Aug. 16, 1932. J. P. CROWLEY 1,872,415

GRINDING SHEET GLASS

Filed Sept. 23, 1921 5 Sheets-Sheet 1

FIG. 1

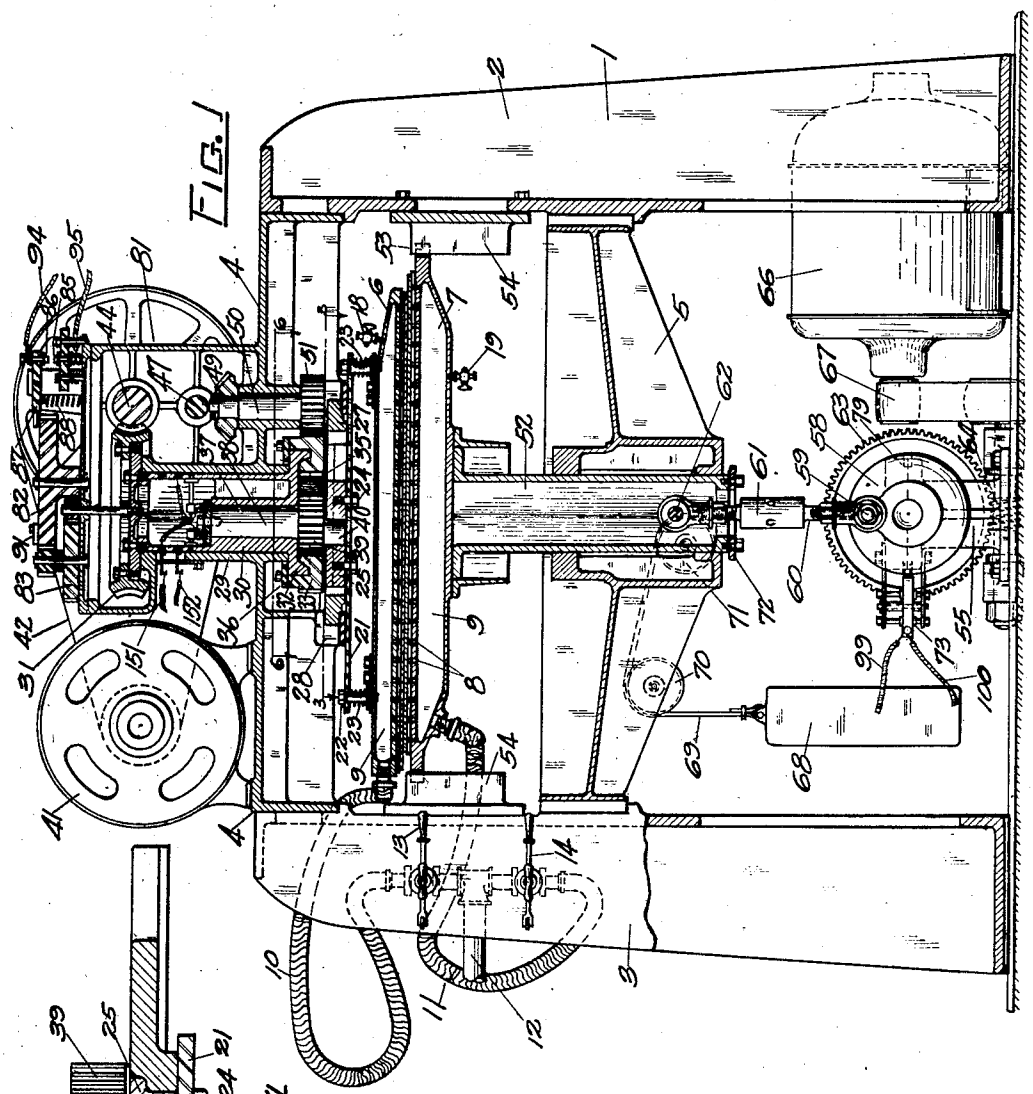


FIG. 4

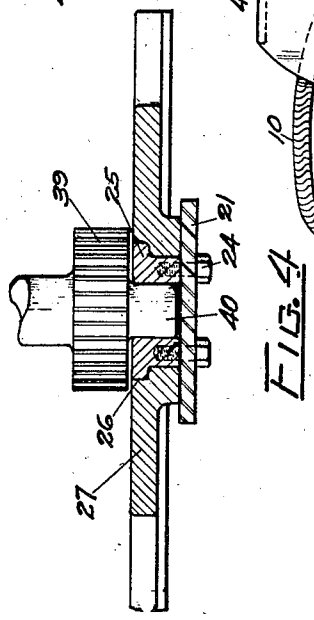
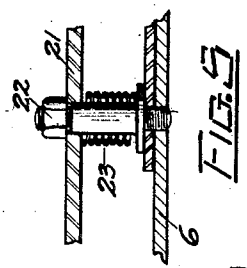


FIG. 5



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GRINDING SHEET GLASS

Filed Sept. 23, 1921 5 Sheets-Sheet 2

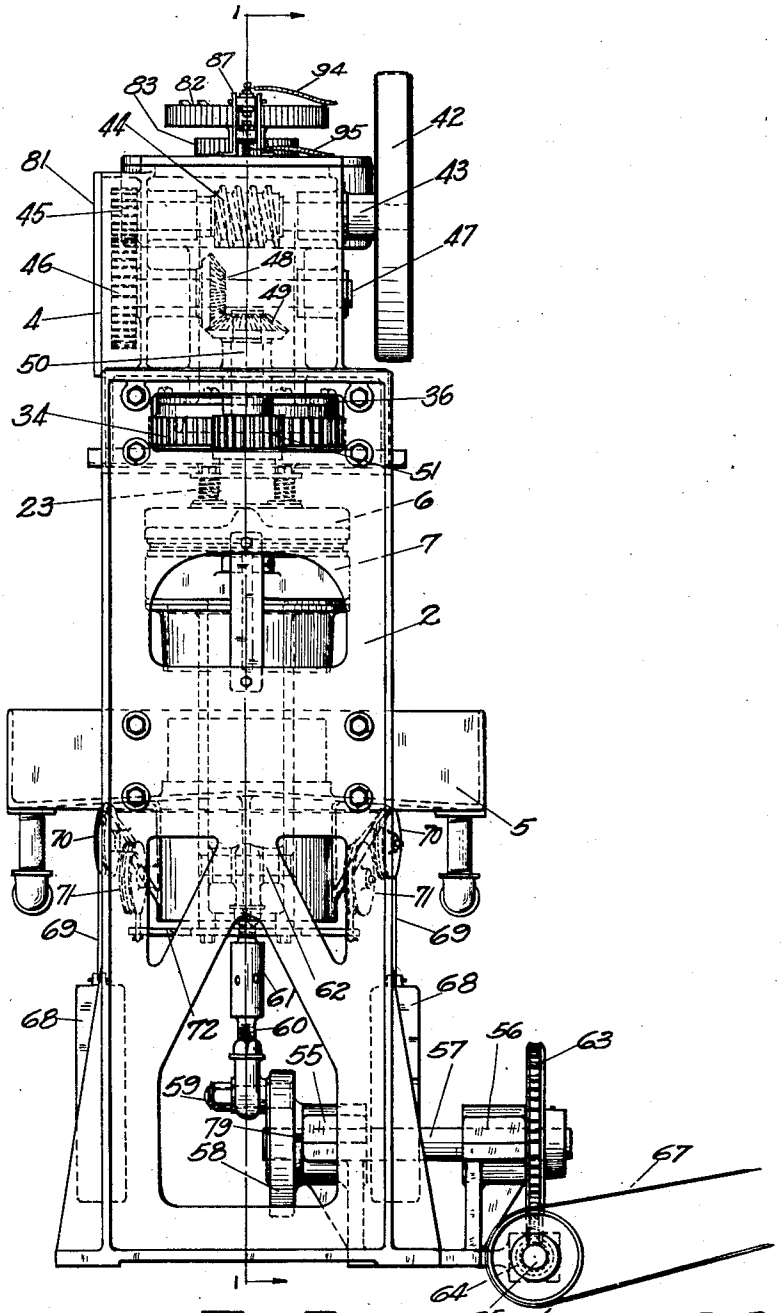

FIG. 2.

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GRINDING SHEET GLASS

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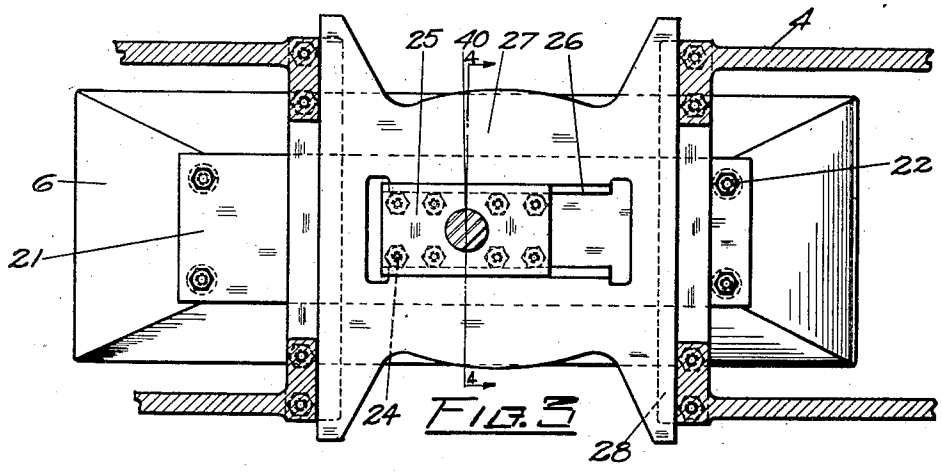

FIG. 5

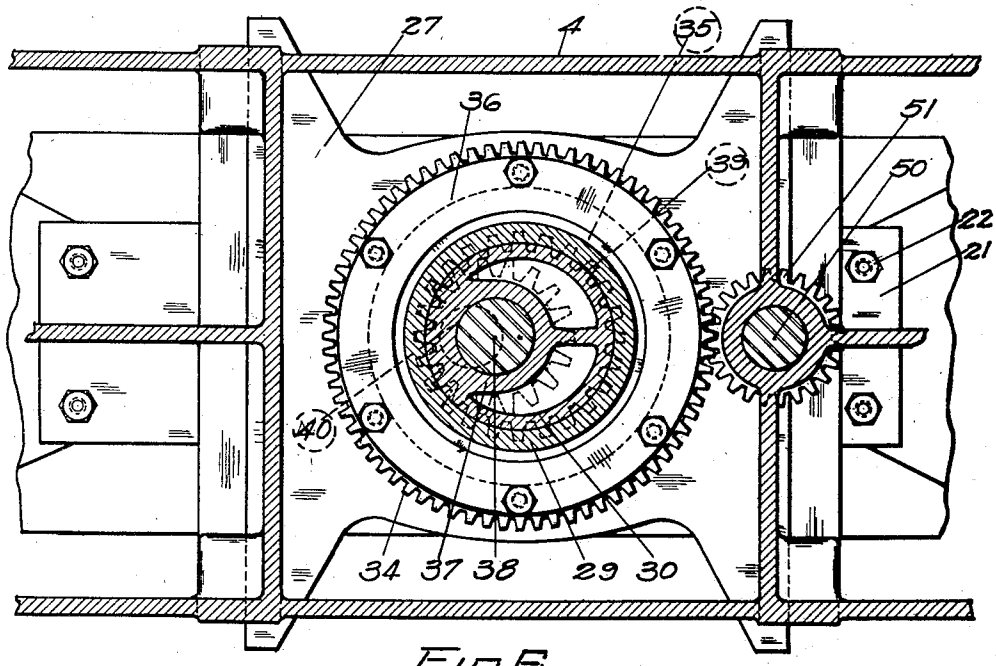

FIG. 6

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GRINDING SHEET GLASS

Filed Sept. 23, 1921 5 Sheets-Sheet 4

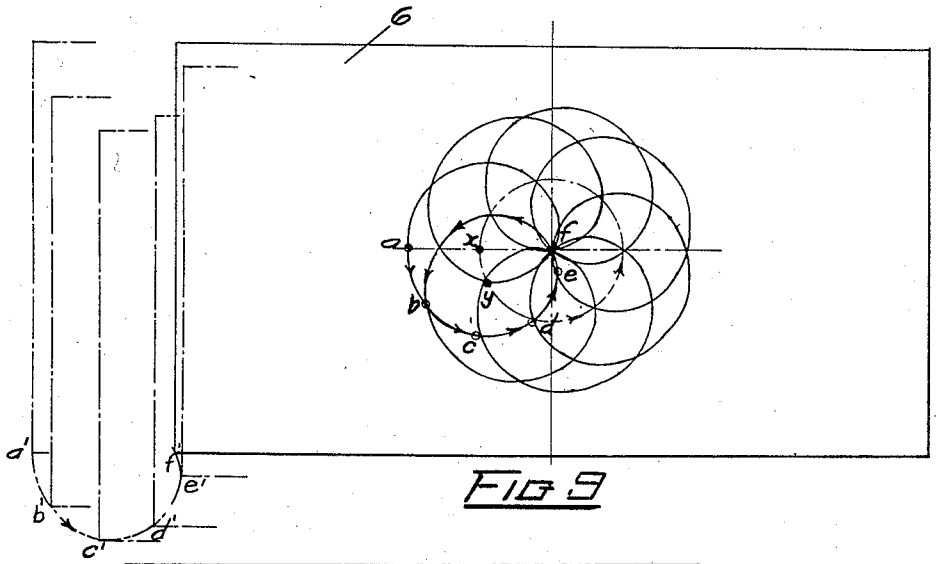

FIG 9

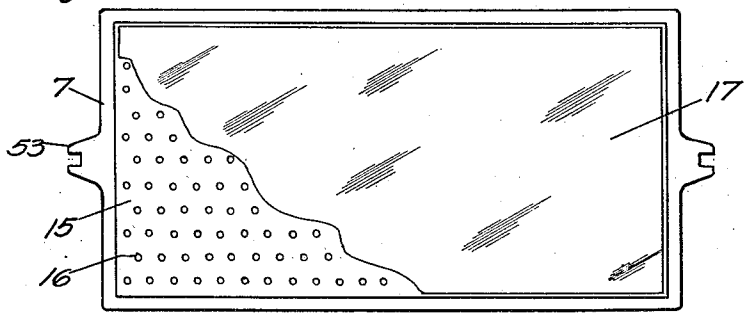

FIG 7

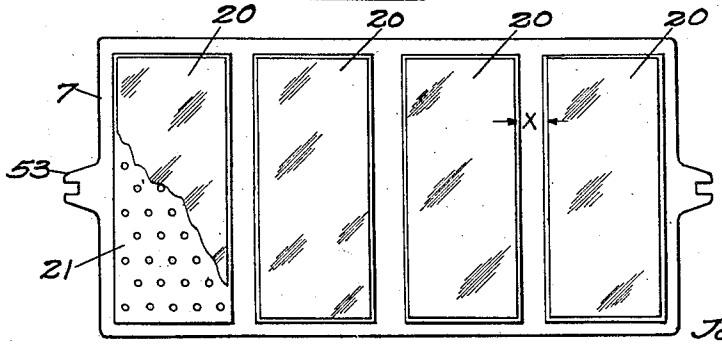

FIG 8

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GRINDING SHEET GLASS

Filed Sept. 23, 1921 5 Sheets-Sheet 5

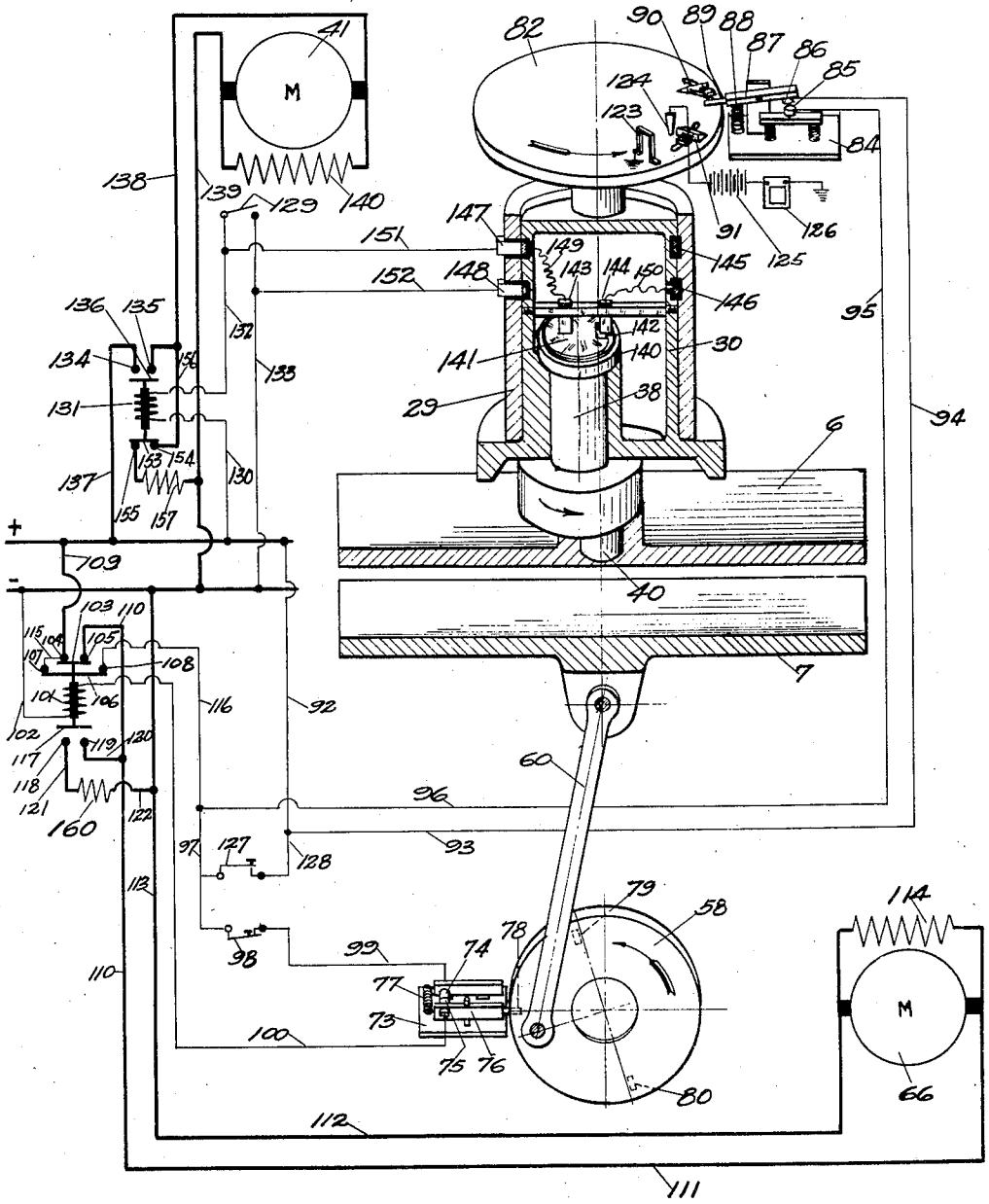

FIG. 10

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Patented Aug. 16, 1932 1,872,415

UNITED STATES PATENT OFFICE

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GRINDING SHEET GLASS

Application filed September 23, 1921. Serial No. 502,655.

This invention relates to a method of grinding sheet glass, to provide smooth, absolutely flat surfaces on the sheets.

In the usual sheet glass grinding system, a series of sheets are cemented to the top of a large rotary table, and over the top of this table a series of grinding tools are continuously moved which eventually smooth down the exposed faces of the sheets. It is then necessary to remove the sheets from the table turn them over, and repeat the operation to grind the other faces. This is necessarily a long and tedious process.

The principal aim of the present invention is to greatly shorten and simplify this grinding operation. In the system here disclosed, a pair of similar glass sheets, or a plurality of similar pairs, are ground one against the other, suitable abrasive being used between the two sheets. In this way the output of the machine is doubled, since each grinding operation produces two ground surfaces instead of one.

The machine for accomplishing this grinding process, comprises a pair of opposed sheet supporting tables, to which the glass sheets are held by suction. In this way the sheets are quickly inserted and held within the apparatus, and are easily removed. Furthermore, a sheet may be transferred from the lower to the upper table, or vice-versa, without removing the sheet from the machine.

A further object is to provide a mechanism for imparting to one of the sheets a lateral shifting movement in its own plane, whereby continually different surfaces of the two sheets will be brought in grinding contact.

A further object is to provide an automatically operable mechanism to separate the sheets at intervals, during which the ground glass may be washed off and the abrasive renewed, and again bring the sheets into grinding contact.

Another object is to provide an electric control system for the apparatus, whereby the parts may be stopped and started at the desired times and in the proper relative positions.

Other objects and advantages of the invention will become apparent as the following detailed description proceeds.

In the accompanying drawings:

Fig. 1 is a central longitudinal vertical section through the machine, taken substantially on the line 1—1 of Fig. 2, some of the parts however being shown in elevation. This is true of a portion of the left-hand side of the frame, on which the valves for controlling the vacuum are located.

Fig. 2 is an end elevation of the apparatus, looking from the right of Fig. 1.

Fig. 3 is a horizontal section, on an enlarged scale, taken substantially on the line 3—3 of Fig. 1. This view shows the slides which compel the sheet supporting table to remain parallel with fixed axes.

Fig. 4 is a vertical section through these slides, the section being taken substantially on the line 4—4 of Fig. 3.

Fig. 5 is a detail section through one of the spring supports for the upper table.

Fig. 6 is a horizontal section, on a still larger scale, taken substantially on the line 6—6 of Fig. 1.

Fig. 7 is a plan view of one of the sheet supporting tables. The glass sheet is partly broken away to reveal the holding platen therebelow.

Fig. 8 is a view similar to Fig. 7, of a modified form of table adapted to simultaneously hold a plurality of separate sheets.

Fig. 9 is a diagram to illustrate the shifting or grinding movement imparted to the upper sheet holding table.

Fig. 10 is a wiring diagram, certain portions of the machine being included rather conventionally in perspective.

The apparatus here shown and about to be described, is designed more particularly to grind comparatively small sheets, or lights, such as those used for small windows, or automobile wind-shields. The apparatus is more especially adapted for grinding drawn sheet glass, which is already comparatively flat and smooth, and does not require the removal of very much material. However, the principles illustrated are entirely applicable to a larger machine, and rolled or pressed sheet glass of any size could be ground in this way.

The supporting frame 1 may be of any suitable form to rigidly sustain the operating parts, and still permit as free access as possible to the grinding tables. As here shown it comprises a pair of similar end castings 2 and 3, sustained at their lower ends by a suitable floor support, and joined at their upper ends by a horizontal casting 4, which carries the grinding motor, and in which are journaled the various parts of the shifting mechanism for the upper table. Approximately midway their ends, the two castings 2 and 3 are joined by a second horizontal casting 5, which serves not only as a support for the lower table, but also acts as a drain-pan to catch the water and waste materials washed off from the tables and glass sheets during the grinding process.

The sheet holding tables 6 and 7 are mounted horizontally within this framework at such a height that they are easily accessible to a workman standing beside the machine. Each of these tables is a rigid metallic structure, having a flat plane sheet holding surface in which are a series of small holes 8, communicating with a chamber 9 within the table body. Flexible air-pipes 10 and 11, connect the tables 6 and 7 respectively with a main conduit 12 leading to a vacuum tank, in which a suitable vacuum is constantly maintained. Hand-operated valves 13 and 14, mounted in an accessible position on the frame 3, control the connections to the vacuum tank, whereby the air may be partially exhausted at will from either or both of the tables 6 and 7. The sheet holding faces of the two tables 6 and 7 are substantially identical, and each is provided, (Fig. 7), with a cover or platen 15 of rubber or similar material. This platen is provided with a series of holes 16, registering with the holes 8 in the table, and the suction through these holes 8 and 16, serves to securely hold the glass sheet 17 against the table face during the grinding operation, or as long as the vacuum connection with the table is maintained. The rubber platen 15 will give sufficiently to allow uneven or "wavy" glass to be held thereagainst without breakage, and at the same time aids in establishing an air-tight connection with the glass sheet. The tables 6 and 7 are provided with relief-valves or pet-cocks 18 and 19, the valve 19 also serving as a drain for the water that may work in to the lower table through the holes in the sheet supporting surface.

The tables 6 and 7 may be constructed as in Fig. 7, where only a single pair of sheets are to be ground, or may be of the form shown in Fig. 8, which is designed to simultaneously grind four pairs of sheets 20. In this case, separate platens 21 for each sheet may be used, or a single large platen, such as 15 in Fig. 7, may be used, the transverse rows of holes lying between the several pairs of sheets being omitted or plugged up. In any case it is to be understood that the shape of the table top here shown is merely illustrative. These tables might be made larger, smaller, longer or wider, or designed to hold any number of sheets of any size or shape, without necessitating any variation in the operating mechanism now to be described.

When the holding tables are designed to carry a plurality of sheets as in Fig. 8, the distance x between any two sheets is always greater than the extreme amplitude of the shifting movement of the movable table (as hereafter described), so that each sheet on the movable table grinds against and contacts with only its companion sheet on the fixed table, and never touches any other sheet.

The upper, shifting, or grinding table 6 is suspended from a plate 21, by a series (here shown as four) of bolts or pins 22, (see Fig. 5), there being compression springs 23 surrounding the bolts between the table and the supporting plate. The upper ends of bolts 22 slide freely through the plate 21, so that the table 6 may always adjust its lower flat face to the corresponding upper surface of table 7. When table 7 is elevated to operating position, as later described, table 6 rests thereon by its own weight together with the added pressure of springs 23.

The table-carrying plate 21 is rigidly secured to, as by screw-bolts 24, and travels with, a slide-plate 25, which is mounted to reciprocate in slideways 26 in a second plate 27, which in turn reciprocates at right-angles to plate 25, in slide-ways 28 in the frame-member 4. The slide 25 allows a movement of translation of the table 6 along its longer axis, whereas slide 27 allows a movement of translation along the shorter or transverse axis of the table 6. Since the two slides may operate simultaneously at the same or different speeds, a combined movement of translation in its own plane in both directions may be imparted to the table, thus giving it a bodily shifting movement through any curved path, within the limits allowed by the travel of the slides. At the same time these slides prevent any turning or twisting movement of the table, its respective edges always remaining parallel with their initial position, in which they are parallel with, and coincide as closely as possible with, the edges of the lower table 7.

As one approved means of shifting this table 6 through a closed curved path, which will bring constantly changing portions of the two glass sheets into grinding engagement, the following system of planetary gearing has been provided. Mounted centrally of the machine in a vertical bearing 29 in frame member 4, is a partially tubular sleeve-member or hollow column 30. Secured to the upper end of sleeve 30, beyond the bearing 29, is a driving worm-gear 31. Carried by an out-

wardly flaring flange 32, at the bottom of the sleeve 30, below bearing 29, is an annular or ring gear 33, having an outer set of teeth 34, as well as a set of internal teeth 35. This annular gear 33 is held in position around the flange 32, by the annular flange-ring 36, as shown in Figs. 1 and 6. Journaled in an eccentric boss 37, within the sleeve 30, is a vertical stub-shaft 38. Secured to the lower end of stub-shaft 38 is a gear 39 which meshes with the internal teeth 35 of annular gear 33. This gear 39 has an eccentric driving pin or projection 40, which is journaled in and imparts motion to the slide 25, already described. Preferably, for reasons later set forth the eccentricity of pin 40 with respect to gear 39 is just equal to the eccentricity of stub-shaft 38 with respect to sleeve 30. In this way, once during each revolution of pin 40, it will be centered with the sleeve 30. When pin 40 is in this centered position, the edges of tables 6 and 7 are in vertical alignment, that is the faces of the two tables, and hence of the glass sheets carried thereby, practically coincide.

Motion is imparted to the gearing just described from an electric motor 41, preferably mounted on frame 4, and connected by belt 42 with drive shaft 43. This shaft 43 carries a worm 44, meshing with and driving the worm-wheel 31 on sleeve-member 30. Shaft 43 also carries a spur-gear 45, driving a similar gear 46, on horizontal shaft 47, which carries bevel-gear 48, driving bevel-gear 49 on the vertical shaft 50. Shaft 50 carries a spur-gear 51, meshing with and driving the external teeth 34 on annular gear 33. In this way, shaft 38, and pin 40, are each caused to revolve through different orbits and at different speeds but in the same direction. Shaft 38, being eccentrically mounted in sleeve 30, revolves about the axis of the sleeve. Pin 40 revolves in a circle of similar radius, about the axis of shaft 38. The worm drive 44 and 31 for sleeve 30, has such a speed relation to the train of gears 45, 46, 48, 49, 51, 33 and 35, which rotate gear 39, that, in the example here shown, the pin 40 will make seven revolutions about the axis of shaft 38, while shaft 38 is making one revolution about the axis of sleeve 30. This ratio of speeds is only illustrative, the only requisite being that the shaft 38 revolves considerably slower than the pin 40.

Since pin 40 revolves about the axis of shaft 38, while shaft 38 is also revolving about a different fixed center, it will be apparent that a compound rotative movement is imparted to the pin 40, and hence to all points on the shifting table 6. The curved path followed by this pin 40 is indicated in the diagram shown in Fig. 9. The outline of table 6 is also indicated in this diagram, although it must be understood that the motion curve is enlarged out of proportion to the table 6, as here shown. In this Fig. 9, the solid line outline indicates the position of table 6 when it is centered and in vertical alignment with the lower table 7. Let us assume first that the table 6 and associate parts are in the relative positions indicated in Figs. 1, 3 and 6. The shaft 38 and pin 40 are now at the extreme left-hand limit of their movement, as seen in Fig. 1, and the centers of pin 40 and shaft 38 lie along the longitudinal center line of the tables. The longitudinal edges of tables 6 and 7 are now in vertical alignment, but table 6 projects beyond table 7, to the left, a distance equal to the combined eccentricities of pin 40 and shaft 38. In Fig. 9, the position of the axis of pin 40 is indicated at a, the outline of the left-hand end of table 6 is indicated in dotted lines at a', and the axis of shaft 38 will be located at x. As the parts move in the direction of the arrows, pin 40 will pass through the successive positions a, b, c, d, e and f, while the corresponding positions of table 6 are indicated at a', b', c', d', e', and f', respectively. When the pin 40 reaches the position f, it is centered with the axis of sleeve 30, and the outlines of tables 6 and 7 now coincide, as indicated at f'. While this movement of pin 40 has been taking place, shaft 38 has moved from the position x to the position y. Consequently the next revolution of pin 40 will take it along a different path from the preceding revolution as the center about which it revolves is also advancing along a circular path. As the edges, or axes, of the table 6 always remain parallel to their initial position, it will be apparent that each and every point on the table 6, has the same and equal movement through space, along parallel paths, the path of each point being that indicated for the pin 40. In this way continually changing portions of the glass sheets carried by the tables 6 and 7 are brought into grinding contact. It will here be noted that once during each revolution or loop of pin 40, its axis coincides with that of sleeve 30, and hence the tables 6 and 7 are lined up once during each loop, although this is the only point or position that the successive loops have in common. It is desirable, although not absolutely necessary, that the two tables be in vertical alignment whenever the operating or moving parts are stopped, and mechanism is provided, which will be described later, for compelling the table 6 to stop when the power is shut off, at the next succeeding time when pin 40 reaches that point in the loop when it lies in the axis of sleeve 30. At this time the tables will be in alignment.

Before describing the control mechanism just referred to, the mechanism for automatically raising and lowering the lower table 7, will be described. As here shown, the table 7 is supported on a rather large column 52, which slides vertically in bearings in the frame member 5. Fingers 53 at the ends of

the table, also have sliding bearing on the vertical tracks or flanges 54, on end frame members 2 and 3. These fingers prevent rotative movement of the lower table 7, and also assist in holding the table rigid and preventing tilting thereof. Mounted in suitable horizontal bearings 55 and 56 projecting up from the floor support for the machine, is a shaft 57 carrying at one end a crank-disc 58. The crank-pin 59 on this disc is connected with the column 52, by a pitman 60, whose length is adjustable by means of turnbuckle connection 61. The pitman has bearing at its upper end on a wristpin 62, within the column. At the other end of shaft 57 is keyed a worm-wheel 63, meshing with and driven by a worm 64 on a horizontal shaft 65, which is driven from electric motor 66, through belt 67. When the crank and pitman are at their upper dead-center, the table 7 will be raised to its extreme upper portion so that the glass sheet thereon will be held in grinding contact with the sheet on upper table 6. When the crank and pitman are at the lower dead-center, the table 7 will be lowered away from table 6, so that free access may be obtained to both sheets of glass. By means of motor 66 and the train of gears last described the table 7 may be moved to or from operative position at any time. Counterweights 68, for balancing the weight of the table 7 and column 52, are suspended by cables 69 passing over pulleys 70 and 71, and connected to the plate 72 at the lower end of column 52.

It is desirable that, after the grinding operation has continued for a short time, the glass sheets be separated for an interval while the ground glass and worn abrasive is washed away and new abrasive, of perhaps a different grade, applied. Automatic stopping and starting mechanism for the motor 66, controlled from the shifting mechanism for upper table 6, is provided, whereby this separation, and return to grinding position, will be accomplished at fixed intervals. Referring to Figs. 1, 2 and 10, a normally closed switch 73, is located adjacent the disc 58. This switch comprises a fixed contact point 74, and a movable contact 75, carried by a lever 76, the contacts normally being held together by spring 77, connecting one end of lever 76 with a fixed portion of the switch. A projecting portion 78 at the other end of lever 76, lies in the path of either of two cams 79 and 80 carried by disc 58. Whenever either of cams 79 or 80 snaps past the projection 78, the circuit passing through contacts 74 and 75 will be momentarily broken.

At the top of the machine, above the housing 81, which encloses the shifting gearing for the upper table, is rotatably mounted a disc or gear 82, which is driven at a quite slow speed, from the table shifting mechanism. Preferably it is driven from the sleeve 30, through appropriate reducing gearing 83. Mounted adjacent this disc is a normally open switch 84, comprising fixed contact 85 and movable contact 86 carried by the switch lever 87. One end of lever 87 is normally held down by spring 88, and a projection 89 at the same end of the lever lies in the path of a pair of cams 90 and 91, which are adjustably fixed to the upper surface of disc 82. Whenever either cam 90 or 91 comes under the end 89 of lever 87, the switch will be closed by bringing together contacts 85 and 86, but this connection will be broken again by spring 88 as soon as the cam passes from beneath the projection 89.

In the wiring diagram shown in Fig. 10, only the main features of the wiring connections have been indicated, some of the starting rheostats and resistances having been omitted for the sake of clearness. At 66 is indicated the motor already described for rotating the crank-disc 58 to raise and lower table 7. The shunt-field of motor 66 is indicated at 114, and 160 is the resistance coil of a dynamic brake for this motor. Let us assume that table 7 is held up against table 6, and that the table 6 is being given its shifting grinding movement in its own plane. The disc 82 will now be slowly rotating in the direction of the arrow and cam 90 will eventually come under the projecting end 89 of switch-lever 87 and close the switch contacts 85, 86. A control circuit will now be established as follows: from the positive main through wire 92, wire 93, wire 94, contacts 86, 85 of switch 84, wires 95, 96 and 97, normally closed push-button switch 98, wire 99, contacts 74 and 75 of the normally closed switch 73, wire 100, coil 101 of the switch-operating solenoid, and wire 102 to the negative main. Now that magnet-coil 101 is energized, the core of the solenoid will be elevated (against the action of a spring not shown, which assists the weight of the core to maintain it in lowered position when the magnet coil is deenergized), and by means of contact plate 103 bridges the two contacts points 104 and 105, and also independently closes by means of plate 106. the circuit through contacts 107 and 108. The main motor circuit is now completed as follows: from the positive main through wire 109, contact 104, plate 103, contact 105, wires 110 and 111, motor 66, wires 112 and 113 to the negative main. Since the shifting mechanism for the upper table 6 is running continuously, the cam 90 will almost immediately pass out from under the projection 89, and the operating control circuit will be broken at 85, 86. This would allow the solenoid to drop and cut off the supply current to the motor 66. To prevent this a shunt circuit through the magnet coil 101 of the solenoid is established as follows: from the positive main, through wires 109 and 115, contact 107, plate 106, contact 108, wires 116 and 97, and thence as be-

fore through 98, 99, 74, 75, 100, 101, 102 to the negative main. By means of this parallel circuit the solenoid will be maintained in its upper operative position after the first established circuit is broken at 85, 86. Crank-disc 58 will now be rotated in the direction of the arrow, by motor 66, and the table 7 will be lowered away from table 6. As shown in Fig. 10 the table 7 is thus being lowered. At the time that pitman 60 reaches its lower dead-center on crank-disc 58, and table 7 is in its lowermost position, the cam 79 on disc 58 will pass momentarily under projecting end 78 of switch-lever 76 and break the circuit last described at 74, 75. Coil 101 being de-energized, the solenoid will now drop breaking both the control circuit and the main motor circuit at the points 107, 108 and 104, 105. At the same time the contact plate 117, at the lower end of the solenoid core will bridge the contacts 118 and 119, thus short circuiting the motor armature through the resistance 160 as follows: from motor 66, through wires 111, 110, 120, contact 119, plate 117, contact 118, wire 121, resistance 160, wires 122, 113 and 112 back to motor 66. As is well-known in the action of dynamic brakes, this throws an electrical load on the motor 66 (now acting as a dynamo), and this load almost instantly overcomes the momentum of the moving parts and stops the motor.

Table 7 will now remain in lowered position for an interval of time sufficient to wash off the ground glass and abrasive and apply new abrasive. The length of this period may be regulated by adjusting the distance between the cams 90 and 91 on the disc 82. When cam 91 comes under the end 89 of switch lever 87, the contacts will be again closed at 85 and 86. It should be noted that before the table 7 was stopped in its lowered position, the cam 79 has passed completely under the lever-end 78, and switch 73 was again in its normally closed condition. The first described control circuit is now again completed, the motor 66 is again supplied with current, and the table 7 will be raised to its operative position. Just before it reaches this upper position the control circuit is again broken by cam 80 snapping under switch-lever end 78, and opening the contacts 74, 75. This again allows the solenoid to drop, opens the control circuit and the main motor circuit, and applies the dynamic brake. Since the pitman 60 is now at its upper dead-center position the table 7 will be held up against the table 6 for a grinding period determined by the length of the long arc between cams 91 and 90 on disc 82, and also by the ratio of the reduction gearing used between the sleeve 30 and the disc 82. Both of these may be varied to give the desired duration to the grinding period.

Conveniently placed on and adjacent to the disc 82, are a pair of contact devices 123 and 124. The contact 123 on the disc may snap under the spring contact 124, and the parts are so placed that this contact will take place a few seconds before cam 91 engages switch lever 87 to close the control circuit and raise table 7 to its upper position. A circuit from a battery 125 passes through a buzzer 126, or other suitable device, and through the contacts 123 and 124, the two ends of the battery circuit being grounded on portions of the machine, all as indicated near the top of Fig. 10. This buzzer acts as a warning signal to the operator, that the tables 6 and 7 are about to be brought into grinding contact, so that the operator's hands, and any tools that may be used, can be removed, and accidents avoided.

In order that the raising and lowering motor 66 may be started or stopped at any time, regardless of the automatically operating circuits just described, the manually operated switches 127 and 98 are provided. The switch 127 is normally open but may be momentarily closed by means of a push-button. The switch 98 is normally closed but may be momentarily broken or opened by means of a push-button. When switch 127 is closed, a circuit is established from the positive main, through wires 92, 128, switch 127, wire 97, switch 98, and thence through 99, 74, 75, 100, 101, 102 and the negative main, as before. This will start the motor, in the same way that switch 84 starts the motor. It will be noted that the control circuit in all cases passes through the switch 98, so that whenever this switch is opened the control circuit is broken. In this way the motor may be stopped at any time regardless of the position of the parts.

A somewhat similar operating circuit is provided for the motor 41, which drives the shifting mechanism for the upper table 6. This motor is started by closing the hand-switch 129. A control circuit is then established from the positive main through wire 130, starting-solenoid coil 131, wire 132, switch 129, wire 133 to the negative main. The starting solenoid now being energized will be raised and will bridge the contacts 134 and 135 by means of plate 136. The motor circuit will now be established from the positive main through wire 137, contacts 134, 135 and plate 136, wire 138, motor 41 (also shunt field 140 of this motor), and wire 139 to the negative main.

As already stated, it is desirable that whenever the table 6 is stopped in its shifting or grinding movement, it should be centered, or be in vertical alignment with the lower table 7. At the upper end of stub-shaft 38 is secured a disc 140, carrying a circular contact plate 141, which is broken away at one point as at 142, this break being in line with the pin 40. A pair of brushes 143 and 144 continuously bear upon this contact plate

141, the brushes being carried by the sleeve or column 30. Brush 143 is continuously in contact with the plate 141, but brush 144 passes out of contact every time the break 142 comes under this brush, which is positioned further from the center of shaft 38 than brush 143. A pair of annular contact rings 145 and 146 are embedded in suitable insulation in the outer surface of sleeve 30, and a pair of brushes 147 and 148, carried by journal-bearing 29, continuously bear on these rings. Ring 145 is joined to brush 143 by lead 149, whereas ring 146 is joined to brush 144 by lead 150. Wire 151 connects brush 147 with wire 132, while wire 152 connects brush 148 with wire 133. It will be seen that a shunt is formed around hand-switch 129, through wire 151, brush 147, ring 145, wire 149, brush 143, contact plate 141, brush 144, wire 150, ring 146, brush 148 and wire 152. Although this shunt circuit is broken every time break 142 in plate 141 comes under brush 144, this will have no effect on the control circuit as long as switch 129 is closed. Suppose now that at any time it is desired to stop the table 6. Switch 129 is opened. This will not immediately break the control circuit, unless break 142 happens at this time to be under brush 144. Otherwise the control circuit will be maintained through this shunt until the break 142 comes under brush 144. At this time, pin 40 is on the axis of sleeve 30 and the tables 6 and 7 are in vertical alignment. Now, since both shunt circuits are broken, the control circuit through solenoid coil 131 will be broken and the solenoid will drop, breaking the main motor circuit. At the same time, contact plate 153 at the bottom of the solenoid core will bridge the contacts 154 and 155. The motor 41, now running as a dynamo due to the momentum of the moving parts will be short-circuited across the following load: from the motor through wires 138 and 156, contact 154, bridge 153, contact 155, resistance 157 of the dynamic brake, wire 139 back to the motor 41. This load will almost instantly stop the motor. Of course, the motor may be started again by closing switch 129, regardless of the fact that the shunt circuit through plate 141 is now broken. As shown in the diagram of Fig. 10 the motor 41 has been stopped and the table 6 is in centered position.

When the grinding operation is to be started, the machine being stopped with the tables separated, a pair of similar sheets of glass are inserted, one against each table face, and are secured in place by turning on the vacuum, by means of valves 13 and 14. Suitable abrasive mixture is now applied to the surface of one or both of the sheets, and the switch 129 is closed to start the motor 41, which gives the grinding motion to upper table 6 and the sheet of glass carried thereby. When cam 91 closes switch 84, the lower motor 66 will bring table 7 and the glass sheet carried thereby, up into grinding engagement with the upper sheet. The grinding operation will continue for a predetermined interval, when the sheets will be automatically separated for a short period, during which they can be washed off if desired and new abrasive applied, and then they are automatically returned to grinding position and the grinding operation is renewed. This cycle of events is repeated automatically until the sheets have been ground down to the required fineness, when the operation is stopped by opening switch 129, preferably just after the table 7 has been lowered. One of the sheets, for example the upper one, is now removed after the vacuum has been released by opening valve 13, (or pet-cock 18). By pressing button 127, the tables are now brought together, and by manipulating the vacuum-control levers 14 and 13, the vacuum is cut off from the lower table 7 and supplied to the upper table 6, this operation transferring the remaining sheet from the lower table to the upper table. A pressure on switch-button 127 will now lower table 7 again, so that a new unground sheet may be applied to the lower table. We now have a sheet on the upper table whose upper surface has been ground and whose lower exposed surface is still unground. The lower sheet is unground on both sides. The grinding operation is renewed by closing switch 129, and after another series of grinding cycles have been accomplished we will have a completely ground sheet (that is, ground on both sides), on the upper table, and a sheet ground on its upper side only on the lower table. The completely ground sheet is now removed and the lower sheet transferred to the upper table as already described, and a new unground sheet inserted therebeneath. This series of operations may be continued indefinitely, and it will be noted that each time an unground sheet is inserted, a finished sheet ground on both sides, is removed. The process of removing and transferring the sheets may be accomplished very rapidly, and the complete grinding operation for a pair of sheets of drawn sheet-glass will require but a few minutes. If the tables are of the form shown in Fig. 8, for simultaneously grinding a plurality of pairs of sheets, the cycle of operations will be the same, except that each time a change of sheets is made, the upper sheet of each pair is removed, the remaining sheets are then simultaneously transferred to the upper table, and a series of new sheets inserted upon the lower table. Of course, it is obvious that this operation could be reversed, and the finished sheets removed from the lower table and the new sheets applied to the upper table. Or, if only a single pair of sheets are required, these sheets may be

ground on one side, both removed and reversed, and their other sides ground, thus simultaneously completing the two sheets.

By means of this system and apparatus, sheet-glass, and especially drawn sheet-glass, which already has fairly flat surfaces, may be quickly and easily ground down till both surfaces are smooth and absolutely flat. Very little polishing is afterwards necessary to produce excellent plate-glass.

It should be understood that the specific form of apparatus here shown is merely one good example of a mechanism for carrying out the principles of this invention, and that many changes in the form and proportion of the various parts may be made without departing from the scope of the invention as set forth in the following claims. As an illustration, the motor-brakes need not be of the "dynamic" type, (although these have proven very efficient), but any form of electrically controlled brake could be used. For example, spring-applied brakes could be used on the armature-shaft, the brakes being held off when the motor is in operation by magnets or solenoids in series with the motor circuit. Such a brake is well-known and needs no further disclosure.

I claim:

The continuous method of grinding glass sheets in a mechanism wherein two sheets are held in grinding contact by a pair of opposed sheet supporting tables, each table removably holding one of the sheets, consisting in separating the tables, removing the completely ground sheet, bringing the tables together, transferring the sheet between the tables from one table to the other, so that its unground face is now unattached, separating the tables, inserting an unground sheet on the unoccupied table, bringing the tables together, and imparting grinding movement to one of the tables, and again separating the tables, whereby one sheet is now completely ground and ready for removal, and the other sheet is ground on one side and ready for transfer to the other table.

Signed at Toledo, in the county of Lucas, and State of Ohio, this 21st day of September, 1921.

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