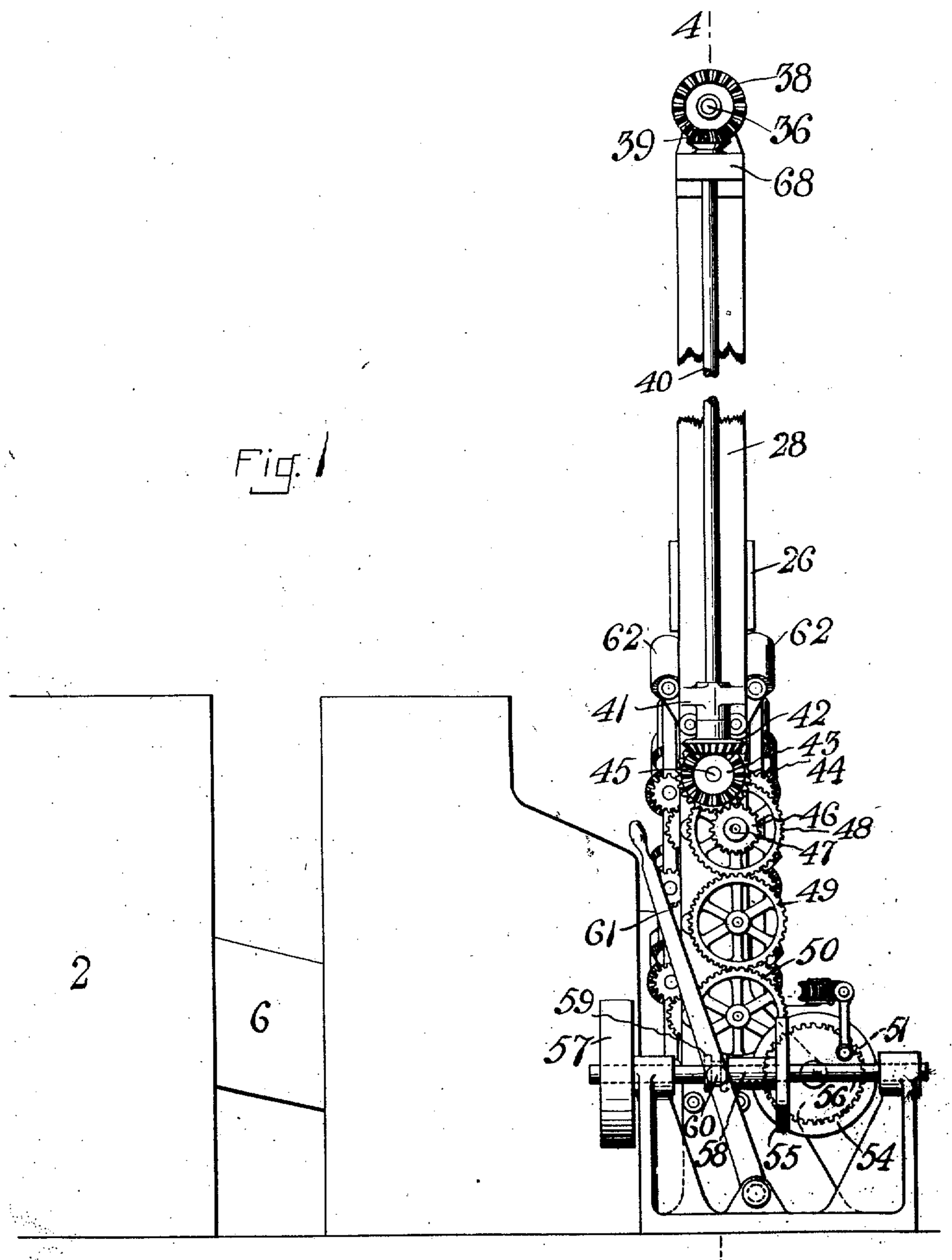
I. W. COLBURN.

METHOD AND APPARATUS FOR DRAWING SHEET GLASS.

APPLICATION FILED OCT. 28, 1903.

7 SHEETS—SHEET 1.

Fig. 1



WITNESSES
Gustave R. Thompson.
Wm. B. Kerkam.

INVENTOR
Irving W. Colburn
BY
Munn Cairns Lewis & Wasse
ATTORNEYS

No. 860,528. PATENTED JULY 16, 1907.

I. W. COLBURN.

METHOD AND APPARATUS FOR DRAWING SHEET GLASS.

APPLICATION FILED OCT. 28, 1903.

7 SHEETS—SHEET 2.

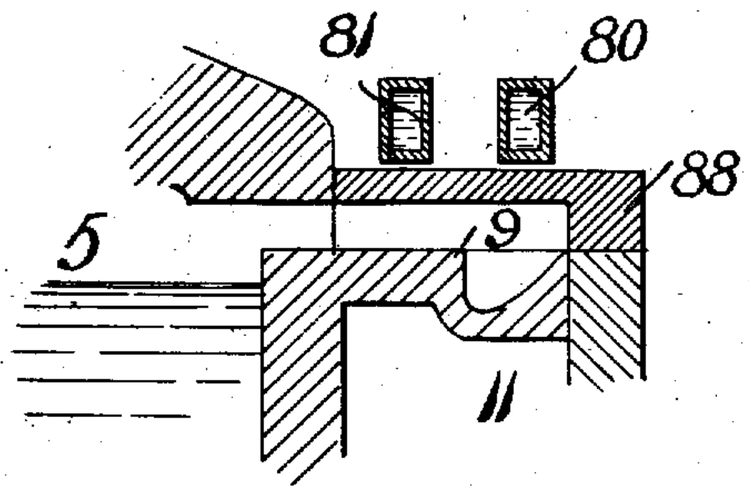


Fig. 3.

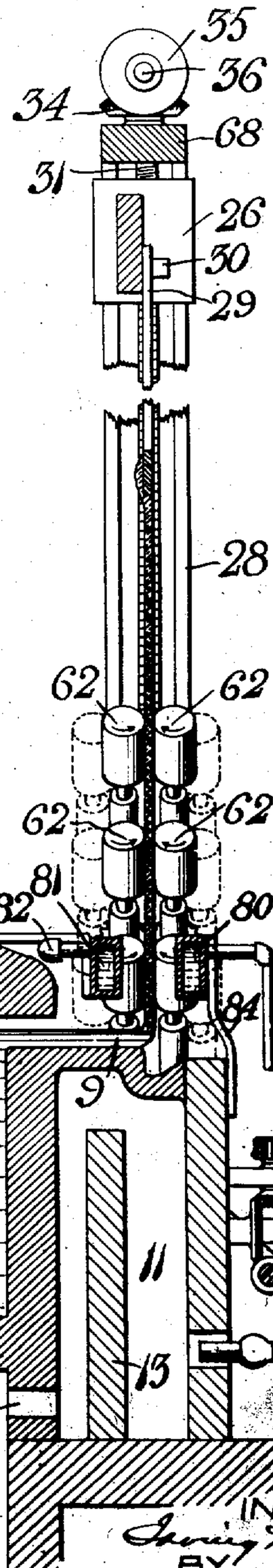
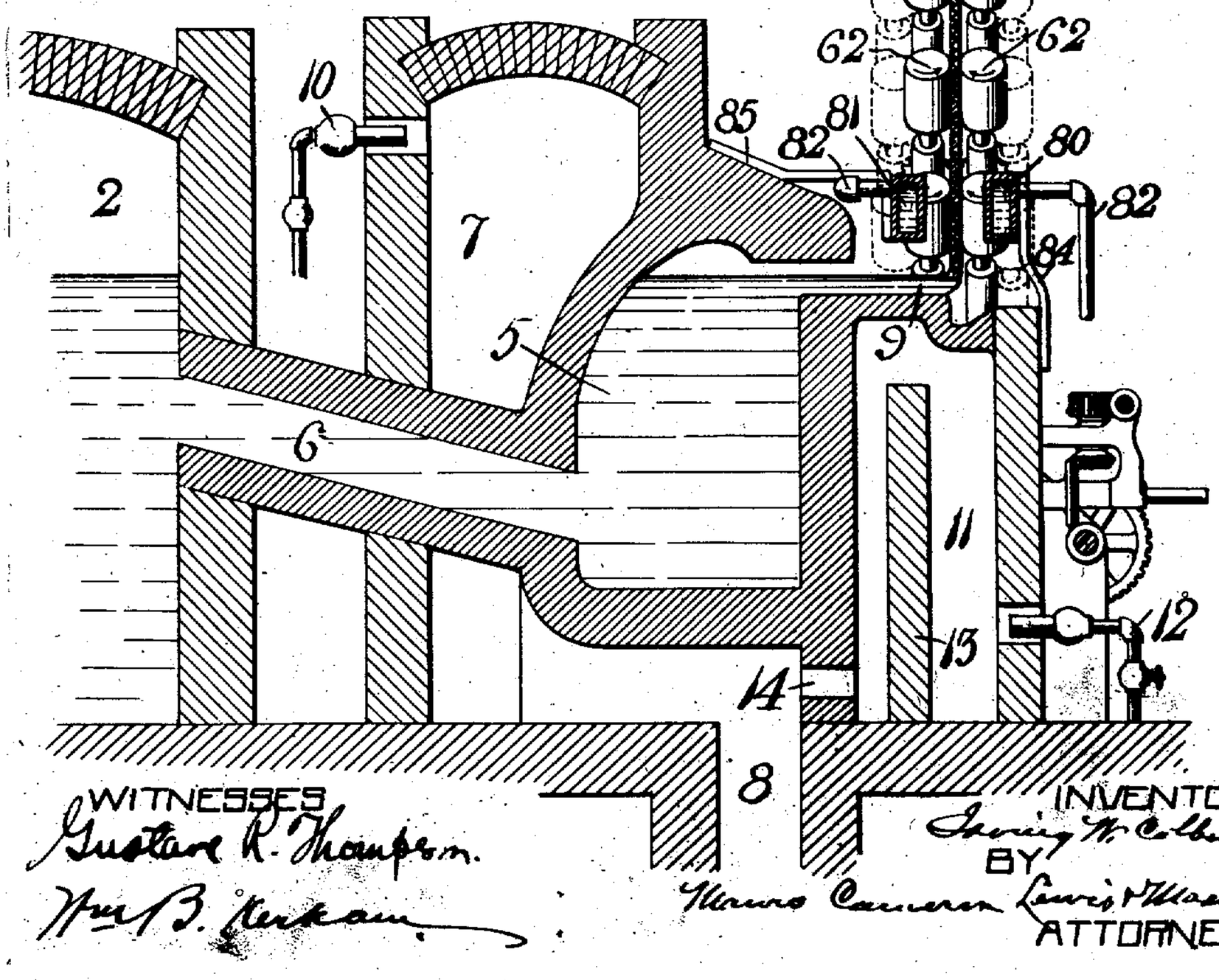


Fig. 2.



WITNESSES
Gustave R. Thompson.
Wm. B. Clarkson.

INVENTOR
Irving W. Colburn
BY
Munn Cameron Lewis & Waddell
ATTORNEYS

No. 860,528. PATENTED JULY 16, 1907.

I. W. COLBURN.

METHOD AND APPARATUS FOR DRAWING SHEET GLASS.

APPLICATION FILED OCT. 28, 1903.

7 SHEETS—SHEET 3.

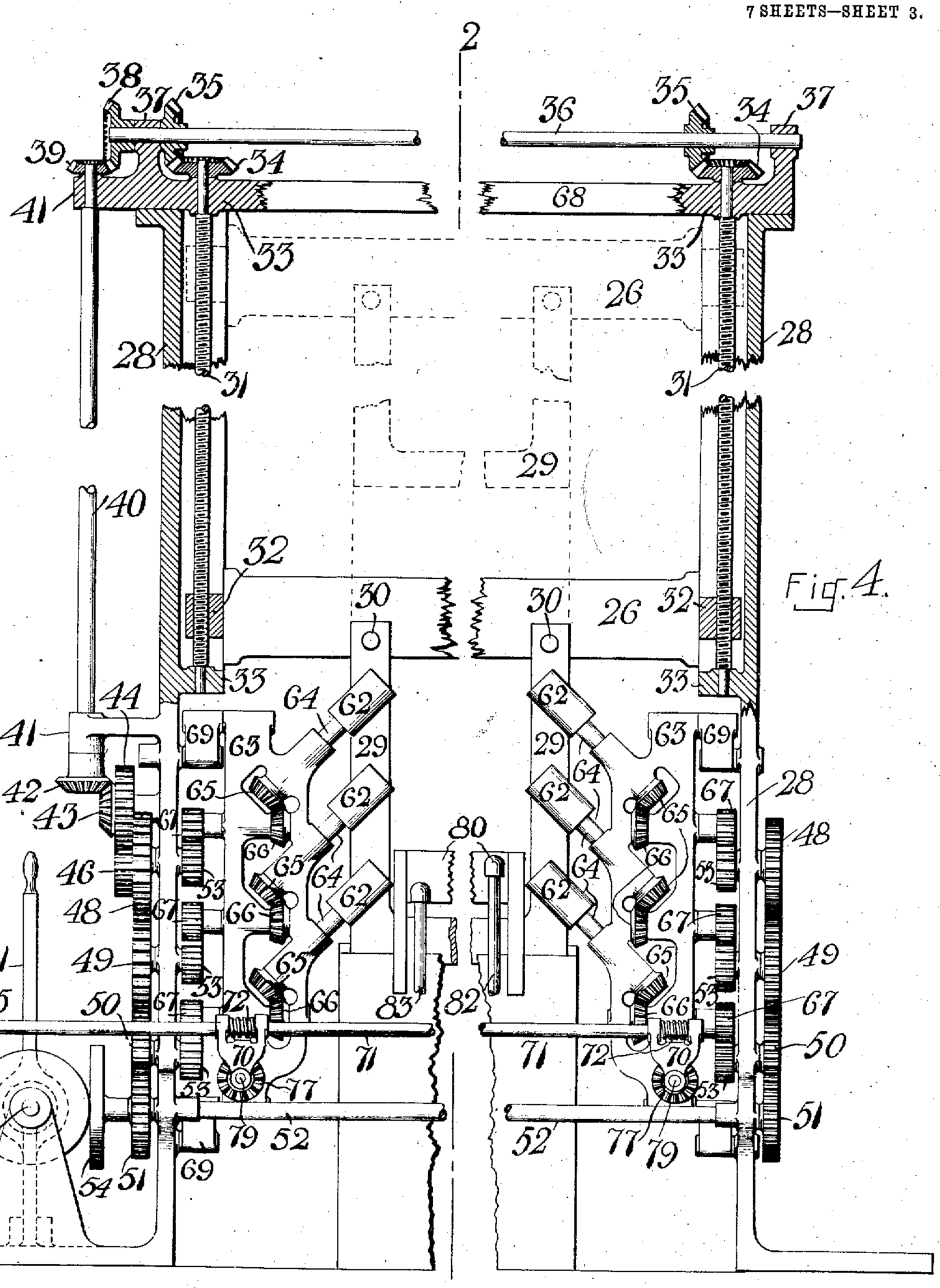


Fig. 4.

WITNESSES
Gustave R. Thompson.
Wm. B. Kerkam.

INVENTOR
Irving W. Colburn
BY
Mauro Cameron Lewis & Musie
ATTORNEYS

No. 860,528. PATENTED JULY 16, 1907.

I. W. COLBURN.

METHOD AND APPARATUS FOR DRAWING SHEET GLASS.

APPLICATION FILED OCT. 28, 1903.

7 SHEETS—SHEET 4.

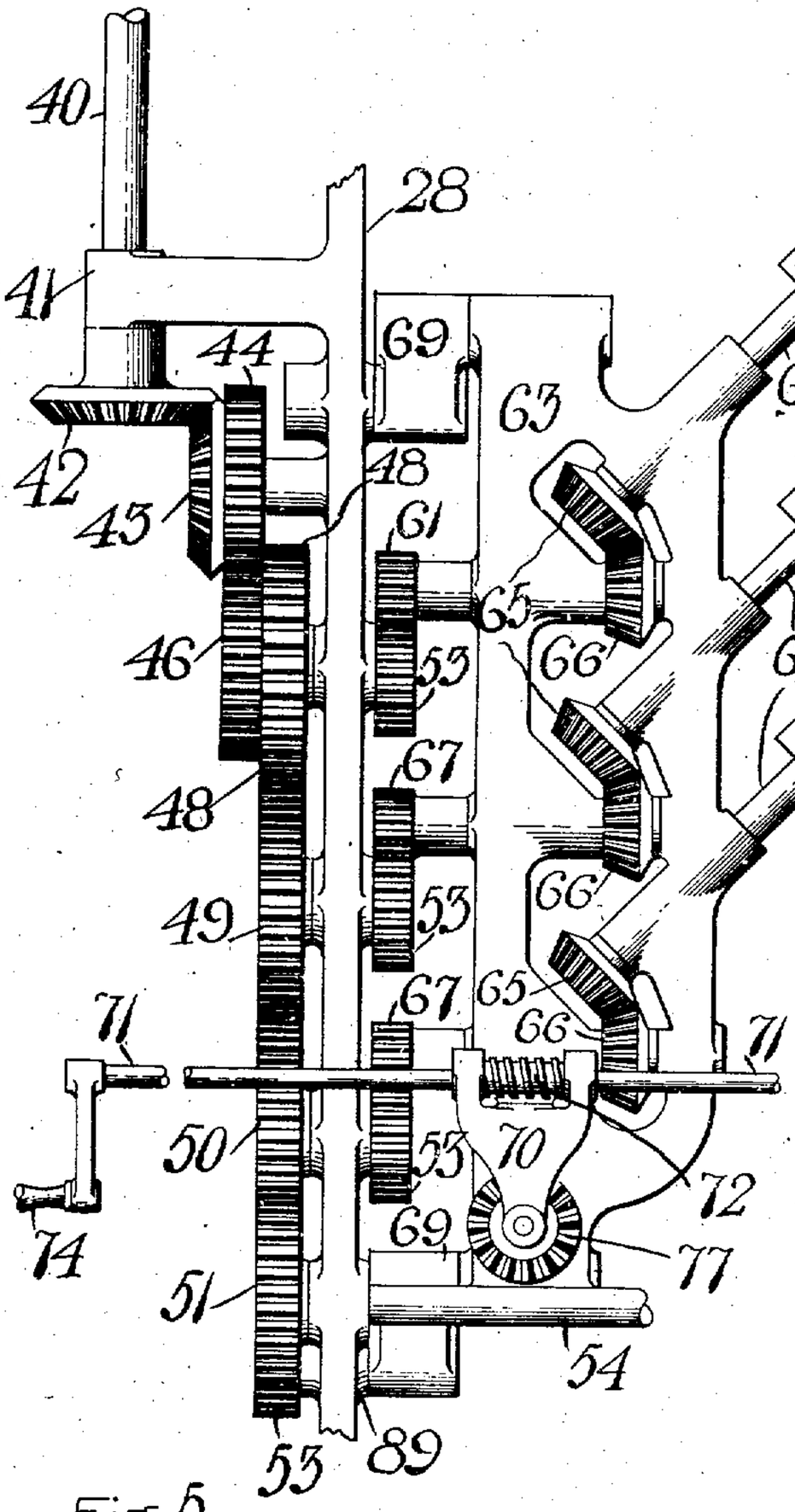


Fig. 5.

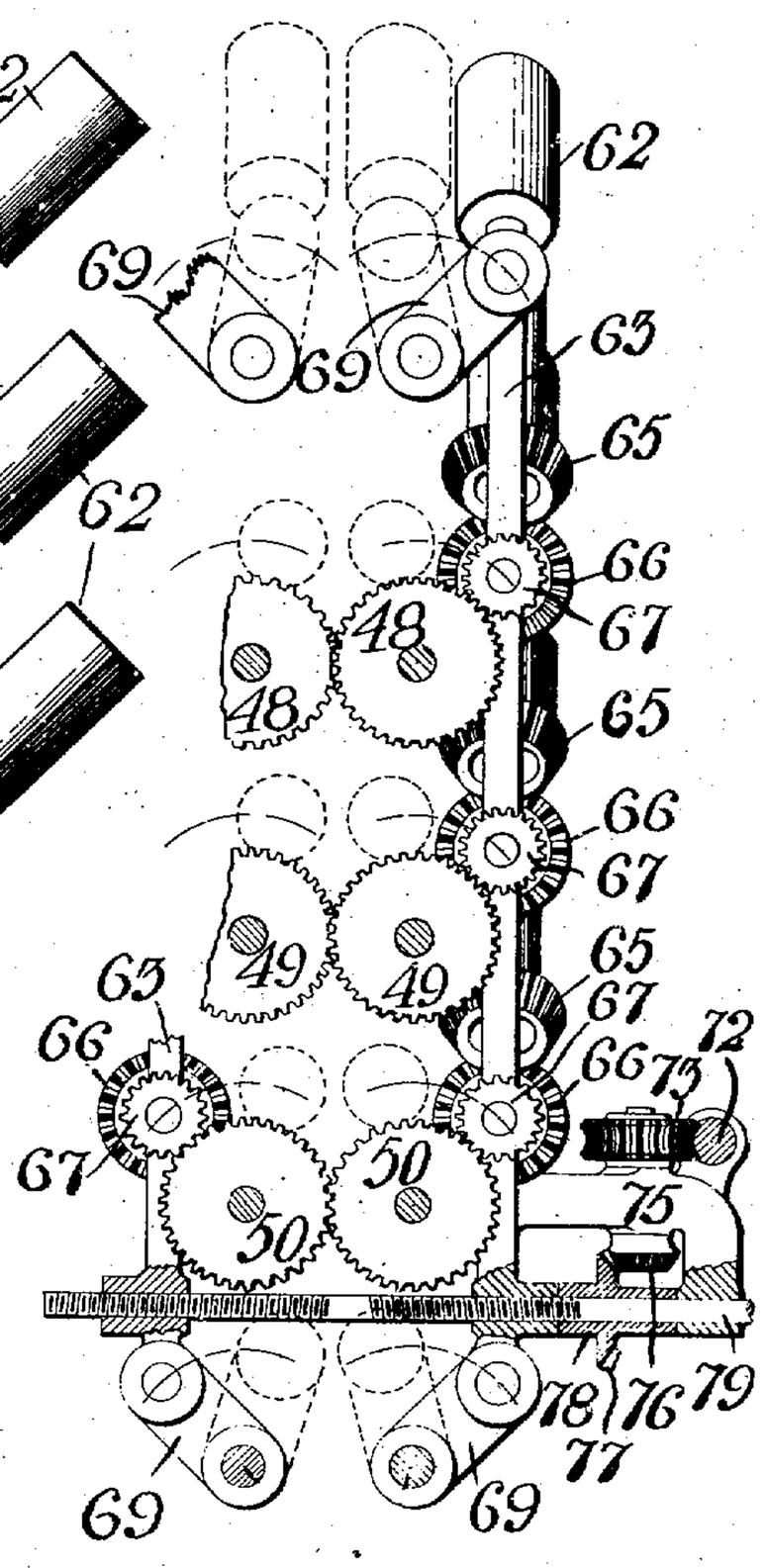


Fig. 6.

WITNESSES
Gustave R. Thompson
Wm B. Kerkam

INVENTOR
Irving W. Colburn
BY
Mauro Cameron Lewis & Macrae
ATTORNEYS

No. 860,528. PATENTED JULY 16, 1907.

I. W. COLBURN.

METHOD AND APPARATUS FOR DRAWING SHEET GLASS.

APPLICATION FILED OCT. 28, 1903.

7 SHEETS—SHEET 5.

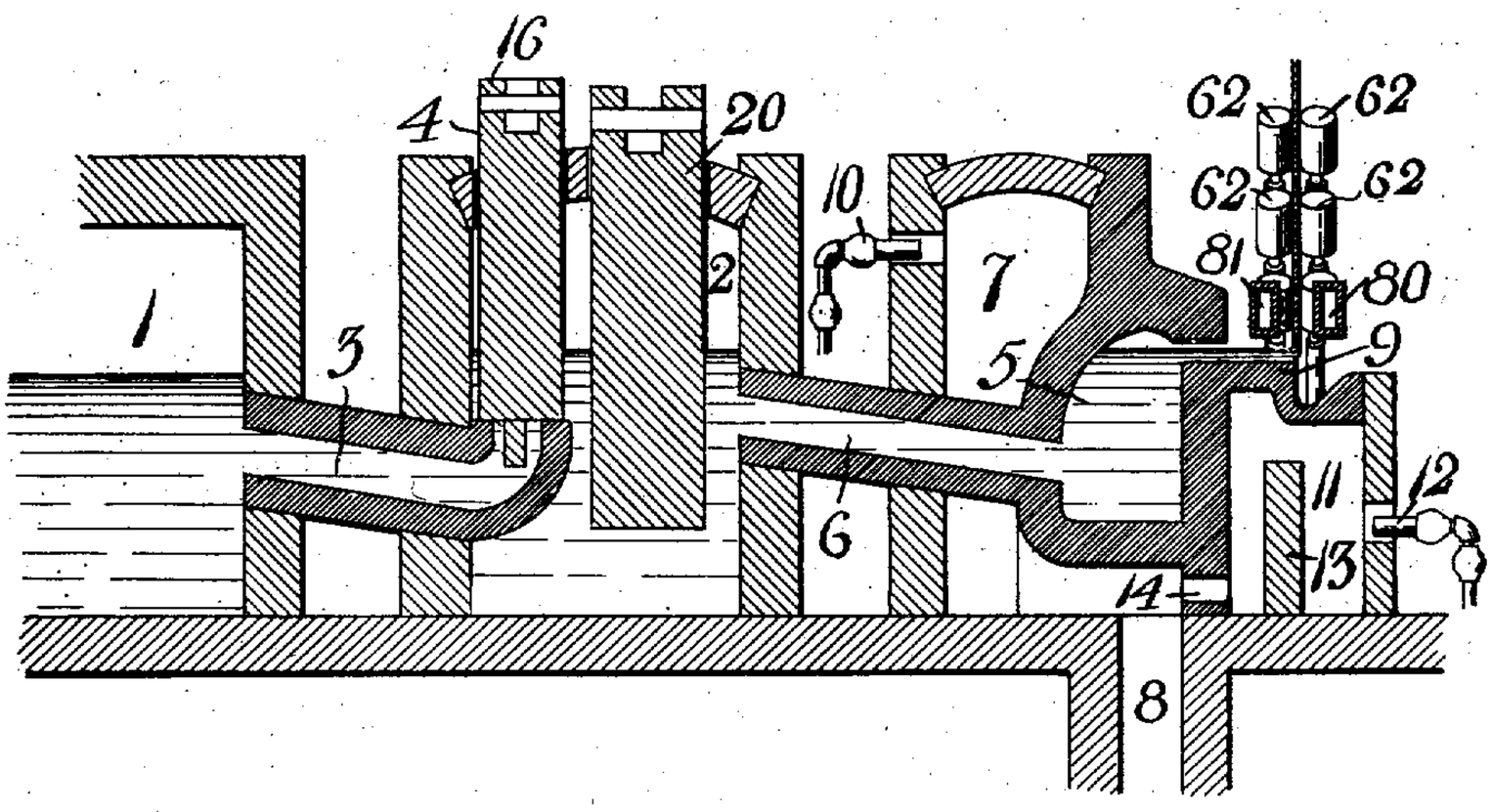


Fig. 8.

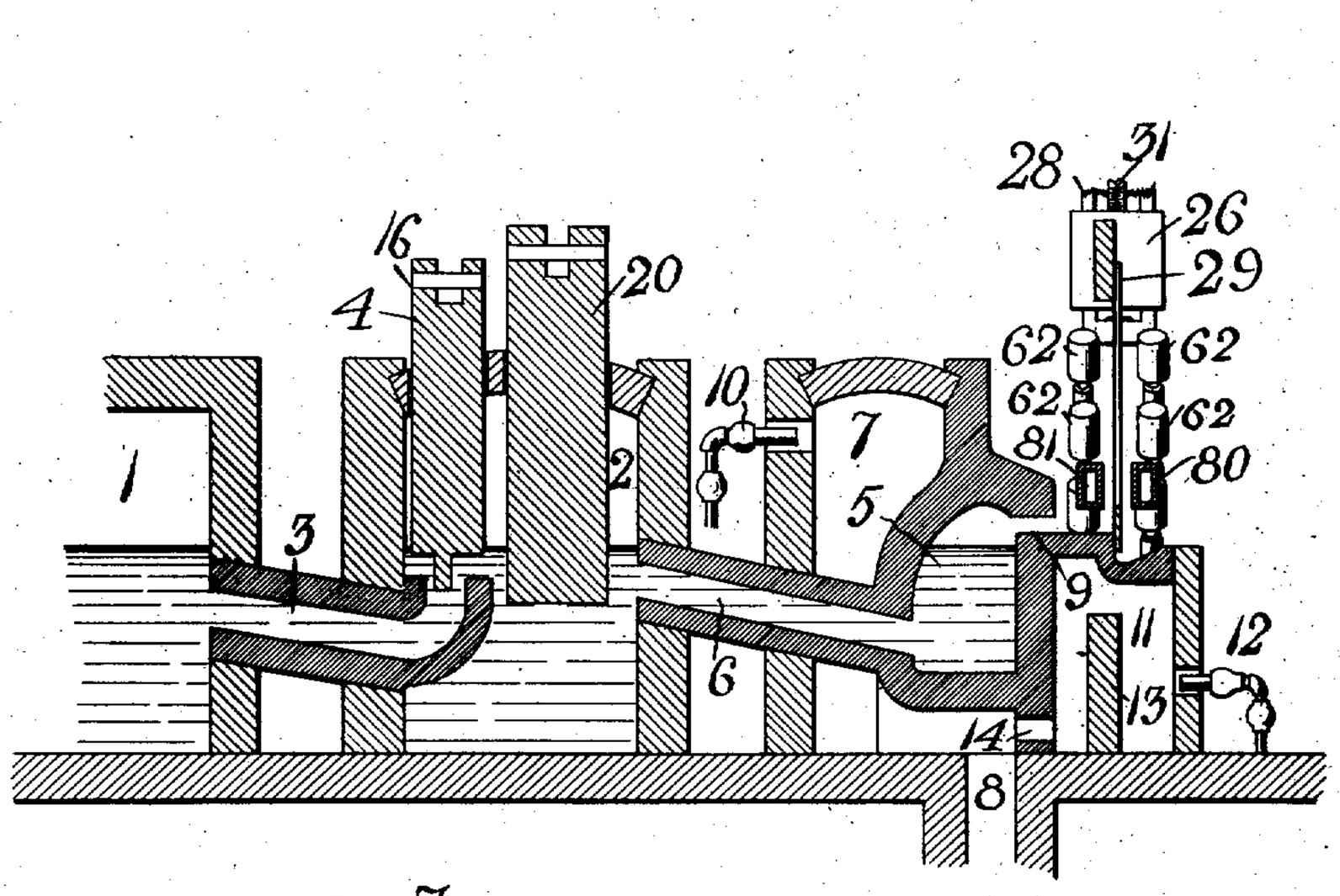


Fig. 7.

WITNESSES
Gustave R. Thompson.
Wm. B. Herbaine

INVENTOR
Irving W. Colburn
BY
Munn Cameron Lewis & Munn
ATTORNEYS

No. 860,528. PATENTED JULY 16, 1907.

I. W. COLBURN.

METHOD AND APPARATUS FOR DRAWING SHEET GLASS.

APPLICATION FILED OCT. 28, 1903.

7 SHEETS—SHEET 6.

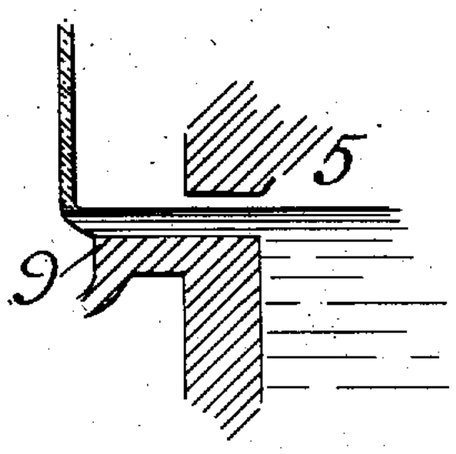


Fig. 9.

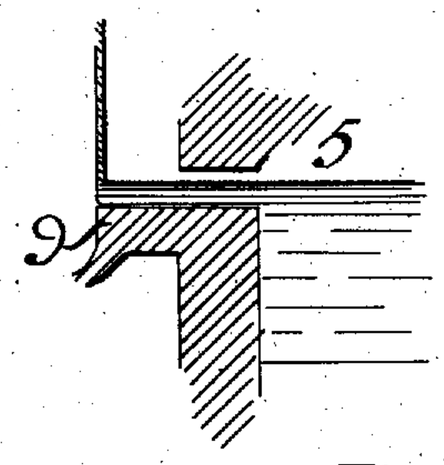


Fig. 10.

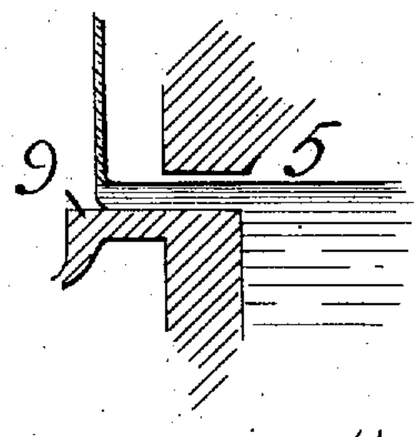


Fig. 11.

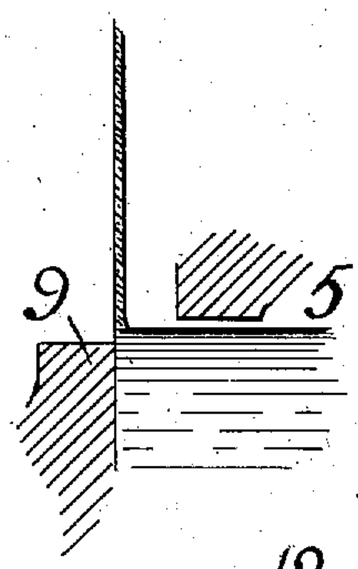


Fig. 12.

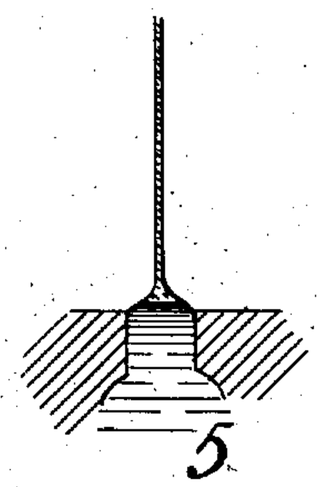


Fig. 13.

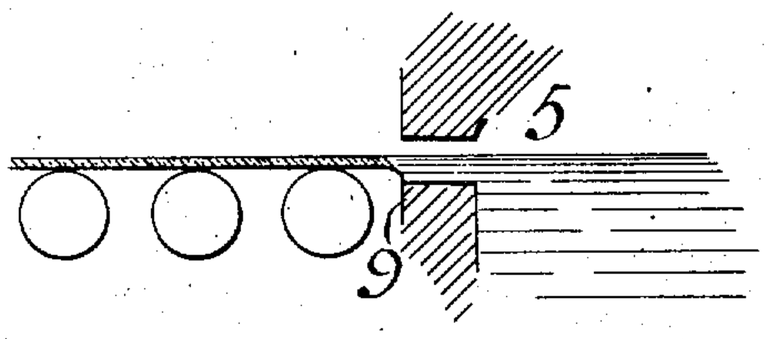


Fig. 14.

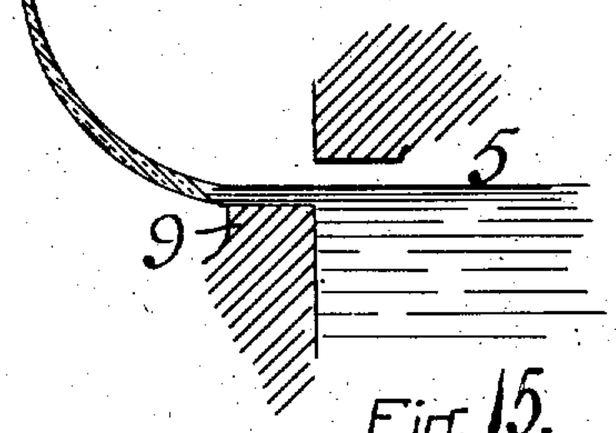


Fig. 15.

WITNESSES
Gustave R. Thompson.
Wm. B. Corcoran;

INVENTOR
Irving W. Colburn
BY
Munro Cameron Lewis & Munro
ATTORNEYS

No. 860,528. PATENTED JULY 16, 1907.

I. W. COLBURN.

METHOD AND APPARATUS FOR DRAWING SHEET GLASS.

APPLICATION FILED OCT. 28, 1903.

7 SHEETS—SHEET 7.

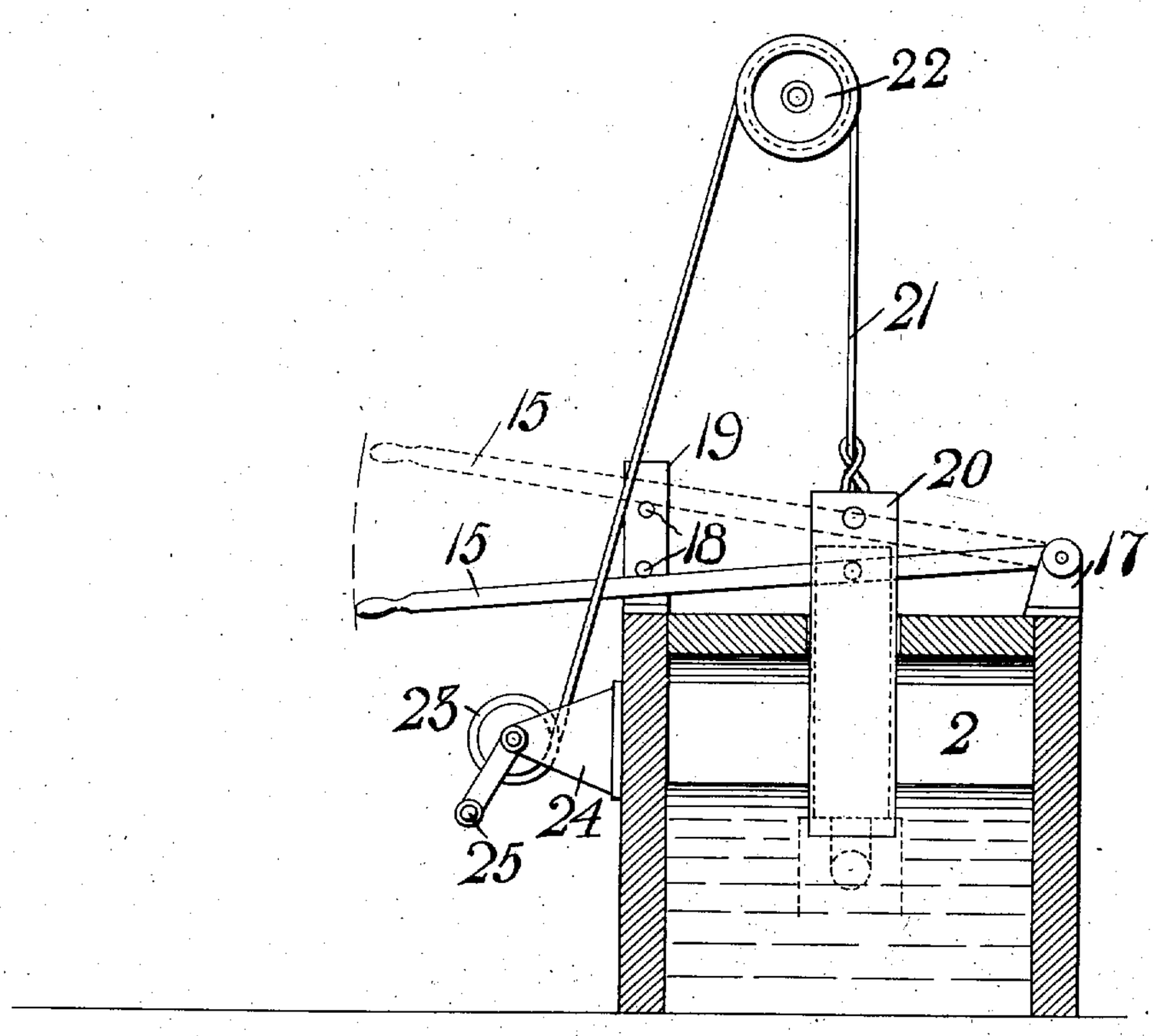


Fig. 16.

WITNESSES
Gustave R. Thompson.
Wm. B. Merkam

Irving W. Colburn INVENTOR
BY
Munn Cameron Lewis & Massie
ATTORNEYS

UNITED STATES PATENT OFFICE.

IRVING W. COLBURN, OF FRANKLIN, PENNSYLVANIA, ASSIGNOR TO COLBURN MACHINE GLASS COMPANY, OF FRANKLIN, PENNSYLVANIA, A CORPORATION OF NEW JERSEY.

METHOD AND APPARATUS FOR DRAWING SHEET-GLASS.

No. 860,528. Specification of Letters Patent. Patented July 16, 1907.

Application filed October 28, 1903. Serial No. 178,912.

To all whom it may concern:

Be it known that I, IRVING W. COLBURN, a resident of Franklin, Pennsylvania, have invented a new and useful Method and Apparatus for Drawing Sheet-Glass, which invention is fully set forth in the following specification.

This invention relates to the art of glass working, and more particularly to the art of drawing sheets of glass from a molten mass of plastic glass.

Many efforts have heretofore been made to draw sheet glass directly from a mass of molten or plastic glass, but so far as I am informed none of these have been commercially successful. A great variety of difficulties have been encountered in the efforts referred to. One of the chief of these is the tendency of the glass to draw into a long string or stick shortly after the operation of drawing has begun, with the result that the extent of sheet glass secured was so meager in character as to render the operation commercially impracticable.

The object of the present invention is to provide a method and apparatus which shall be capable of drawing sheets of glass of given or determinate width from a mass of molten or plastic glass which shall be commercially practicable, and which shall produce a superior quality of glass, the method being particularly applicable to sheet window glass.

With this object in view the invention consists in the method of drawing, from any suitable receptacle for molten glass, a flat sheet of glass which, simultaneously with the operation of drawing the same from the receptacle, is stretched in a lateral direction so as to maintain the sheet of uniform width and by the stretching or drawing action to impart to the same the flatness and smoothness of surface requisite in glass of this character.

The invention further consists in apparatus provided with means for presenting a mass of molten glass to be drawn, combined with means for drawing a flat sheet of glass therefrom, and means for simultaneously stretching, in a lateral direction, the sheet of glass as drawn, whereby the drawn sheet is maintained of uniform width and the stretching action necessary to impart a flat and smooth surface to the drawn sheet of glass is secured.

While the foregoing is a fairly accurate statement of the method and apparatus wherein the invention resides, there are minor details of the method and of the apparatus employed which will be hereinafter more particularly described, and then defined in the claims.

In order to insure uniform condition of the glass as drawn, and in order that it may be presented to the stretching apparatus always in substantially the same condition throughout every part of the sheet, the glass is, by the present invention, preferably maintained at a constant level in the receptacle for the molten glass, which level is, in the apparatus here shown, slightly above that of the overflow lip or margin of the glass-containing receptacle. Moreover, in order that the molten glass may be cooled to the proper consistency before it is presented to the lateral stretching apparatus, cooling means are provided which are located at a determined distance above the overflow lip or margin of the receptacle. By maintaining the glass at an approximately constant level, and by providing means for heating the glass so that it shall issue from the overflow lip or margin of the receptacle at a temperature which experience proves to be the most suitable for the particular character of glass under treatment, and by lowering this temperature by the use of cooling devices located at a suitable distance from the mouth of the receptacle, and by then laterally stretching the sheet of glass after it has been cooled to the most effective temperature, but while it is still plastic, it has been found possible to continuously and progressively manufacture a plate of glass of constant width, and whose length is determined only by the extent or length of draw of the apparatus employed.

The inventive idea involved may receive various expressions, and the apparatus employed for practicing the method may be varied in many ways. The apparatus herein shown, however, is one which is capable of use in the practice of this method of glass-drawing, and is to be regarded as illustrative of the form of apparatus suitable for the purpose.

In said drawings, Figure 1 is a side elevation of an apparatus for drawing glass according to the method of the present invention; Fig. 2 is a central vertical section on the line 2—2, Fig. 4; Fig. 3 is a sectional detail of the mouth of the receiving chamber or pot from which the molten glass is drawn, with cover 88 in place; Fig. 4 is a broken vertical section on the line 4—4, Fig. 1, some of the parts, however, being shown in elevation; Fig. 5 is a front elevation of a portion of the stretching apparatus; Fig. 6 is an end elevation thereof, parts being broken away; Fig. 7 is a sectional detail showing the melting or refining chamber, the receiving chamber or pot and the delivery chamber interposed between the refining and receiving chamber, with means for closing the communication between the melting and delivering chambers and for maintaining the glass in the receiving chamber or pot at a constant level, the same in this figure, however, being shown with the communications between the melting and refining chamber, the delivery chamber and the receiving chamber open and unobstructed, and the glass being at a level below that at which it is preferred to draw the same; Fig. 8 is a view similar to Fig. 7 but with the communication between the deliv-

ery and the melting chambers closed and the glass in the receiving chamber or pot raised so that it overflows the margin or lip of the same, and a sheet of glass in the act of being drawn therefrom; Figs. 9, 10, 11, 12, 13, 14 and 15 are sectional details showing modifications of the overflow margin or lip of the receiving chamber or pot and of the manner of drawing a sheet of glass therefrom; Fig. 16 is a vertical section, partly in elevation, of the delivery chamber showing the means for closing communication between the melting and delivery chambers and for maintaining the molten glass in the delivery and receiving chambers at the desired level for drawing the sheet of glass.

Referring to the drawings, 1 is the melting and refining chamber, 2 is the delivery chamber and 3 is a conduit connecting the melting and refining chambers with the delivery chamber, said conduit being controlled by valve 4 which, in the present instance, is shown in the form of a vertical plunger made of some refractory material, as tank block weighted, if necessary, to make it heavier than the molten glass displaced so that it will sink therein.

5 is the receiving chamber or pot which receives the molten glass from the delivery chamber 2 by way of conduit 6. This receiving chamber or pot 5 is provided with a suitable opening through which the molten glass passes as a sheet of glass is being drawn therefrom, in a manner hereinafter described. The receiving chamber or pot 5 is provided with what is here designated as an overflow lip 9 which, in the present instance, is the margin or edge of the receiving chamber 5, which may be either of the same thickness as the wall of the said receiving chamber, as shown in Figs. 12, 14 and 15, or it may consist of such wall extended so as to form a projecting lip or table, as shown in Figs. 2, 9, 10 and 11.

It has been found that the drawing of a sheet of glass from a mass of molten material is facilitated by having the said overflow lip or margin heated to a temperature somewhat in excess of that of the body of the mass of molten glass contained within the receiving chamber or pot. In order to provide for the heating of said lip in the manner desired, the overflow lip 9 is preferably so constructed as to form the top or roof of the heating chamber 11, which chamber is connected by off-take flue 14, to the stack flue 8, through which the burnt gases pass. The chamber 11 is heated in any suitable manner, as by flames from gas jets 12 projecting into said chamber, which is provided with a fire bridge wall 13 extending upwards near to, but not in contact with, the roof of said chamber. This construction conducts the heated gases of combustion upward against the under side of the overflow lip 9, and then downwards and out of the stack through flues 14 and 8. The construction of the heating apparatus for the overflow lip is shown in Figs. 2, 7 and 8. In order to keep the molten or plastic glass in the receiving chamber 5 at the proper temperature, there is provided a heating chamber 7 which surrounds the greater portion of the receiving chamber 5. The heating chamber 7 is connected at its lower portion with the flue 8 leading to the stack flue through which the burnt gases pass. The chamber 7 is heated in any suitable manner, preferably by gas jets 10 projecting into the said chamber at its upper portion, so as to direct the flames from the jets 10 against the top of the receiving chamber 5, which flames will be drawn around the receiving chamber 5 into the off-take flue 8, all as clearly shown in Figs. 2, 7 and 8.

The valve 4 for controlling the flow of molten glass from the melting chamber 1 to the delivery chamber 2 may be operated in any suitable manner, and as here shown (reference being had particularly to Fig. 16), its operation is accomplished by means of a lever 15, fulcrumed at 17 upon the walls of the furnace, and connected by the pin 16 to the valve 4. The valve 4 may thus be elevated or depressed by the operation of the lever 15, the lever being held in its depressed position by the pin 18, or in its elevated position by the pin 19, as will be readily understood by an inspection of Fig. 16. For the purpose of securing the constant level of the molten glass in the receiving chamber or pot 5, any suitable means may be employed, that here illustrated being in the form of a displacement block or piece 20 made of any suitable refractory material, as tank block, which is preferably constructed of such mass as to displace the molten glass by its own weight, though the block may be weighted if desired. This displacement piece 20 is provided with means for raising and lowering it, here shown in the form of a cable 21 passing over a pulley 22, and around a drum 23, which drum is mounted in bearings formed in a bracket 24 and operated by a crank 25. It will be readily understood that by operating the crank 25 the block may be permitted to descend into the mass of molten glass or be raised therefrom, depending upon the direction in which the crank is turned. When the block is withdrawn a predetermined distance from the mass of the molten glass in the delivery chamber 2, the level of the glass in said chamber 2 and the receiving chamber or pot 5 can be maintained below the margin or overflow lip 9 of the delivery opening of said chamber or pot, as is shown in Fig. 7; but by permitting the displacement piece 20 to descend into the mass of the glass, as shown in Fig. 8 (the valve 4 being in position to close the conduit 3), the level of the glass in the delivering chamber and the receiving chamber or pot can be raised to the desired point and preferably slightly above the overflow lip or margin of the receiving chamber or pot, as very clearly appears in Fig. 8.

As the glass issues from the receiving chamber or pot, preferably on the overflow lip or margin 9, it is received by a bait 29, which by preference is suitably prepared so as to cause the glass to adhere thereto, and the glass is then continuously drawn away from the overflow lip or margin, thereby drawing out a sheet of glass. This drawing action may take place in a vertical or in a horizontal direction, or at any angle inclined from the vertical or horizontal that may be desired, and the molten glass may be drawn into sheet form at the instant it makes exit from the opening in the overflow chamber or pot 5, as illustrated in Figs. 13 and 14, or it may be permitted to extend partially or entirely along the surface of the overflow lip or margin, as shown in Figs. 9, 10, 11 and 15; or, if preferred, the sheet of glass may be drawn from the mass of molten material in the receiving chamber or pot 5 without actually permitting any of the glass to flow along the surface of the overflow lip or margin, as shown in Fig. 12, all of these various modifications being within the invention herein described. For the purpose of moving the bait 29 away from the mouth of the receiving chamber or pot 5, in order to draw the sheet of

glass from said pot, it is attached to a suitable member provided with means for continuously drawing it away from the chamber or pot in the direction in which the sheet is desired to be drawn. As above stated, this direction may be vertical, horizontal or at any angle between the vertical and horizontal.

There is herein shown an apparatus designed for drawing the sheet of glass vertically from the receiving chamber or pot, which apparatus is best shown as a whole in Figs. 1, 2 and 4, and consists of a cross-head 28, moving in guides or ways 27, 27, formed in side frames 28, 28, the bait 29 being suspended from the cross-head 26 by pins 30, 30, and the cross-head itself having up and down movement imparted to it by screws 31, 31, passing through nuts 32, 32, on opposite ends of the cross-head. These screws 31 are mounted to turn in bearings 33 in the side frames 28 and in a top cross-rail 68, and are provided with beveled gears 34 meshing with bevel gears 35 fast on the shaft 36 turning in bearing 37, 37, on the top cross rail 68. This shaft has a bevel gear 38 fast on one end thereof which gears with a bevel gear 39 on vertical shaft 40, turning in bearings 41, 41, and provided on its lower end with the bevel gear 42. This bevel gear 42 meshes with bevel gear 43, which is fast to spur gear 44 free to rotate on shaft 45, Fig. 1, projecting from the side frame 28. Spur gear 44 meshes with spur gear 46 fast on shaft 47, which shaft 47 also has a spur gear 48 fast thereon. This spur gear 48 is one of a line of gearing which is connected with a shaft 52 driven from the main source of power, the chain of gearing in this instance consisting of gears 48, 49 and 50, meshing with gear 51 on transverse shaft 52. By an inspection of Fig. 4 it will be observed that there are two exactly similar lines of gearing 48, 49, 50 and 51, the several gears being mounted on shafts taking bearing in the respective side frames 28, which shafts have fast upon their inner ends spur gears 53. These spur gears 53 serve to drive the gearing for operating the rollers employed for stretching the glass, as will be hereinafter more clearly described. The shaft 52 has upon one of its ends a friction disk 54 which receives motion from a friction disk 55 at right angles thereto, the disk 55 being keyed so as to turn with but slide upon shaft 56 driven by pulley 57 receiving motion from any suitable source of power. The friction disk 55 has secured thereto and preferably formed integrally therewith a sleeve 58, having an annular groove 59 into which a pin 60 on a lever 61 enters, said lever being fulcrumed in any suitable manner upon the framework of the apparatus.

It will be readily understood that by operating the lever 61 the friction disk 55 may be made to approach toward or recede from the center of the disk 54, and thereby vary the speed of the shaft 52; and that by causing the disk 55 to pass the center of the disk 54 the direction of movement or revolution of the shaft 52 may be reversed.

For the purpose of laterally stretching the sheet of glass, as it is in the act of being drawn, a series of rollers 62 are mounted in suitable frames 63 on either side of the apparatus. Each of the rollers 62 is keyed to a shaft 64 turning in suitable bearings in the framework and preferably inclined at an angle to the direction of movement of the sheet of glass to be drawn. Each of the shafts 64 has on the end opposite the roller 62 a beveled gear 65 meshing with a bevel gear 66 fast on another shaft also taking bearing in the frame 63, and having on its opposite end a spur gear 67 meshing with one of the spur gears 53 hereinbefore referred to. It will thus be seen that each roller 62 is driven from a spur gear 53 through the intermediate gears 67, 66 and 65, and the shafts bearing such gears, and that each roller receives its motion from one of the chain of gears 48, 49 and 50, driven by the shaft 52. From an inspection of Fig. 4, it will be understood that there is a series of these rollers 62 operating upon the opposite edges of the sheet of glass as the same is being drawn; and from an inspection of Fig. 2 it will be seen that there is a like set of rollers operating upon the opposite sides or faces of the sheet of glass as the same is being drawn, the rollers being preferably arranged in pairs placed immediately opposite each other and rotating in opposite directions, as indicated by the arrows in Fig. 2. The effect of this arrangement of rollers is that the glass is gripped between the respective members of each pair of rollers and by the rollers is pulled or drawn laterally, thereby stretching the glass and maintaining the sheet at an approximately constant width and thickness.

In order that the rollers may be adjustable to sheets of glass of various thickness, and for the further purpose that the grip of the rollers upon any given sheet of glass being drawn may be adjusted, as well as for getting the bait between the rollers, means are provided whereby the frames 63 bearing the rollers may be adjusted so as to bring the rollers closer to or withdraw them further from the surface of the sheet of glass, and at the same time maintain the parallelism of the oppositely disposed frames and rollers borne thereby. The means employed for this purpose will be best understood by reference to Figs. 4, 5 and 6.

Each of the roller bearing frames 63 is articulated to the respective side frames 28 by a pair of hinge links 69, 69, in such way as to permit the respective pairs of roller bearing frames which are on opposite sides of the sheet of glass to be withdrawn from or approached towards the surface of the glass while at all times remaining parallel with each other, and also maintaining the gears 67 constantly in mesh with gears 53, so that the roller bearing frames 63 can be adjusted at will into parallel planes and always remain in operative engagement with the driving gears therefor. For the purpose of effecting the movement of the roller bearing frames 63 upon the hinge links 69, 69, brackets 70 are carried by the frames 63, within which brackets a worm shaft 71 takes bearing, said shaft being provided with a worm 72 for each of the pair of frames on one side of the sheet of glass. Each of worms 72, 72, meshes with a worm gear 73, (Fig. 6), on a vertical shaft turning in bearing 75, and on the lower end of the shaft bearing the worm gear 73 is a bevel gear 76, which meshes with a bevel gear 77 fast to or formed integrally with a sleeve 78, splined to the shaft 79 so as to slide thereon. This shaft 79 has bearings in the lower portion of the bracket 70 and extends from front to rear of the apparatus, and has on its respective ends right and left hand screw threads, as clearly shown in Fig. 6. The right-hand screw threads engage in a nut formed on the lower end of one of the roller bearing frames 63 and the left-hand screw threads engage in a nut formed in the lower end of the roller bearing

frame 63 on the opposite side of the sheet of glass; so that, by turning the screw shaft 79, the screw threads on said shaft operate to draw the roller bearing frames 63, 63 closer to each other, or to force them apart, depending upon the direction in which the shaft is turned.

It has been found in practice that in drawing a sheet of glass from the overflow of a pot of molten glass, the glass which overflows the lip of the pot is a little too hot to stretch or draw perfectly even, and to overcome this difficulty cooling devices, here shown as in the form of water boxes 80, 81 (Figs. 2 and 3) are provided, which boxes have pipes 82, 83, for the induction and eduction of a cooling medium, such as water. The said boxes 80 and 81 are placed on opposite sides of the sheet of glass just above the drawing point and act by radiation to chill the glass to the proper degree just above the drawing point. These water cooling boxes may be supported in any suitable manner, as by brackets 84 and 85, fast to the walls of the furnace.

It will be understood, of course, that power is applied to the machine through the pulley 57 and that the same may be applied with the usual counter-shaft or belt-shifter or any other suitable device whereby the machine may be stopped or started at pleasure.

Operation: Assume the machine to be at rest and the parts in the position shown in Fig. 7. In this position the valve 4 is elevated off its seat, as shown, and the displacement piece 20 is raised, thereby leaving the glass in the melting and refining chamber 1, the delivering chamber 2 and the receiving chamber 5, at the same level. The molten glass in the receiving chamber 5 having been brought to the desired temperature and condition, the water being circulated through the water cooling boxes 80 and 81, while the roller bearing frames 63, 63, are moved apart so as to open the rollers sufficiently to allow for the passage of the bait; and the cross-head 26 being in a position for the bait to overlap the overflow lip 9, as shown in Fig. 7, and said overflow lip having been heated to the desired degree, the friction disk 55 is adjusted with relation to the friction disk 54 so as to give the desired upward speed to the cross-head 26 bearing the bait 29. It is understood, of course, that the bait has been previously prepared so as to cause the plastic glass to adhere thereto. The parts being thus in readiness, the valve 4 is adjusted so as to close the conduit 3 leading from the refining chamber 1 and the displacement piece 20 is lowered into the mass of glass in the delivering chamber 2 (as shown in Fig. 8), thereby causing the surface of the glass in said delivering chamber and in the receiving chamber 5 to rise above and flow over the overflow lip 9, when it is caught by and adheres to the bait 29 which is held firmly against the overflow lip by the operator. When the plastic glass has adhered firmly enough to the bait, the cross-head 26 is started upwards by throwing on the power. This not only causes the cross-head 26 and the attached bait 29 to move upward, but it also starts the series of rollers 62, 62, to rotating, and as the sheet of glass is advanced and the bait raised above or withdrawn from between the outermost rollers, the roller bearing frames 63, 63, on the opposite sides of the sheet of glass are caused to approach each other by the operator turning the crank 74 attached to the worm shaft 71, which worm shaft through the medium of the worm 72, worm gear 73 and inter-meshing bevel gears 76 and 77, operate the spline sleeve 78 and witn it the screw shaft 79, the direction of the revolution of this latter shaft being such as to draw the roller bearing frames 63, 63, towards, and their sustained rollers 62, 62, into contact with, the sheet of glass on the opposite sides thereof. When the sheet of glass passes between the rollers 62, 62, they act to stretch the sheet sidewise and, owing to the angle of the axis of their rotation, they will assist also in drawing the sheet of plastic glass. The rollers are shown in operation in Figs. 2 and 8, the dotted lines in Fig. 2 indicating the open or non-operative position of said rollers. While the sheet of glass is being drawn, the overflow of molten glass at the lip 9 is kept constant, *i. e.*, is fed to the sheet as fast as the sheet is drawn, this being accomplished by the constant lowering of the displacement piece 20 into the molten glass in the delivering chamber. The speed of movement of the cross-head 26 can be varied at will by means of lever 61, operating to force the friction disk 55 nearer to or further from the center of the friction disk 54, as will be understood by an inspection of Fig. 1. When the sheet has been drawn to the desired length the rollers are opened by rotating the crank 74 in the proper direction, and the overflow of molten glass from the overflow lip 9 is stopped or, more accurately speaking, the overflowing molten glass is allowed to drop back into the receiving chamber 5 by elevating the displacement piece 20 out of the molten glass in the delivering chamber 2, the communication between the refining chamber 1 and the delivering chamber 2 being also preferably re-established by the elevation of the valve 4 from its seat. The upward travel of the cross-head 26 is continued, and as the sheet has no more plastic glass on the overflow lip 9 to draw from, it will speedily draw thin and can be readily separated from the overflow lip by cutting with shears or by any other means well known in the art for handling glass. The cross-head is then moved high enough so as that the bottom of the sheet of glass will clear the rollers, and the bait and the sheet of glass are transferred to some suitable carriage and moved off and placed in a horizontal position, or otherwise, when the bait may be cracked from the sheet of glass. In the meantime another bait is hung upon the cross-head 26 by means of the pins 30, 30, and the cross-head lowered into position, as shown in Fig. 7, and the operation is then repeated for drawing another sheet of glass.

As hereinbefore indicated, it is not essential that the glass should be drawn over any particular style or form of overflow lip, nor is it essential that the glass should be drawn in any particular direction from the horizontal surface of the lip.

Figs. 9–15, inclusive, illustrate some of the various ways in which the sheet of glass may be drawn from the receiving chamber 5, and will serve to illustrate the fact that this particular step or feature in the invention may be modified in a great variety of ways.

Referring to Figs. 9, 10 and 11, it will be apparent that the sheet of glass may be drawn just after the molten metal has passed beyond the exterior edge of the lip; or just when it reaches the edge of the lip; or just before it reaches the edge of said lip, as circumstances may seem to make most desirable.

Referring to Figs. 12 and 13, it will be apparent that the glass need not necessarily overflow or come in actual

contact with the upper surface of the lip at all, as it may be drawn from the open mouth of the furnace before it has been actually permitted to overflow the lip.

Figs. 9 to 13, inclusive, all show the plate of glass being drawn in a vertical direction, but it may be drawn horizontally, as indicated in Fig. 14, or it may be drawn at any desired angle from the horizontal, as indicated in Fig. 15.

During the intervals between the drawing operations it may be necessary to heat the molten glass in the receiving chamber 5, and this is accomplished by placing a suitable cover over the opening in the said chamber and the flames from the burners 12 turned on and those from the burners 10 increased.

The stretching action of the series of rollers 62, 62, serves to maintain the glass of an approximately constant or even width and thickness, and at the same time to impart to it that flatness of surface which is essential to drawn glass of this character. Moreover, it will be observed that the apparatus is so entirely simple and the control of it so readily effected, that the operation of drawing the glass may be effected with the minimum of expert labor, and the drawing operations may proceed or be repeated one after the other with great rapidity, while the glass can be removed from the bait after it has been taken away from the drawing apparatus by ordinary or unskilled labor.

It will also be observed that the drawn sheet of glass is separated with great facility from the mass of molten material in the receiving chamber or pot 5, this being due to the fact that the glass is permitted to drop away from the overflow lip or point over which the sheet is drawn, so that a very thin and insignificant amount of glass remains. Moreover, this method of procedure is superior to those processes wherein a measured or determinate amount of glass is contained in the receptacle sufficient for the drawing of a given sheet, since without any change of the apparatus or any measuring of the quantity of glass that is placed into the receptacle, sheets of varying thickness, and hence requiring different quantities of the molten glass for drawing the same, may be readily drawn, it only being necessary to adjust the stretching rollers and to properly manipulate the displacement block in the delivering chamber and control the speed of drawing or stretching to secure any desired thickness of sheet.

What is claimed is:

1. The improvement in the art of glass working which consists in drawing a sheet of glass in a longitudinal direction and simultaneously and constantly stretching the sheet in a lateral direction.

2. The improvement in the art of glass working which consists in drawing a sheet of glass in a longitudinal direction and simultaneously stretching the sheet at an acute angle to the line of draft, whereby the stretching action serves to assist in the drawing of the sheet of glass.

3. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten glass, maintaining the level of the molten mass approximately constant during the drawing operation, and stretching the sheet in a lateral direction as it is drawn.

4. The improvement in the art of glass working which consists in providing a mass of molten glass heated at the drawing point to a high temperature, drawing a sheet of glass therefrom, lowering the temperature of the sheet as drawn, and then constantly stretching the sheet in a lateral direction.

5. The improvement in the art of glass working which consists in providing a mass of molten glass heated at the drawing point to a high temperature, drawing a sheet of glass therefrom, lowering the temperature of the sheet by radiation as said sheet is drawn, and then constantly stretching the sheet in a lateral direction.

6. The improvement in the art of glass working which consists in drawing a sheet of glass, lowering the temperature of the sheet as drawn, and then constantly stretching the sheet in a lateral direction.

7. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten glass, maintaining the level of the molten mass approximately constant during the drawing operation, lowering the temperature of the sheet as drawn, and then stretching the sheet in a lateral direction.

8. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten glass, maintaining the level of the molten mass approximately constant during the drawing operation, lowering the temperature of the sheet as drawn, by radiation, and then stretching the sheet in a lateral direction.

9. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten material and constantly stretching the sheet in a lateral direction.

10. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten material and stretching the sheet in a lateral direction at an acute angle to the line of draft.

11. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten material, constantly stretching the glass laterally as drawn, causing the level of the molten mass to recede when the sheet is drawn the desired length, thereby leaving a thin film of glass at the end of the sheet adjacent to the molten mass, and then severing said film.

12. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten material, stretching the glass laterally as drawn, maintaining the level of the mass approximately constant during the drawing operation, causing the level of the molten mass to recede when the sheet is drawn the desired length, thereby leaving a thin film of glass at the end of the sheet adjacent to the molten mass, and then severing said film.

13. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten material, constantly stretching the glass laterally as drawn, lowering the temperature of the sheet as drawn, causing the level of the molten mass to recede when the sheet is drawn the desired length, thereby leaving a thin film of glass at the end of the sheet adjacent to the molten mass, and then severing said film.

14. The improvement in the art of glass working which consists in drawing a sheet of glass from a mass of molten material, stretching the glass laterally as drawn, maintaining the level of the mass approximately constant during the drawing operation, lowering the temperature of the sheet as drawn, causing the level of the molten mass to recede when the sheet is drawn the desired length, thereby leaving a thin film of glass at the end of the sheet adjacent to the molten mass, and then severing said film.

15. In a glass drawing machine, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, means laterally stretching the sheet as drawn, and connecting mechanism for operating said drawing and stretching means.

16. In a glass drawing machine, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, means laterally stretching the sheet as drawn, means lowering the temperature of the sheet as drawn, and connecting mechanism for operating said drawing and stretching means.

17. In a glass drawing machine, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, laterally stretching means, a cooling device interposed between said laterally stretching means and said receptacle, and connecting mechanism for operating said drawing and stretching means.

18. In a glass drawing apparatus, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, and laterally-stretching devices operating at an acute angle to the sheet-drawing means.

19. In a glass drawing apparatus, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, laterally-stretching devices operating at an acute angle to the sheet-drawing means, and means lowering the temperature of the sheet as drawn.

20. In a glass drawing apparatus, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, laterally-stretching devices operating at an acute angle to the sheet-drawing means, and means lowering the temperature of the sheet as drawn and located between said receptacle and stretching devices.

21. In a glass drawing apparatus, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, means maintaining the level of the glass in said receptacle approximately constant as the sheet is drawn, and means laterally stretching the sheet.

22. In a glass drawing apparatus, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, means maintaining the level of the glass in said receptacle approximately constant as the sheet is drawn, means laterally stretching the sheet, and means lowering the temperature of the sheet as drawn.

23. In a glass drawing apparatus, the combination of a receptacle for molten glass, with means for drawing a sheet of glass therefrom, means maintaining the level of the glass in said receptacle approximately constant as the sheet is drawn, means laterally stretching the sheet, and cooling devices located between said receptacle and lateral stretching means.

24. In a glass drawing apparatus, the combination of a receptacle for molten glass, and means for varying the level of the glass in said receptacle, with sheet-drawing devices, and laterally-operating sheet stretching devices.

25. In a glass drawing apparatus, the combination of a receptacle for molten glass, and means for varying the level of the glass in said receptacle, with sheet-drawing devices, laterally-operating sheet stretching devices, and a cooling device located between said receptacle and said stretching devices.

26. In a glass drawing apparatus, the combination of a receptacle for molten glass, sheet-drawing devices and laterally-operating sheet stretching devices, a power shaft and connections from said shaft to the drawing devices and to the stretching devices.

27. In a glass drawing apparatus, the combination of a receptacle for molten glass, sheet-drawing devices and laterally-operating sheet stretching devices, a power shaft, connections from said shaft to the drawing devices and to the stretching devices, and means for varying the speed of said shaft.

28. In a glass drawing machine, the combination of a receptacle for molten glass, sheet-drawing devices, laterally-operating stretching devices operating on the opposite faces of the sheet of glass, and connecting mechanism for operating said drawing and stretching devices.

29. In a glass drawing machine, the combination of a receptacle for molten glass, with sheet-drawing devices, laterally-operating stretching devices operating on the opposite faces of the sheet of glass, means for lowering the temperature of the sheet as drawn, and connecting mechanism for operating said drawing and stretching devices.

30. In a glass drawing machine, the combination of a receptacle for molten glass, with sheet-drawing devices, laterally-operating stretching devices operating on opposite faces of the sheet of glass, means for lowering the temperature of the glass, said means being located between said receptacle and said stretching devices, and connecting mechanism for operating said drawing and stretching devices.

31. In a glass drawing apparatus, the combination of a receptacle for molten glass, with sheet-drawing devices and laterally-operating stretching devices, said sheet-drawing and stretching devices being operated from a common power shaft and said stretching devices engaging opposite faces of the sheet of glass.

32. In a machine for drawing glass, the combination of a receptacle for molten glass, with sheet-drawing devices, laterally-operating stretching devices engaging the opposite faces of the sheet of glass and adjustable towards and from each other, whereby said stretching devices can accommodate themselves to the sheets of different thickness, and connecting mechanism for operating said drawing and stretching devices.

33. In a glass drawing apparatus, the combination of a receptacle for molten glass, with sheet-drawing devices, laterally-operating sheet-stretching devices engaging the sheet of glass on opposite faces, and means for adjusting said devices towards and from each other on parallel lines.

34. In a glass drawing apparatus, the combination of a receptacle for molten glass, with sheet-drawing apparatus, stretching rollers engaging the opposite faces of the sheet, frames supporting said oppositely disposed rollers, and means for adjusting said frames with their supported rollers from and towards each other.

35. In a glass drawing apparatus, the combination with a receptacle for molten glass, with sheet-drawing means, a plurality of laterally-operating stretching rollers located along each edge of one face of the sheet, a plurality of laterally-operating stretching rollers located along each edge of the opposite face of said sheet, frames for supporting said rollers, a power shaft and gearing connecting said shaft with said sheet-drawing means and with said stretching rollers.

36. In a glass-drawing apparatus, the combination of a receptacle for molten glass, and means for varying the level of the glass in said receptacle, with sheet-drawing devices, two roller bearing frames located along one edge but on opposite faces of the sheet, and two like frames located along the other edge but on opposite faces of the sheet, sheet-stretching rollers supported by said frames, and means for adjusting the frames lying on opposite sides of the sheet towards and from each other.

37. In a glass drawing apparatus, the combination of a receptacle for molten glass, and means for varying the level of the glass in said receptacle, with sheet-drawing devices, a pair of roller bearing frames located along one edge of the sheet but on opposite sides thereof, and another pair of roller-bearing frames located along the other edge of the sheet but on opposite faces thereof, rollers supported by the said several frames, a power shaft, gearing connecting said power shaft with the sheet-drawing devices and also transmitting power to the sheet-stretching rollers on said frames, and a cooling device located between said receptacle and stretching rollers.

38. In a glass drawing apparatus, the combination of the receptacle for molten glass, and means for varying the level of the glass in said receptacle, with sheet-drawing devices, a pair of roller-bearing frames located along one edge of the sheet of glass but on opposite faces thereof, and a like pair of roller-bearing frames located along the other edge but on opposite faces of the sheet of glass, laterally operating stretching rollers supported by said frames, means for adjusting the members of each pair of frames towards and from each other, a power shaft, and gearing transmitting motion from said shaft to said sheet-drawing devices and to said rollers, and means for reversing the direction of revolution of said shaft.

39. In a glass drawing apparatus, the combination of a receptacle for molten glass, and means for varying the level of the glass in said receptacle, with sheet-drawing devices operating in a right line, a pair of roller-bearing frames located adjacent to one edge of the sheet of glass but on opposite faces thereof, and a like pair of roller-bearing frames located adjacent to the other edge of the sheet of glass but on opposite faces thereof, rollers supported in said frames at an acute angle to the line of movement of said sheet-drawing devices, and means for simultaneously operating said drawing devices and said rollers.

40. In an apparatus for forming sheet glass, the combination of a receptacle for molten glass, a bait for drawing a glass sheet therefrom, and means for increasing the width of the sheet as it is drawn by the bait, whereby said bait and said means produce a sheet of uniform width.

41. In an apparatus for forming sheet glass, the combination of a receptacle for molten glass, a bait for drawing a glass sheet therefrom, and means for increasing the

width of the sheet adjacent to the ends of the bait during a part of the operation of the latter.

42. In an apparatus for drawing sheet glass, the combination of a receptacle for molten glass, a bait, and means for moving the bait away from said receptacle to draw a sheet with means coöperating with the edges of the sheet to increase the width of the latter as the sheet is drawn by the bait.

43. In an apparatus for drawing sheet glass, the combination of a receptacle for molten glass, a bait, and means withdrawing said bait from said receptacle to form a sheet, and means coöperating with the edges of the sheet to increase the width of the latter and located in operative proximity to the molten glass in the receptacle.

44. In an apparatus for drawing sheet glass, the combination with a receptacle for molten glass, a bait, and means withdrawing said bait from said receptacle to form a sheet, of means located adjacent to each edge of the sheet and operating to increase the width of the latter by stretching the same in opposite directions towards the edges.

45. In an apparatus for drawing sheet glass, the combination with a receptacle for molten glass, a bait, and means withdrawing said bait from said receptacle to form a sheet, of means coöperating with the edges of the sheet to increase the width of the latter in excess of the width of said sheet produced by the drawing operation of the bait.

46. In an apparatus for drawing sheet glass, the combination of a receptacle containing molten glass, means for drawing a sheet of glass therefrom, and means for increasing the width of the glass sheet at opposite edges and whereby the sheet is held to uniform width.

47. In an apparatus for drawing sheet glass, a receptacle containing molten glass, means for drawing glass therefrom in sheet form in a longitudinal direction, and means for simultaneously increasing the width of the glass as it is longitudinally drawn.

48. In an apparatus for drawing sheet glass, a receptacle containing molten glass, means for drawing glass therefrom in sheet form in a longitudinal direction, and a plurality of surfaces coöperating with the edge portions of the glass sheet to increase the width of the latter simultaneously with the longitudinal drawing action thereof.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

IRVING W. COLBURN.

Witnesses:
FRANCES L. KING,
A. R. OSMER.