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2,729,324	7/1956	Howdle	198/127UX
2,864,406	12/1958	Schewel	239/521X
3,071,365	1/1963	Faerber	34/160X
3,319,354	5/1967	Hering	34/160X
3,398,466	8/1968	Brown	34/160
3,429,057	2/1969	Thygeson	34/160

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[54] **CIRCUIT BOARD DRIER**
 11 Claims, 4 Drawing Figs.

[52] U.S. Cl. **34/218,**
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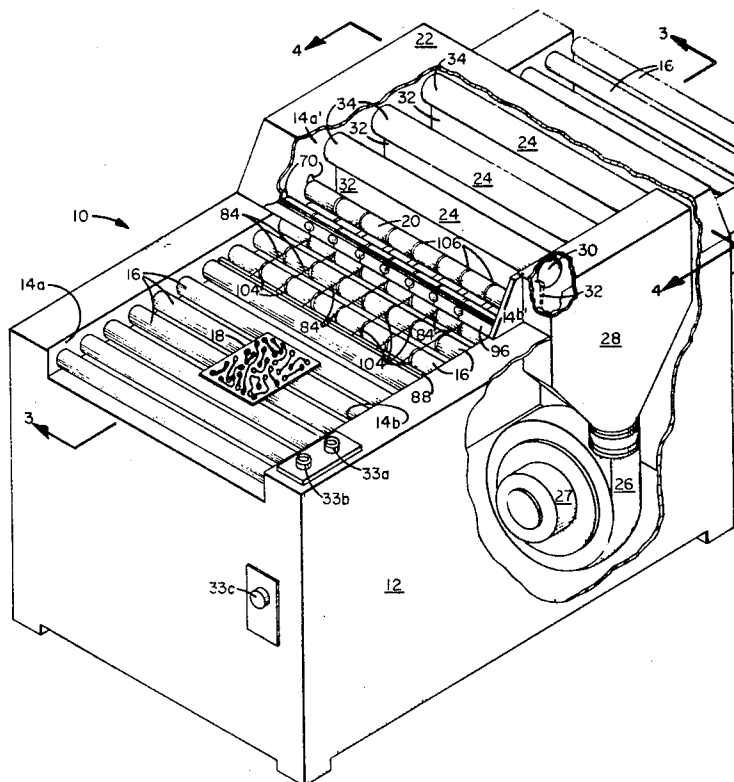
[50] Field of Search 34/218,
 160, 148; 198/127; 239/597, 598, 523

[56] **References Cited**

UNITED STATES PATENTS

1,320,108	10/1919	Werlin	239/523
2,192,657	3/1940	Werther	239/523X
1,759,804	5/1930	Pieron	34/160

ABSTRACT: In an apparatus for drying circuit boards, two sets of rollers convey a circuit board past a set of air knives of novel configuration. Each air knife comprises a pair of planar blade members converging to form adjacent their apex an elongate orifice having a width on the order of 0.085 inches. A deflector lip projects from one edge of the orifice. Air forced through the orifice forms an air knife edge having an anemometer static pressure of greater than 10 inches of water, providing exceptionally quiet, highly effective drying of the board. In some embodiments, a plurality of upper and lower horizontally disposed guidewires facilitate drying of thin, flexible boards.



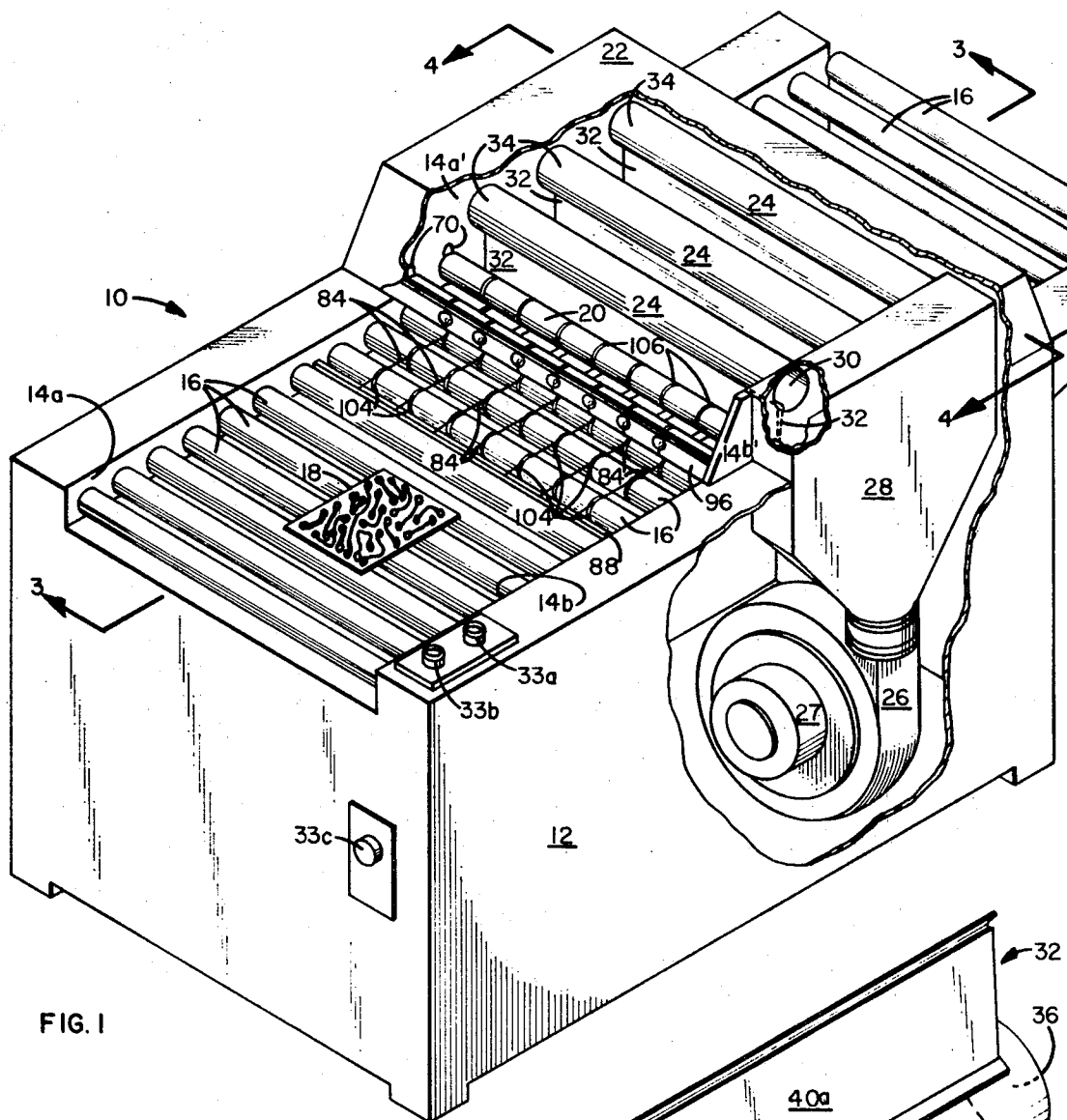


FIG. 1

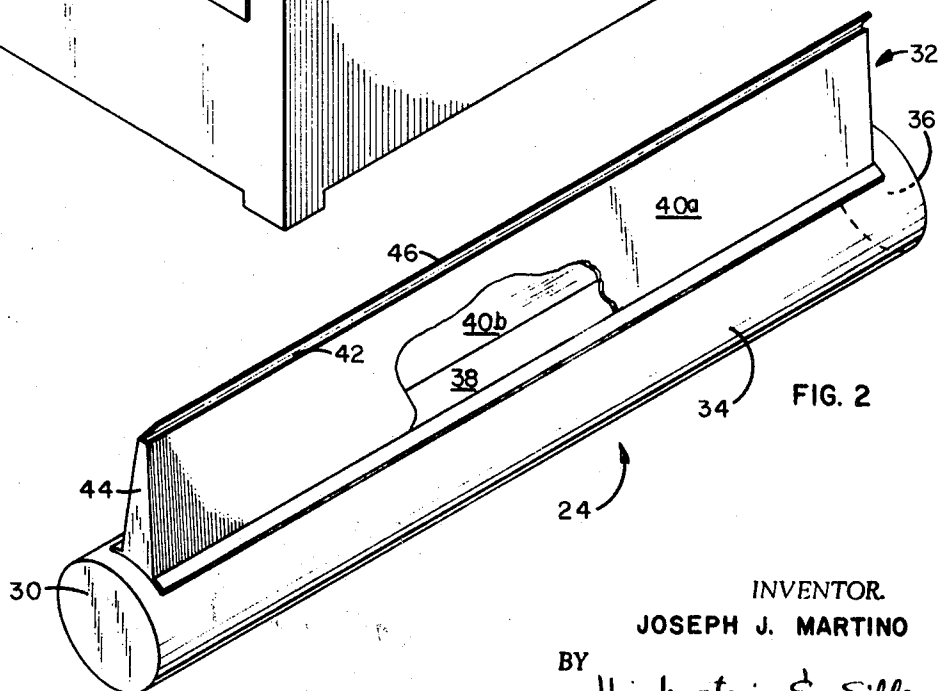
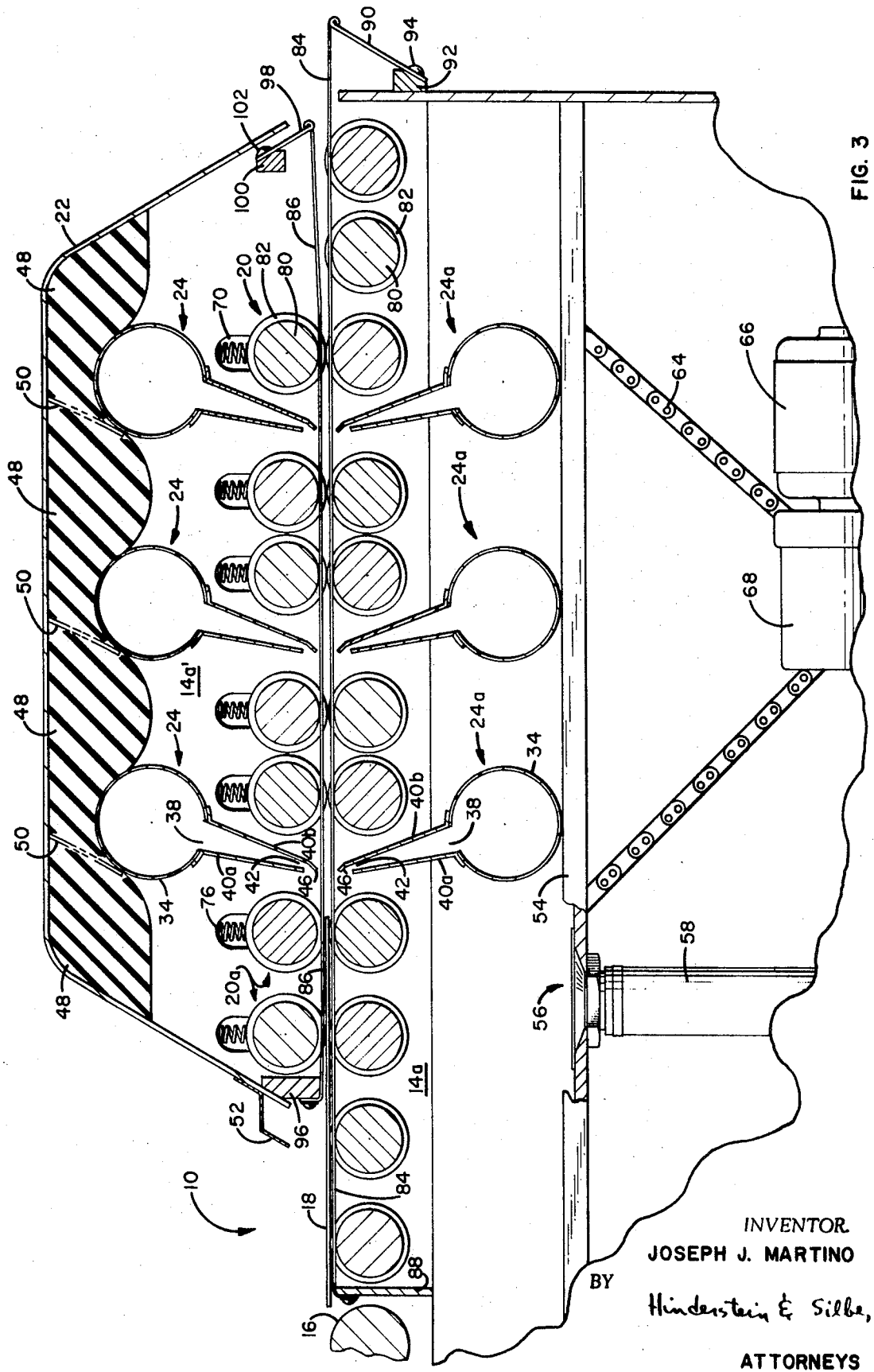
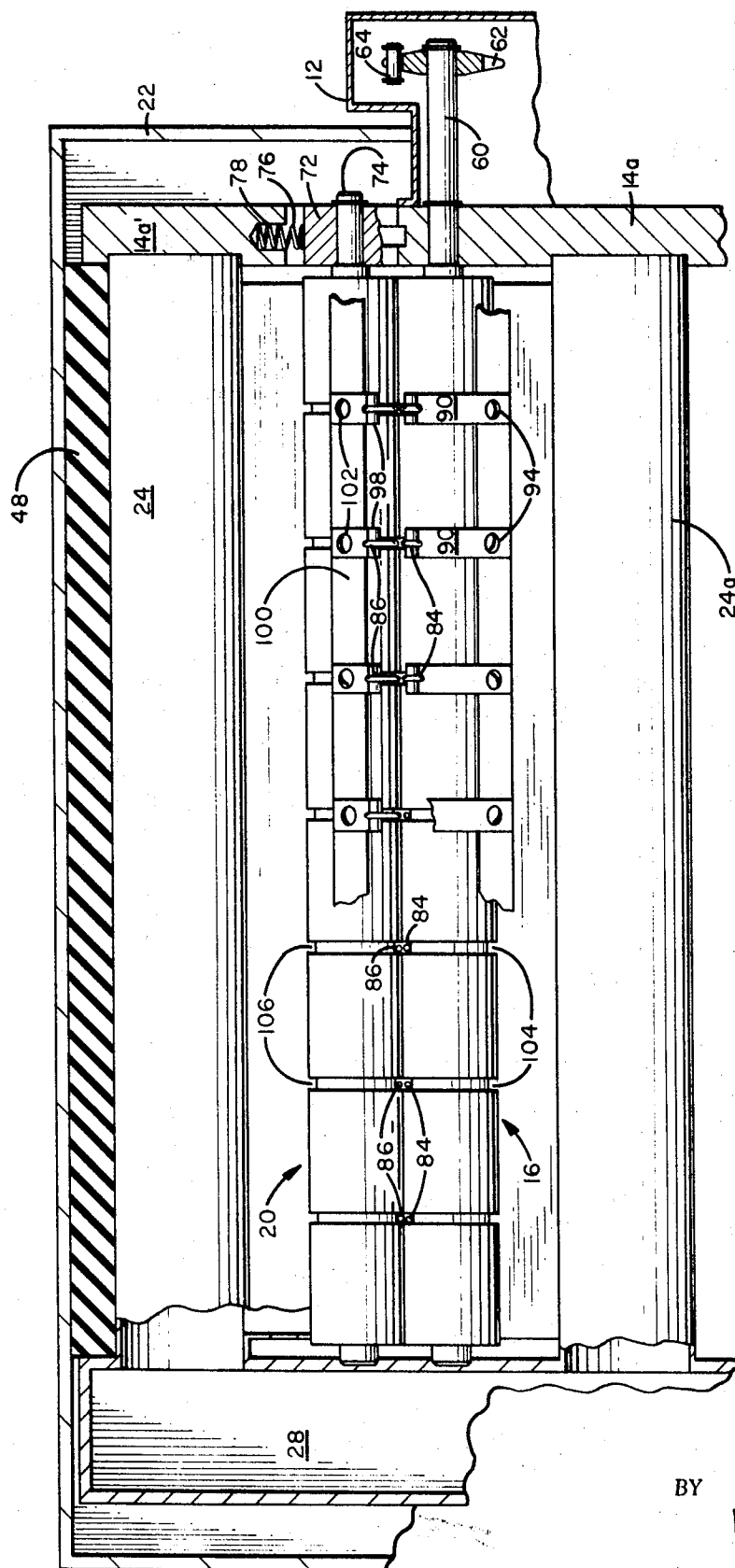


FIG. 2

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CIRCUIT BOARD DRIER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for drying circuit boards, and, more particularly, to a circuit board drier employing an air knife having a thin, elongate orifice and a deflector lip extending from one edge thereof.

2. Description of the Prior Art

In virtually all present day electronic equipment, the various electronic components, be they individual transistors, resistors and capacitors or complex microelectronic chips, are interconnected by means of printed circuit boards. These circuit boards typically comprise an insulative substrate of phenolic, glass impregnated epoxy or the like, both surfaces of which are provided with thin, planar interconnections of a conductive material such as copper. Often, through-plated holes interconnect the circuitry on the two sides of the board.

Formation of such circuit boards generally begins with the drilling of through-holes, followed by electroless and electrolytic plating of the entire board with copper or other conductive material. This copper layer then is coated with a photosensitive resist material such as Kodak KPR, the resist then being exposed to light through a photographic mask containing an image of the desired circuit pattern. When the exposed photoresist is developed, the areas defining the desired circuit pattern polymerize, while the remaining areas may be washed with an appropriate solvent. The thus developed pattern serves as a mask for an acid which preferentially etches away the copper from regions not covered with photoresist. The etchant does not attack the insulative substrate. When the etching has been completed, the residual polymerized photoresist is removed with an appropriate stripper, leaving a circuit board having a conductive pattern on one or both surfaces of the insulative substrate.

It will be appreciated that at several stages of fabrication such circuit boards must be immersed in various liquids such as solvents, photoresists, etchants and the like; the boards also must be washed in water at certain times. To insure defect-free boards, the boards must be dried completely after several of these fabrication steps.

For example, after the insulative substrate has been drilled and deburred, but before it has been metal-plated, the board must be completely dry to insure that electroless copper deposited on the surface and through-holes will form a continuous coating, free from voids which may result in intermittent or open electrical circuits. Similarly, after the plated copper has been etched, the board must be completely dry before the photoresist is removed. If water is present, it tends to cause coagulation of the photoresist stripper, significantly decreasing its effectiveness. Finally, it is important that the finished board be dried completely. This insures the absence of residual water which might cause tarnishing or oxidation of the copper interconnections during storage of the board between the time it is fabricated and the time when components are mounted thereon.

Prior art circuit board driers have suffered from a number of disadvantages. For example, one commonly used drier is fashioned in the form of a two-pronged yoke or fork. The circuit board to be dried is placed between the prongs and air then is directed through the prongs edgewise over the board. Such an apparatus is clumsy in that each board must be placed on the drier individually. More important, the airflow from opposite edges of the board is nonuniform over the entire surface, leading to nonuniform drying of the board. Further, only limited air pressure can be used with such an apparatus.

Another approach of the prior art is simply to place one or more boards on a rack and then direct an air hose over the boards. Such a technique is haphazard at best, the effectiveness of the drying being a function of how carefully the air hose is directed back and forth over the boards.

Conveyor-type circuit board driers have been used in the past, but these too have suffered from various problems. Typi-

cal is the apparatus in which a board was conveyed under one or more cylinders each provided with a plurality of holes. Air under pressure was directed into the cylinders, the air being forced out at relatively high velocity through the holes toward the board to be dried. With such an arrangement, the drying air was random directed, with air blasts from several of the holes often causing splashing of the water onto other parts of the board, thereby making more acute the wetting problem. Typically, it was necessary to pass the board under the drier several times to accomplish even reasonable drying.

In other prior art driers, the circuit board was conveyed past a cylinder having a narrow slot in it through which a bladelike flow of air was directed toward the board. However, such prior art blades had several disadvantages. First, it was difficult to direct the flow of air through such openings, and when using air of even reasonably high pressure, these slotted cylinders generated such an excessively high noise level as to make them commercially unacceptable.

Another shortcoming indigenous to prior art conveyor-type circuit board driers was that very thin, flexible circuit boards could not be dried by these machines. Such circuit boards, typically on the order of 0.002 inch thick, are extremely flexible, and when run through prior art conveyor-type driers tended to be blown upward or downward into the conveyor or air knife mechanism, fouling the drier apparatus rather than drying the board.

These and other shortcomings of the prior art are overcome by using the inventive circuit board drier wherein a unique air knife is employed permitting quiet, effective drying of a circuit board conveyed past the air knife. A unique conveyor arrangement permits utilization of the same machine for boards of varying thickness, including permitting drying of very thin flexible circuit boards.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a circuit board drier employing a novel air knife. The air knife itself comprises a cylindrical duct opening longitudinally into a blade portion formed by a pair of elongate, planar blade members. The blade members converge to form, adjacent their apex, a narrow elongate orifice or slit having an opening ranging in width from 0.032 to 0.125 inch. A deflector lip extends from one edge of the orifice for length of at least 0.125 inch and at an angle of between 15° and 25° with respect to a normal to the plane of the orifice. When air under pressure is fed to the interior of the cylindrical duct, it escapes through the orifice, deflected by the deflection lip, to form a thin blade of air having an anemometer static pressure of at least 10 inches of water. When directed at the surface of a circuit board at an appropriate angle, the air knife is exceptionally effective in drying the board. Further, the air knife is considerably quieter than slotted air knife devices of the prior art.

The inventive air knives are incorporated in a drier apparatus utilizing a conveyor formed by a plurality of rotating rollers having their upper edges aligned in a horizontal plane. A second set of rollers, disposed atop the first set and adapted for limited vertical motion, serves the function of maintaining the circuit board in a horizontal plane as it is conveyed past the set of air knives.

In a preferred embodiment, several air knives are situated above the plane of the conveyed circuit board and oriented in an angle of from 10° to 20° with respect to that board surface. These air knives effect drying of the upper board surface, an appropriate baffle arrangement being used to prevent the air from each knife from circulating into the space associated with the next adjacent air knife. A second set of air knives is disposed beneath the plane of the conveyed circuit boards, and positioned at an appropriate angle to effectuate drying of the circuit board bottom. An underlying pan and drain catches residual liquids blown from the board as it is dried.

To permit conveyor drying of very thin circuit boards, the inventive drier is provided with upper and lower sets of

guidewires recessed respectively in grooves in the upper and lower conveyor rollers. The between-wire spacing is selected in accordance with the dimensions of the board to be dried. A thin circuit board, when conveyed through the drier, will be maintained in a horizontal plane between the guidewires despite the flexibility of the board and the pressure exerted by the air knives.

Thus, it is an object of the present invention to provide an improved air knife drying apparatus.

Another object of the present invention is to provide an improved apparatus for drying circuit boards.

It is another object of the present invention to provide an apparatus for the conveyor drying of circuit boards of any dimension or thickness.

Yet another object of the present invention is to provide a circuit board drier capable of drying thin, flexible boards.

It is a further object of the present invention to provide an air knife having an elongate slit-type orifice and a deflection lip angularly extending from one edge of the slit.

A further object of the present invention is to provide a circuit board drier utilizing a plurality of horizontally aligned driven rollers to convey a circuit board past one or more air knives of the type incorporating an elongate slit and a deflection lip extending from one edge of the slit.

Still a further object of the present invention is to provide a circuit board drier incorporating two sets of guidewires disposed to maintain a flexible circuit board in a horizontal planar orientation while passing through the drier.

BRIEF DESCRIPTION OF THE DRAWINGS

Still other objects, features and attendant advantages of the present invention will become apparent to those skilled in the art from a reading of the following detailed description of the preferred embodiments constructed in accordance therewith, taken in conjunction with the accompanying drawings wherein like numerals designate like parts in the several figures and wherein:

FIG. 1 is a perspective view of a preferred embodiment of the inventive circuit board drier, the view being partially cut away to disclose the centrifugal blower, duct and air knives employed in the drier.

FIG. 2 is a perspective view of a high velocity air knife in accordance with the present invention; several such air knives are incorporated in the circuit board drier illustrated in FIG. 1.

FIG. 3 is a partial sectional view of the inventive circuit board drier, as seen generally along the line 3-3 of FIG. 1. Evident in the FIG. are six air knives, of the type illustrated in FIG. 2, arranged for drying both the top and bottom of a printed circuit board conveyed past the air knives by a plurality of rotating rollers.

FIG. 4 is a partial rear plan view, partly in section, of the inventive circuit board drier as seen generally along the lines 4-4 of FIG. 1. This view best illustrates the grooved rollers used to accommodate two sets of guidewires useful for directing very thin printed circuit boards through the drier.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and particularly to FIG. 1 thereof, it may be seen that the inventive circuit board drier 10 generally is enclosed in a housing 12 of conventional metal fabrication. Mounted within housing 12 are a pair of spaced parallel support members 14a and 14b (support member 14b being hidden in FIG. 1) between which extend a plurality of lower rollers 16. The axes of rollers 16 all are parallel, and the rollers all are of the same diameter, their upper edges lying within a common horizontal plane. An appropriate roller drive mechanism, described in detail hereinbelow, imparts rotational motion at a common speed to some or all of rollers 16, so that when a printed circuit board 18 is placed upon lower rollers 16 adjacent the front of drier 10, as shown in FIG. 1, the circuit board will be transported toward the rear of drier 10 atop the rollers.

Still referring to FIG. 1, it may be seen that support members 14a and 14b respectively include upwardly projecting portions 14a' and 14b', between which extend a plurality of upper rollers 20. As will be described hereinbelow, upper rollers 20 are not driven, and are appropriately mounted to permit their vertical displacement as printed circuit board 18 passes thereunder. A ventilated hood 22 also is supported by members 14a' and 14b', hood 22 enclosing upper rollers 20.

Actual drying of circuit board 18 is accomplished by a plurality of inventive air knives 24, the upper three of which are evident in FIG. 1. A high speed centrifugal blower 26, powered by motor 27, supplies air at high velocity through a duct 28 to air knives 24 via the open ends 30 thereof. This high velocity air in turn is directed via air knife blade 32 toward the printed circuit board 18 being conveyed through the drier atop rollers 16.

Still referring to FIG. 1, circuit board drier 10 is provided with appropriate on and off switches 33a and 33b which control the supply of electricity to blower motor 27 and to the drive system for rollers 16. The apparatus further is provided with a conventional electrical speed control device 33c permitting adjustment of the speed of rotation of lower rollers 16, and hence of the linear rate at which printed circuit board 18 is conveyed through drier 10.

The configuration of the inventive air knife 24 employed in circuit board drier 10 most clearly is illustrated in FIG. 2. As seen therein, air knife 24 comprises a cylindrical duct 34 which is open at end 20 and closed at end 36. An elongate, axial opening 38 permits communication between the interior of cylindrical duct 34 and the interior of air knife blade 32. Blade 32 itself comprises a pair of planar, elongate blade members 40a and 40b extending from adjacent opposite edges of opening 38 and converging to form an elongate, slotted orifice 42 of substantially constant width. The ends 44 of air knife blade 32 are closed. An elongate deflection lip 46 extends from one edge of orifice 42, forming an obtuse angle with planar blade member 40b.

In a preferred embodiment, the width of orifice 42 is at least 0.030 inch but less than 0.125 inch. The angle between planar blade members 40a and 40b typically may be on the order of 20°. With respect to deflection lip 46, if a radius were drawn from the axis of cylindrical duct 34 through the centerline of elongate orifice 42, the preferred angle between this extended radius and deflection lip 46 is between 25° and 35°. The length of lip 46 preferably is between one-eighth inch and three-eighths inch, a length of about 0.25 inch being optimum. Further, the preferred orientation of air knife 24 with respect to the article to be dried is with this extended radius (i.e. a radius of duct 36 passing through the center line of orifice 42) forming an angle of from 10° to 20° with respect to the surface of the article to be dried.

With duct end 36 closed, when 1,000 cubic feet per minute of air is supplied to cylindrical duct 34 via open end 30, a knife edge of air having an anemometer reading of greater than 10 inches static pressure of water is exhausted via orifice 42. It has been found empirically that with the preferred dimensions described, an air knife edge of greater than 10 inches static pressure of water accomplishes exceptionally effective drying of a surface. Further, due at least in part to the action of deflector lip 46, the airflow through air knife 24 is remarkably quiet, producing substantially less noise than produced by air knives of the prior art.

The manner in which air knives 24 are incorporated in circuit board drier 10 is shown most clearly in FIG. 1 and in the sectional view of FIG. 3. Referring to these FIGS. it may be seen that drier 10 incorporates six air knives 24, three being disposed above lower rollers 16 so as to dry the upper surface of circuit board 18. The remaining three air knives (herein designated 24a) are disposed below the upper edges of lower rollers 16, so as to affect drying of the bottom surface of circuit board 18. Lower air knives 24a, although hidden from view in FIG. 1, also interiorally communicate via their open ends 30 with duct 28, so that centrifugal blower 26 serves as the high velocity air source for all of the drier air knives.

For optimum drying efficiency, each of air knives 24 and 24a is oriented so that an extended radius drawn from the axis of cylindrical duct 34 through the center of orifice 42 intersects the plane defined by the upper edges of lower rollers 16 at an angle of from 10° to 20°, with an angle of about 15° being preferred. Note that the resultant airflow over the circuit boards is toward the front of the drier, i.e., toward the trailing edge of the board being dried.

As most clearly evident in FIG. 3, a foam rubber 48 is provided within hood 22, the foam rubber being of sufficient thickness so as to abut against the upper portions of cylindrical ducts 34 of upper air knives 24. Foam rubber 48 serves two functions. First, it acts as a sound dampener, further reducing the low level of noise produced by air knives 24. Secondly, foam rubber 48 prevents high velocity air, exhausted forwardly of a particular air knife 24, from flowing back into the region in front of the next rearward air knife. It has been found empirically that significantly improved circuit board drying is achieved by so limiting air communication between the regions associated with adjacent air knives. Of course, this configuration also insures that liquids blown from the board surface by a particular air knife will not be splashed back onto portions of the board which have passed that air knife. In an alternative embodiment, foam rubber 48 may be dispensed with and appropriate baffles 50 (shown in phantom in FIG. 3) may be used to limit air communication between the regions of adjacent air knives.

An air shield 52 (see FIG. 3) is provided to deflect downward air flowing out of the forward edge of hood 22. Air shield 52 thus prevents this exhausted air from blowing in the face of an operator who is inserting printed circuit boards into the drier. Also apparent in FIG. 3 is a drain pan 54 situated below lower rollers 16 and lower air knives 24a so as to collect water or other liquids dripping from circuit board 18 as it proceeds through the drier. A drain 56 and an associated drainpipe 58 are provided to carry away water or other liquids accumulating in pan 54.

As best illustrated in FIGS. 3 and 4, each of lower rollers 16 is provided with a shaft 60 extending through support member 14a and terminating in a sprocket 62. A chain drive 64 engages each of sprockets 62, and is driven by a conventional variable speed motor 66 and gear drive 68 (FIG. 3), the speed of which is adjustable by means of control 38. Thus, motor 66, transmission 68, chain drive 64 and sprocket 62 all cooperate to rotate lower rollers 16 clockwise as seen in FIG. 3, thereby providing a system for conveying circuit boards through drier 10.

Each of upper rollers 20 is adapted to be displaced vertically as printed circuit board passes beneath it. This is illustrated in FIG. 3, wherein printed circuit board 18 is shown passing beneath the first two upper rollers 20a, each of which has been displaced upward by an amount equal to the thickness of board 18. In contradistinction, the remainder of upper rollers 20 illustrated in FIG. 3 have not been displaced upward, but are resting in tangential contact with the corresponding ones of lower rollers 16.

The system permitting vertical displacement of the right end of roller 20 best is shown in FIG. 4. Although not shown in FIG. 4, a similar arrangement is used at the left end of roller 20. Upper support members 14a' and 14b' each are provided with a plurality of vertically disposed slots 70, corresponding in number to the number of upper rollers 20. Disposed within each slot 70 is a slideable member 72 through which extends the shaft 74 of upper roller 20. Of course, a conventional ball bearing (not shown) may be employed to mount shaft 74 to member 72. Member 72 itself is free to slide vertically in slot 70, and is biased downward by a coil spring 76 extending from a countersunk hole 78 in upper support member 14a'. This configuration provides an independent floating mount for each end of upper roller 20, and permits the upward displacement of each roller 20 to accommodate itself to the particular thickness and width of the circuit board being dried.

While upper rollers 20 may be driven rotationally, this has not been found necessary for proper functioning of the inventive drier, and the embodiment shown incorporates no driving mechanism for these upper rollers. However, the upper rollers do play the important roll of preventing circuit board 18 from being blown upward off of lower rollers 16 by the force of the air projecting from lower air knives 24a. By imparting a downward force, upper rollers 20 maintain circuit board 18 substantially horizontal throughout the time that the board is moving through drier 10. To prevent damage to the surfaces of circuit board 18, it has been found desirable to fashion each of lower rollers 16 and upper rollers 20 of a tough yet resilient material such as neoprene rubber.

In modern electronic systems it is becoming increasingly common to use exceptionally thin printed circuit boards. Such circuit boards, which typically may be on the order of 0.002 inch thick, may be used independently or may be laminated with other boards of like thickness to provide a multilayer circuit board structure. The drying of such thin circuit boards present unique problems in that such boards tend to bend or flex very easily, and would readily be deflected downward or upward around rollers 16 or 20 (see FIG. 3) under the force exerted by air knives 24 or 24a. To permit such exceptionally thin circuit boards to be dried by apparatus 10, the present invention incorporates two sets of guidewires which prevent the curling or vertical displacement of thin circuit boards as they are conveyed through the inventive drier. The lower set of guidewires 84 is evident in FIG. 1, 3 and 4, while the upper set of guidewires 86 best may be seen in FIGS. 3 and 4.

In embodiments of the inventive circuit board drier 10 incorporating guidewires, lower guidewires 84 are stretched between a lower forward guidewire support bar 88 (see FIGS. 1 and 3) and a set of resilient fingers 90 (see FIGS. 3 and 4) equal in number to the number of guidewires 84. Fingers 90 preferably are of spring steel, each finger being attached at its lower end to a tapered rear support bar 92 by means of screw 94.

Similarly, upper guidewires 86 are stretched between an upper forward guidewire support bar 96, which bar itself is supported between members 14a' and 14b', and an upper set of resilient fingers 98 equal in number to the number of guidewires 86. Fingers 98 also are of spring steel, each finger being attached at its upper end to a tapered upper rear support bar 100 by means of a screw 102.

As best shown in FIGS. 1 and 4, those lower rollers 16 spanned by guidewires 84 are grooved to permit the guidewires to rest in a horizontal plane slightly lower than the plane defined by the topmost edges of rollers 16. Thus, in a typical embodiment the diameter of guidewires 84 may be on the order of from 0.020 inch to 0.045 inch, while grooves 104 typically may be 0.25 inch wide and have a depth on the order of 0.075 inch. With this configuration the top edges of rollers 16 will project slightly above the level of lower guidewires 84, as is apparent in FIG. 3. This permits sufficient contact between the upwardly projecting edges of rollers 16 and the lower surface of circuit board 18 so as to convey the circuit board through the drier. The spring action of fingers 90 tends to keep wires 84 taut within the grooves 104 of rollers 16.

In a similar manner, those upper rollers 20 spanned by upper guidewires 86 are provided with a like set of grooves 106. While the wire size for upper guidewires 86 also typically is on the order of from 0.020 inch to 0.045 inch, the depth of grooves 106 will depend on the anticipated thickness of the boards to be dried by apparatus 10. Where only relatively thin boards are to be dried, grooves 106 typically may be on the order of 0.25 inch wide and 0.075 inch deep. However, where it is anticipated that drier 10 also will be used to dry circuit boards of greater thickness, grooves 106 may be as deep as 0.30 inch. In either instance, fingers 98 are sufficiently resilient to keep upper guidewires 86 taut within grooves 106 regardless of the thickness of the board being conveyed through the drier.

It will be appreciated that although the circuit board drier 10 illustrated in FIGS. 1, 3 and 4 includes upper and lower guidewires, such guidewires are not required, and may be omitted completely from embodiments of the invention which are not to be used for drying very thin, flexible circuit boards. On the other hand, in those embodiments incorporating such upper and lower guidewires, the drier may be used for drying very thin flexible boards and for drying thicker, substantially rigid boards. When thin, flexible boards are dried, the boards will be guided through the drier by wires 84 and 86, these wires preventing the board from curling upward or downward as a result of the air pressure from air knives 24 and 24a. When a rigid circuit board is conveyed through drier 10, the guidewires will not interfere with passage of the board between air knives 24, the depth of grooves 106, and the springiness of fingers 98 cooperating to allow upper wires 86 to be displaced upward sufficiently to allow passage of a board which may be much thicker than the minimum distance between the upper and lower guidewires.

While circuit board drier 10 herein has been illustrated as employing six air knives, this is not required, and fewer or more air knives may be employed. Similarly, other embodiments may utilize air knives only above, or only below the object being dried, and not both above and below as illustrated in the embodiment shown in the drawings. Moreover, while the invention has been described in terms of its application for drying printed circuit boards, the invention is by no means so limited, and the apparatus could be employed for drying articles of any variety. Nor need such articles be limited to those which are generally flat in shape, the inventive air knife configuration of FIG. 2 being useful for providing an effective, quite, high velocity flow of air for drying objects of any shape.

While the invention has been described with respect to several physical embodiments constructed in accordance therewith, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. Accordingly, it is to be understood that the invention is not to be limited by the specific illustrative embodiments, but only by the scope of the appended claims.

I claim:

1. An air knife adapted for drying an article, and characterized by a body, the cross-sectional area of which converges to a slitlike orifice, comprising a cylindrical duct having a longitudinally extending opening therein, and a pair of elongate planar blade members extending from opposite edges of said opening and converging to form said slitlike orifice adjacent their apex, and a deflector lip extending from one edge of said blade member at an angle thereto.

2. An air knife as defined in claim 1 wherein the length of said deflector lip is at least one-eighth inch.

3. An apparatus for drying a circuit board, said apparatus comprising:
at least one air knife of the type defined in claim 1; and
conveyor means for transporting said circuit board past said orifice.

4. An apparatus as defined in claim 3 wherein said air knife is oriented so that a radius extending from the axis of said cylindrical duct through the center of said orifice intersects the surface of said transported circuit board at an angle of from 10° to 20°.

5. An apparatus as defined in claim 4, and comprising a plu-

ality of said air knives, at least one of said air knives being directed toward the top surface of said transported circuit board, at least one other of said air knives being directed toward the bottom surface of said transported circuit board.

6. An apparatus as defined in claim 5 further comprising means for exhausting air through the orifices of each of said air knives at a rate sufficient to produce an air knife edge having a static pressure of at least 10 inches of water.

7. An apparatus as defined in claim 6 where said conveyor means comprises a first set of rollers having their upper edges disposed in a first horizontal plane, and means for rotating said rollers.

8. An apparatus as defined in claim 7 wherein said conveyor means further comprises a second set of rollers having their lower edges disposed in a second horizontal plane above said first horizontal plane, each roller of said second set being adapted to be displaced vertically as said circuit board is transported therebeneath.

9. A device for conveying a thin flexible circuit board past a drier, said device comprising:

a first set of rollers having their upper edges disposed in a first horizontal plane, each roller of said first set having plural circumferential grooves therein;
means for rotating said first set of rollers;

a first plurality of guidewires aligned perpendicular to the axes of, and disposed within the grooves of said first set of rollers;

a second set of rollers having their lower edges disposed in a second horizontal plane disposed immediately above said first horizontal plane, each roller of said second set being adapted independently to be displaced vertically as said circuit board is conveyed thereunder, each roller of said second set having plural circumferential grooves therein; and

a second plurality of guidewires aligned perpendicular to the axes of, and disposed within the grooves of said second set of rollers.

10. A device as defined in claim 9 wherein said drier comprises one or more air knives each characterized by a body the cross-sectional area of which converges to a slitlike orifice and a deflector lip extending from one edge of said orifice at an acute angle with respect to a normal to the plane of said orifice.

11. An apparatus as defined in claim 6 wherein said conveyor means comprises:

a first set of rollers having their upper edges disposed in a first horizontal plane, each roller of said first set having plural circumferential grooves therein;
means for rotating said first set of rollers;

a first plurality of guidewires aligned perpendicular to the axes of, and disposed within the grooves of said first set of rollers;

a second set of rollers having their lower edges disposed in a second horizontal plane disposed immediately above said first horizontal plane, each roller of said second set being adapted independently to be displaced vertically as said circuit board is conveyed thereunder, each roller of said second set having plural circumferential grooves therein; and

a second plurality of guidewires aligned perpendicular to the axes of, and disposed within the grooves of said second set of rollers.