

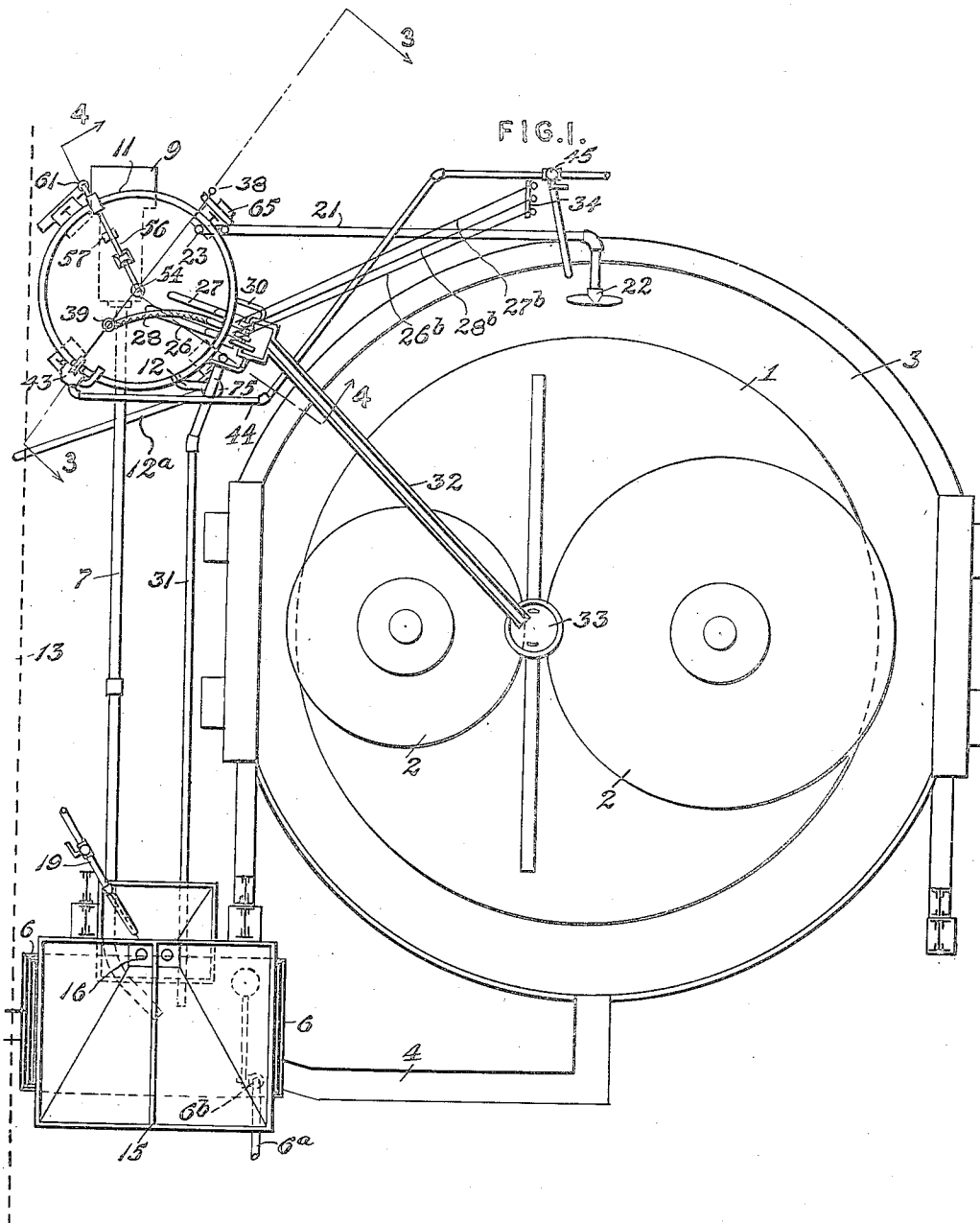
H. K. HITCHCOCK.
 APPARATUS FOR APPLYING ABRASIVES TO GRINDING MACHINES.

1,281,371.

APPLICATION FILED DEC. 31, 1913.

Patented Oct. 15, 1918.

5 SHEETS—SHEET 1.



WITNESSES

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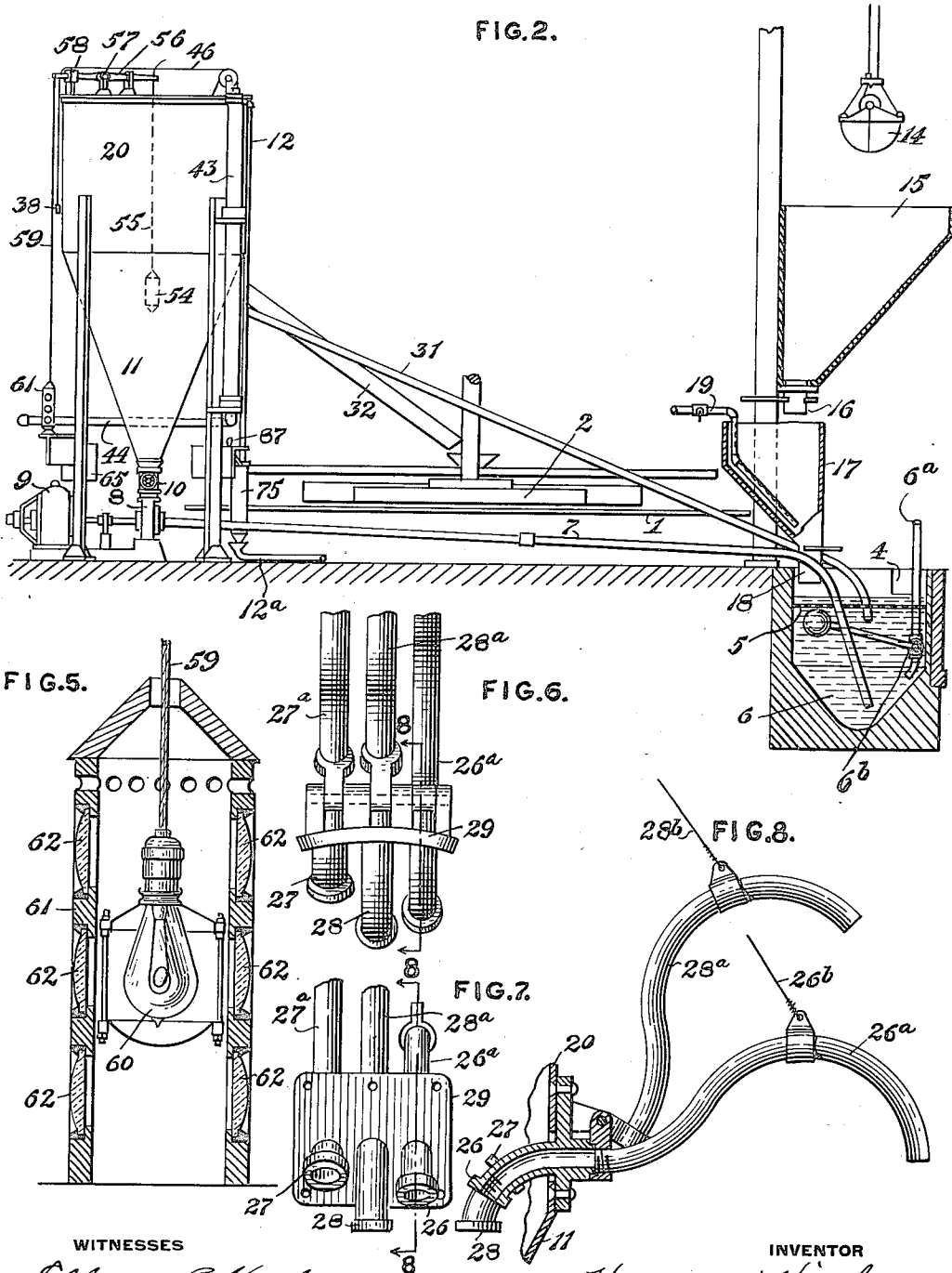
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5 SHEETS—SHEET 2.



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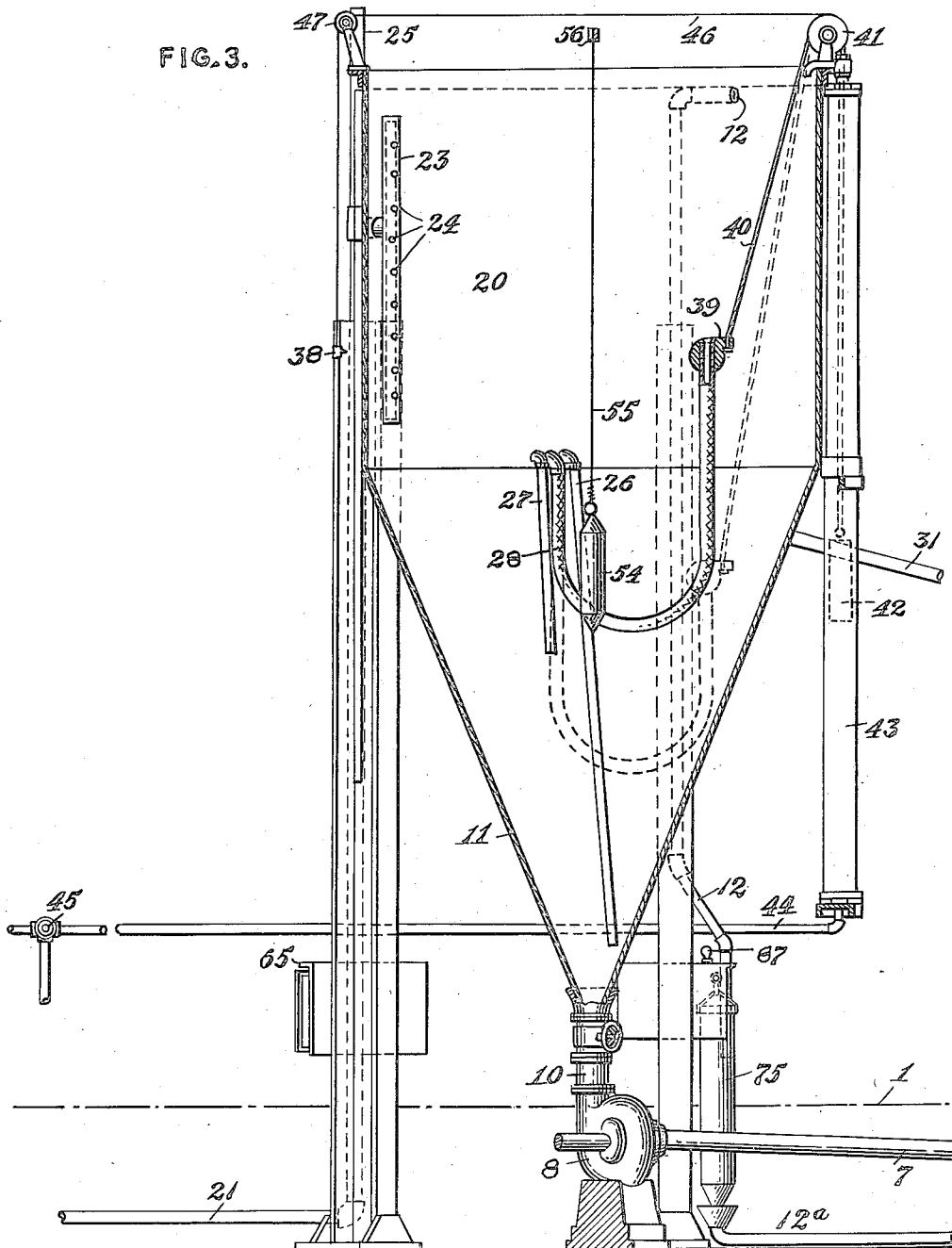
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5 SHEETS—SHEET 3.



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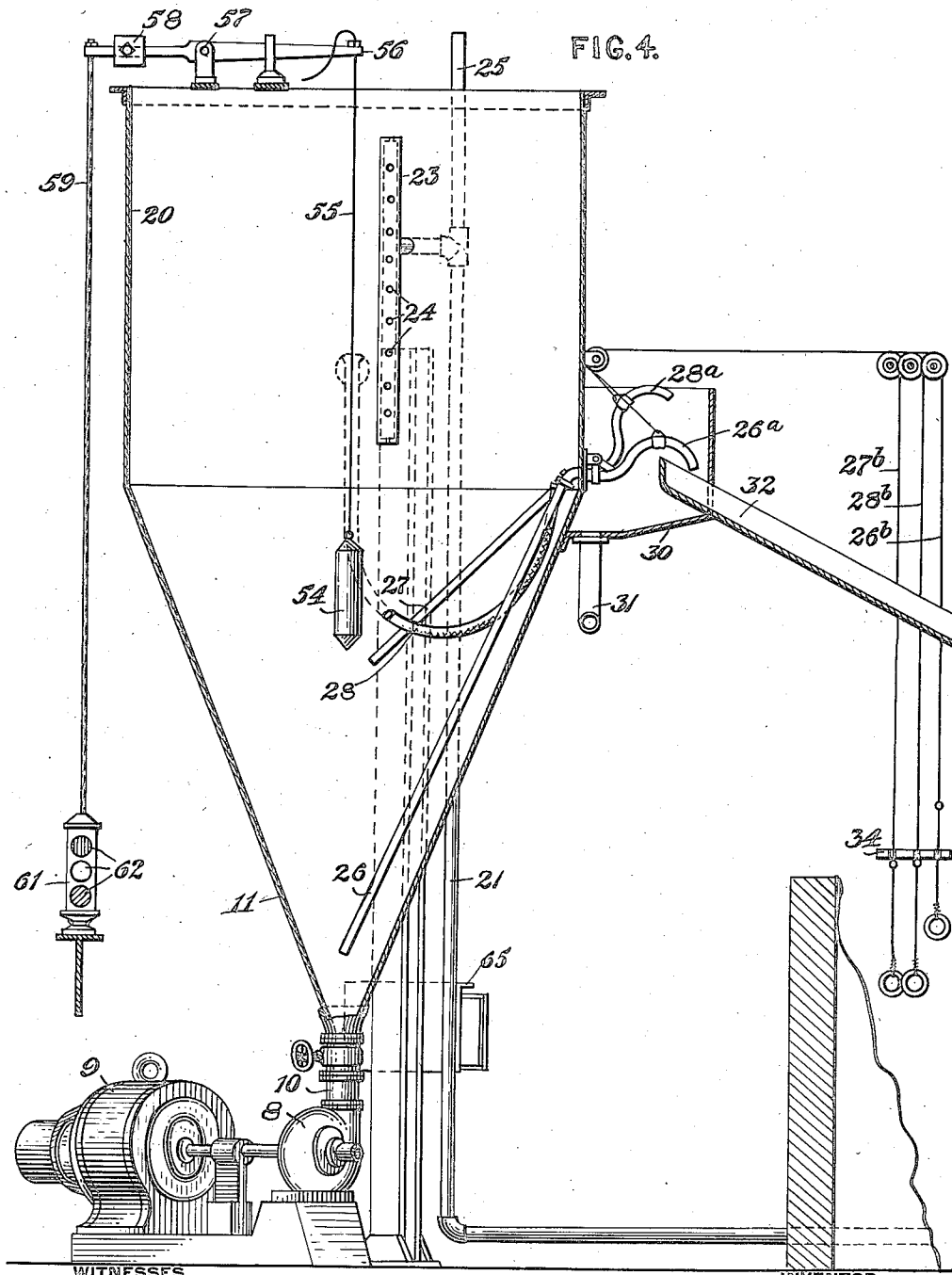
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5 SHEETS—SHEET 4.



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 5 SHEETS—SHEET 5.

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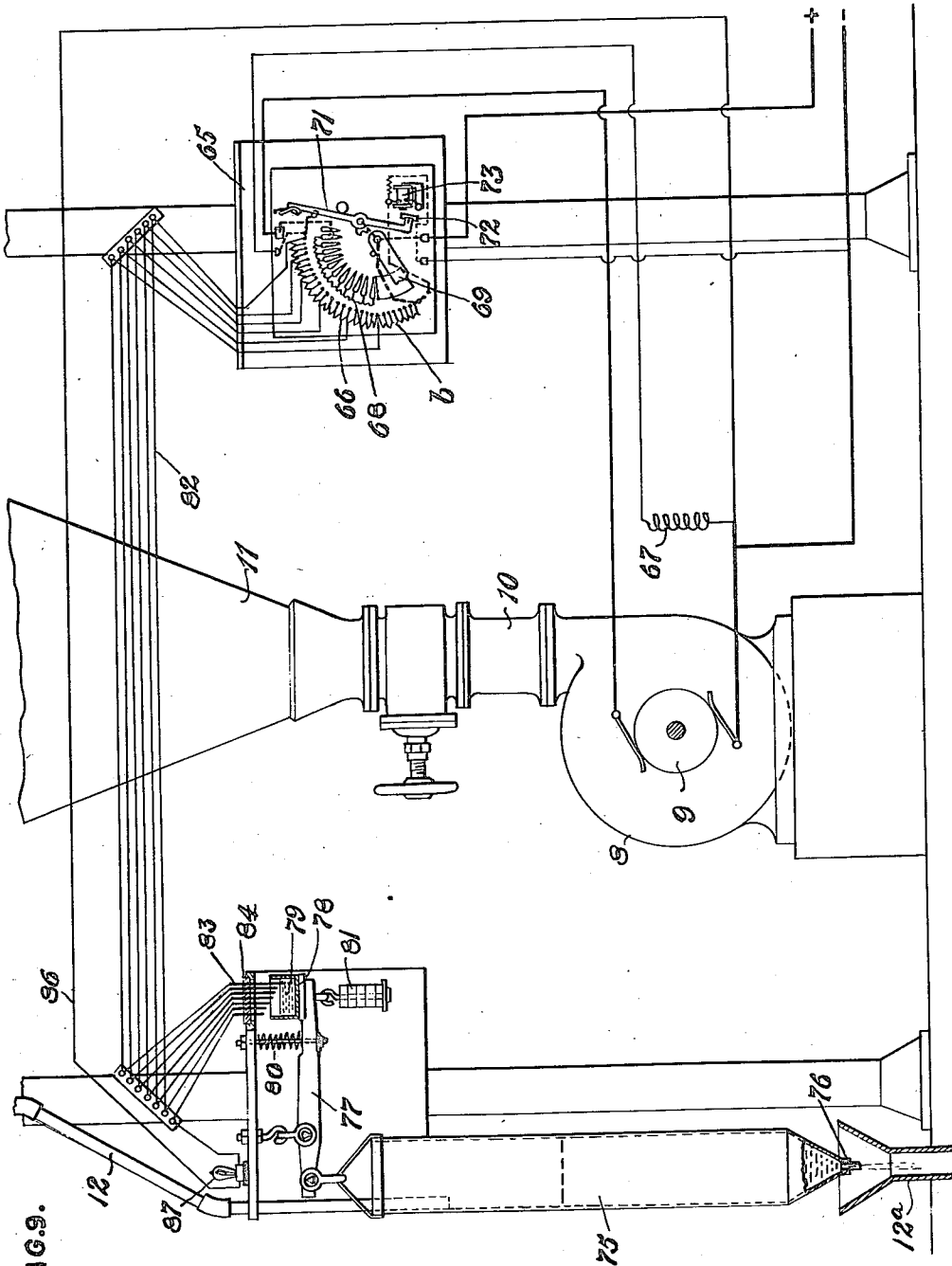


FIG. 9.

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APPARATUS FOR APPLYING ABRASIVES TO GRINDING-MACHINES.

1,281,371.

Specification of Letters Patent.

Patented Oct. 15, 1918.

Application filed December 31, 1913. Serial No. 809,695.

To all whom it may concern:

Be it known that I, HALBERT K. HITCHCOCK, resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Apparatus for Applying Abrasives to Grinding-Machines, of which the following is a specification.

This invention relates to apparatus for handling, grading and applying finely divided abrasive material to grinding machines, and particularly for grading and applying sand to glass grinding and smoothing machines.

The invention relates to that class of apparatus wherein the finely divided abrasive material, such as sand, is separated into grades of different sizes while in suspension in a liquid, as described in my Patent No. 934,441, September 21, 1909, and, while in suspension in the liquid, is circulated repeatedly from the grading vessel to the grinding machine and back again, as described in my Patents No. 934,612 of September 21, 1909, and No. 1,056,415 of March 18, 1913.

One object of the present invention is to provide apparatus whereby a measured charge of abrasive material sufficient for completing a single grinding operation, such as facing and finishing a side of glass, may be applied as a single batch or portion and repeatedly circulated in suspension in a liquid from the grinding table to the grader and back again, being thereby gradually reduced to finer and finer grades which are supplied to the table in turn as the grinding operation requires finer and finer abrasive, thereby increasing the efficiency and shortening the time of the grinding operation, avoiding liability of defects in the surface being ground, reducing the quantity and consequently the cost of the sand used, and also conserving the fine sand for finishing operations.

Another object of the invention is to provide apparatus whereby the mixture of water and abrasive material may be graded and supplied to the table under uniform conditions, that is, under a constant head or pressure of liquid, and whereby the upward velocity of the liquid through the grading vessel may be maintained uniform, thereby producing uniform results and avoiding the liability of intermingling abrasives of sev-

eral different sizes, which would reduce the grinding efficiency or injure the surface being smoothed.

Another object of the invention is to provide, in apparatus of the character described, means for controlling or regulating the speed of the circulating pump in order to produce a uniform overflow from the grading vessel and thereby insure the maintenance of a uniform upward velocity of the liquid through the grading vessel.

Another object of the invention is to provide apparatus of the type described embodying a governor controlled or operated by the overflow from the grading vessel and arranged to maintain a uniform upward velocity of the liquid therein, so that the grading operation is carried on under uniform conditions.

Another object of the invention is to provide apparatus whereby, as compared with prior apparatus, a more uniform grading, or more sharp separation into grades of different densities, and particularly in the finer grades, and a more uniform distribution of the several grades in the grading vessel, is obtained, as a consequence of which the time required for the facing and finishing operations is greatly reduced, and the product improved, while at the same time the apparatus is simplified and the space required for its installation is reduced.

Another object of the invention is to provide apparatus whereby the grade of the abrasive mixture supplied to the table may be uniformly or gradually reduced by imperceptible changes, so that the time for a complete grinding operation is materially shortened.

Another object of the invention is to provide apparatus of the character described embodying means for indicating to the operator the condition of the mixture within the grading vessel, that is, its density, and, roughly, the amount of material therein, and which also advises the grinding foreman of the condition of each table in a series of tables, so that he is constantly informed whether the tables are properly supplied with sand and the character of the operation in progress.

A further object of the invention is to simplify and improve the entire apparatus, so that the space required for its installation

is reduced, its efficiency is increased, the time for the grinding and finishing operations is reduced, and the liability of injuring the surface being smoothed is lessened.

Further objects of the invention are in part obvious and in part will appear more in detail hereinafter.

In the grinding and smoothing of plate glass, and other surfaces where abrasive material is applied, it has been found highly desirable to have the abrasive supplied at any one time as nearly uniform in size as possible. The harmful effects of improperly graded material are apparent even during the rough or coarse grinding, in which case if finer material is mixed with the coarse, it interferes with the most effective grinding action because to the extent that it displaces coarse material it decreases the total grinding action, and is also wasteful of abrasive material because such finer particles are being reduced to a still finer condition without producing any corresponding grinding effect. But it is during the stages of finer grinding that the effects of non-uniform grading are most harmful, as any coarse material mixed with the finer material produces deep crushes or sand holes in the surface being ground, thereby necessitating further grinding to take out such rough ground spots and greatly delaying the final finishing, or if not done the finished product is of an inferior quality.

In operating prior apparatus of this type it has been the practice to add fresh abrasive material, such as coarse sand, to the circulating system from time to time during the grinding operation. This is liable to produce non-uniformity in the grades and contributes to some of the harmful effects above described. I have so perfected this system of grading and applying abrasives to grinding machines that the time required has been so shortened and the amount of abrasive used has been so reduced that the operator now has not time to accurately gage the amount of abrasive required from time to time, from merely observing the operation as it proceeds, for there is always a certain lapse of time after starting to feed fresh abrasive into the system before its effect is felt in the grinding operation, and likewise this effect continues some time after the supply of fresh abrasive ceases, all of which makes it advantageous to start the new abrasive into the system before the grinding begins and shut it off before it is completed. I have found that in order to get the best results it is necessary to have definite times for starting the fresh abrasive and introduce definite quantities of fresh abrasive into the system, so that when the grinding actually begins the system will have enough fresh abrasive to insure that none of the finer grades which will be

needed later are used in the rough grinding or facing, as each grinding operation produces only sufficient fine abrasive to insure a perfect surface in the finished product.

I have found that a great reduction in the time of grinding and greater perfection in the product can be effected by carefully measuring the coarse or unused sand or other abrasive material and introducing it in a single batch, or at least rapidly, during the early stages of the rough grinding, and in any event completing the introduction of the coarse abrasive material prior to the completion of the rough grinding or facing and the beginning of the smoothing or finishing operation. This results in reducing the time of grinding for two reasons, first, it insures that only the coarsest of the new sand is used for the facing operation and thereby greatly reduces the liability of any of the coarse sand being carried onto the table with the fine sand, and second, it insures that the rough grinding operation will produce sufficient fine sand to complete the finishing operation. Furthermore, efficiency of the system requires the conservation of the usable fine sand so produced in order to furnish a sufficient supply of the finer grades for the finishing operations. Consequently, if any of the finer sand finds its way to the table during the rough grinding operation it is a mere waste of valuable material that will be needed later, and reduces the efficiency of the system.

It is therefore essential for the greatest efficiency to arrange the apparatus and so operate it that it will produce as uniform grades as possible and to prevent as far as possible the mixture of abrasives of different grades or sizes and to preserve during the entire grinding operation as nearly uniform as possible those conditions which affect either the grinding operation or the supply of material to the table.

The present invention is intended to secure the beneficial results above specified and to provide apparatus whereby all of the abrasive material, both the original supply and the used material, is graded or regraded under uniform conditions. To this end each grading apparatus is arranged to take care of but a single grinding table, and the grading is effected under a constant or uniform head of liquid, and in a stream of liquid having a uniform velocity of upward flow, thereby insuring that in the grading vessel the several grades will never vary materially from a given level, and any given grade may be supplied without change as long as desired.

To the same end the abrasive material necessary to perform a complete grinding operation on a given surface, such as a side of glass, is carefully measured out and is introduced into the circulation system in a

single batch or portion at the beginning of the operation, so that it becomes thoroughly graded before the finer grinding operations begin. The abrading material is kept constantly in suspension in the liquid and is circulated from the grading vessel to the grinding table and back again into the grading vessel and there regraded, following this cycle repeatedly through the entire course of the grinding operation. On the table most of the coarse sand is broken and reduced in size between the runners and the glass and by the grinding actions between the particles themselves, but a small quantity of the coarse sand is liable to be thrown from the table without being broken or reduced in size, and especially while the runners are being applied to the glass and before the runners are fully down. Every time the sand passes over the table some of it is reduced to particles too small for further use, and such material together with the scum and slime are separated out during the course of each cycle, the useful abrading material alone being retained and regraded each time it returns to the grading vessel, from whence it is returned to the table as long as it is coarse enough to be useful in that stage of the grinding operation then proceeding. As the material gradually becomes finer and finer, it is automatically separated out in the grading vessel into the proper grades, and is therein held back to be used during the successive stages of finer and finer grinding.

The invention may be embodied in various forms of apparatus, one suitable arrangement being shown in the drawings, but it is understood that this is merely illustrative and does not limit the invention to the apparatus shown.

In the drawings Figure 1 is a plan view of the apparatus; Fig. 2 is an elevation thereof, the sump being shown in section; Fig. 3 is a sectional elevation of the grading vessel taken on the line 3—3, Fig. 1, and looking in the direction of the arrows; Fig. 4 is a similar section taken on the line 4—4, Fig. 1 and looking in the direction of the arrows; Fig. 5 is a detail view of a suitable indicating device; Fig. 6 is a detail plan view of the outlet from the grading vessel; Fig. 7 is an elevation thereof viewed from the inside of the tank; Fig. 8 is a sectional elevation on the line 8—8, Figs. 6 and 7; and Fig. 9 is a detail view, partly diagrammatic, of the motor and pump controlling devices.

In the drawings 1 indicates in conventional sign a typical form of glass grinding table provided with a pair of runners of rubbing members 2 of the usual form. These parts, however, are merely typical of one form of grinding apparatus which may be used.

The table 1 is surrounded by a gutter 3 connecting with a cross gutter 4 which carries the liquid and used abrasive from the table over a screen 5 to the pit or sump 6 from which it is drawn through pipe 7 by means of a suitable pump, such as a centrifugal pump 8, driven by a suitable motor, such as the electric motor 9, and is forced through pipe 10 upwardly through the bottom of the grading vessel 11, thereby producing in said vessel an upward flow of the liquid relative to the abrading material and producing a separation of the material into grades of different sizes, depending upon the ratio of the weight of the particles to the resistance to fall offered by the upward current of liquid, as is well understood and is described in my Patent No. 934,441, above identified.

The grading vessel 11 is designed to grade the new material and also regrade all of the used material and to continuously maintain in said vessel at constant or uniform levels all of the different grades of material above a size too fine for further use. The material too fine for further use, including the dirt and scum, escapes constantly through overflow pipe 12 leading to the ditch or sewer 13, which also receives the overflow from the sump 6.

The fresh abrading material, such as coarse sand, may be added to the system at any point, either into the grading vessel 11 or upon the table 1, but preferably is supplied to the sump 6. As shown it is delivered by the clam-shell bucket 14 into a suitable bin or hopper 15 having a valved outlet 16 arranged to deliver the sand into a measuring box or reservoir 17 large enough to hold sufficient sand for one complete grinding operation. The measuring box 17 has a sloping bottom and is provided with a valved outlet 18 arranged to deliver sand upon the screen 5 and into the sump 6. Preferably, a water supply pipe 19 having a number of small side openings is placed in the box 17 so that water may be supplied thereto to wash the sand quickly into the sump and get it into the circulation system before the finishing operation begins.

The grading vessel 11 may be of any suitable or preferred size or form, but preferably has its lower portion in the form of an inverted cone, as shown, and having an upper portion 20 of cylindrical form, the walls of the vessel having such slopes that the velocity of the upwardly flowing water therein will decrease at such rate that the particles of abrasive material will assume positions at different levels therein, according to their size, as is now well understood. The upper portion of the vessel is made cylindrical, as shown, in order to enable the use of a smaller tank and also to secure a denser mixture of the finer grades with a

smaller total quantity of fine material in the grading vessel. The progressive decrease of upward velocity of the water in said cylindrical portion in order to facilitate such grading and insure a more uniform density and distribution of the various grades is secured by withdrawing a portion of the mixture through a secondary outlet pipe 21 which discharges into the gutter 3 at 22 and whose inner end is connected inside of the cylindrical portion 20 of the grading vessel, to a vertical pipe 23 provided with a plurality of small ports or openings 24 at different levels, each of which admits a small portion of the mixture at that level. The secondary outlet pipe 21 passes through the wall of the grading vessel near its top, and is provided with an open-ended branch 25 which extends above the top of the grading vessel to break the siphon and decrease the head which forces the mixture through said outlet pipe.

The discharge of a small quantity of liquid at each of the openings 24 results in progressively reducing the upward velocity in the cylindrical portion 20, by a series of steps so that the finer grades assume a greater density and a more even distribution than would otherwise be the case, and the height of this portion of the vessel can be greatly reduced while still giving a wide variation in the size of material held therein. There is therefore a gradual reduction in velocity upwardly, due to the plurality of outlet openings 24 and consequently at each level a certain grade or size of material gradually accumulates, the grades becoming gradually finer and finer upwardly between successive levels as the interstitial velocities of the particles decrease. The several zones between the successive outlet openings 24 therefore form a series of traps, each accumulating its own particular grade of fine material and storing it for later use, each grade becoming denser and denser as the grading operation continues. The cylindrical portion 20 of the grading vessel therefore forms a supplemental grader superposed upon the lower or conical portion of the vessel and having substantially the same effect as though it were conical, but because of its cylindrical form the total volume of liquid to be taken care of is considerably reduced so that the vessel itself can be smaller and its supporting structure lighter than would otherwise be the case, thereby decreasing the cost and reducing the space required.

The mixture withdrawn through the outlet pipe 21 flows to the sump and returns to the circulation and the usable material therefore is not wasted. It also assists in washing out and keeping clean the gutter 3, thereby reducing the amount of clean water otherwise required for this purpose,

and, indeed, because of its specific gravity, it is more efficient for washing out the coarse sand in the gutter 3 than if the water were clear.

Provision is made for separately withdrawing the several grades from the grading vessel by providing a plurality of withdrawal pipes, the number thereof depending upon the number of grades which are to be separately withdrawn. Three such pipes are shown in the drawings and are marked respectively 26, 27 and 28, and all pass out through the walls of the grading vessel at the same level, thereby contributing to the maintenance of a constant head or pressure. As shown, these pipes are all connected to a common casting or member 29 which is secured to the wall of the grading vessel and is provided with a plurality of inwardly projecting tubular portions, one for the attachment of each of the withdrawal pipes. As shown, the withdrawal pipe 26 has its inner end opening near the bottom of the grading vessel 11, in the coarse sand zone; the withdrawal pipe 27 has its inner end opening at a point between the top and bottom of the cone, in the intermediate sand grade zone, while the withdrawal pipe 28 is in the form of a flexible hose or pipe of sufficient length to reach to the bottom and also to the top of the grading vessel and having its end vertically movable, as hereinafter described, so that it can take the sand out of said grading vessel at any desired point.

The several withdrawal pipes are constantly open so that water and abrasive material from each of the several grades in which said pipes terminate is constantly discharged, thereby further contributing to the maintenance of a uniform pressure and uniform head in the grading vessel. As shown, the openings through the casting 29 discharge into a vessel or casing 30 secured to the outer wall of the grading vessel and provided with an outlet conduit 31 leading to the sump 6. Pivotaly mounted adjacent to the discharge openings through the casting 29 are a plurality of discharge pipes, marked respectively 26^a, 27^a and 28^a, which are so mounted and have their inner ends so formed that when lowered each fits over its respective discharge opening in the casting 29 and forms a conduit for conducting the discharge through that particular opening to a trough 32 extending through the outer wall of the vessel or casing 30 and leading to the spout 33 which projects over the grinding table, 1, preferably between the runners 2, and which is perforated to discharge the mixture of sand and water onto the table. The discharge pipes 26^a, 27^a and 28^a are preferably bent to substantially goose-neck form, as shown, although this is not essential, and are arranged to be swung upwardly about their pivots by suitable op-

erating cords 26^b, 27^b and 28^b, each of which is knotted so that it may be slipped into a notch in a holding member 34, or provided with other means whereby the pipe can be

5 held in elevated position.

When all of the pipes are elevated the mixture discharging through each of the withdrawal pipes 26, 27 and 28 returns through conduit 31 to the sump 6, but whenever one
10 of said pipes is lowered, the mixture coming through the corresponding discharge pipe is conducted to the table. By this arrangement, therefore, the desired grade can be conducted to the table by merely lowering
15 the proper discharge pipe 26^a, 27^a or 28^a, and that particular grade will continue to be supplied to the table as long as that discharge pipe remains in its lowered position.

This arrangement does away entirely with
20 valves, which are subject to severe wear by the sand mixed with the water, while at the same time, placing the supply of the different grades of sand to the table entirely within the control of the operator.

In order to bring the inner open end of withdrawal pipe 28 to different heights for withdrawing different grades, as is necessary during the finishing operation, its free end is supplied with a weight 39 for sinking
30 said end. This weight is connected by a cord or cable 40, which passes over a sheave or pulley 41, to a float 42 in a cylinder 43 supported at the side of the grading vessel 11. Connected to the lower end of cylinder
35 43 is a water pipe 44 which preferably extends to a point adjacent to the front of the table where it is provided with a suitable three-way cock or valve 45 which has a discharge outlet and also communicates with
40 a water supply, so that by merely setting said cock to the proper position water may be either admitted to the cylinder 43 to lift the float 42 and allow the weight 39 to sink the end of the flexible pipe 28, or to discharge water from cylinder 43 and allow the
45 float 42 to drop and elevate the end of flexible pipe 28 in the grading vessel.

Preferably, a second cable or cord 46 is connected to the float 42 and passes over pulleys 41 and 47 to the opposite side of the tank where it operates a suitable indicating means, shown as a weight 38 which is preferably held at the same level as the weight 39, so that the position of weight 38 indicates the exact position of the inner open
55 end of pipe 28 in the grading vessel.

Preferably, also, suitable means is provided for indicating to the operator the density of the mixture within the grading vessel. The indicating means shown comprises a suitable displacement member or hydrometer 54 which is so constructed and so loaded as to assume a state of equilibrium at a level between the coarse and intermediate
65 grades of abrasive material. although it may

lie at any desired level. This hydrometer is connected by a cord 55, lever 56 pivoted at 57 and counter-weighted at 58, and cord 59, to a suitable indicator, shown as an electric lamp 60 arranged to move up and down in
70 casing 61 having a plurality of windows 62 located at different levels and preferably covered with different colored glasses, such as red for the upper, white for the intermediate and green for the bottom window. 75

The position of the hydrometer 54 depends upon the density of the mixture in which it is immersed. It is substantially entirely immersed in the liquid and rises as the amount of abrasive material in suspension increases, 80 and falls as the amount of abrasive material decreases. It is of such a size vertically of the grader that it is affected by changes in density in practically only a single grade or zone of material, which may be, say, the
85 coarse sand, in which case the indicator 60 gives a visual indication of the condition of the coarse sand mixture, that is, its density and, roughly, the amount of material therein, while variations in the density of 90 the other grades do not affect the hydrometer. This indicator also advises the grinding foreman of the condition of each table in a series of tables, that is, whether a table is just beginning the rough or facing
95 operation, whether it is at the intermediate grinding operation, or whether it is doing fine grinding or finishing. By watching the changes in the indicators on each of a series of grinding tables the foreman can tell
100 at a glance whether the tables are properly supplied with sand as well as the character of the operation then in progress, and can so adjust the amount of coarse sand used at each facing operation that the proper mixture will be insured. 105

To grade the abrading material under conditions which are maintained uniform in all respects, it is essential that the upward velocity of flow of liquid in the vessel
110 be maintained uniform. The weight of the material in the vessel, that is, the head against which the pump is working, varies from time to time as the proportions of abrading material and liquid vary in the
115 grading vessel. The suction head in the sump may also vary, especially with variations in the supply of abrading material thereto, either the original batch of material or the used material returned from the grinding table. Either condition affects the quantity of liquid delivered by the pump at any given rate of speed. Consequently, it is highly desirable to control or regulate the speed of rotation of the pump, and therefore
125 of the driving means for the same, in such manner as to cause it to deliver a uniform supply of abrasive material mixed with the liquid into the grading vessel, irrespective of variations in density of the mixture therein, 130

or variations in any other conditions which affect the velocity of flow.

As before described, the mixture flows constantly from all of the withdrawal pipes 26, 27 and 28, whether it is delivered to the grinding table or not. There is also a constant flow of material out through the secondary outlet pipe 21. The discharge of material through all four of these pipes is maintained uniform and is under constant head or pressure, so that it does not produce a variation in the upward velocity of the grading vessel. The waste overflow through the pipe 12 may, however, vary, and if it does, there is a variation in the upward velocity of the mixture through the grading vessel. Preferably therefore, I utilize the waste overflow from the grading vessel to control the speed of the pump, the apparatus being so arranged that if the overflow increases the pump speed is decreased and vice versa. In effect the pump is governed and controlled in such manner as to produce and maintain in the grading vessel a uniform upward velocity of liquid therein.

In the form shown in the drawings the pump is driven by a motor 9, which is preferably an electric motor. Said motor may be of any suitable type of variable speed motor and is shown as a shunt-wound motor of common type. Referring more particularly to Fig. 9, the motor is controlled by a starting box indicated more or less diagrammatically at 65. This starting box may be of any suitable construction and is shown as of a common type with certain modifications and additional circuits adapting it for control by the overflow from the grading vessel. The starting box includes a series of resistance elements 66 in series with the field windings 67 of the motor, and a second series of resistance elements 68 in series with the motor armature. The operating handle 69 is arranged to wipe over a series of contacts controlling said resistance elements and when moved in the clockwise direction to extreme position throws over an auxiliary arm 71 to permanently cut out all of the resistance elements 68 from the armature circuit. The lower end of the auxiliary arm carries a contact 72 arranged when said arm is oscillated to contact a magnet 73 in a shunt circuit around the motor and which holds said arm in its new position. After the starting lever 69 has been pushed clear over it is moved back step by step to throw into the field circuit more and more of the resistance elements 66, thereby weakening the field and increasing the motor speed. This is a common form of starting box and requires no further description.

According to my invention the overflow from the grading vessel which passes out through the pipe 12 is delivered into a suitable tank or vessel 75, shown as a hollow cyl-

inder, and provided at its lower end with a restricted outlet 76 discharging into a pipe 12^a, which forms a continuation of the pipe 12 and leads to the sewer, as before described. Cylinder 75 is suspended from the short arm of a weight beam or lever 77, which at its other end carries a series of weights 81, which are proportioned to balance the cylinder and the amount of liquid necessary to discharge the desired volume through the orifice 76. The movement of the weight arm is also restricted by a light resilient spring 80, which prevents too sudden movement of the weight beam and a mercury cup 78 carried thereby, as herein-after described, and confines the movement of said cup to a practical working range. When the required amount of overflow is passing out from the grading vessel, there is a certain head in the cylindrical tank 75, but as the volume of overflow increases, the head required to discharge the increased volume also increases, thereby causing an increase in the weight of the tank and its contents, which depresses the short end of the weight beam and elevates the long end. The long end of the beam carries a cup 78 formed of insulating material and having a quantity of mercury 79 therein. This cup controls a series of shunt circuits so arranged as to short circuit or cut out from the field circuit of the motor, one or more of the several resistance elements 66. As shown, a number of wires 82 are tapped off at intervals from the resistance elements 66, each of said wires leading to one of a series of contact members 83 carried by an insulating member 84 supported above the mercury cup 78. The lower ends of the contact member 83 lie at different levels, as shown in Fig. 9, and dip into the mercury when the cup rises.

In starting the motor and pump the starting lever 69 is thrown clear over in the clockwise direction to oscillate the auxiliary arm 71 and short circuit the resistance elements in the armature circuit. It is then pulled back step by step to a position marked *a*, which throws into the field circuit all of the resistance elements 66 and speeds the motor up to a point where it produces a greater inflow of liquid to the grading vessel than is normally desired. This produces a waste overflow through the pipe 12 which flows into the vessel 75. The outlet 76 from said vessel is made of such size that it will require a certain head to discharge therefrom what may be termed the normal waste overflow, which may be any fixed quantity, but should be maintained uniform. If the overflow increases for any reason, the liquid head rises in the vessel 75 and thereby increases its weight, depresses the tank end of lever 77 and lifts the mercury cup until two or more contacts 83 dip into the mercury.

This short circuits or cuts out one or more of the resistance elements 66, strengthens the motor field and decreases the motor speed. If the overflow decreases, the level of liquid in vessel 75 falls and the mercury cup falls away from the contacts 83, thereby throwing into the field circuit one or more additional resistance elements 66, weakening the motor field and increasing the motor speed.

In practice the parts are so proportioned and arranged that the overflow through the pipe 12 is just sufficient to carry away from the grading vessel the mud and abrading material too fine for further use and does not carry off any of the finer grades of abrading material which are useful in the finishing operation. When the device is running under normal conditions vessel 75 is about half full of liquid, about half of the contacts 83 dip into the mercury and half are out of contact therewith, so that about half of the resistance elements 66 are in the field circuits and half are short circuited therefrom. This gives a margin either way, so that the motor speed may be corrected if the overflow varies in either direction. The device may be made as sensitive as desired by using the proper number of branch circuits 82, that is, by cutting up the resistance elements 66 into the proper number of divisions. The sensitiveness increases with the number of such divisions and with the sensitiveness of the spring 80.

Preferably, all of the resistance elements 66 in the starting box are not included in the shunt circuits through the automatic overflow controlling device, but a portion of said resistance elements, in series with the rest and indicated at *b*, are left for hand control. These resistance elements are beyond those which are automatically controlled, and in starting, the lever 69 may be moved back in the counter-clockwise direction to include as many of the resistance elements *b* as is found necessary to cause the scale arm to assume a position midway between its highest and lowest points when working with a normal overflow, thus insuring automatic regulation which will either increase or decrease the overflow as may be required. Under normal conditions, therefore, some or all of the resistance elements *b* may be left permanently in the field circuit and the automatic control is secured through the other elements by the shunt circuits through the mercury cup. Enough resistance elements are shunted through the mercury cup to give a range of regulation sufficient to cope with all ordinary conditions and to correct all variations from normal overflow which ordinarily may occur. As the pump wears, however, a higher speed is required to give the necessary volume of overflow and additional resistance is cut in

by hand until the scale arm assumes under normal overflow the middle position above described. However, it might happen under some circumstances, as through carelessness of the operator, or abnormal voltage in motor, that the waste overflow through the pipe 12 would increase to a point where the automatic regulator can not sufficiently cut down the motor speed to reduce the overflow. This might result in so increasing the upward velocity in the grading vessel as to elevate the several grades above their normal positions and also carry out to the sewer some of the finer grades of abrading material required for use in the finishing operation. This is very objectionable as the system does not produce a large excess of fine abrading material and the loss thereof requires accumulation of further fine abrading material before the finishing operation can be completed. In the arrangement shown a special contact 85, whose end lies just above the end of the highest contact 83, is connected in a shunt circuit 86 around the motor and which includes a lamp 87. If the waste overflow increases beyond the capacity of the automatic regulating device contact 85 dips into the mercury and lamp 87 lights up. This advises the operator and foreman of the department of the abnormal condition, which is corrected by manually moving the starting lever 69 in clockwise direction to cut out a sufficient number of the resistance elements *b* to decrease the motor speed and reduce the overflow to normal proportions.

In practice the automatic regulating device acts after the manner of a governor and increases or decreases the motor speed in such manner as to confine the waste overflow from the grading vessel within very narrow limits.

In use of the apparatus described, the sump 6 and grading vessel 11 are first filled with liquid, such as water, and after closing the line switch the starting box is operated to speed up the motor and start the pump circulating the water. All of the discharge pipes 26^a, 27^a, and 28^a are elevated so that the liquid is discharged therefrom into the casing or vessel 30 and returns through pipe 31 to the sump 6. Liquid is also discharged from the secondary outlet 21. Vessel 75 gradually fills up with liquid and the automatic regulating device soon regulates the resistance in the field circuit of the motor so that the waste overflow through the pipe 12 becomes uniform, and thereafter maintains it at a fixed quantity within narrow limits. This produces a uniform velocity of flow of the liquid upwardly in the grading vessel.

A measured charge of sand sufficient for a complete single grinding operation from roughing to finishing is measured into the

hopper 17 and delivered or washed into the sump at such a rate as to secure the proper density of the mixture and so that all of the sand gets into the circulation system before the fine grinding begins. This sand is carried up into the grading vessel and is graded according to its size, the larger particles assuming positions near the bottom of the cone and the grades becoming finer and finer up through the conical and cylindrical portions of the vessel. All dirt, scum and material too fine for use is washed out through the overflow 12, and a portion of the mixture in the cylindrical part 20 is also delivered through the outlet 21 to the gutter 3 and returns to the sump. Since the coarse sand at first predominates, the mixture in the bottom of the cone 11 is dense so that the hydrometer 54 rises and moves the indicating lamp 60 to a position opposite the lower window in casing 61 and displays a green light, which means that the system is supplied with the proper quantity of coarse sand for economically effecting the rough grinding.

By properly manipulating the several discharge pipes 26^a, 27^a, and 28^a, the several grades may be supplied from the grading vessel to the grinding table separately and independently and in any order and to any extent or degree desired. During the rough grinding, pipe 26^a is lowered to supply coarse material from near the bottom of the grading vessel into the trough 52 from which it flows to the spout 53 and is discharged upon the table, while the discharge pipes 27^a and 28^a are in elevated position so that the mixture discharging through withdrawal pipes 27 and 28 returns to the sump 6. When the whole batch of sand has been introduced into the sump and carried to the grader the hydrometer is in its highest position, and as the grinding proceeds and the coarse sand is reduced in size it gradually falls as the sand supplied to the table from the pipe 26^a becomes finer and finer. When the rough grinding operation has proceeded far enough the discharge pipe 26^a is lifted and the discharge pipe 27^a is lowered, and thereafter a considerably finer grade of material is delivered to the table from a level between the top and bottom of the cone, while for the final finishing operation the pipe 27^a is lifted and the pipe 28^a is lowered, thereby discharging into the trough 52 material coming through the withdrawal pipe 28.

During the rough grinding some of the sand is thrown off the table in the condition in which it is received, especially during the stage of adjusting the runners into full contact and full pressure with the table. The material so thrown off the table into the gutter 3 returns to the sump and back again into the grading vessel. During all of the

grinding operations some of the sand is broken up by the grinding action, producing grades of smaller size, some mud and some material too fine for further use. During each cycle of the circulation the mud and material too fine for further use are carried off to the sewer through the overflow pipe 12, while all material still of a size capable of further use is returned to the grading vessel and regraded. The water carried out from the circulation system through the overflow pipe 12 is replenished by a water supply pipe 6^a, which discharges into the sump 6 and is preferably provided with a ball float controlled valve 6^b arranged to turn on the water supply whenever the level of liquid in the sump falls to a certain level, say to a level one-third the depth of the sump below the overflow therefrom. This prevents the pump from wholly depleting the liquid and abrasive supply in the sump.

The final finishing is done with the several grades of abrasive material held in suspension in the cylindrical portion 20 of the grading vessel. The inner open end of pipe 28 is placed in the zone of the grade with which the finishing operation is to begin, say, at the bottom on the cylindrical portion 20 of the vessel 11, and may then be raised at intervals by a series of steps or jumps so as to deliver to the grinding table successively portions of the material of finer and finer grades, until the smoothing operation is completed. Preferably, however, the open end of pipe 28 is moved upward at a uniform rate of speed, traversing in turn each of the various levels in the cylinder 20 in a series of imperceptible changes, so that the grade of material supplied to the table changes gradually from the intermediate grade near the top of the cone to the very finest grade at the top of the cylinder. To secure uniform results and also to regulate the time of grinding, the three-way cock 45 is so set as to discharge the water from cylinder 43 at just such a rate that the float 42 will raise the open end of pipe 28 at the proper rate of speed. If desired, the outlet of cock 45 may be made of such a size as to constitute the limit of the maximum rate of discharge. This does away with the necessity of watching the apparatus closely during the fine grinding and adjusting the flexible pipe at proper intervals for changes in grades.

As heretofore stated, the flexible withdrawal pipe 28 is preferably made long enough to extend to both the bottom and the top of the grading vessel, so that if desired it may be used to deliver to the grinding table abrasive material from any zone or level in the grading vessel. Consequently, said pipe can be utilized at any time to deliver an extra supply of material in addition to that delivered by either of the pipes

26 or 27. It may also be used as the sole source of supply for the entire grinding operation from the beginning of the roughing operation to the final finishing. Cylinder 43 is long enough to allow a sufficient movement of float 42 to move the end of pipe 28 from the bottom to the top of the grading vessel, and by starting the operation with the pipe 28 at the bottom and properly setting the valve 45, the float 42 may be caused to progressively and uniformly elevate the pipe 28 to take a complete section of the entire grading vessel, or by starting it at a higher level, a section may be taken of any portion of the tank. The time for the rough grinding operation may be longer or shorter than for finishing so that in some cases it may be necessary to regulate the discharge from cylinder 43 to produce a slower movement of the pipe 28 during one operation than during the other. The time required for facing a rough surface, that is, to produce a perfect plane, varies according to the roughness and straightness of the rough glass, while the time required to bring the rough face of the plane surface so produced to a fine and uniform smoothness is practically constant. I prefer, therefore, to supply the abrasive for the grinding operation from a fixed level, as from the pipe 26, so as to insure that only the coarsest material is used for this operation, but the finishing is best accomplished by supplying the various grades from the beginning of the finishing operation to the completion thereof, successively in a definite progression and length of time.

During all of the grinding operation, from roughing to finishing, the abrasive material is in suspension in a liquid and is circulated repeatedly from the grading vessel to a grinding table, then to the sump, and back to the grading vessel; slimes and fine material being separated during the course of each cycle. After the introduction of the initial supply or charge of abrading material from the hopper 17 no more abrasive is introduced into the system, but the original charge becomes finer and finer during the progress of the grinding operation, and supplies the necessary amount of fine sand for the finishing. The grading vessel supplies only a single table, and therefore the conditions of water supply, sand supply, and pressure or head are at all times uniform. By having all of the discharge openings from the grading vessel open at all times, by maintaining a uniform waste overflow from the upper portion of the vessel, and by taking all of the abrasive mixtures to the grinding table out of the grading vessel at the same level, uniformity in pressure and head is insured.

As the grinding operation proceeds the density of the coarse mixture in the grading

vessel decreases and the hydrometer 55 sinks, thereby raising the lamp 60 and changing the indication from green to white and then to red, thereby indicating to the foreman the particular stage of grinding operation.

When the grinding operation is completed all of the discharge pipes 26^a, 27^a and 28^a are raised and the mixture is allowed to flow from the grading tank into the vessel or casing 30 from which it flows to the sump 6, thereby enabling the circulation to be continued between successive grinding operations, or during the time that the glass on the table is being changed.

Usually, upon starting a given system a slight excess of coarse sand is supplied with each of the first few batches, so as to insure sufficient coarse sand for the rough grinding, and which excess is broken up on the table to form finer grades which accumulate in the cylindrical portion 20 of the grading vessel and form a reserve supply of fine material which can be drawn upon in case it is necessary or desired to finish or refinish a side of glass without first going through the grinding operation. After a sufficient excess of fine sand has accumulated in the vessel 11 the measured batches of sand thereafter introduced are calculated so as to be just sufficient for one complete grinding operation. The mud and fine material washed out through the overflow during each grinding operation are equal in quantity to the new batch of sand supplied to the system for each grinding operation. By operating the system in this manner each batch of sand introduced into the system is graded and supplied to the table under conditions identical with those in the preceding operation, and these conditions are maintained during the entire course of each and every grinding operation.

The flexible outlet pipe 39 with its lifting means for withdrawing the grades from the grading vessel and varying the same by imperceptible changes, and also the function or method effected by the secondary outlet 24, are not claimed in this application, but are claimed in my application filed August 9, 1915, Serial No. 44,624. Also, the general arrangement of the apparatus comprising a single grinding table and a grading apparatus and circulating system associated therewith and supplying the individual grinding table alone, is not claimed herein but is claimed in my application, Serial No. 245,655, filed July 19, 1918, as a division hereof.

What I claim is:

1. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, means for producing in said vessel an upward flow or travel of the liquid relative to the material so as to separate the material into grades, and means responsive to variations in the rate of flow

for automatically maintaining the rate of flow substantially uniform.

2. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, a pump for producing in said vessel an upward flow or travel of the liquid relative to the material so as to separate the material into grades, and means responsive to variations in the rate of flow of the liquid for automatically regulating the pump to maintain the rate of flow of liquid substantially uniform.

3. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, a pump for producing in said vessel an upward flow or travel of the liquid, means for driving the pump, and means responsive to the rate of flow of said liquid for automatically regulating the driving means to maintain the rate of flow of liquid substantially uniform.

4. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, a pump for producing in said vessel an upward flow or travel of the liquid, a motor for driving said pump, and means responsive to the rate of flow of the liquid for automatically regulating the motor speed to maintain the rate of flow of liquid substantially uniform.

5. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from the upper portion of said vessel, means for producing in said grading vessel an upward flow or travel of the liquid relative to the material so as to separate said material into grades while in suspension in the liquid, and means controlled by said overflow for maintaining uniform the velocity of flow of the liquid.

6. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from the upper portion of said vessel; a pump for producing in said vessel an upward flow or travel of the liquid relative to the material so as to separate said material into grades while in suspension in the liquid, and means controlled by said overflow for regulating the pump so as to maintain a uniform velocity of flow of the liquid.

7. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from the upper portion of said vessel, a pump for producing in said vessel an upward flow or travel of the liquid, means for driving said pump, and means controlled by said overflow for regulating said driving means so as to maintain a uniform velocity of flow of the liquid.

8. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from

the upper portion of said vessel, a pump for producing in said vessel an upward flow or travel of the liquid, a motor for driving said pump, and means controlled by said overflow for regulating the motor speed so as to maintain a uniform velocity of flow of the liquid.

9. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from the upper portion of said vessel, a pump for producing in said vessel an upward flow or travel of the liquid, an electric motor for driving said pump, and electrical connections controlled by said overflow for regulating the motor speed so as to maintain a uniform velocity of flow of the liquid.

10. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from the upper portion of said vessel, a centrifugal pump for producing in said vessel an upward flow or travel of the liquid, and means controlled by said overflow for regulating the speed of said pump for maintaining a uniform velocity of flow of the liquid.

11. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from the upper portion of said vessel, a movable vessel arranged to receive said overflow and provided with a discharge outlet therefor, means for producing in said grading vessel an upward flow or travel of the liquid, and means controlled by said movable vessel for maintaining uniform the velocity of flow of the liquid.

12. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, an overflow connection from the upper portion of said vessel, a movable vessel arranged to receive said overflow and provided with a discharge outlet therefor, a pump for producing in said grading vessel an upward flow or travel of the liquid, a motor for operating said pump, and means operated by said movable vessel for controlling the motor speed to maintain a uniform velocity of the liquid.

13. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, means for producing in said vessel an upward flow or travel of the liquid, an overflow connection from the upper portion of said vessel, a movable vessel arranged to receive said overflow and provided with a restricted discharge outlet therefor, said movable vessel being arranged to rise and fall as the overflow decreases or increases, and means operated by said movable vessel for maintaining a uniform velocity of flow of the liquid.

14. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, a pump for producing in said

vessel an upward flow or travel of the liquid, an overflow connection from the upper portion of said vessel, a movable vessel arranged to receive said overflow and provided with a discharge outlet therefor, said vessel being
 5 arranged to rise and fall as the overflow decreases or increases, a motor for operating said pump, and means operated by said movable vessel for regulating the motor speed to
 10 maintain a uniform velocity of flow of the liquid.

15. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, means for producing in said
 15 vessel an upward flow or travel of the liquid, an overflow connection from the upper portion of said vessel, an electric motor for operating said means, a series of resistance
 20 elements in the field circuit of said motor, and means controlled by said overflow for throwing said resistance elements into or out of the field circuit to thereby regulate the motor
 speed and maintain a uniform velocity of flow of the liquid.

25 16. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, means for producing in said
 vessel an upward flow or travel of the liquid to thereby separate the material into grades,
 30 means for independently withdrawing the several grades from said vessel, and a plurality of secondary outlets from said grading vessel arranged to decrease step by step
 upwardly the velocity of upward flow of the
 35 liquid.

17. Apparatus for grading finely divided material mixed with a liquid, comprising a
 grading vessel, means for producing in said
 40 vessel an upward flow or travel of the liquid to thereby separate the material into grades, means for independently withdrawing the
 several grades from said vessel, and a secondary outlet pipe arranged to withdraw
 45 from said grading vessel a portion of the material in each grade and thereby decrease upwardly through said vessel the velocity of
 upward flow of the liquid.

18. Apparatus for grading finely divided material mixed with a liquid, comprising a
 50 grading vessel, means for producing in said vessel an upward flow or travel of the liquid to thereby separate the material into grades, means for independently withdrawing the
 several grades from said vessel, and a secondary outlet pipe having a vertical branch
 55 lying inside the grading vessel and provided with a plurality of openings at different levels therein, said pipe being arranged to withdraw a portion of the material in each
 60 grade and to thereby decrease upwardly through said vessel the velocity of upward flow of the liquid.

19. Apparatus for grading finely divided material mixed with a liquid, comprising a
 65 grading vessel having a cylindrical portion,

means for producing in said vessel an upward flow or travel of the liquid relative to the abrading material to thereby separate the material into grades, means for independently withdrawing the several grades of
 70 material from said vessel, and a plurality of secondary outlets from the cylindrical portion of said grading vessel arranged to decrease step by step upwardly in said vessel the upward flow or travel of the liquid relative to the material therein.

20. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel having a cylindrical portion,
 80 means for producing in said vessel an upward flow or travel of the liquid relative to the abrading material to thereby separate the material into grades, means for independently withdrawing the several grades of material from said vessel, and a secondary out-
 85 let pipe arranged to withdraw from the cylindrical portion of said grading vessel a portion of the material in each grade to thereby decrease upwardly through said vessel the velocity of upward flow or travel of
 90 the liquid relative to the material.

21. Apparatus for grading finely divided material mixed with a liquid, comprising a
 grading vessel having a cylindrical portion, means for producing in said vessel an up-
 95 ward flow or travel of the liquid relative to the abrading material to thereby separate the material into grades, means for independently withdrawing the several grades of material from said vessel, and a secondary out-
 100 let pipe having a vertical branch lying inside the cylindrical portion of said grading vessel and provided with a plurality of openings at different levels, said pipe being ar-
 105 ranged to withdraw from the cylindrical portion of said vessel a portion of the material in each grade and to thereby decrease upwardly through said vessel the velocity of
 upward flow or travel of the liquid relative to the material.

22. Apparatus for grading finely divided material mixed with a liquid, comprising a
 grading vessel having its lower portion conical with the side walls thereof converging
 11 downwardly and having a cylindrical portion superposed thereon, means for producing in said vessel an upward flow or travel
 of the liquid to thereby separate the material into grades, means for independently withdrawing the several grades from said ves-
 11 sel, and a plurality of secondary outlets arranged to withdraw from the cylindrical portion of said grading vessel a portion of the material in each grade and to thereby decrease upwardly through said vessel the velocity of upward flow or travel of the liquid relative to the material.

23. Apparatus for grading finely divided material mixed with a liquid, comprising a
 grading vessel having its lower portion conical

cal with the side walls thereof converging downwardly and having a cylindrical portion superposed thereon, means for producing in said vessel an upward flow or travel of the liquid to thereby separate the material into grades, and a secondary outlet pipe arranged to withdraw from the cylindrical portion of said grading vessel a portion of the material in each grade to thereby decrease step by step upwardly the upward flow or travel of the liquid relative to the material therein.

24. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel having its lower portion conical with the side walls thereof, converging downwardly and having a cylindrical portion superposed thereon, means for producing in said vessel an upward flow or travel of the liquid to thereby separate the material into grades, means for independently withdrawing the several grades from said vessel, and a secondary outlet pipe having a vertical branch inside the cylindrical portion of said grading vessel and provided with a plurality of openings at different levels, said pipe being arranged to withdraw from the cylindrical portion of said vessel a portion of the material in each grade and thereby decrease upwardly through said vessel the velocity of upward flow or travel of the liquid relative to the material.

25. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, means for producing therein a downward flow or travel of the material

relative to the liquid, a hydrometer arranged to assume a state of equilibrium beneath the surface of the mixture in the grading vessel, and means connected to said hydrometer and arranged to indicate the density of the mixture.

26. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, means for producing therein a downward flow or travel of the material relative to the liquid, a hydrometer suspended in the grading vessel and of such size as to be affected by only a single zone of the mixture therein, and means connected to said hydrometer and arranged to indicate to the operator the density of the mixture in said zone.

27. Apparatus for grading finely divided material mixed with a liquid, comprising a grading vessel, means for producing therein a downward flow or travel of the material relative to the liquid, a hydrometer suspended in the grading vessel and of such size as to be affected by the mixture in only a single zone, therein, a pivoted lever, one arm of which supports said hydrometer, and means on the outside of the grading vessel and supported by the other arm of said lever and arranged to indicate to the operator the density of the mixture in said zone.

In testimony whereof, I have hereunto set my hand.

HALBERT K. HITCHCOCK.

Witnesses:

ELBERT L. HYDE,
GLENN H. LERESCHE.