United States Patent [19]

Katzke

[11] **3,841,028**

[45] **Oct. 15, 1974**

[54] **APPARATUS FOR HANDLING WORKPIECES TO BE POLISHED**

[75] Inventor: **Ernest F. Katzke,** Des Plaines, Ill.

[73] Assignee: **Crane Packing Company,** Morton Grove, Ill.

[22] Filed: **Aug. 24, 1972**

[21] Appl. No.: **283,582**

[52] **U.S. Cl.** **51/125,** 51/131, 51/235

[51] **Int. Cl.** **B24b 7/22**

[58] **Field of Search** 51/129, 131, 235, 125.5, 51/125

[56] **References Cited**

UNITED STATES PATENTS

765,105	7/1904	Setter	51/131 UX
1,275,447	8/1918	Hodny	51/131
2,963,830	12/1960	Hook	51/131
3,128,580	4/1964	Davis	51/131
3,437,543	4/1969	Winings	51/131 UX
3,579,916	5/1971	Boettcher	51/131

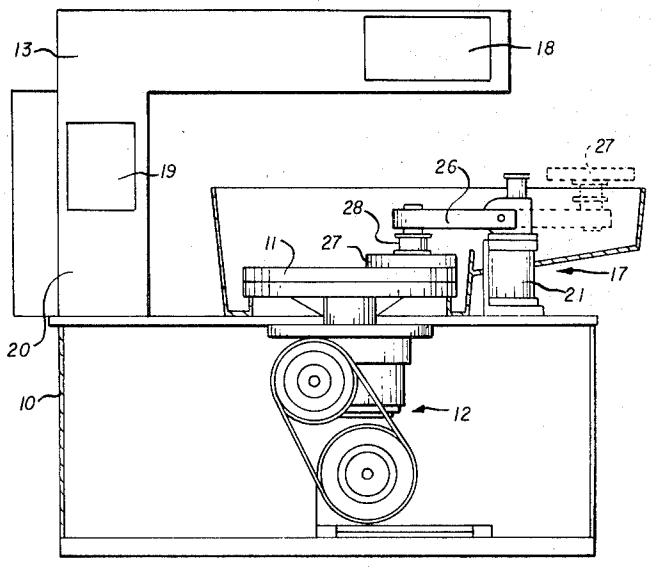
Primary Examiner—Harold D. Whitehead

Attorney, Agent, or Firm—Charles F. Voytech

[57] **ABSTRACT**

Disclosed is an apparatus for handling workpieces to be polished on a rotatable disc type of polishing machine and comprising a workholder mounted on an arm oscillatable in a vertical plane through substantially 180° so that in one position the workholder is inverted to facilitate loading and unloading thereof, and in another position the workholder supports the workpieces by differential pressure thereon over the polishing disc. The movement of the arm may be arrested as the workpieces touch the polishing disc, and an air cylinder on the arm moves the workholder against the disc and presses the workholder against the disc with a higher pressure than is permissible with wax-adhered workpieces. At the termination of the polishing operation the workholder is raised from the polishing disc and the arm is rotated to invert the workholder, after which a cleaning spray is automatically applied to the workpieces.

6 Claims, 4 Drawing Figures



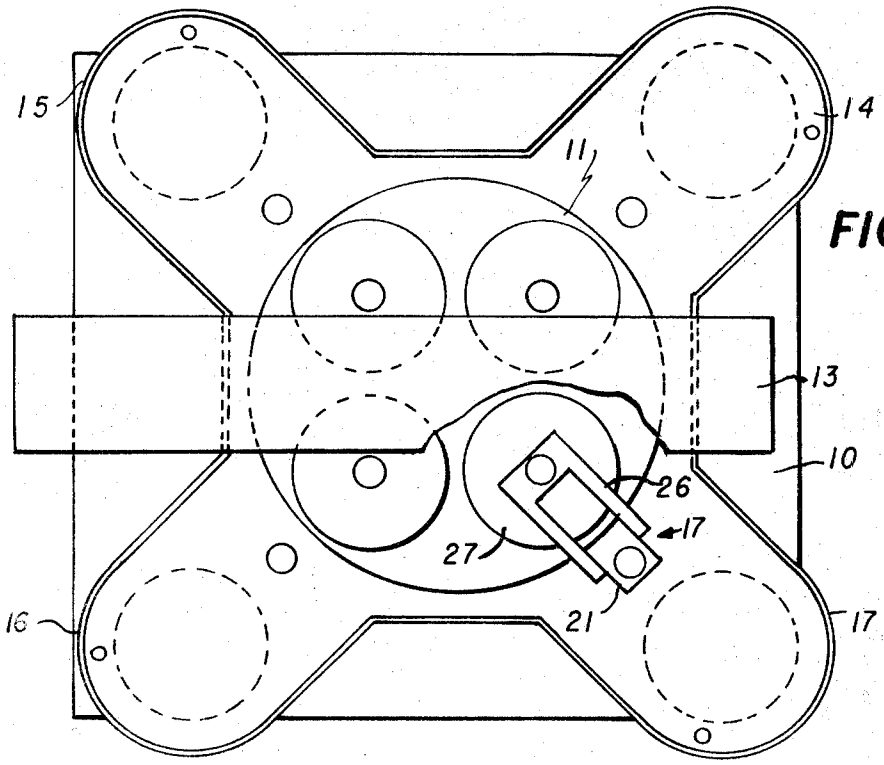


FIG. 1

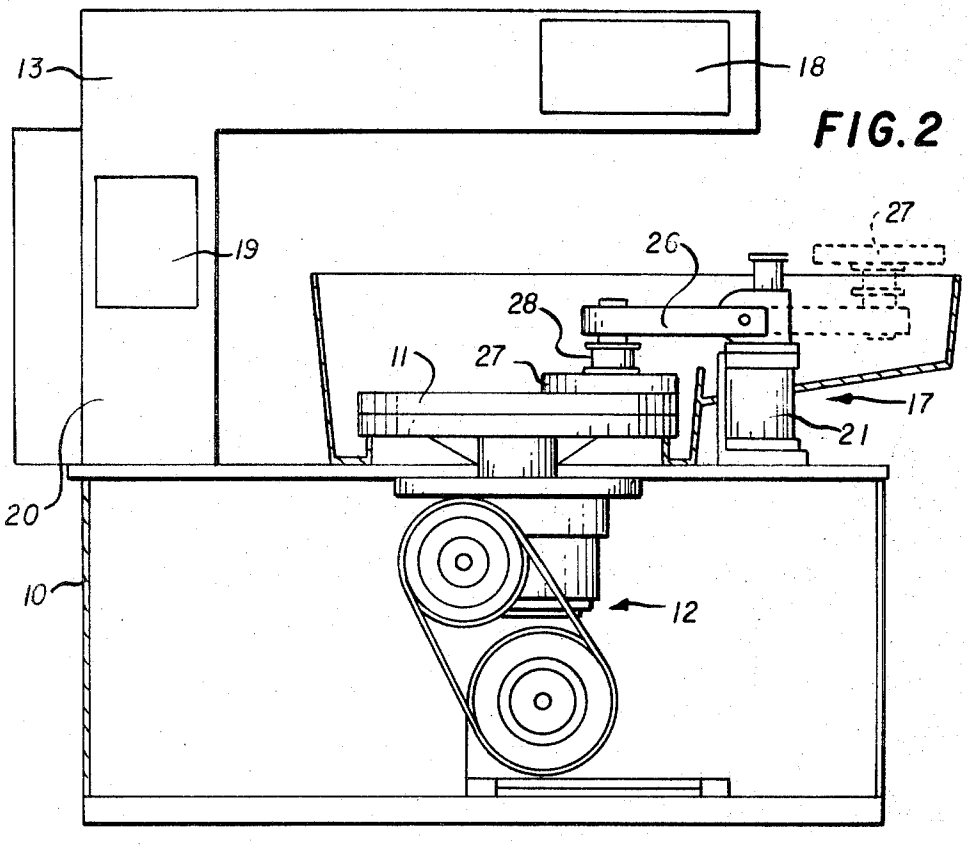


FIG. 2

FIG. 3

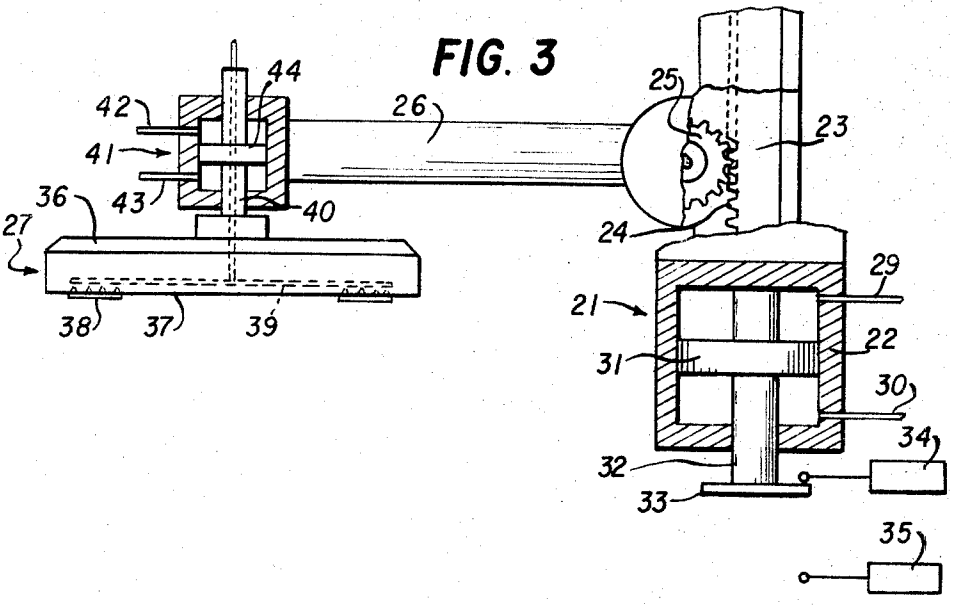
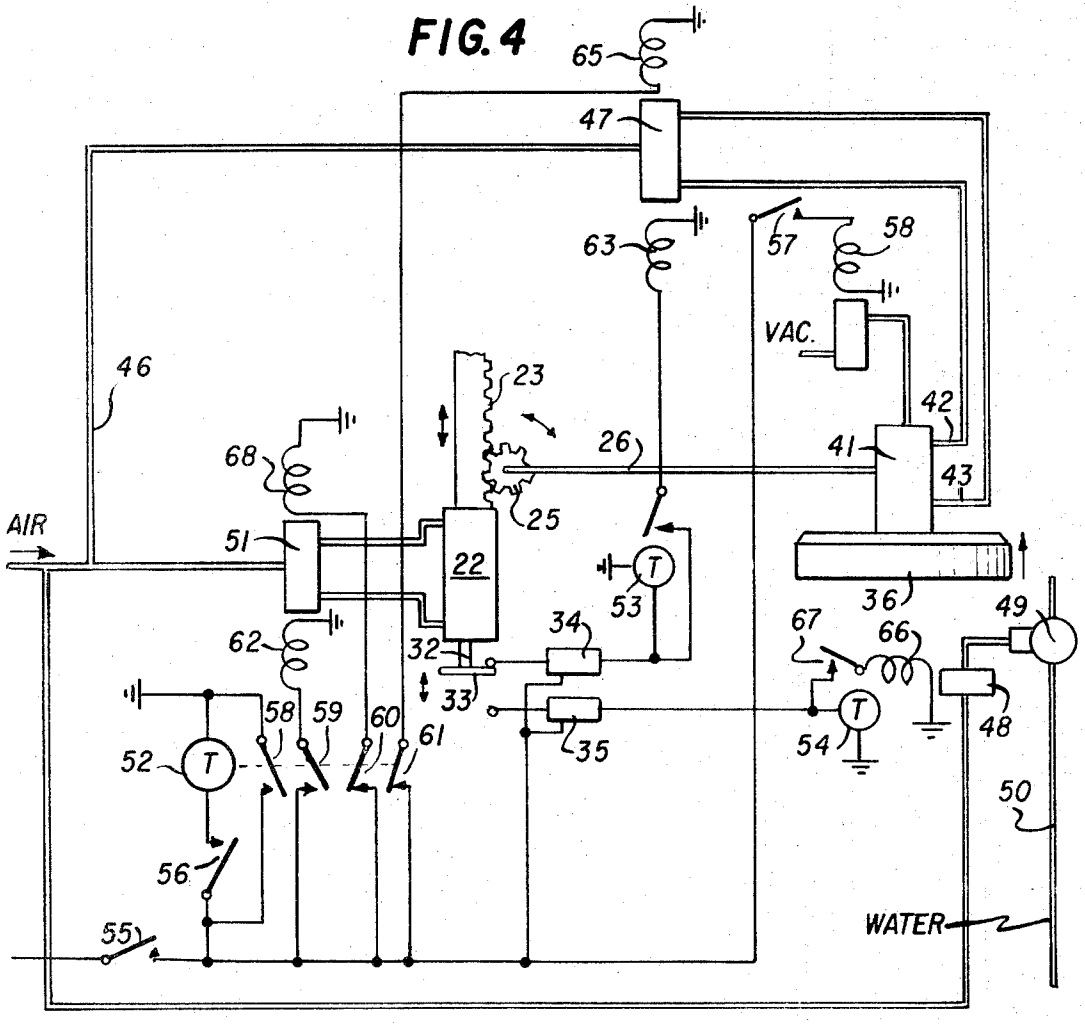

44
42
41
43
36
27
40
26
25
23
24
29
21
22
31
30
34
32
33
35
38
37
39

FIG. 4


65
47
63
57
58
VAC.
46
23
42
41
43
68
26
AIR
51
22
25
53
T
36
49
62
34
32
67
66
33
58
59
60
61
52
35
54
48
50
56
55
WATER

APPARATUS FOR HANDLING WORKPIECES TO BE POLISHED

This invention relates to abrading machines such as lapping and polishing machines and particularly to a means for handling workpieces of a thin disc-like shape to be abraded by said machine.

An important component used in the electronic art is the silicon wafer. This wafer varies from 0.005 inch to 0.015 inch thick and is disc-shaped in outline. It is important for its electrical characteristics that such wafer is made with parallel, highly polished surfaces, and that for uniformity the polishing be done automatically and under controlled conditions.

Rotating disc-shaped polishing tools have been used for polishing wafers, the latter being adhered by wax to a flat platen which is pressed against the rotating tool and held there for a predetermined time. For maximum production per hour, it is desirable that the time required to polish a wafer, or a batch of wafers, be kept to a minimum, which means that the pressure on the wafer during polishing should be as high as surface finish will permit. The higher pressures, however, increase the friction between the wafer and polishing disc which then heats up the wafer and melts the wax holding the wafer to the holder. The wafers thus loosened are destroyed, as are those at other stations on the polishing machine contacted by the loose wafers, resulting in an appreciable monetary loss to the polisher.

In my co-pending application, Ser. No. 202,965 filed Nov. 29, 1971 for APPARATUS FOR POLISHING WAFERS, there is disclosed and claimed a differential pressure-operated workpiece holder which eliminates the use of wax as an adherent for the wafers and which permits higher pressure to be used on the wafers to speed up the polishing operation. Although the wafers are heated by the polishing tool, it has been found that the higher temperature assists in breaking down the surface of the wafer and hence speeds the polishing operation. It is necessary, however, to go through several steps each time a polishing cycle is effected, the steps being to load, invert, press upon the polishing tool, return, wash the wafers while on the holder, and unload; and it is accordingly an object of this invention to provide means for automatically providing each of these operations for a wafer polishing machine except the load and unload operations.

More specifically, it is an object of this invention to provide a pressure-differential operated means for oscillating a workholder from a load position to a work position and, back again, the work position being held under a predetermined pressure.

For another object, this invention seeks to provide a pressure-differential operated arm on which is mounted a workholder, the arm being oscillated about a horizontal axis, wherein the mounting for the workholder on the arm includes a pressure-differential operated motor for providing operating pressure to the workholder, with control means automatically operated by the position of the arm for applying and releasing the pressure, and with timer means for moving the arm to invert the workholder and to apply a cleansing spray to the workpieces.

These and other objects of this invention will become apparent from the following detailed description of a preferred embodiment of the invention when taken together with the accompanying drawings in which

FIG. 1 is a plan view of a polishing machine incorporating this invention;

FIG. 2 is a side elevational view, partly in section of the machine of FIG. 1;

FIG. 3 is a side elevational view, partly in section and on an enlarged scale of the workholder of this invention; and

FIG. 4 is a schematic diagram of the controls for the workholder of FIG. 3.

The form of polishing machine selected to illustrate this invention is shown in plan view in FIG. 1. The workpieces are thin wafers of silicon or the like used as electronic components and are of disc form. The flat surfaces of the wafers are required to be polished to a predetermined standard, and with the polishing cycle calculated to produce such standard polish upon the wafers and the time required to load and unload a workholder it has been determined in the illustrative machine that a single polishing disc with four work stations could be readily tended by one operator.

Thus, the machine shown in FIG. 1 is comprised of a frame **10** on which is mounted a polishing disc **11** rotatable about a vertical axis and driven by an appropriate motor shown at **12** in FIG. **2.** A control panel **13** extends over disc **11** in proximity to four work stations **14, 15, 16** and **17** and contains four sets of manually-operated switches only one of which sets is shown in outline at **18.** One set of switches is supplied for each station. A separate master control panel **19** is located on a post **20** supporting the sets **18** of station switches. Said master control panel contains switches (not shown) for controlling (1) motor **12** for driving disc **11,** (2) a vacuum pump for generating the vacuum used to hold the wafers on the workholder, (3) a polishing compound pump for supplying the disc with abrasive for the polishing operation and (4) a master switch which controls the electrical energy to the entire machine. These controls, though necessary for the successful operation of the machine as a whole, form no part of this invention and hence will not be described in detail.

The four work stations **14, 15, 16** and **17** and their controls are identical and hence for brevity only one station **17** will be described. Said station is shown in elevation in FIG. **2** and in enlarged elevation in section in FIG. **3.** As shown in FIG. **2,** it is comprised of a vertically disposed pneumatic rotary actuator **21** which is essentially a pneumatic cylinder **22** (FIG. **3**) the rod **23** of which carries a gear rack **24** meshing with a pinion **25** the shaft of which is connected to an arm **26.** A workholder, shown generally at **27** in FIG. **2,** is mounted on the end of arm **26** through a pressure-differential operated motor **28,** said arm in one position overlying polishing disc **11** and pressing the workpieces upon the surface of said disc and in another position, shown dotted in FIG. **2,** substantially 180° away from the said one position, supporting the workholder **27** in an inverted position so that the workpieces rest on top of the holder and can readily be placed upon and removed from the workholder.

Referring now specifically to FIG. **3,** the cylinder **22** of pneumatic rotary actuator **21** is double acting and has ports **29** and **30** leading to opposite sides of a piston **31** therein. Extending below cylinder **22** is a rod **32** on which is an abutment **33** the function of which is to operate limit switches **34** and **35** at the ends of the reciprocating movements of rod **32.** Said switches control

certain operations of the station as will be described in detail hereinafter.

The workholder **27**, as shown more clearly in FIG. **3**, comprises a plate **36** preferably circular in outline and having a flat surface **37** upon which the workpieces **38** are held by differential pressure. To this effect surface **37** is provided with relieved areas under the workpieces **38** connected by passages **39** to a source of subatmospheric pressure. The details of construction of the relieved areas are disclosed in my co-pending application for APPARATUS FOR POLISHING WAFERS filed Nov. 29, 1971 Ser. No. 202,965.

Plate **36** is secured to a piston rod **40** of a double acting pressure-differential operated motor **41** having ports **42, 43** for conducting fluid under pressure to one side or the other of the piston **44** of motor **41.** Motor **41** is secured to the end of arm **26** and hence is movable therewith. It is contemplated that arm **26** will be rotated through 180° to invert workholder **36** so that the workpieces can be readily loaded upon and unloaded from said workholder. It is also contemplated that workholder **36** will be moved and held against the polishing disc **11** to press the workpieces thereagainst and thus accelerate the polishing process. Finally, it is desirable that the polished workpieces, while still on the workholder, be sprayed with water to wash off any polishing compound that may adhere to them. The means by which the movements of cylinder **22** and motor **41,** and the application of water spray are controlled will be described with reference to the diagram of FIG. **4** to which attention is now directed.

Inasmuch as air under pressure is generally available in shops and factories where polishing is done, the motive fluid for cylinder **29** and motor **41** is air under pressure. Although hydraulic power can also be used, it involves the use of a separate pump, a reservoir and filters, all of which add to the cost of the machine. Furthermore, to avoid the use of a large solenoid-operated valve to control the water for the spray, the motive power for the water spray valve is also air under pressure controlled by a solenoid-operated valve. For brevity the components of the machine and its controls are shown schematically in FIG. **4.**

The sequence of operations for a full cycle at one station is as follows, assuming that the disc has been set in rotation and the polishing compound is flowing upon the rotating disc: (1) the workholder is loaded with workpieces (manual); (2) the vacuum is turned on to establish the differential pressure by which the workpieces are held on the workholder (manual); (3) a switch is turned on to start the timer for the polishing cycle (manual); (4) arm **26** is rotated to a positive stop where the workholder holds the workpieces just above the disc. The weight of the workholder, and absence of any air under pressure in the motor **41,** allows the workholder to descend slowly to the polishing disc; (5) motor **41** is operated to press the workpieces against the disc which had previously been set in rotation, and to hold the workpieces against the disc for the entire polishing operation (automatic); (6) a second timer (to be hereinafter described) operates the motor **41** to raise the workpieces off the disc **11** (automatic); (7) arm **26** returns to its starting position (automatic); (8) a water spray is automatically turned on to wash the workpieces (automatic); (9) vacuum is turned off (manual); (10) workpieces are removed from workholder **36** (manual).

In the control diagram shown in FIG. **4,** air under pressure is connected to a station supply pipe **45** from which it is conducted through a pipe **46** to a solenoid-operated valve **47** and thence as dictated by valve **47** to ports **42** and **43** on motor **41** the function of which is to move workholder **36** against polishing disc **11.** A second branch pipe **47** conducts air under pressure to an air valve **48** which controls a small pressure differential motor on a water valve **49** controlling in turn the spray water from a water line **50.**

Pipe **45** is connected to a valve **51** which controls the admission of air under pressure to cylinder **22** of the fluid actuator **21** (FIG. **2**) for arm **26.** Valves **47, 48** and **51** are solenoid operated to open and spring-returned to closed position. The solenoids in turn are controlled by timers **52, 53** and **54,** timer **52** controlling the polishing cycle and being manually adjustable to the length of time required to polish a workpiece, and timers **53** and **54** being fixed as to duration and designed to produce a short delay in the application of electric current to the solenoid valves operated thereby. Each station has a manually-operated "start" switch **55** which controls all electrical equipment for that station and a manually-operated "cycle" switch **56** which energizes timer **52** to start the polishing cycle.

The operation of the machine is as follows:

Initially, cylinder **22** is in the position wherein its piston and attached gear rack **23** are in their lowermost position. Workholder plate **36** is therefore in its inverted position radially removed from polishing disc **11** and ready to be loaded. The vacuum has been turned off by manually-operated switch **57** which controls the solenoid-operated valve **58** for the vacuum to plate **36.** Workpieces are placed upon plate **36** over the areas influenced by vacuum as described in detail in my aforesaid co-pending application Ser. No. 202,965; and when the plate is filled, the station switch **55** is turned on to activate the electrical components of the station following which the vacuum switch **57** is turned on to cause the workpieces to be held by differential pressure on plate **36.** Next, cycle switch **57** is turned on to energize timer **52** and start the automatic sequence of operations.

The energization of timer **52** actuates a series of switches **58, 59, 60** and **61** which are reversed when the timer times out. Switch **58** is a holding switch for timer **52** so that manual switch **56** need not be held down during the polishing cycle. Switch **59** energizes a solenoid **62** on air valve **51** to cause said valve to admit air under pressure to the bottom of actuator **22** and thus raise rack **23** to rotate pinion **25** and arm **26** toward polishing disc **11.** When rack **23** reaches the end of its stroke, limit switch **34** is actuated to activate timer **53** which when it times out energizes a solenoid **63** on valve **47** to admit air under pressure to port **42** of pressure cylinder **41** and thus move workholder plate **36** toward polishing disc **11** and hold it against the disc with a predetermined pressure. Since the polishing disc had been set in motion previously and remains in motion until the machine is to be shut down, the polishing operation commences and continues until timer **52** times out.

With timer **52** timed out, switches **58** and **59** are opened and switch **60** is closed to energize a solenoid **68** on valve **51** to condition said valve to admit air under pressure to the top of cylinder **22** which lowers rack **23** and raises workholder plate **36** off the polishing

disc 11. Simultaneously, with the energization of switch 60 a switch 61 is closed by timer 52 which energizes a solenoid 65 on valve 47 to remove air pressure from plate 36 and to raise said plate with respect to cylinder 41.

Upon completion of the reverse rotation of arm 26, limit switch 35 is activated by abutment 33 to energize a solenoid 66 on air valve 48 the air from which then operates water valve 49 to spray water upon the polished workpieces. A timer 54 is activated simultaneously with solenoid 66 and when it times out, a switch 67 is opened to de-energize solenoid 66 and thus, through the spring-returned valves 48 and 49 shut off the water to the spray. Vacuum switch 57 is then opened to remove differential pressure from the workpieces and the polished workpieces are subsequently removed and replaced with workpieces to be polished. The operator moves to the next station that has timed out and that is ready for removal of polished workpieces and loading of workpieces to be polished.

The machine herein described thus automatically brings the workpieces to the polishing disc, brings pressure to bear upon the workpieces while they are being polished, to speed up the polishing operation both from the standpoint of increased abrading action as well as of disintegration through chemical action which is accelerated by the increased temperature of the workpiece surface, removes the pressure and brings the workpieces back to the loading position.

It is understood that although the invention has been described with reference to its application to a machine for polishing wafers, it can be used with machines for lapping or grinding other workpieces, and the scope of this invention therefore is not to be limited to the wafers and polishing machine herein disclosed but is to be determined by the appended claims.

I claim:

1. Apparatus for applying workpieces to and removing them from a substantially horizontally operating abrading tool, said apparatus comprising a platen, means for mounting the workpieces on said platen for a movement therewith, an arm having a horizontally disposed pivot located to one side of the tool, means for oscillating said arm about its pivot through substantially 180°, means for mounting the platen on the arm to cause said platen at one extreme position of the arm to assume an inverted position to permit loading of the workpieces thereon and at the other extreme position to be located over said abrading tool with the workpieces adjacent said tool, said platen mounting means comprising means for advancing said platen toward said tool independently of said arm oscillating means and independently of said workpiece mounting means, and fluid pressure means for holding said workpieces against said tool with a predetermined pressure while said tool is abrading said workpieces.

2. Apparatus as defined in claim 1, and means, automatically operable upon said arm reaching its extreme position opposite said first-mentioned extreme position, for spraying said articles with a cleaning fluid.

3. Apparatus as defined in claim 2, said means for supporting said workpieces comprising a platen having a plurality of stations thereon one for each workpiece, means at each station for applying sub-atmospheric pressure to the workpiece to hold said workpiece on the platen, manually operable means for controlling the application of subatmospheric pressure and means controlled by movement of the platen for controlling the application of the cleaning liquid.

4. Apparatus as defined in claim 1, and comprising further means operated in timed relation to the position of the portion of said arm over the tool for initiating the operation of the means for advancing said workpiece-supporting means toward said tool.

5. Apparatus as defined in claim 2, said means automatically operable upon said arm reaching its extreme position opposite said first-mentioned extreme position for spraying said articles with a cleaning fluid comprising an air-operated valve, a source of air under pressure, a solenoid-operated valve for controlling application of air under pressure from said source to said air-operated valve, and a switch operated by said platen for energizing said solenoid-operated valve.

6. Apparatus as described in claim 1, said tool comprising a polishing disc, and means for driving said disc about a vertical axis, said workpieces comprising discs of a thickness varying from 0.005 inch to 0.015 inch, and pressure-differential operated means on said workpiece supporting means and comprising the sole means for holding said workpieces on the workpiece supporting means, said workpieces being of a material characterized by increased abrading action by the tool as the temperature of the material increases, and said predetermined pressure increasing the friction between the workpiece and tool thereby increasing the temperature of the workpieces above the melting point of wax to increase the abrading action of the tool thereon.

* * * * *