Oct. 7, 1958 W. E. McCOWN ET AL 2,854,795

GRINDING APPARATUS

Filed Oct. 11, 1954

2 Sheets-Sheet 1

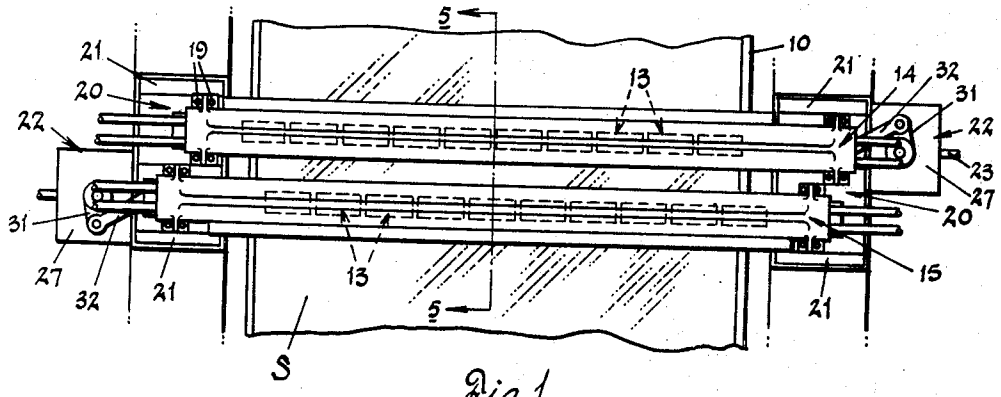


Fig. 1

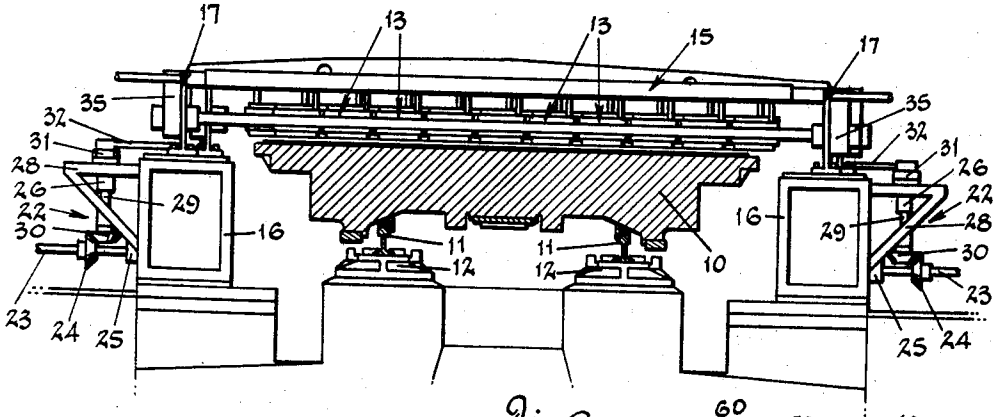


Fig. 2

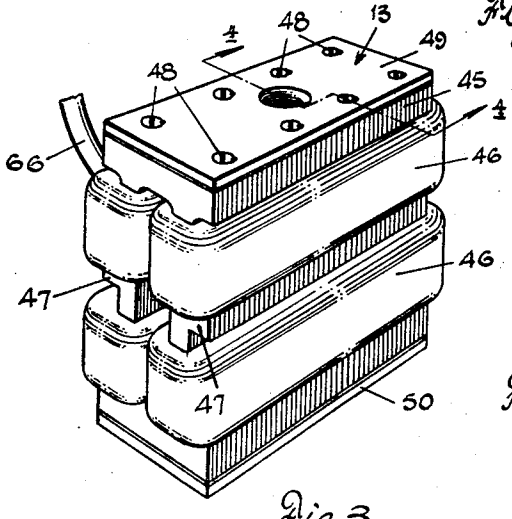


Fig. 3

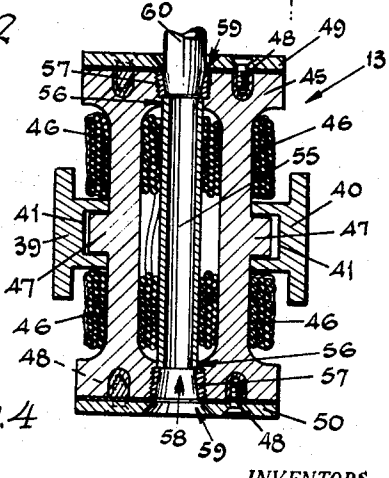


Fig. 4

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GRINDING APPARATUS

Filed Oct. 11, 1954 2 Sheets-Sheet 2

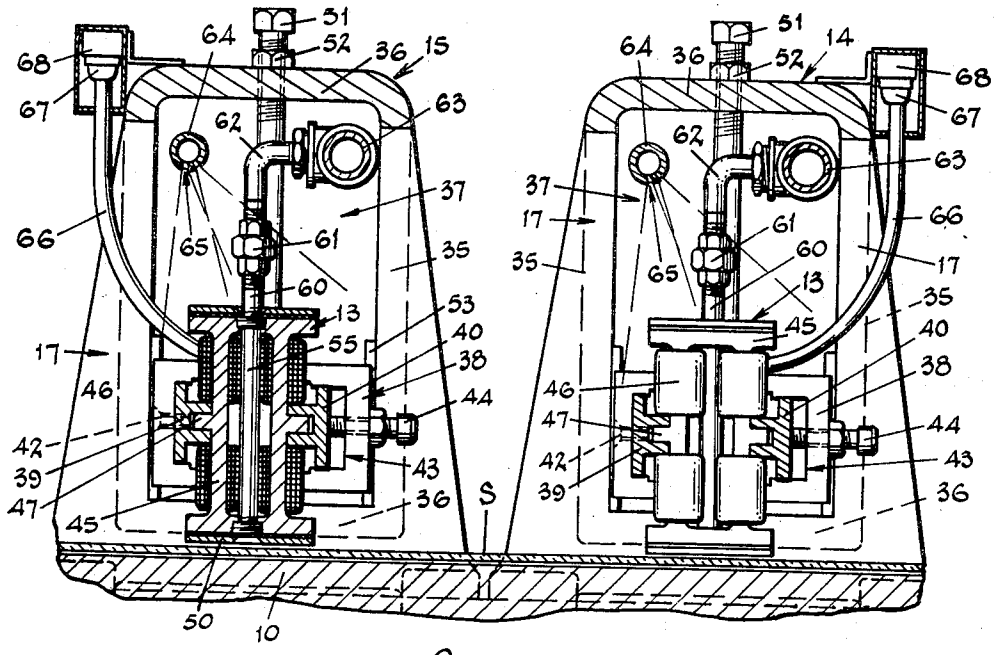


Fig. 5

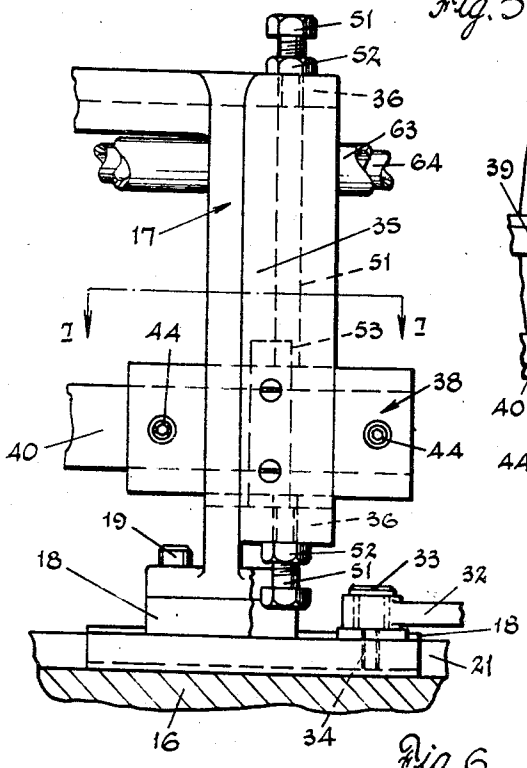


Fig. 6

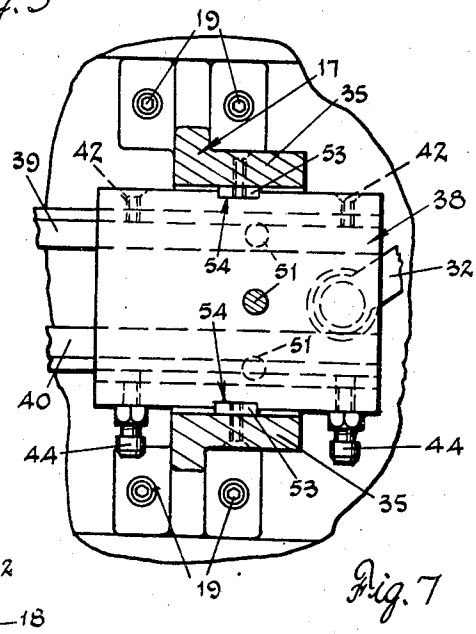


Fig. 7

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GRINDING APPARATUS

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Application October 11, 1954, Serial No. 461,456

9 Claims. (Cl. 51—59)

The present invention relates broadly to grinding, and more particularly to an improved method and apparatus for grinding surfaces by high frequency vibration.

Although the invention is not restricted to the grinding of any particular article or type of surface, it is especially well adapted to carry out the difficult job of grinding the surfaces of flat glass sheets and will be described in that connection here.

In the regular commercial production of plate glass, the unfinished glass blanks are ordinarily bedded upon surfacing tables in a layer of plaster of Paris or the like and then passed beneath horizontal grinding discs which are revolved in the presence of sand and water to obtain the desired grinding effect. Because of the pressure of the grinding discs upon the sheets of glass in the conventional processes, the sheets are subjected to a crushing action as the discs force the abrasive particles into the surface being ground. Consequently, the sheets oftentimes exhibit small cracks or fissures which affect the optical qualities thereof, and if numerous enough, cause the sheets to crack. Of course, any cracking of the sheets not only has an adverse effect upon production efficiency, but also upon the felt-covered polishing discs used in subsequent polishing steps which are easily torn by sharp glass edges and chips.

Further deficiencies are also inherent in commercial grinding processes in that it is necessary that heavy complicated precision equipment be used to maintain the grinding discs in an exact horizontal position with respect to the sheets passing therebeneath so that a uniformly ground surface may be obtained. Also, the large amounts of water and different grades of sand that are necessary to obtain the desired grinding effect cause the grinding area to be damp, dangerous and unsightly thereby increasing maintenance and accident prevention costs.

According to the present invention, to alleviate the above mentioned deficiencies that have been inherent in conventional grinding methods, vibration frequencies preferably over 100 cycles per second are applied to the surfaces of the sheets through a suitable medium having an abrasive or grinding compound therein. These vibration frequencies are transmitted in the form of mechanical vibration sound waves, and as the sound waves are propagated through the medium, which is preferably a fluid, the motion of the abrasive particles in said medium is related to the characteristics of the sound waves themselves. In this manner, the sound waves create a cavitation effect in the liquid medium; cavitation being the effect of the alternate formation and collapse of gas bubbles and cavities. This collapse of the cavities creates an agitation effect of sufficient magnitude to cause the abrasive particles to alternately bombard the surface of the sheets and to erode or grind the said surface as the sheets are moved past the cavitation area.

Thus, it is therefore a primary object of this invention to provide a relatively simple and light weight device which will grind flat-surfaced bodies in an expeditious

and efficient manner by the use of sonic or ultrasonic vibrations.

Another object of the invention is to provide a means whereby a plurality of vibration generating elements may be mounted above the path of a conveying means so that the generating faces thereof will completely traverse the path of the articles carried by the conveying means as they pass beneath said generating elements.

Another object of the invention is to provide a means whereby a thin film of a liquid transmitting medium having an abrasive or grinding material therein may be confined to a very small and localized area over the surface being ground.

A further object of the invention is to provide a method of grinding sheet material wherein relatively few grades of grinding or abrasive material are needed to produce a relatively smooth surface.

A still further object of the invention is to provide a method and apparatus for grinding glass sheets which will leave relatively few fissures or cracks in said sheets.

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

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

Fig. 1 is a fragmentary plan view of one form of grinding apparatus constructed in accordance with the invention;

Fig. 2 is a transverse vertical section through a glass finishing line showing the apparatus of the invention mounted thereabove;

Fig. 3 is a perspective view of one form of vibration generating element that may be used with the invention;

Fig. 4 is a sectional view taken substantially along line 4—4 of Fig. 3;

Fig. 5 is a partial vertical sectional view taken along line 5—5 of Fig. 1;

Fig. 6 is a partial side elevation of a means for the mounting of the vibration generating elements; and

Fig. 7 is a sectional view taken substantially along line 7—7 of Fig. 6.

With reference now to the drawings and particularly to Figs. 1 and 2, there is shown one section of a continuous grinding and polishing line made up of a series of surfacing tables or conveying means **10** which are arranged end to end for movement along rails **11** mounted on a suitable mounting base **12**. The conveying means **10** are moved along a substantially horizontal path to carry glass sheets mounted thereupon beneath a series of grinding units and then beneath a series of polishing units not shown.

According to the present invention, the glass sheets "S" to be surfaced are secured upon the tops of the tables **10** by a relatively thin layer of plaster and then passed beneath vibration generating elements **13**. As shown in Figs. 1 and 2, the vibration generating elements are mounted upon two identical reciprocating supporting cross beams **14** and **15** arranged above the tables upon standards **16**.

More particularly, the supporting cross beams **14** and **15** are provided with depending legs **17** at their end portions which are mounted on slide plates **18** by bolts **19**. The slide plates **18** are mounted in ways indicated generally at **20** (Figs. 1 and 6) formed between guide blocks **21** suitably secured to the standards **16**.

Movement of the respective cross beams **14** and **15** relative to one another is accomplished by means of similar drive mechanisms **22**. Specifically, the drive mechanisms **22** include a drive shaft **23** having a bevel gear **24** thereon and journaled in a bearing **25**. Extending in a

substantially vertical direction and suitably journaled by a bearing 26 in the upper plate 27 of support frame 28 is a shaft 29. Connected to the lower end of shaft 29 is a bevel gear 30 which engages and is driven by the bevel gear 24 on drive shaft 23. On the upper end of shaft 29 there is mounted an eccentric or crank 31 which has a drive arm 32 pivotally connected thereto. As shown in Fig. 6, the said drive arm 32 is in turn pivotally connected to one of the slide plates 18 by means of a pin 33 which fits in a suitable hole 34 in the said slide plate. Thus, for a purpose to be described hereinbelow, upon rotation of the drive shaft 23, the shaft 29 and the crank 31 will be rotated causing the drive arm 32 to reciprocate the respective cross beam connected thereto in the ways 20. In other words, each of the cross beams 14 and 15 are connected to similar individual drive mechanisms 22 which may reciprocate the said cross beams together or in a staggered or opposed relationship with respect to one another.

Provided on each end of the cross beams 14 and 15 adjacent the legs 17 thereof are vertical flange portions 35 and horizontal flange portions 36 which define rectangular openings 37 therebetween at the end of the beam. Slidably mounted for vertical movement in each of the openings 37 is an open frame-type clamping bracket 38. Mounted within the clamping brackets 38 and bridging the tables 10 are especially formed channels 39 and 40 having grooves 41 therein; the channel 39 is secured to one side of each of the brackets 38 by means of screws 42, and the channel 40 is slidably mounted along a finished slot 43 formed along an opposite side of the brackets 38, being held therein by an adjustment screw 44.

The transducers 13, which are preferably of a magnetostrictive type having laminated core 45 and electrical coil windings 46 (Figs. 3 and 4), are supported by the channels 39 and 40 along nodal tabs 47 on the core 45 which tabs fit into the grooves 41 of the channels 39 and 40. The nodal tabs 47 are located at a point of substantially zero vibration of the transducer vibratory system so that a minimum of vibration energy will be imparted to the supporting structure thus allowing a maximum amount of energy to be expended upon the surface being ground. Secured to the vibrating ends of each of the transducer cores 45 by suitable screws 48 are upper and lower protective shoes or plates 49 and 50 respectively. In this connection, the lower shoe 50 serves as the working face of the transducer and prevents the abrasive grinding material from eroding the transducer core 45 and, in the event that the said shoe 50 should become unduly worn or eroded, it may be replaced by simply removing the screws 48.

When all of the transducers 13 are properly supported along the channels 39 and 40, the whole bank of transducers may be vertically adjusted to place the transducer working surfaces or faces 50 at the desired height above the surface to be ground by means of opposed adjustment screws 51 (Fig. 6), held in place by lock nuts 52 and carried by the horizontal flange portions 36 of the cross beams 14 and 15. These adjustment screws engage the clamping brackets 38 and provide a means whereby the brackets may be raised or lowered in the opening 37 defined by the flanges 35 and 36, and thus cause the channels 39 and 40 to raise or lower the transducers 13 to place them in proper position with respect to the surface of the sheets S carried by tables 10. The clamping brackets 38 are kept in aligned position with respect to the vertical flanges 35 by means of keys 53 mounted on the inside of the flange portions which engage key-ways 54 formed in the sides of the clamping brackets. Thus, when the brackets are moved upwardly and downwardly, the keys 53 engage the ways 54 and allow the brackets and channels 39 and 40 associated therewith to move only in a vertical direction.

In accordance with the invention, as noted hereinbefore, a supply of liquid energy transmitting medium having an abrasive or grinding material therein is maintained between the working surfaces 50 of the transducers and the surface being ground so that a cavitation effect can be set up in the liquid medium which will cause the abrasive particles therein to bombard and erode or grind the surface of the sheets. This energy transmitting medium may be supplied between the working surfaces 50 of the transducers and the sheets S through a tube 55 (Fig. 4) passing through the central portion of the transducers 13. More particularly, the tube 55 is preferably formed of a pliable fiber or rubber material and is held in place in openings 56 formed in the transducer core 46 by suitably threaded plugs 57. The plugs 57 have an opening 58 therein which mates with a flared opening 59 provided in the protective shoes 49 and 50.

The energy transmitting medium may be brought to each of the transducers 14 by means of rubber hose conduits 60, the lower ends of which fit snugly in the upper plug 57 in the transducer core, while the upper ends may be connected by a suitable joint 61 to individual pipe sections 62 positioned above each of the said transducers. In turn, each of the pipe sections 62 are connected to a main distribution pipe 63 extending along the length of each of the support beams 14 and 15. Because of the flexible hose connections 60 and the flexible tubes 55 within the transducers, the transducers may vibrate freely without having any damping effects exerted thereon by the said conduits or tubes and thus may impart a maximum amount of energy to the abrasive containing medium.

It will be apparent that as the abrasive containing liquid flows through the tube 55 in the transducer core under pressure, it will pass to the flared opening 59 in the lower protective shoe 50 and spread out onto the surface of the sheet S as it leaves the said opening. In this manner, it is possible to set up and maintain a film of fluid over a narrow area of the surface being ground. While this film or layer of energy conducting liquid is extremely thin and vertically unconfined, it nevertheless completely fills the space between the transducer working faces 50 and the sheet surface due, at least to some extent, to surface tension and capillary attraction effects. These effects act to maintain the energy conducting medium beneath the transducer faces at a level substantially higher than that of the unconfined film of the liquid that flows away from the transducers onto the remaining portion of the sheet. On the other hand, for some applications, it may be desirable to place the transducer working faces 50 in slight pressure contact with the sheets so that better vibratory contact may be had with the abrasive particles. If this were done, the thin film of the abrasive containing liquid may still be forced between the said working faces and the sheets being ground in the same manner as described above. In any case, however, it will be evident that the liquid medium, although unconfined may be maintained in a thin but effective layer over the necessary narrow width of surface being ground by the means described above, thus eliminating the need for tanks or other confining means to contain the liquid in sufficient volume to cover the transducer generating faces.

In order to obtain best results, the distance between the transducer working faces 50 and the surface being ground can be varied by means of the adjustment described hereinbefore, and the distance provided therebetween related to the surface tension and capillary attraction characteristics of the energy transmitting liquid being used. For example, with liquids having the greater surface tension and capillary attraction characteristics, the transducers can be maintained at a greater distance from the surface being ground inasmuch as the surface tension will not be overcome as easily to permit the liquid to become separated from the working faces 50.

With the transducer position so determined, the conducting medium is deposited therebeneath upon and over

a narrow width of the surface being ground where it will substantially fill the narrow space between the transducer generating faces **50** and the said surfaces and be maintained therebetween by the natural forces mentioned above. The transducers are then energized by an alternating voltage supplied to the coils **46** thereof causing extremely rapid vibrations to occur along the area of the working faces **50**. Since the generating surfaces **50** are in direct contact with the liquid medium, alternate positive and negative pressure fronts which travel directly from the vibrating surfaces or faces to the surface being ground along a path normal thereto are created. These variable pressure fronts cause a cavitation or bubble effect to take place in the medium which in turn causes the abrasive particles to be alternately accelerated toward the surface and pulled away therefrom toward the vibration generating elements as the bubbles collapse and create a negative pressure area. In this manner, by the high acceleration of the abrasive particles toward the surface, the said surface is subjected to a grinding and smoothing effect as the sheets move relative to the generating faces **50**.

To aid in evenly distributing the grinding action of the abrasive particles over the entire surface of the sheets as they are moved past the transducers by the tables **10**, the respective support beams **14** and **15** are reciprocated at a relatively high rate of speed relative to one another by the drive mechanisms **21** so that the surfaces of the sheets are swept by the eroding action of said particles. In other words, the transducers are moved transversely of the path of the sheets passing therebeneath so that a uniform grinding pattern will be obtained over the entire surface area of the sheets.

While for purposes of illustration, only two banks of transducers have been shown mounted above the path of the tables **10**, it will be apparent that any number may be used along with various grades of abrasives to obtain the desired grinding and smoothing effect. Some of the abrasives that may be employed include sand, boron oxide, aluminum oxide, rouge and others, which may be used alone or in combination to produce the desired grinding effect. However, regardless of the type of abrasive used, it will be evident that the sheets may be ground by the apparatus of the invention without the crushing effect that is ordinarily involved with the large metal discs used in conventional processes, which as noted above, have a tendency to produce large numbers of cracks and fissures in the glass sheets.

While an energy transmitting medium of water may be advantageously used in many cases, in others it is desirable to use a detergent medium as the transmitting medium so that dirt and other undesirable particles may be removed during the grinding operation. Alternately, other methods of disturbing the molecular structure of the surface being ground using similar type vibration generating elements may be practiced. For example, if the sheets are susceptible to chemical reactions, an acid or other type medium may be used in conjunction with an abrasive to remove and grind the sheet surfaces.

Also, while the vibration generators used to produce the cavitation effect in a liquid medium may operate continuously without interruption, it has been found that they overheat and tend to lose their efficiency when operated continuously for long periods of time. To compensate for this condition, there is herein provided a cooling means which includes a pipe **64** mounted along the beams **14** and **15** above the transducers **13**. The pipe **64** is provided with spray holes **65** which act to direct water or other suitable cooling mediums upon the transducers so as to provide a cooling effect therefor and thus allow the transducers to operate at peak efficiency. However, it is to be pointed out that other types of cooling means may be employed such as cooling pipes which cool by heat absorption, or air jets, etc.

Should it be desired to move any one of the transducers from the supporting beams **14** and **15**, they may be removed therefrom by mere loosening of the adjustment screws **44** so as to allow the channels **40** to slide in the slot **43** thus causing them to disengage the nodal tabs **47**. After the channel **40** has been withdrawn from contact with the transducer tabs **47**, any one of the transducers may be removed by pulling the rubber hose **60** from contact with its associated plug **57** and by disengaging the transducer power lead **66** and plug **67** from the power supply housing **68** mounted upon the upper side of the supporting cross beams.

It will also be apparent that while the grinding apparatus disclosed herein has been described in connection with the grinding of glass sheets, that it may also be used to grind sheet material such as steel plate or plastic, and that the transducers may be moved while the object being ground remains substantially stationary or moves relative thereto. Also, while the abrasive medium has been shown in the drawings to be deposited upon the sheets through a conduit passing through the transducers, it may also be deposited upon the sheets by suitable external pipes which may spray the said medium between the working faces of the transducers and the surface of the sheets.

It is of course to be understood that the form of the invention disclosed herein is to be taken as the preferred embodiment thereof and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the following claims.

We claim:

1. Apparatus for grinding flat surfaced objects, comprising means for moving the objects to be ground along a definite path, a support mounted above the path of said moving objects, a plurality of elastic vibration generating elements mounted on said support in spaced relation to said objects, means for building up a layer of an abrasive containing energy transmitting medium on a localized area of said objects as they move past said vibration generating elements, and means for reciprocating said vibration generating elements laterally relative to said moving objects during grinding of the latter.

2. Apparatus for grinding surfaces of objects as described in claim 1, in which means are provided for supplying said abrasive containing medium through said vibration generating elements.

3. Apparatus for grinding glass sheets, comprising means for moving a sheet to be ground along a definite path, a support mounted above said path, a plurality of vibratory devices for inducing elastic vibrations mounted on said support in spaced relation to the glass sheet, means for depositing an energy transmitting medium containing abrasive therein between said vibratory device and said sheet, and means for moving said vibratory devices substantially transversely of the path of said sheet during grinding of the latter.

4. In a method of grinding a flat surface, the steps of moving said surface in face-to-face relation along a path past an elastic vibration generating element, providing a film of an abrasive containing energy conducting medium between said surface and said vibration generating elements and in contact therewith, and transmitting undamped elastic vibrations to said energy conducting medium from said vibration generating element while moving said element in a plane parallel to said surface.

5. In a method of grinding a flat surface as defined in claim 4, the additional step of moving said surface and said vibration generating element relative to one another during grinding of said surface.

6. In a method of continuously grinding a flat surfaced object as it moves along a definite path, the steps of arranging a plurality of vibration generating elements with their working surfaces in spaced relation with the object to be around providing a film of an abrasive containing energy conducting medium between said object and said

vibration generating elements, transmitting elastic vibrations to said energy conducting medium from said vibration generating elements, and moving some of said vibration generating elements relative to one another in a plane parallel to the flat surfaced object and during grinding thereof.

7. Apparatus for grinding glass surfaces, comprising means for moving a glass sheet having a surface to be ground along a definite path, support means extending across said path, elastic vibration inducing means mounted on said support means and having a working face positioned adjacent the path of travel of the surface of said sheet, means for supplying an abrasive containing energy transmitting medium to the sheet surface to be ground, and means for moving said working face transversely to the direction of movement of the glass sheet during grinding of said sheet.

8. Apparatus for grinding glass surfaces as defined in claim 7, wherein the means for moving the working face includes means for reciprocating the support means in a plane substantially parallel to the sheet surface to be ground during grinding of said sheet surface.

9. A method of surfacing glass sheets which comprise positioning a glass sheet with the surface to be treated parallel with the working surfaces of a plurality of vibration generating elements, conveying said sheet surface past said vibration generating elements along a predetermined path spaced from but substantially parallel with said parallel working faces, maintaining an unconfined mass of a suspension of abrasive particles in an energy conducting liquid in the space between the parallel working faces of said vibration generation elements and the portion of said sheet surface that is moving therepast and in contact with both, and transmitting elastic vibrations to said unconfined mass of liquid.

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CERTIFICATE OF CORRECTION

Patent No. 2,854,795 October 7, 1958

William E. McCown et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 74, for "around" read -- ground --.

Signed and sealed this 27th day of January 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON

Commissioner of Patents