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(54) **POLISHER**

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(57) **ABSTRACT**

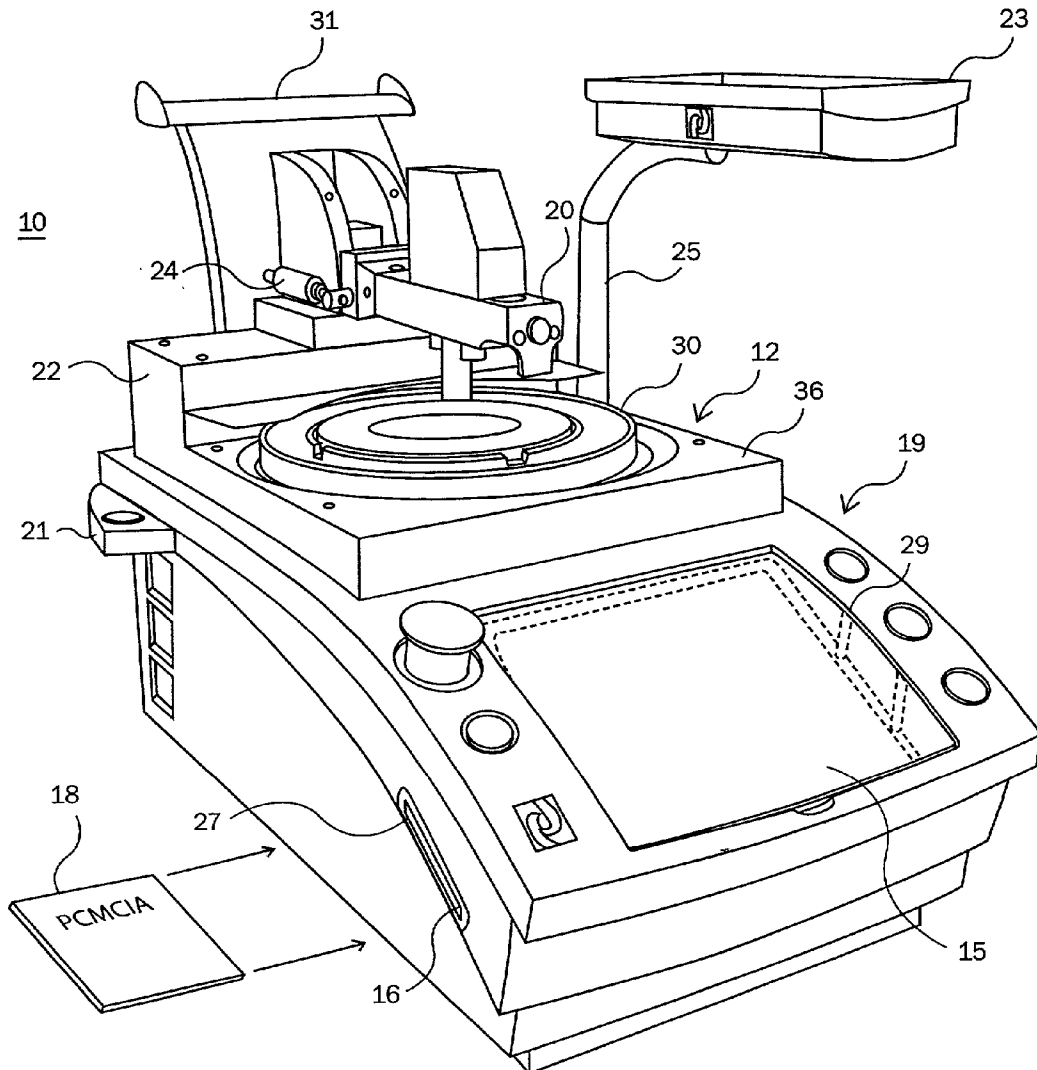
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The subject polisher includes a polishing unit, a processor, a porting device for a portable memory device, and multiple input devices. The polishing unit is comprised of a pneumatic arm assembly and a platen assembly. The processor communicates with the polishing unit, regulating and monitoring its operation. The processor also communicates with a porting device for a portable memory device, allowing the processor to upload or download information from an external source. The processor also communicates bilaterally with an interactive display system in which a color touch-sensitive screen is used as a projection surface.



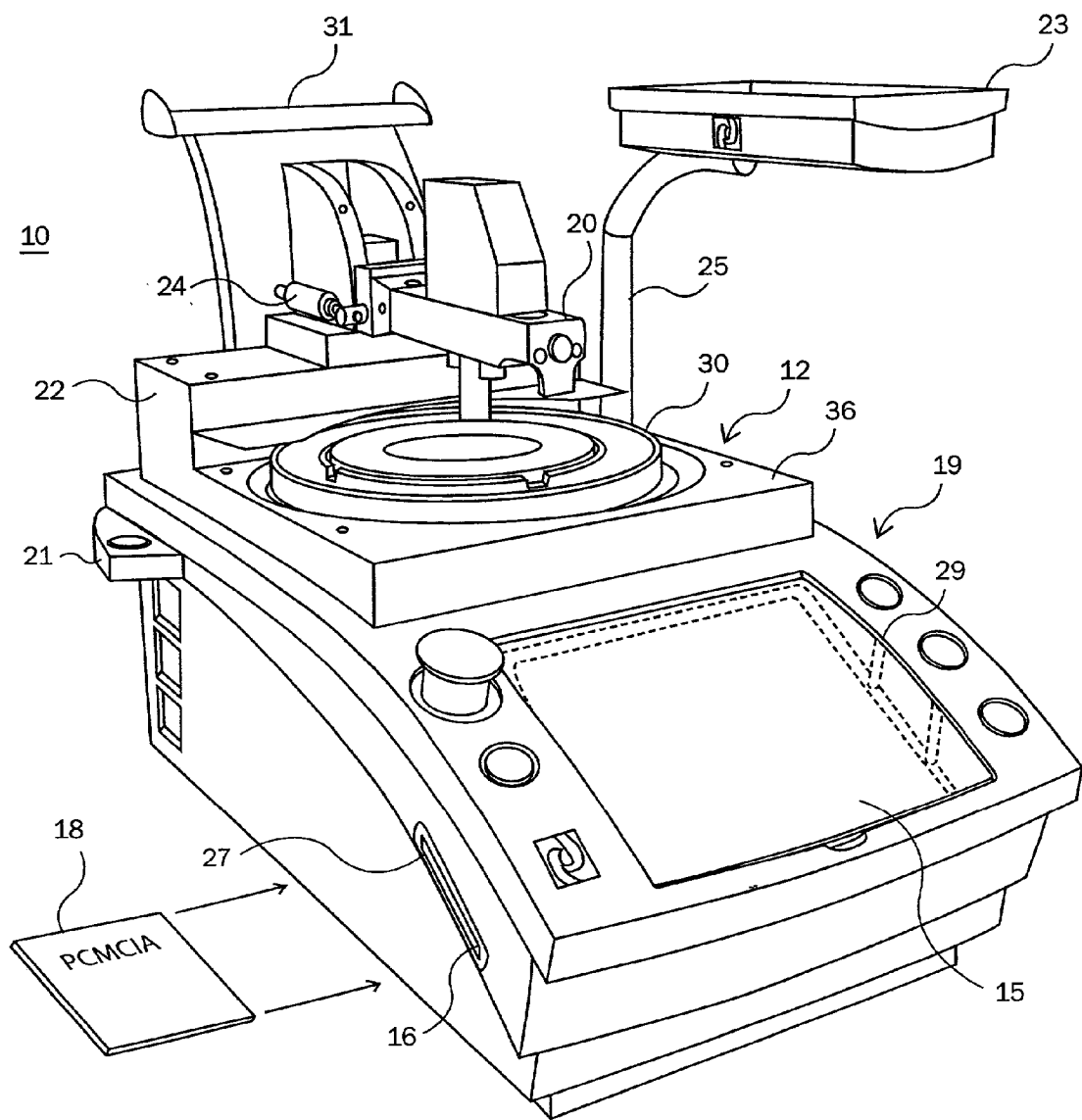


Fig. 1

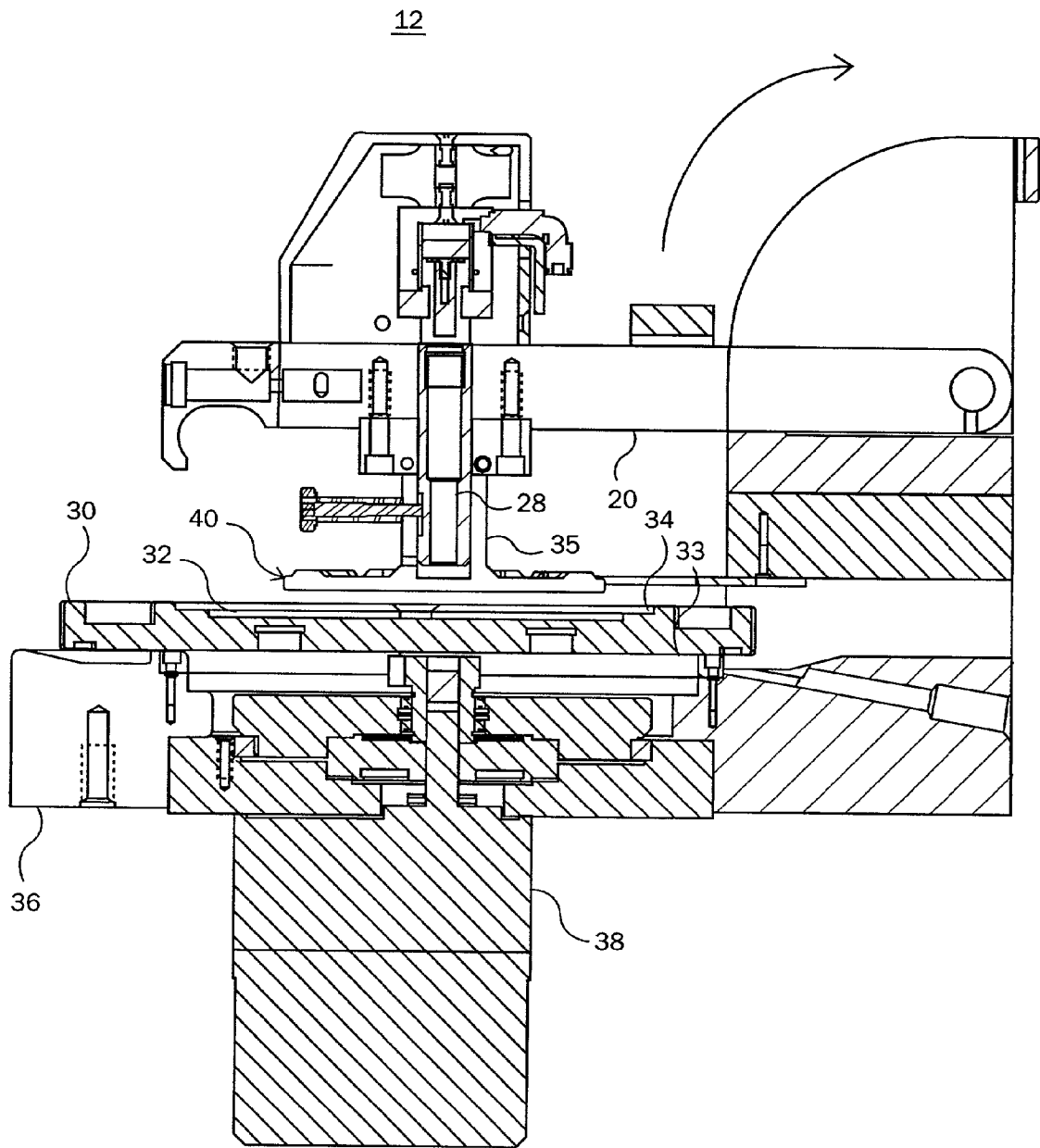


Fig.2a

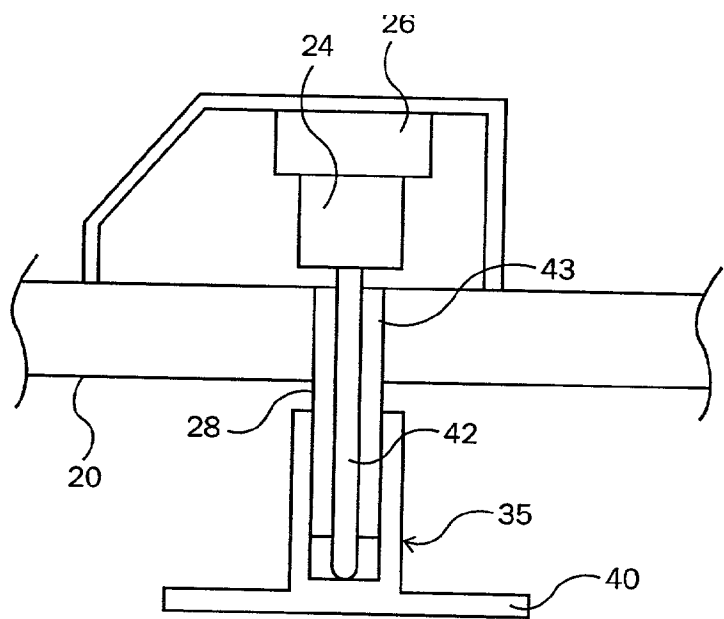


Fig. 2b

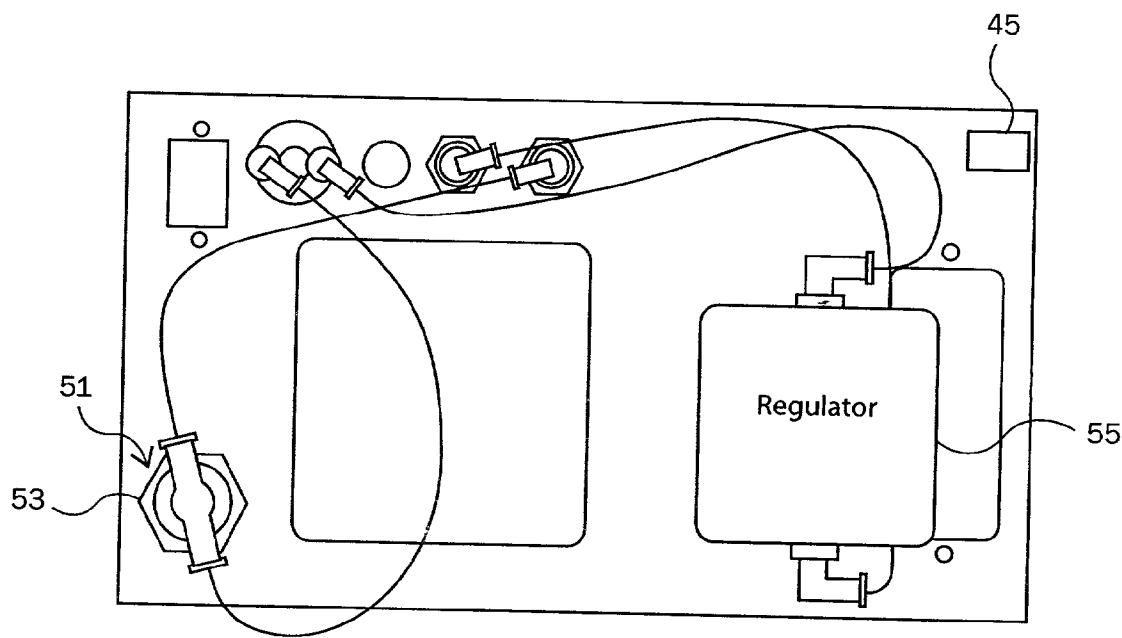


Fig. 3

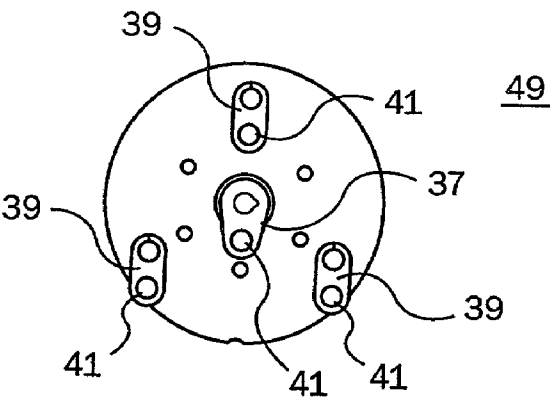


Fig. 4

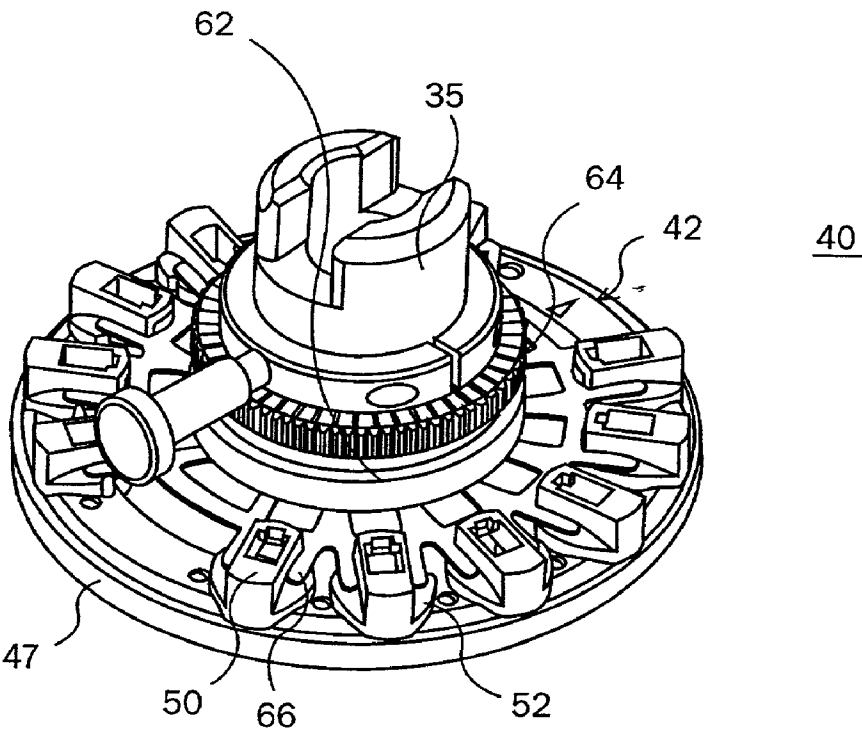


Fig. 5

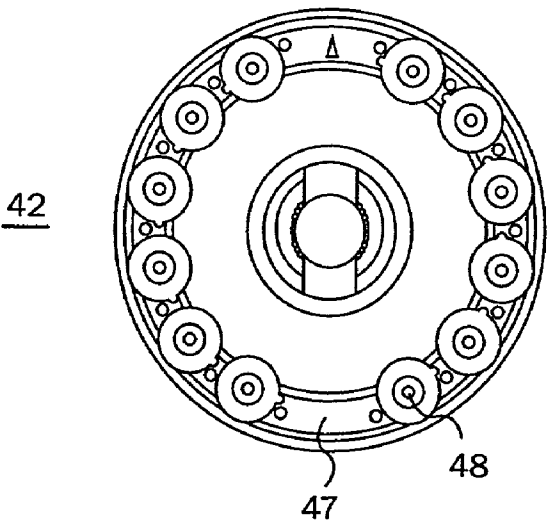


Fig. 6

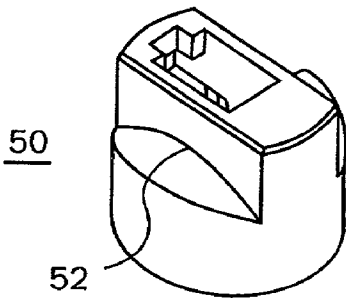


Fig. 7

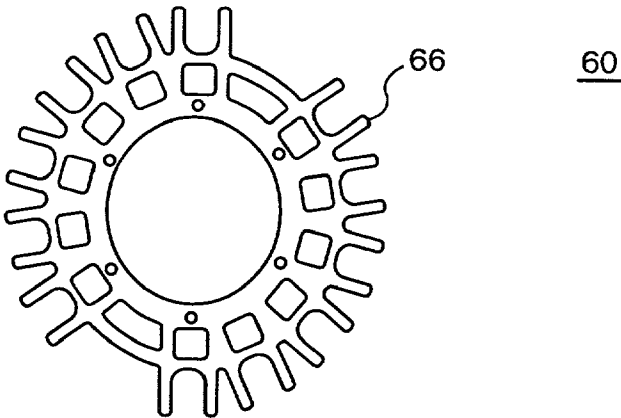


Fig. 8



Fig. 9

Fig. 10

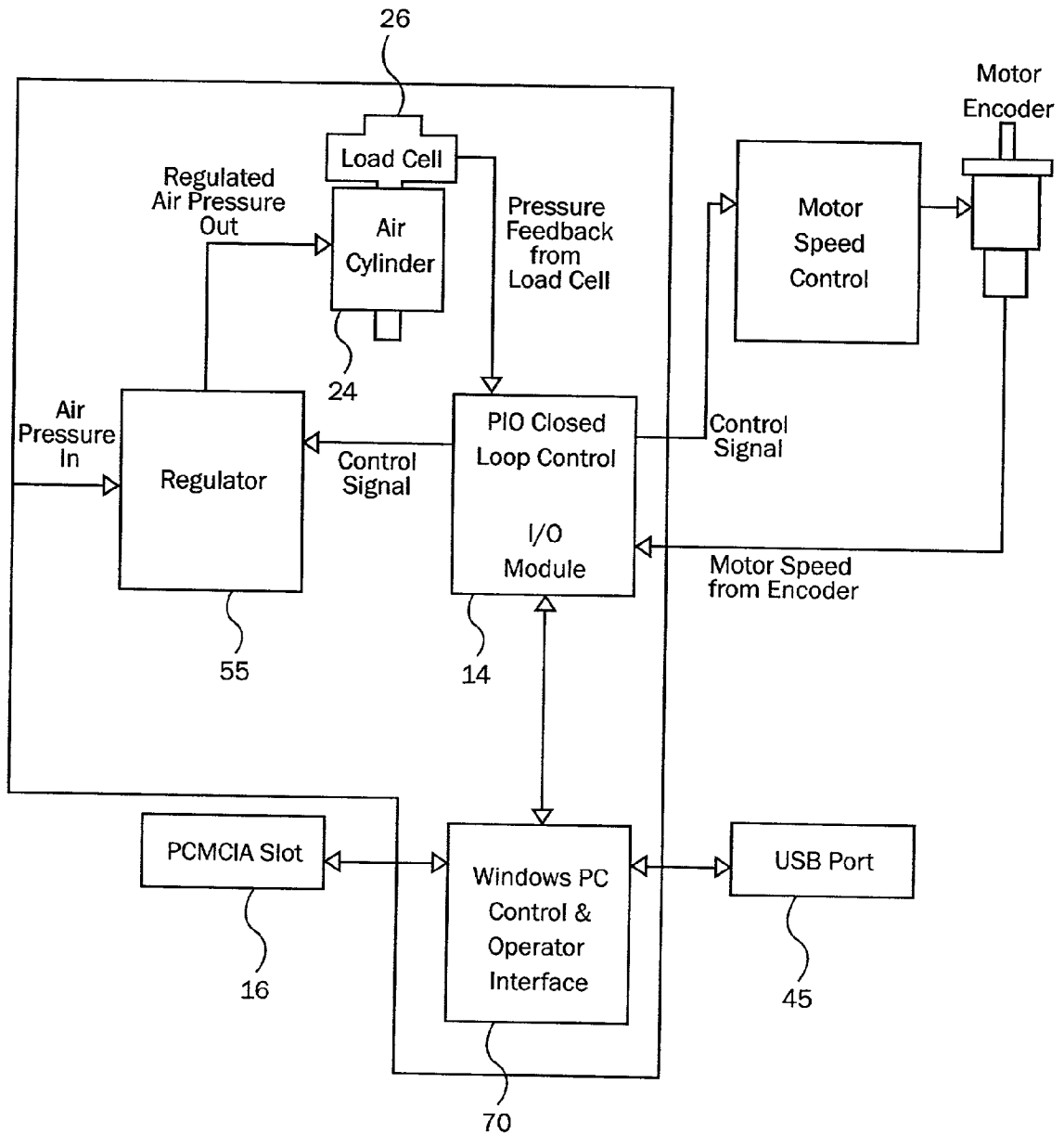


Fig. 11

POLISHER

FIELD OF THE INVENTION

[0001] The subject invention relates generally to a polishing apparatus. More specifically, the subject invention pertains to a microprocessor controlled polishing apparatus for precision polishing of a number of items such as, but not limited to, silicon arrays, wafers, and optical fiber.

BACKGROUND OF THE INVENTION

[0002] A typical fiber-optic cable is typically comprised of concentric layers of protective or supporting material with an optical fiber located at the center of the cable. These fiber-optic cables typically have connectors located on each end to connect them to another fiber-optic cable or to a peripheral device. These connectors are high precision devices which position the fiber-optic cable in line with another fiber-optic cable or to a port on a peripheral device.

[0003] In order to communicate with a port or another cable, the end face of the connector (comprising of a ferrule and an optical fiber) must typically abut an adjacent cable or port. The finish of the end face of a connector will typically determine the amount of back reflection at the connection site, thus greatly affecting the ability of the fiber-optic cable to transmit information. The apex offset, protrusion/recession, insertion loss, return loss, and angularity are also integral parameters of a connector's finish. As such, the end face of a connector is usually polished to exacting standards so as to produce a finish with minimal back reflection. Fiber-optic cables having multiple optical fibers can also be polished to produce a particular finish.

[0004] Optical fiber polishers are typically used to produce a finish on the end face of a fiber-optic cable. These machines typically include a rotating platen and an arm mechanism which positions and supports the connectors during the polishing process. Typically, the end face is lowered onto a film resting on the platen, and depending upon the film, the speed of the platen, the pressure applied, and its duration, acquires a finish suitable for a particular application.

[0005] Current optical fiber polishers typically rely on spring loaded arm assemblies to apply pressure between the end face of the connector and the film. While these spring loaded assemblies generally work for their intended purposes, they typically lack the desired precision for more intricate polishing procedures since the pressure of the springs will typically weaken with age. Furthermore, they often require substantial supervision during the polishing process.

[0006] There are known optical fiber polishers which utilize a pneumatic assembly to apply pressure to the end face, and these units are generally more precise than the spring loaded units. However, they are usually not able to compensate for run time variations in pressure attributable to mechanical operation of the device (air cylinder stiction, small leaks in the pneumatic system, etc.). These variations in pressure are typically not compensated for and can affect the uniformity of a finished product.

[0007] Typical optical fiber polishers must often be adjusted and readjusted to account for different polishing procedures or different connectors. Since there are typically

a number of machines utilized for the polishing process in a cable manufacturing setting, configuring the machines for a specific polishing procedure can often require a significant amount of user time. Furthermore, due to the extensive user interactions required to implement a polishing procedure, user error may lead to further inconsistencies in the finished product.

[0008] In order to create fiber-optic connectors having the requisite finish and uniformity, strict control over the polishing procedures are required. Consequently, what is needed is a polisher that closely monitors the polishing process to ensure uniformity. Furthermore, there is also a need for an optical fiber polisher that is easily programmable to run specific polishing routines, and is capable of receiving polishing routines from a portable memory storage device.

BRIEF SUMMARY OF THE INVENTION

[0009] Accordingly, a polisher is presented which is particularly adapted to provide precise and relatively uniform polishing of a number of different items which include, but is not limited to, silicon arrays, wafers, optical fiber connectors, and optical fiber.

[0010] In one embodiment, the subject invention is a microprocessor controlled optical fiber polishing machine which monitors and maintains rigid control of the polishing process through a number of feedback mechanisms and sensors. The subject optical fiber polisher also is configured for simple operation and rapid setting of parameters. The subject polisher includes a polishing unit, a processor, a porting device for a portable memory device, and multiple input devices.

[0011] The polishing unit is comprised of a pneumatic arm assembly and a platen assembly. The pneumatic arm assembly includes an arm hingedly and rotatively secured along one end to a base. A pair of pneumatic cylinders are coupled to the arm, opposing rotational movement thereof, a mounting pole depends from the arm, and a load cell is coupled to the arm adjacent to the mounting pole.

[0012] In one embodiment, the platen assembly includes a platen that is generally circular and having a top surface and a bottom surface. The top surface is generally used to support flexible or rigid materials like rubber pads and glass plates. The bottom surface includes a means for mounting onto a motor. The platen is rotatively supported by a stage and is coupled to a motor.

[0013] A fixture is secured onto the mounting pole to hold one or a number of connectors. In one embodiment, the fixture is adapted to enable a connector to move in a longitudinal direction in response to pressure being applied by the platen. The fixture includes a fixture base, terminal seated on the fixture base, and an adjustable pressure regulating mechanism.

[0014] An embodiment of the subject optical fiber polisher includes a processor having a number of task oriented applications stored therein. The processor communicates with the polishing unit, regulating and monitoring its operation. The processor also communicates with a porting device for a portable memory device, allowing the processor to upload or download information from an external source. The processor also communicates bilaterally with an interactive display system in which a color touch-sensitive screen

is used as a projection surface. In this way, a completely interactive display system is provided in which the user can highlight and edit information generated by the computer program by simply touching the screen. In addition, the user may also input and edit information through the use of a keyboard interface.

[0015] While several embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description. As will be realized, the invention is capable of modifications in various obvious aspects, all without departing from the spirit and scope of the present invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a perspective view of one embodiment of the subject optical fiber polisher.

[0017] FIG. 2a is an enlarged, side, cross-sectional view of the optical fiber polisher of FIG. 1.

[0018] FIG. 2b is an enlarged frontal, cut-away view of the pneumatic arm and fixture.

[0019] FIG. 3 is an enlarged rear view of the polishing unit of FIG. 1.

[0020] FIG. 4 is reduced overhead planar view of the drive assembly of FIG. 2a.

[0021] FIG. 5 is one embodiment of a fixture.

[0022] FIG. 6 is cut-away view of the fixture of FIG. 5 showing only the base plate.

[0023] FIG. 7 is a front view of a fixture terminal.

[0024] FIG. 8 is an overhead planar view of a spring plate.

[0025] FIG. 9 is an overhead planar view of an adjustable plate.

[0026] FIG. 10 is an overhead planar view of a pressure plate.

[0027] FIG. 11 is a flow diagram of one embodiment of the pneumatic control system.

DETAILED DESCRIPTION

[0028] General Overview

[0029] The subject invention is a polisher apparatus which is particularly adapted to provide precise and relatively uniform polishing of a number of different items which include, but is not limited to, silicon arrays, wafers, optical fiber connectors, and optical fiber. For the purposes of explanation only, the subject invention is described in terms of an apparatus which is particularly configured for optical fiber polishing. However, one skilled in the art can readily appreciate that the subject invention is easily adaptable to perform a number of different polishing applications.

[0030] FIG. 1 shows one embodiment of the subject invention. The embodiment is a microprocessor controlled optical fiber polishing machine 10. The subject polisher includes a polishing unit 12 comprising a pneumatic over-

arm assembly and a platen assembly, a processor 14 (FIG. 11), a porting device 16 for a portable memory device 18, and an input device 15.

[0031] The subject polisher maintains rigid control of each polishing process through feedback mechanisms which control the operation of both the platen assembly and the pneumatic overarm assembly. The feedback mechanisms communicate with the processor 14 to continuously monitor the performance of the platen assembly and the pneumatic overarm assembly, and ensures that both are functioning at their set levels.

[0032] In one embodiment, the processor 14 communicates with both the porting device 16, input device 15 and a USB port 45 for a keyboard (FIG. 3), to enable rapid programming of the subject fiber-optic polisher. The input device 15 also serves as a visual indicator of actual operating parameters.

[0033] Housing

[0034] As shown in FIG. 1, in one embodiment, the subject invention includes a housing 19 which is particularly adapted for the polishing process. The housing's main function is to support and align the polishing unit 12, the processor 14, and the input device 15 in an operative position.

[0035] The housing 19 also includes a retractable ring 21 for use as a point of attachment for ancillary devices. One such ancillary device is a drip pan 23 rotatively coupled to the retractable ring 21 by an elongated stem 25. A slot 27 is inserted along one side of the housing 19 to allow a portable memory device to access the porting device 16. A retractable shield 29 is located along a front portion of the housing 19 to protect the input device 15, which is angularly supported in the front of the housing 19. A cable management attachment 31 is connected to the back of the housing for supporting fiber-optic cables undergoing a polishing process.

[0036] Polishing Unit

[0037] FIG. 2a shows one embodiment of a polishing unit 12 comprised of a pneumatic arm assembly and a platen assembly. The polishing unit is self-contained, and is easily transferable to another housing.

[0038] As shown in FIGS. 1 and 2, the pneumatic arm assembly includes an overarm 20 hingedly secured along one end to a base 22, the overarm 20 rotatable about the hinged end. A pair of pneumatic cylinders 24 are coupled to the overarm 20, opposing rotational movement thereof. A mounting pole 28 depends from the overarm 20. A polishing fixture 40 includes a mounting tube 35 which releasably engages the mounting pole 28.

[0039] As shown in FIG. 2b, in one embodiment, a load cell 26 is positioned on the overarm 20 adjacent to the mounting pole 28 and coupled to an air cylinder 24. A passage 43 extends generally concentrically through the overarm 20 and the mounting pole 28. Disposed within the passage 43 is a plunger 42. The plunger 42 is coupled to the air cylinder 24 and the fixture 40. During operation, the plunger translates pressure applied to the fixture by moving longitudinally with respect to the mounting pole 28. The longitudinal movement of the plunger 42 results in an increase or decrease in the pressure within the cylinder 24.

The load cell **26** reads this pressure and transmits it to the processor, enabling the processor to determine a contact pressure.

[0040] It should also be noted that the disclosed pressure detection system is particularly suited for the load cell shown. It would be obvious for any person skilled in the art to adapt a different load cell onto the subject invention for the purpose of monitoring and controlling contact pressure.

[0041] As shown in **FIG. 3**, an air source **51** supplies pneumatic pressure to the air cylinder **24**. The air source includes an air supply **53** and a pneumatic regulator **55**. The pneumatic regulator **55** communicates with the processor **14**, and is controlled thereby. The processor and the pneumatic cylinder cooperate to ensure that the pneumatic cylinder is appropriately pressurized.

[0042] As shown in **FIGS. 2a** and **4**, in one embodiment, the platen assembly includes a platen **30** that is generally circular and having a top surface **32** and a bottom surface **33**. The top surface **32** includes retaining structures **34** for receiving a film or pad. The bottom surface **33** includes a means for mounting onto the motor **38**. Preferably, the mounting means include a number of openings extending through the bottom surface **33**. A plurality of bearings (not shown) are disposed between the top and bottom surface. The bearings cooperate with each opening to receive a locking pin **41** from a drive arm **37** or an eccentric free arm **39**.

[0043] As shown in **FIGS. 2** and **4**, the platen **30** is rotatively supported by a stage **36** and is coupled to the motor **38**. Preferably, the platen **30** is rotated in an eccentric fashion, and so an eccentric drive arm **37** is used to couple the motor **38** to the platen **30**. A plurality of eccentric free arms **39** are rotatively supported on one end by a drive plate **55** and engage the platen **30** along the other end. The eccentric free arms **39** guide and support the radial movement of the platen **30**. The drive arm **37** and the free arms **39** both have a free end with a locking pin **41** which extends perpendicularly therefrom to engage the bottom surface **33** of the platen **30**.

[0044] Fixture

[0045] As shown in **FIGS. 5, 6** and **7**, in one embodiment, a fixture **40** is adapted to enable a connector to move longitudinally in response to the pressure being applied by the platen **30**. The fixture **40** includes a fixture base **42** comprised essentially of a circular plate **47** with a number of seats **48** positioned circumferentially around the circular plate **47** and a mounting tube **35** extending generally perpendicular to the circular plate **47**. A terminal **50** is disposed within the seat **48**, and is adapted to receive a connector from a fiber optic cable. A terminal **50** is adapted to mate with a particular type of connector. The terminal **50** includes a pair of laterally extending flanges **52**.

[0046] As shown in **FIGS. 8, 9**, and **10**, the fixture also includes an adjustable pressure regulating mechanism **46** comprising of a spring plate **60**, a pressure plate **62**, and an adjustable plate **64**. The spring plate **60** has a plurality of spring leaves **66** which engage the flanges **52** on each terminal **50**, and provide a consistent retentive pressure thereon. The spring plate **60** is retained on the fixture base **42** by the pressure plate **62**, the pressure plate overlaying the spring plate **60**. The adjustable plate **64** overlays the pressure

plate **62** and is rotatively coupled to the mounting tube **35**. The adjustable plate **64** is coupled to the mounting tube **35** so that there is minimal coaxial movement.

[0047] The adjustable plate **64** and the pressure plate **62** each have opposing surfaces which have ramped annular flanges **68** extending therefrom. The ramped flanges **68** contact each other and drive coaxial movement of the pressure plate **62**. Movement by the pressure plate generates movement of the spring plate **60**. Pressure exerted by the spring plate **60** on the terminal **50** is then controlled by simply rotating the adjustable plate **64** which then drives the pressure plate **62** to increase or decrease the pressure applied by the spring plate **60**.

[0048] The above fixture is a novel embodiment that works in conjunction with the subject optical fiber polisher, or with other similar polishers, and provides a novel means for adjusting the amount of contact pressure on a connector. However, there are a number of other fixtures known in the art which are also capable of being utilized by the subject optical fiber polisher. The subject optical fiber polisher is easily adaptable to accommodate most fixtures that are known in the art.

[0049] Processor

[0050] As shown in **FIGS. 1** and **11**, an embodiment of the subject optical fiber polisher includes a processor **14** having included therein a number of task oriented applications. The processor communicates with the polishing unit to control polishing fixture pressure, platen rotational speed, and duration of the polishing process. The processor includes a plurality of sensors and feedback mechanisms to monitor the polishing process.

[0051] The processor **14** can be any computer known to those skilled in the art, including standard attachments and components thereof (e.g., a disk drive, hard drive, CD/DVD player or network server that communicates with a CPU and main memory, a sound board, a keyboard and mouse, and a monitor). The processor **14** may be any conventional general-purpose single- or multi-chip microprocessor. In addition, the processor **14** may be any conventional special purpose processor such as a digital signal processor or a graphics processor. The microprocessor can include conventional address lines, conventional data lines, and one or more conventional control lines.

[0052] In one embodiment, the processor **14** communicates with a porting device **16** for a portable memory device **18**. The porting device **16** includes a PCMCIA slot for supporting communication between the processor and a PCMCIA card **18**. However, it is not intended to limit the porting device to such. The porting device **16** can be any device used to support communication between the processor and a portable memory device, the porting device may include, but is not limited to, a CD rom drive, a memory slot, a disk drive, and a hard drive.

[0053] In one embodiment, the processor also communicates with an input device **15** and an USB port **45** (**FIG. 3**) which connects to a keyboard (not shown). The input device **15** includes an interactive display system in which a touch-sensitive screen is used as a projection surface. Control signals are generated by the touch-sensitive screen in the usual manner responsive to user applied pressure. At the same time, the processor **14** is used to execute any one or

more applications programs, in the usual manner. Control signals received from the touch-sensitive screen are integrated with the computer generated graphics created by the processor so as to be projected therewith onto the touch-sensitive screen. In this way, a completely interactive display system is provided in which the user can highlight and edit information generated by the processor 14 by simply touching the screen.

[0054] It is not intended that the subject invention be limited by the above-described input devices. A person skilled in the art can readily appreciate that there are a number of input devices which can be implemented to allow a user to interface with the processor. A number of other input devices such as a keyboard, keypad, mouse, switch, and buttons, to name a few, can also be utilized.

[0055] Operation

[0056] To perform a polishing process, operational parameters such as process time, platen speed, pressure, film type, pad type and lubricant type are entered for each step of the polishing process. The process of inputting this information into the processor is performed by scrolling through a plurality of screens on the input device 15 and selecting from a menu of parameters. Once inputted, the procedure can be saved into memory and inputted automatically by the processor at a later date. Alternatively, the porting device 16 may be utilized to download the inputted polishing procedure onto a portable memory device 18. Once stored onto a portable memory device 18, the polishing process can be downloaded onto another polisher device, or downloaded onto a computer wherein the process is transported to another site by e-mail.

[0057] To download polishing parameters from a portable memory device 18, a portable memory device 18 is inserted into the porting device 16 and the porting device 16 is designated utilizing the input device 15. A file containing an applicable polishing process is selected from the portable memory device 18, and a process transfer procedure is initiated through the input device 15 to transfer the process from the portable memory device 18 to the processor 14.

[0058] The subject invention is also capable of automatically adjusting pressure to reflect the number of connectors in a particular load. Typically, the number of connectors that a fixture 40 can hold is originally inputted into the processor 14. Then, prior to each run, the user is able to input the number of connectors loaded onto the fixture 40. After receiving the input, the processor 14 adjusts the amount of pressure applied in proportion to the number of connectors in the fixture 40.

[0059] In one embodiment, this adjustment is simply an arithmetic progression. The desired pressure is divided by the number of connectors in a full load. The amount of pressure applied during the run is then simply calculated by multiplying the number of connectors in the load. As can be appreciated by someone skilled in the art, there are a number of other methods and procedures known in the art to determine an offset for a less than full load. Any of these methods or procedures can be easily adapted for implementation with the subject invention.

[0060] Referring to FIGS. 2b, 3, and 11, the subject invention also continually adjusts the pressure applied by the overarm to the fixture through a feedback mechanism which

couples the load cell 26, and the processor 14. In one embodiment, the plunger 42 is coupled to the air cylinder 24 and the fixture 40, and during operation, the plunger 42 translates pressure applied to the fixture by moving longitudinally with respect to the mounting pole 28. The longitudinal movement of the plunger 42 results in an increase or decrease in the pressure within the cylinder 24. The load cell 26 reads this pressure and transmits it to the processor, enabling the processor to determine a contact pressure.

[0061] The processor 14 receives the signals from the load cell and determines if the pressure signal is greater or less than the user-selected pressure for the polishing procedure. The processor 14 corrects any deviations by communicating with the pneumatic regulator 55, and causing the pneumatic regulator to increase or decrease the flow of air into the air cylinder 24.

[0062] While the present invention has been described with reference to several embodiments thereof, those skilled in the art will recognize various changes that may be made without departing from the spirit and scope of the claimed invention. Accordingly, this invention is not limited to what is shown in the drawings and described in the specification but only as indicated in the appended claims. Any numbering or ordering of elements in the following claims is merely for convenience and is not intended to suggest that the ordering of the elements of the claims has any particular significance other than that otherwise expressed by the language of the claim.

I claim:

1. A polisher comprising:

a polishing mechanism;

a processor in communication with the polishing mechanism; and

a port device for a portable memory device, the port device in communication with the processor.

2. The polisher of claim 1, wherein the port device is a PCMCIA interface.

3. The polisher of claim 1, and further comprising a portable memory device received by the port device.

4. The polisher of claim 3, wherein the portable memory device is a PCMCIA card.

5. The polisher of claim 1, wherein the polishing mechanism includes a pneumatic system coupled to a polishing arm, and wherein the processor interfaces with the pneumatic system to control polishing process.

6. The polisher of claim 1, wherein the processor includes memory wherein polishing parameters are stored.

7. The polisher of claim 1, wherein the processor downloads polishing parameters through the port device.

8. The polisher of claim 1, and further comprising a keyboard in communication with the processor.

9. An optical fiber polisher comprising

a pneumatic polishing arm;

a load cell coupled to the pneumatic arm;

a processor in communication with the load cell.

10. The polisher of claim 9, and further comprising an air source in pneumatic communication with the polishing arm, and wherein the air source is controlled by the processor.

11. The polisher of claim 10, wherein the processor receives a pressure signal from the load cell, and outputs a control signal to the air source.

12. The polisher of claim 10, wherein the air source includes a pneumatic regulator for controlling air flow to the pneumatic arm.

13. The polisher of claim 10 wherein the pneumatic polishing arm includes an elongated arm hingedly mounted on one end and an air cylinder coupled to the arm, the air cylinder in pneumatic communication with the pneumatic regulator.

14. A polisher comprising:

a pneumatic polishing arm; and

a fixture coupled to the polishing arm;

wherein the fixture includes an adjustable pressure regulator.

15. The polisher of claim 14, wherein the adjustable pressure regulator includes a spring plate, a pressure plate, and an adjustable plate.

16. The polisher of claim 15, wherein the terminal includes a flange, and wherein the spring plate includes a plurality spring leaf which extend from the spring plate and engage the flange.

17. The polisher of claim 15, wherein rotation of the adjustable plate drives the pressure plate to move coaxially thereto.

18. The polisher of claim 15, wherein the fixture includes a plurality of circumferentially positioned seats, and wherein the terminals are disposed within the seat so as to allow for a sliding coaxial movement relative to the seat.

19. A fixture for a polisher comprising:

a base plate;

a plurality of terminals with each disposed on the base plate; and

an adjustable pressure mechanism coupled to the terminal.

20. The fixture of claim 19, wherein the adjustable pressure mechanism includes a spring plate, a pressure plate, and an adjustable plate.

21. The fixture of claim 20, wherein the terminal includes a flange, and wherein the spring plate includes a plurality spring leaf which extend from the spring plate and engage the flange.

22. The fixture of claim 20, wherein rotation of the adjustable plate drives the pressure plate to move coaxially thereto.

23. The fixture of claim 22, wherein the pressure plate and the adjustable plate each include a ramped annular surface on confronting surfaces.

24. The fixture of claim 19, wherein the base plate includes a plurality of circumferentially positioned seats, and wherein the terminals are disposed within the seat so as to allow for a sliding coaxial movement relative to the seat.

25. A polisher comprising:

a housing;

a touch screen display device supported at an angle by the housing; and

a rigid retractable cover enclosing the touch screen display device within the housing.

26. The polisher of claim 25, and further comprising a stop button extending from the housing.

27. The polisher of claim 25, and further comprising a drip pan rotatively coupled to the housing.

28. The polisher of claim 25, and wherein the housing includes retractable utility loops.

29. The polisher of claim 25, and further comprising an access opening for a porting device for a portable memory device.

30. The polisher of claim 25, and further comprising a hinged pneumatic arm.

31. A polisher comprising:

a pneumatic polishing arm;

a platen; and

a feedback system for continuous adjustment of the pneumatic pressure applied by the polishing arm.

32. The polisher of claim 31, wherein the feedback mechanism includes a pneumatic regulator for controlling air flow to the pneumatic arm and a processor in communication with the pneumatic regulator.

33. The polisher of claim 31, wherein the feedback mechanism includes a load cell in cooperation with the pneumatic polishing arm and a processor in communication with the controller.

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