3,270,464
Patented Sept. 6, 1966

3,270,464

ABRASIVE BLASTING APPARATUS

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Filed Apr. 28, 1964, Ser. No. 363,160
20 Claims. (Cl. 51—15)

This invention relates to abrasive blasting apparatus for machining work pieces, particularly, silicon wafers.

Silicon wafers used in the electronics industry must be made with precise dimensions. As a result, the faces of the saw-cut slices are lapped to a uniform thickness and surface finish. These slices are then machined into a number of smaller wafers. Although abrasive airblast machines are sometimes used in accomplishing this, it is difficult to uniformly feed the very fine abrasive particles because of their high repose angles and their tendency to pack or dump in the abrasive supply hopper from which the abrasive is returned to the blasting nozzles.

An object of this invention is to provide an apparatus for efficiently machining objects, such as silicon slices, wherein the abrasive does not pack in the hopper so that the abrasive can be constantly recirculated through the apparatus.

Other objects and advantages of the invention will become more apparent from a study of the following description and drawings wherein:

FIG. 1 is a front view of one embodiment of this invention;

FIG. 2 is a side view of the embodiment of FIG. 1;

FIG. 3 is a section taken along line 3—3 of FIG. 2;

FIG. 4 is an interior front view of a portion of the embodiment of FIGS. 1–2;

FIG. 5 is an interior side view of the embodiment shown in FIGS. 1–2;

FIG. 6 is a section taken along line 6—6 of FIG. 4;

FIG. 7 is a front view on an enlarged scale of a portion of the embodiment of FIGS. 1–2; and

FIG. 8 is a section taken along line 8—8 of FIG. 7.

As shown in FIGS. 1–2, machine 10 includes a cabinet or housing 12 having a supply hopper 14 for the abrasive 16. As shown in FIG. 6 the silicon slices 23 are secured to pieces of glass batt 19 by wax or other suitable adhesive. Masks 21 are then applied to the exposed surfaces of silicon slices 23 to protect the slices being cut. The work pieces or batt mounted silicon are inserted through a side door (not shown) in housing 12 and secured to the periphery of rotatable work table 20 by, for example, clamps. The side door is then closed and machine 10 is ready for operation. Vision window 24 and lights 26 permit the operator to see into the otherwise opaque housing 12.

Table 20 is rotated by a variable speed drive unit 28 as shown in FIGS. 2–3 which includes motor 30 and chain drive 32 connected to table 20. Chain drive 32 is mounted within tunnel 34 to prevent carry-out of abrasive by the chain drive.

After the pieces are positioned on table 20, an air compressor (not shown) is started to feed air through line 36 (FIG. 2) which leads to air lines 38, 40, and 42 connected to blast nozzles 44, 46 and 48 respectively.

As shown in FIGS. 4 and 5, blast nozzles 44, 46, and 48 are conveniently adjustable in a number of ways with respect to table 20. For example, all three nozzles are simultaneously and vertically adjustable by turning crank 50 which is accessible from the outside of housing 12 as shown in FIG. 1. Referring to FIG. 5, crank 50 drives a jack-screw or rack and pinion arrangement 52 which moves rack or bar 54 up and down with respect to table 20 by turning coaxially mounted pinion 55. Bar 54 is connected to cross bar 56 upon which nozzles 44, 46, and 48 are mounted and bar 54 slides in chamber 58 which is secured to slotted partition 60. Bellows 62 connected to bar 54 and chamber 58 permits the bar to move up and down while preventing abrasive from entering the chamber and escaping through slotted partition 60. As bar 54 moves vertically, guide rollers 64 secured to bar 54 slide against the inner surface of chamber 58.

Nozzles 44, 46, and 48 are additionally independently and vertically adjustable by thumb screws 66 and are independently and horizontally adjustable by thumb screws 68 as shown in FIG. 4.

The nozzles are additionally provided with an adjustable oscillating mechanism 70 for machining work pieces which are wider than the diameter of the nozzle stream. As shown in FIG. 4, oscillating mechanism 70 includes cylinder 72 which reciprocates air driven piston 74 between guide rollers 98 in blocks 88 and 90. The compressed air is supplied to cylinder 70 after being fed to conduit 76 and through direction control valve 78. Adjustable stops 80 and 82 are mounted on piston 74 and contact valve controls 84 and 86, respectively, which are welded to blocks 88 and 90. When stop 82 contacts control 86, as shown in FIG. 4, the air is fed to cylinder 72 through air line 92 to move piston 74 toward the left of FIG. 4. Conversely, when stop 80 contacts control 84 air is fed through air line 94 to move piston 74 to the right of FIG. 4. The frequency of oscillation is easily adjustable in accordance with the position of stops 80 and 82 which are movable on piston 74 by loosening thumb screws 96.

The oscillating mechanism is also provided with an operating cylinder or oil tank (not shown) which meters oil into the system through an orifice by means of an air pressure actuated piston in the cylinder. As a result, the nozzle movement is very smooth and continuous even at low speed and low pressure.

As shown in FIG. 4 bar 54 is connected to piston 74 and reciprocates in a slot (not shown) in partition 60 to thus cause nozzles 44, 46, and 48 to oscillate also. Advantageously, chamber 58 is mounted under slotted partition 60 to prevent abrasive from escaping through it. While bar 54 reciprocates back and forth in chamber 58, its guide rollers 64 move along the inner surface of chamber 58. Since table drive 28 is of the variable speed type, table 20 can be rotated at a speed out of phase with the nozzle oscillation to provide uniform blast coverage of the work pieces.

As shown in FIGS. 1, 2, and 7, hopper 14 is resiliently secured to housing 12 by a flexible mounting 100 and additionally includes resilient cushions or base mountings 102 of the type shown in Patent No. 3,063,207 for permitting the hopper to vibrate. Hopper 14 is maintained in a state of agitation by vibrator 104 secured to it at right angles to the direction of feed pipes 106, 108, and 110. As a result, as shown in FIGS. 1 and 8 abrasive 16 is maintained substantially level in hopper 14 and the abrasive is prevented from packing within the hopper. Blow-off nozzle **112** (FIG. 1) also helps prevent the abrasive from packing in the hopper.

Feed pipes **106**, **108**, and **110** lead to nozzles **44**, **46**, and **48**, respectively and are in venturi relationship with air lines **38**, **40**, and **42** respectively as shown in FIGS. 2 and 4 so that the flow of air from the air lines through each nozzle draws abrasive through the feed lines from the bottom of hopper **14** to continuously re-circulate the abrasive from hopper **14** to nozzle **44**, **46**, **48** and back to hopper **14**.

Screen **114** is secured above hopper **14** to assure that only the fine abrasive is in hopper **14**. Additionally, housing **12** is provided with a large vent hood **116** to keep any carry out of small abrasives to a minimum, while reclaimer or dust collector **120** of the type shown in U.S. Patent Nos. 3,053,031; 2,667,233; and 2,876,862 traps any particles which do escape.

The effective opening or orifice size of feed lines **106**, **108**, and **110** is controlled by adjustable gates **122**, **124**, and **126** respectively as shown in FIGS. 7–8. The lip **128** of each gate is slidable in front or at the mouth of its feed line by manipulating bolt and nut arrangement **130** secured to each gate to thereby regulate the flow of abrasive through each feed line.

Gates **122**, **124** and **126** also provide a unique way of controllably aerating or diluting abrasive **16** to facilitate the suction of abrasive **16** through feed lines **106**, **108**, and **110** and into nozzles **38**, **40** and **42** respectively. Each gate is made channel shaped thus permitting air to flow into outer end **132**, through each gate along the inner surface of web **134**, and out of lip **128** into each feed line. Consequently, by manipulating bolt and nut arrangement **130** to move lip **128**, the amount of air entering each feed pipe is controlled as well as its effective opening.

As is readily apparent, the nozzles can be adjusted to any desired relationship with work table **20** both simultaneously and independently. Once the operation begins, vibrator **104** maintains hopper **14** in a state of agitation to prevent abrasive **16** from packing in the hopper. This insures continuous feeding to all feed lines with no starving or bridging at any feed line. As air flows through the nozzles it sucks abrasive through the feed lines and directs the abrasive at the work pieces supported on the rotating work pieces. Abrasive **16** falling back into hopper **14** are accordingly continuously recirculated throughout the system until hopper **14** is empty.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. Abrasive blasting apparatus for machining work pieces comprising a housing, nozzles in said housing, air supply means connected to said nozzles for causing a flow of air therethrough, a work table in said housing disposed under said nozzles, an abrasive supply hopper under said work table for receiving abrasive material, vibrating means cooperating with said hopper for maintaining said abrasive material substantially level and in a constant state of agitation in said hopper, and abrasive return means connecting said hopper to said nozzles for ejecting said abrasive material from said nozzles and for recirculating said abrasive back to said nozzles after it falls into said hopper.

2. The apparatus of claim **1** wherein adjusting means are connected to said nozzles for regulating the relative position of said nozzles with respect to said work table.

3. The apparatus of claim **2** wherein said adjusting means includes oscillating means for moving said nozzles back and forth over said work table.

4. The apparatus of claim **3** wherein said oscillating means includes control means for adjusting the frequency of oscillation.

5. The apparatus of claim **3** wherein said adjusting means includes height adjustment means for simultaneously moving all of said nozzles toward and away from said work table.

6. The apparatus of claim **5** wherein said oscillating means includes a reciprocating piston, said height adjustment means including a bar connected to said piston, said nozzles being secured to said bar, a chamber having an open end, said bar being movable in said chamber, and a bellows closing said open end of said chamber and connected to said bar to permit said bar to move in said chamber and to prevent said abrasive material from entering said open end of said chamber.

7. The apparatus of claim **2** wherein said adjusting means includes height adjusting means for simultaneously moving all of said nozzles up and down with respect to said work table.

8. The apparatus of claim **7** wherein said height adjusting means comprises a rack secured to said nozzles, a pinion engaging said rack, and a crank connected to said pinion on the outside of said housing for rotating said pinion to move said rack up and down.

9. The apparatus of claim **7** wherein said adjustable means includes height regulating means on each of said nozzles for independently moving each of said nozzles toward and away from said work table, and horizontal regulating means on each of said nozzles for independently moving each of said nozzles back and forth over said work table.

10. The apparatus of claim **1** wherein resilient mounting means secures said hopper to said housing for permitting said hopper to vibrate with respect to said housing.

11. The apparatus of claim **10** wherein a second resilient mounting means is connected to the base of said hopper for facilitating the vibration of said hopper.

12. The apparatus of claim **1** wherein said abrasive return means includes feed conduits connecting each of said nozzles to the base of said hopper, each of said conduits being connected to its respective nozzles in venturi relationship with said air supply means whereby said flow of air through each of said nozzles causes said abrasive material to be drawn into said conduits from said base of said hopper and into the air stream through each nozzle.

13. The apparatus of claim **12** wherein aerating means are connected to each of said feed conduits for diluting said abrasive material to facilitate its being drawn into said nozzles.

14. The apparatus of claim **12** wherein flow control means are connected to the mouth of each of said conduits at said base of said hopper for adjusting the effective opening of each conduit to regulate the flow of abrasive material therethrough.

15. The apparatus of claim **14** wherein said control means comprises a movable gate slidable in front of the mouth of each of said conduits.

16. The apparatus of claim **15** wherein each of said gates is channel shaped, one end of each gate communicating with each of said feed conduits and the other end being exposed to the atmosphere to provide an air passage into each of said feed conduits.

17. The apparatus of claim **12** wherein said abrasive return means includes blow-off nozzle means mounted in said housing and directed toward said hopper for preventing said abrasive material from packing in said hopper.

18. The apparatus of claim **1** wherein oscillating means are connected to said nozzles for moving said nozzles back and forth over said work table, and variable speed drive means being connected to said work table for rotating said work table at a speed out of phase with the nozzle oscillation to provide uniform coverage of the work pieces on said work table.

19. The apparatus of claim 18 wherein said variable speed drive means includes a chain drive connected to said work table, a tunnel being in said housing under said work table, and said chain drive being disposed within said tunnel to prevent the carry-out of said abrasive material by said chain drive.

20. The apparatus of claim 1 wherein a vent hood is secured to said housing, and reclaimer means communicating with said vent hood for trapping particles of said abrasive material which escape from said housing.

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ABRASIVE BLASTING APPARATUS

Filed April 28, 1964 5 Sheets-Sheet 1

Fig. 3.

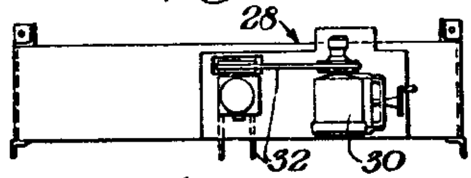

Fig. 1.

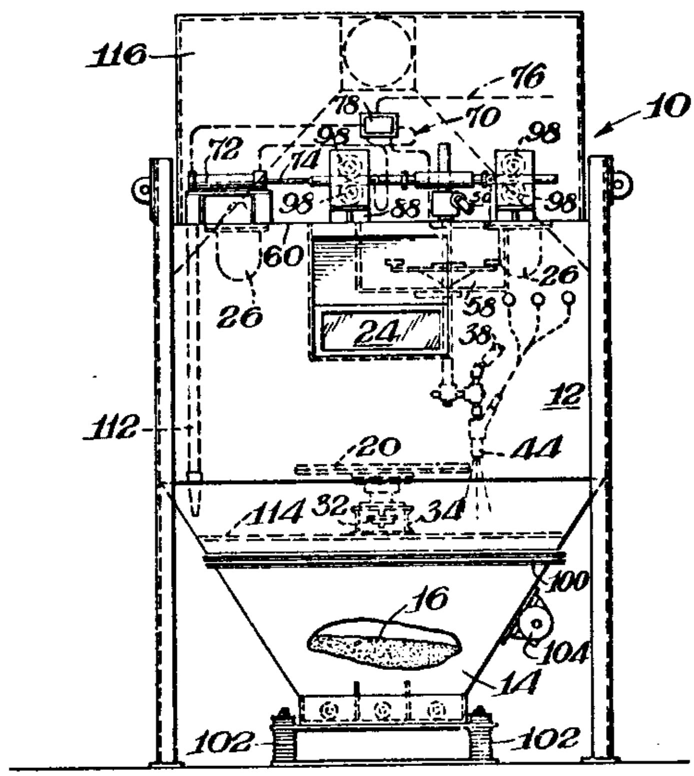

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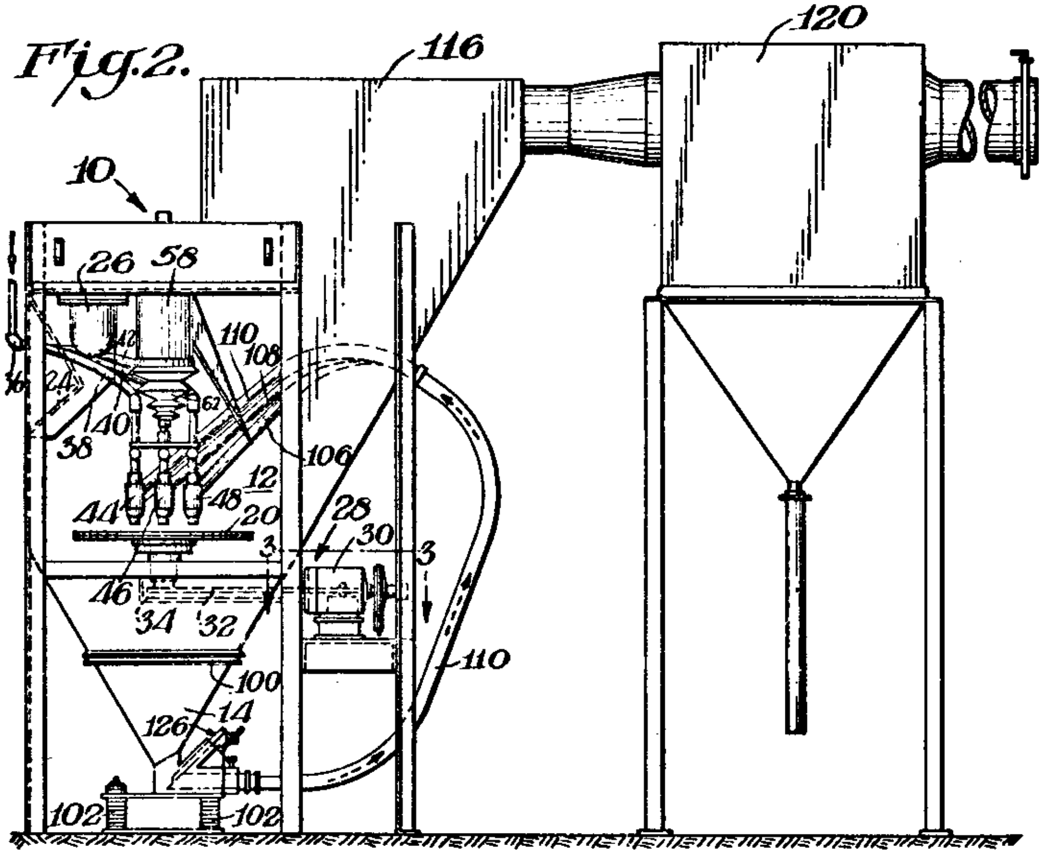
Fig.2.



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ABRASIVE BLASTING APPARATUS

Filed April 28, 1964 5 Sheets-Sheet 3

Fig. 4.

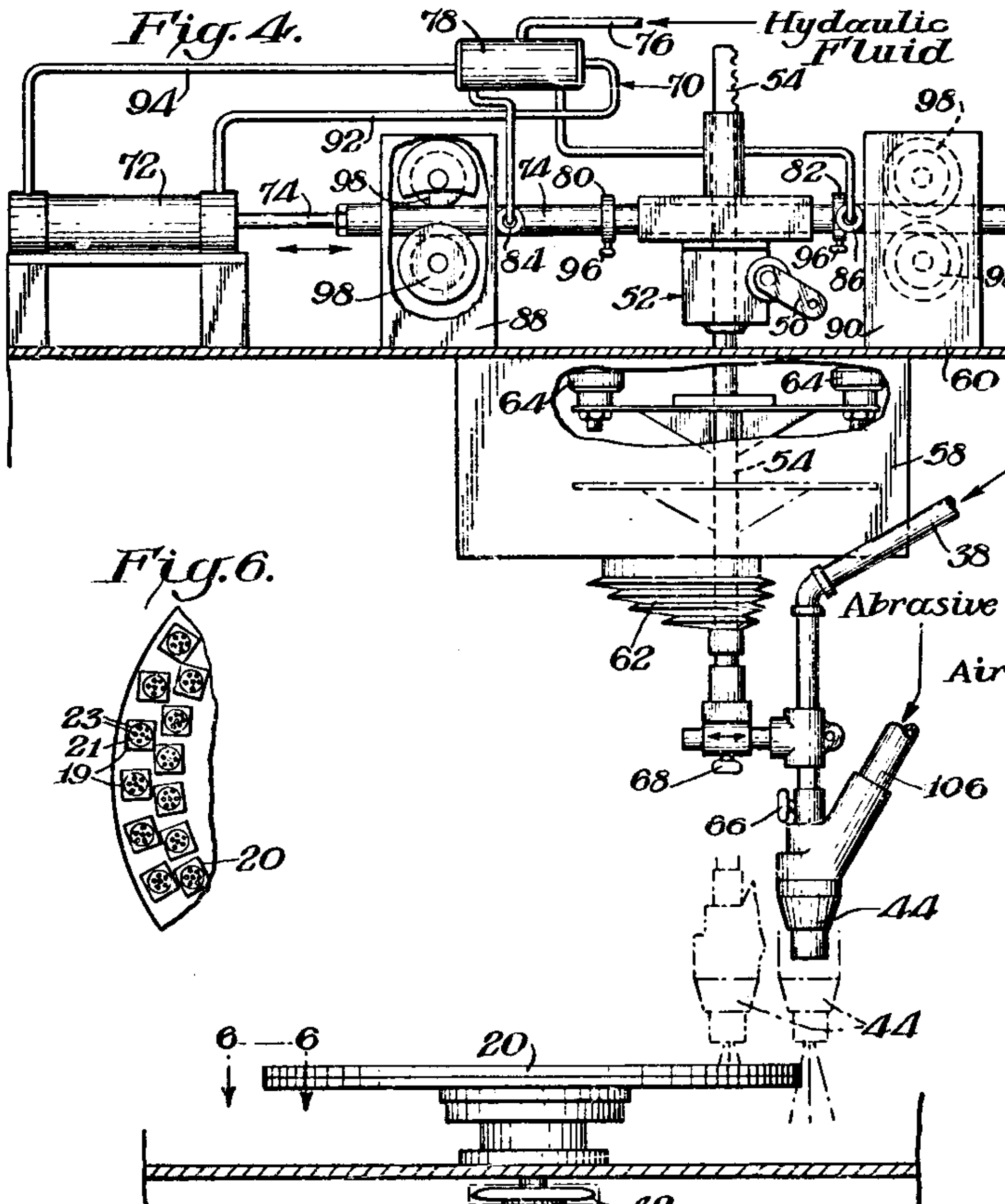

Fig. 6.

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ABRASIVE BLASTING APPARATUS

Filed April 28, 1964 5 Sheets-Sheet 4

Fig. 5.

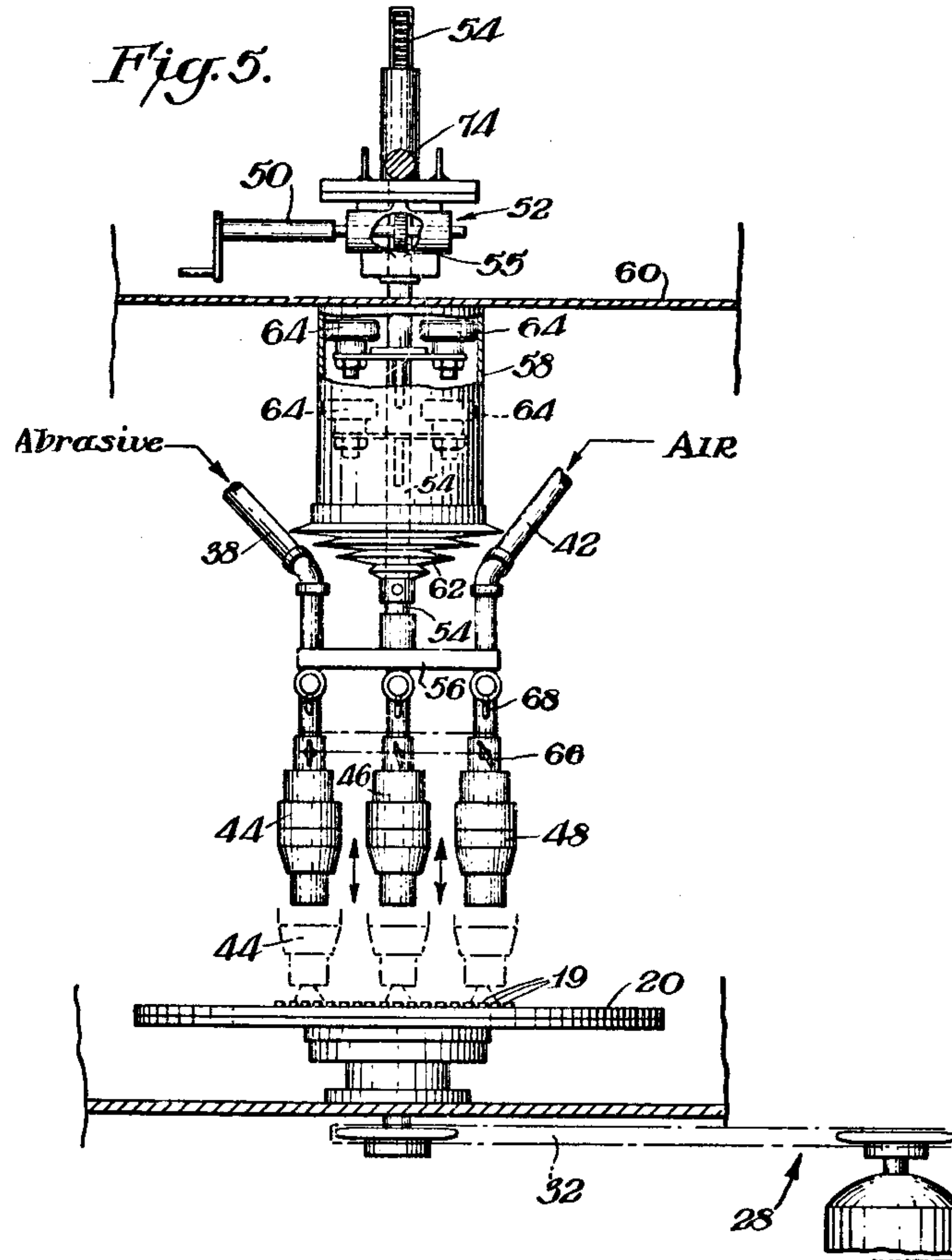

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Fig. 7.

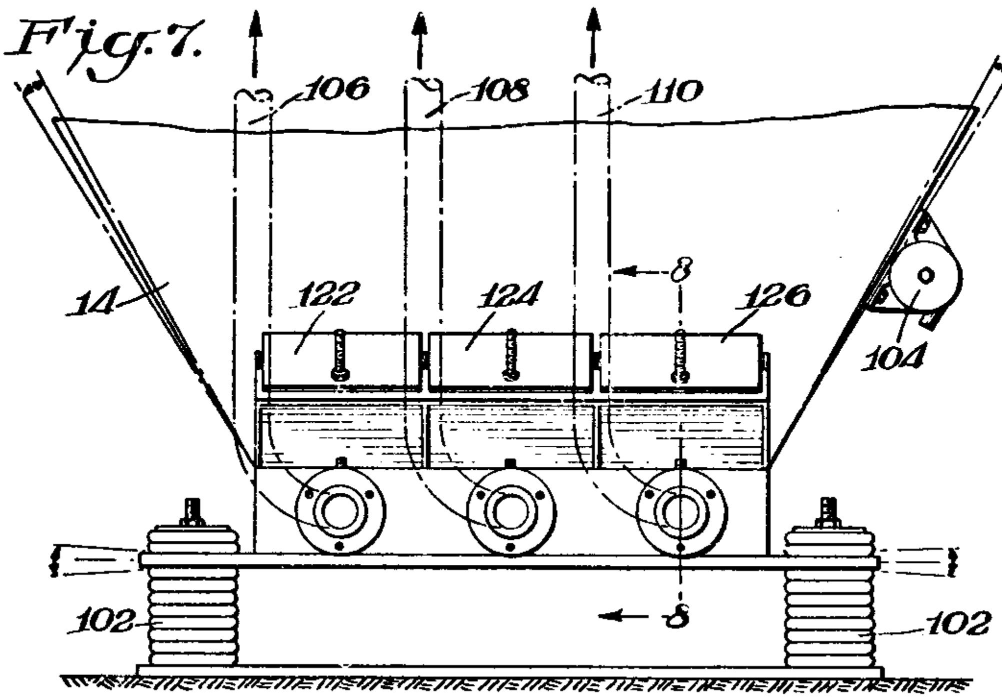
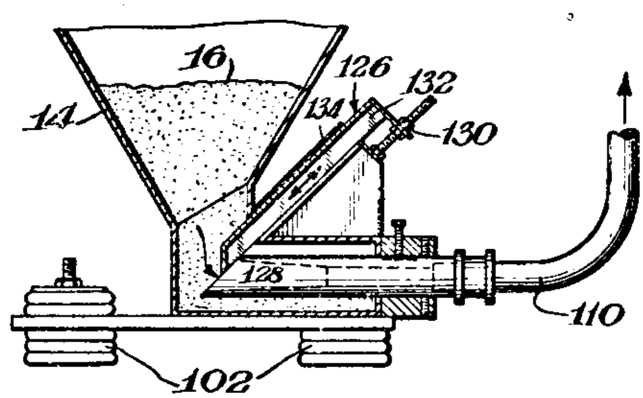


Fig. 8.



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