United States Patent

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[54] **MOVABLE SUPPORT FOR ABRADING APPARATUS**
2 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **51/8**, 51/14, 51/217, 269/56
[51] **Int. Cl.** **B24c 3/12**
[50] **Field of Search** 51/8, 9, 14, 217, 218, 224; 269/55, 56, 71, 72, 73, 76

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ABSTRACT: A nozzle for directing an abrasive stream and a workpiece holder are adjustably positioned relative to one another in horizontal directions by means of device which supports one or the other by horizontal slide structures that are movable at right angles to each other.

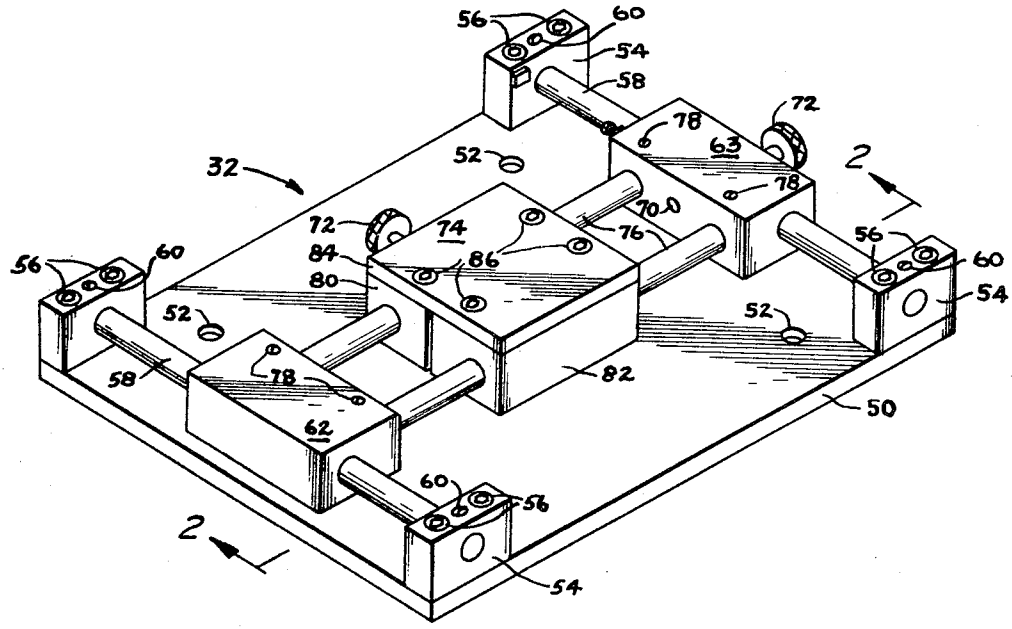


FIG. 1

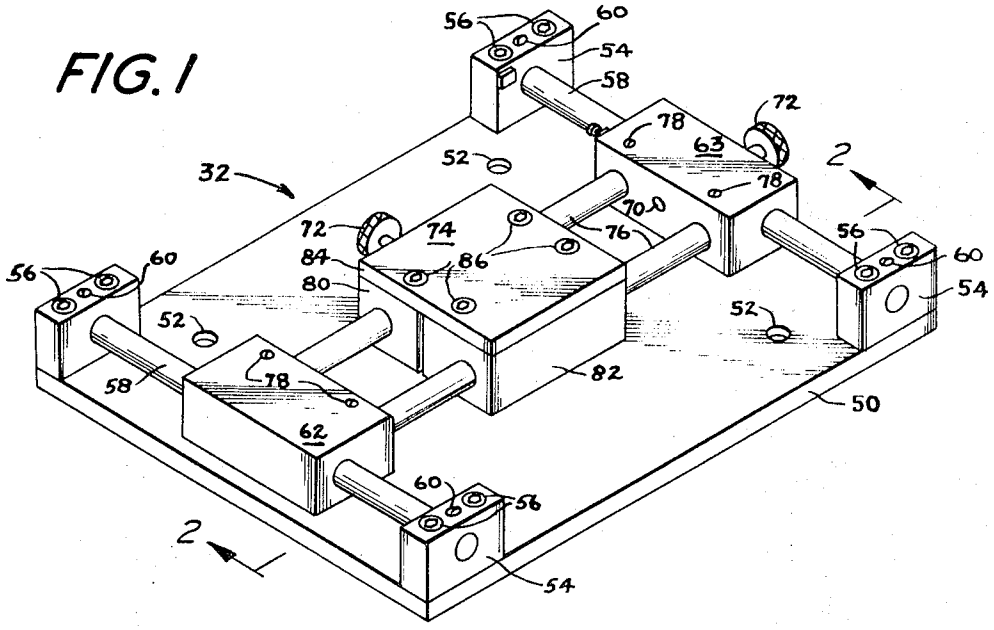
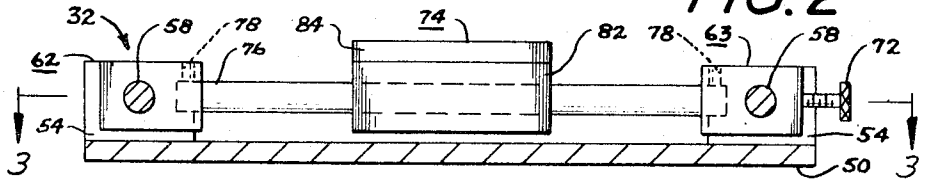


FIG. 2



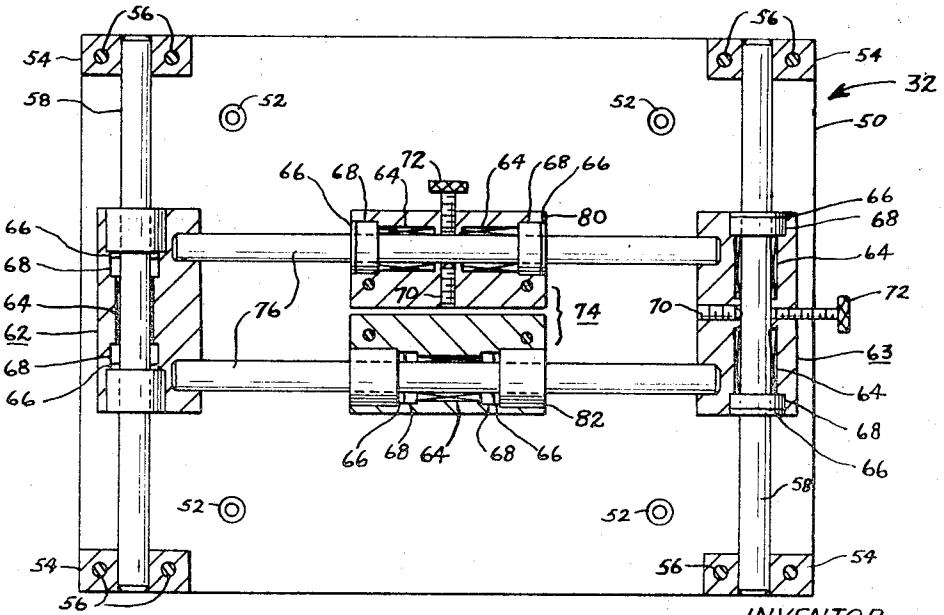


FIG. 3

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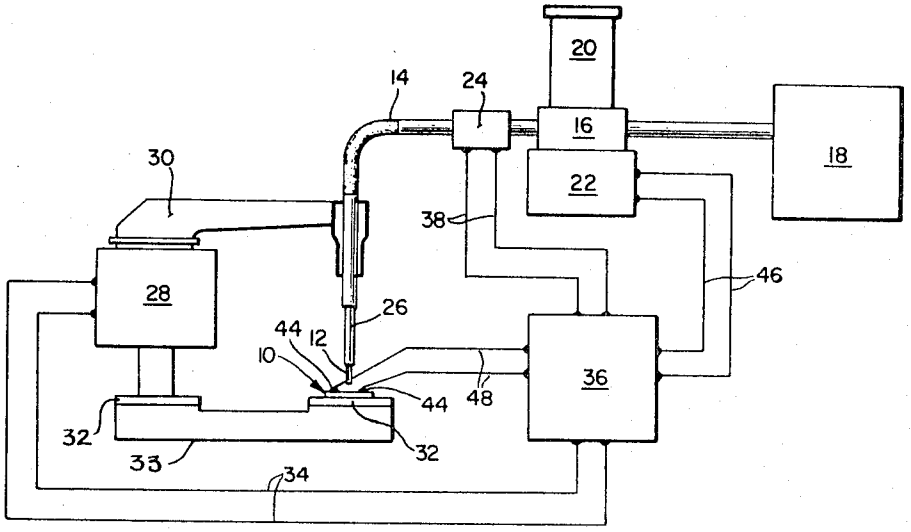


FIG. 4

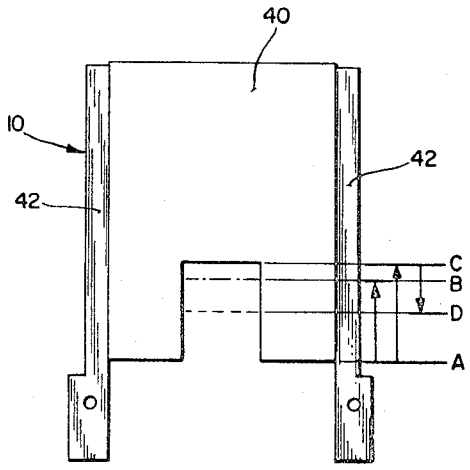


FIG. 5

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MOVABLE SUPPORT FOR ABRADING APPARATUS

This invention relates to abrading apparatus, especially abrading apparatus of the type wherein an abrasive stream issuing from a nozzle is employed for trimming miniature electrical resistors of circuits printed on nonconductive substrates. More particularly, the invention relates to an improvement in the supporting structure of the apparatus which permits the workpiece holder and the nozzle to be movably positioned relative to one another in horizontal directions prior to the abrading operation.

Abrading apparatus of the type described is usually provided with separate supports for the workpiece holder and the trimming head including the nozzle. The nozzle is pointed downwardly toward the upper surface of the workpiece where the workpiece is secured. Conventionally, it is a tedious procedure to loosen and then retighten various bolts of the supports when aiming the nozzle as part of the initial setup for an abrading operation. Although the lost time resulting from this procedure has been tolerated when large numbers of identical workpieces have been trimmed with one setup, it becomes intolerable when only a small number of workpieces are to be processed or when repositioning of the nozzle must be accomplished with maximum speed.

According to the present invention, one or the other of the supports is movably mounted on a horizontal slide structure movable in a path extending at a right angle to the path of movement of a second horizontal slide structure connected to the first slide structure. Preferably the second slide structure comprises slides connected to the opposite ends of the first slide structure and mounted on respective spaced and parallel bars. The first slide structure may be constructed similar to the second slide structure, although they are movable at right angles to one another within substantially the same horizontal plane.

The invention will now be described in greater detail with reference to the drawings, in which:

FIG. 1 is an isometric view of a movable support constructed according to the invention;

FIG. 2 is a vertical sectional view of the same, taken along line 2–2 of FIG. 1;

FIG. 3 is a horizontal sectional view of the same, taken along line 3–3 of FIG. 2;

FIG. 4 is a diagrammatic illustration of abrading apparatus in which the movable support of FIG. 1 is incorporated; and

FIG. 5 is an enlarged plan view of a miniature resistor which can be trimmed by the apparatus of FIG. 4.

Before describing the movable support of FIG. 1 to 3, the abrading apparatus as a whole illustrated in FIG. 4 and the workpiece of FIG. 5 will be described.

The abrading apparatus is applied to the trimming of a thick-film resistor or other workpiece designated generally by the numeral **10**, utilizing a high velocity abrasive stream issuing from a nozzle **12**. The latter is supplied through a supply conduit **14** by a mixing chamber **16** where dry, filtered, pressurized air at about 85 p.s.i. from a compressor **18** is uniformly mixed in the desired proportions with abrasive powder from a reservoir **20**. By means of a unique arrangement more fully described in the present inventor's application Ser. No. 365,123, filed May 5, 1964, now U.S. Patent No. 3,344,524, a vibrator **22** is employed to apply vibrations to the chamber **16**. This arrangement can produce an automatically replenished trickle of about 3 to 5 grams per minute of aluminum oxide or other abrasive powder having an average particle size of 27 microns, from the reservoir **20** through a passageway (not shown) to the mixing chamber **16** for combining with the pressurized air.

The flow of airborne abrasive particles is initiated by the energization of a solenoid operated pinch valve **24** in the upstream end of the supply conduit **14**, that is, at the outlet of the mixing chamber **16**. The nozzle **12** will have a restricted orifice, e.g. 0.018 inch diameter, of much smaller cross-sectional flow area than the supply conduit **14**, and thus the entire system is pressurized. In order to achieve uniform cutting action the apparatus is arranged to provide a uniform concentration of particles in a constant airstream issuing from the nozzle at about 40 to 80 p.s.i.

The supply conduit **14** may be flexible hose of abrasion resistant material at the end of a length of rigid tubing, and it is preferred that the terminal or end portion adjacent the nozzle **12** be of rigid tubular construction so that it can serve as nozzle holder **26** capable of having its movements accurately controlled by a traversing mechanism **28** connected thereto by a rigidly constructed arm **30**. The nozzle holder **26** is suitably journaled in the extended free end of the arm **30**, in upright position above a support **32** for the workpiece **10**. The support **32** is mounted on a base **33**. The traversing mechanism **28** may also be mounted on a support **32**, mounted in turn on the base **33**. The mechanism **28** serves to move the nozzle **12** in horizontal direction by its holder **26**, transverse to the longitudinal extent of the holder, or into and out of the place of the drawing illustrating the apparatus, whereby the abrasive stream is traversed along the length of the workpiece to cut or abrade along the line of travel. The traversing mechanism **28** responds to signals received via conductors **34** from a control **36** to move a controlled distance first in one direction and then usually in opposite or reverse direction upon completion of an abrading operation. The control **36** also sends energizing current through conductors **38** to the solenoid of pinch valve **24** to effect its closing upon completion of an abrading operation; but otherwise during abrasive trimming the pinch valve **24** is held open.

The workpiece **10** shown in FIG. 5 is an electrical resistor having a thick, electrically resistive film **40** printed on a nonconductive substrate and having a pair of terminals **42** joined to opposed parallel edges thereof. As shown, the resistor **10** has been trimmed between the lines designated by the letters A and C. The trimmed area lying between lines B and C represents the amount of the film **40** trimmed by overshooting during the elapsed time between issuance of the signal to stop and the actual point of stopping. Broken line D represents the point at which abrasive flow ceases during reverse movement of the nozzle.

Referring again to FIG. 4, a pair of probes **44** are connected during trimming between terminals **42** and control **36** by conductors **48** so that the electrical resistance of the resistor **10** can be continuously monitored by the control **36** as work proceeds.

The vibrator **22** may be connected as shown to the control **36** by conductors **46**. The concentration of abrasive particles in the abrasive jet can be set by adjusting the amplitude of vibrations applied to the mixing chamber in direct relation to the desired abrasive capability of the jet since the cutting action of the abrasive stream corresponds to the abrasive concentration.

Accordingly, the electrical resistor **10** is trimmed by directing a jet of airborne abrasive particles toward the film **40** at close range, while moving the jet at constant forward speed across part of the surface of the film in a path between the terminals **42** so as to reduce its cross-sectional area. While moving the jet the increasing resistance of the resistor **10** is continuously measured and the additional time required to further increase resistance to the desired value can be projected, so that the film material remaining has the desired electrical resistance within a high degree of accuracy. With forward nozzle travel speeds of 1 inch per minute, resistor values within plus or minus one-tenth percent can be achieved without difficulty. With trimming speeds up to 6 inches per minute, accuracy within three-tenths percent can be obtained; and where less accuracy is required, trimming speeds can be increased to and beyond 15 inches per minute.

For maximum accuracy, trimming should be accomplished by moving the nozzle, not only at constant forward speed, but also with a constant distance between the nozzle **12** and the film **40**.

The control **36** may incorporate a 4-wire resistance limit bridge, integral to the electrical control system, for monitoring the resistor as it is being trimmed and sending a signal to the pinch valve **24** and to the traversing mechanism **28** in the manner and at the time described.

Although the apparatus has been described as applied to the trimming of electrical resistors, the invention is also applicable to the trimming of other kinds of electrical elements such as capacitors. Therefore, the apparatus can be employed whether trimming effects an increase or decrease in the electrical value being measured.

Although not shown, the workpiece **10** can be mounted on a support **32** which includes a clamping device affording quick, secure and easy insertion and removal of the workpiece. The present invention is directly concerned with an adjustably movable support **32** for the workpiece **10**, but the same construction may be used for the support **32** for the mechanism **28**. Either or both supports **32** may be made as in FIG. **1** to **3**, whereby the nozzle **12** and the workpiece **10** are horizontally movable relative to one another during the initial set up and then locked in place for repeated use on a number of similar workpieces.

The movable support **32** of FIG. **1** to **3** includes a horizontal mounting plate **50** having holes **52** for securing the plate to the base **33**. It also includes four upright corner posts **54** fixed to the plate **50**, as by screws **56**, and extending upwardly therefrom. Rigidly supported by the posts **54** above the plate **50** are a pair of widely spaced, parallel bars **58**. The bars **58** are of uniform circular cross section and they extend horizontally. Setscrews **60** secure the bars **58** at their end portions to the corner posts **54**.

Slidably mounted on the respective bars **58** are horizontally elongated slide blocks **62** and **63** having a horizontal passageway extending longitudinally therethrough. The passageway of block **62** is fitted with a ball bushing **64** which snugly receives the bar **58** in rolling contact to ensure smooth and straight movement of the block on the bar with a minumum of friction. The ball brushing **64** is secured in position by retaining rings **66** engaging the wall of the passageway at opposite ends of the bushing. A felt washer **68** encircles the bars **58** outwardly of each bushing **64** and provides a seal for the passageway.

The other slide block **63** is preferably provided with a ball plunger **70** and locking screw **72** with a knurled head, arranged on the opposite sides of the bar **58** for locking the block **63** to that bar. For this block **62** and the ball bushings **64** may be disposed in a passageway thereof on opposite sides of the lock screw **72**, and further provided with retaining rings **66** and felt washers **68**.

Connected between the slide blocks **62** and **63** is horizontally elongated slide structure **74**. The slide structure **74** is movable with the slide blocks **62** and **63** in a first horizontal directions on the bars **58**, although the slide structure is elongated in a second horizontal direction which is at right angles to the direction of movement on the bars **58**.

The slide structure **74** comprises a pair of closely spaced bars **76** similar in construction to the bars **58** and disposed in the same horizontal plane with them. The bars **76** are at right angles with the bars **58**, however. The ends of the bars **76** are received in sockets in the slide blocks **62** and **63** and secured by screws **78**.

The slide structure **74** further includes slide blocks **80** and **82** which are slidably mounted on the bars **76** and joined by a cover plate **84** with screws **86** for unitary movement.

The slide block **80** is structurally similar to the slide block **62** previously described. Therefore, a description thereof will not be repeated, and like reference numerals are employed to designate correspondingly similar parts of the blocks **62** and **80**.

Likewise, the slide blocks **82** and **63** are structurally alike, and again like reference numerals are used to designate correspondingly similar parts thereof without descriptive repetition.

As will be apparent from the drawings, the movable portion **80**, **82** and **84** of the slide structure **74** is movable in one horizontal direction with the slide blocks **62** and **63**, and it is also movable in another horizontal direction between the slide blocks **62** and **63**. The two horizontal directions are at right angles to each other. Furthermore, the slide bars **58** and **76** are in substantially the same horizontal plane in order to minimize the overall vertical dimension of the support **32**.

The cover plate **84** is suitable for mounting either a workpiece **10** thereon, as with an appropriate clamping device (not shown), or for carrying the traversing mechanism **28** in the general manner shown.

In operation, assuming the support **32** to be under a workpiece **10**, the lock screws **72** are turned outwardly to disengage them from their respective slide bars. When unsecured the slide blocks **62** and **63** and the slide structure **74** are freely movable in a wide horizontal range within the edges of the mounting plate **50** for positioning the workpiece **10** and the nozzle **12** relative to one another prior to abrading the resistive film **40**. Once positioned as desired, the lock screws **72** are turned inward to secure the blocks **62** and **63** and the slide structure **74**, and abrading operations may be started.

I claim:

1. In abrading apparatus, the combination with a first assembly comprising a vertical nozzle adapted to direct a pressurized abrasive stream toward a workpiece, means for supplying said pressurized abrasive stream to said nozzle, and a stationary support therefor, of a movable support having a horizontally flat surface for supporting said workpiece beneath said nozzle, said movable support being adapted to initially position said workpiece with respect to said nozzle, said movable support including a base mounted to said stationary support a first pair of spaced and parallel bars carried by said base and extending in a first horizontal direction, first slides mounted on the respective first pair of bars for sliding movement in said first horizontal direction, horizontally elongated slide structure extending between said slides, said slide structure including a second pair of spaced and parallel bars extending in a second horizontal direction at a right angle to said first pair of bars, second slides mounted on the respective second pair of bars for sliding movement in said second horizontal direction, and a locking screw carried by at least one of each set of slides and being engageable with the bar associated therewith for locking said movable support against movement.

2. The combination described in claim **1**, wherein each of said pairs of bars is disposed in substantially the same horizontal plane.