Kollmorgen Technologies Corporation

of C/o CT Corporation, Republic National Bank Building,
Dallas, Texas 75201, United States of America

hereby apply for the grant of a Patent for an invention entitled

"IMPROVED METHODS AND APPARATUS FOR MAKING
SCRIBED CIRCUIT BOARDS"

APPLICATION ACCEPTED AND AMENDMENTS
ALLOWED 17/80

which is described in the accompanying complete specification.
This application is a Convention Application and is based on the
application numbered 823,153

for a patent or similar protection made in United States of America

on 9th August, 1977

My address for service is:

Care: SPRUSON & FERGUSON
PATENT ATTORNEYS
ESSO HOUSE, 127 KENT STREET
SYDNEY. NEW SOUTH WALES.
AUSTRALIA.

At Hartford, Connecticut U.S.A. Dated this 12th day of October 1977

The Common Seal of
Kollmorgen Technologies Corporation was hereeto
affixed in the presence of:

To:
The Commissioner of Patents

Signature of Applicant
George Peter Stephan
COMMONWEALTH OF AUSTRALIA

DECLARATION IN SUPPORT OF A CONVENTION
APPLICATION FOR A PATENT OR PATENT OF ADDITION

In support of the Convention Application made for a
patent
for an invention entitled

"IMPROVED METHODS AND APPARATUS FOR MAKING Scribed
CIRCUIT BOARDS"

Full name and address of Declarant.

1. George Peter Stephan

of 60 Washington Street, Hartford, Conn. 06106 -
United States of America

do solemnly and sincerely declare as follows:-

I am the applicant for the patent

(or, in the case of an application by a body corporate)

1. I am authorised by KOLLMORGEN TECHNOLOGIES CORPORATION

the applicant for the patent

to make this declaration on its behalf.

2. The basic application as defined by Section 14: of the Act was made in

United States of America on the

9th day of August 1977 by Robert P. Burr,
Raymond J. Keogh and Ronald Morino

3. I am the actual inventor of the invention referred to in the basic application:

(or where a person other than the inventor is the applicant)

3. ROBERT PAGE BURR of R.D. No. 3, Lloyd Lane,

Lloyd Harbor, Huntington, New York. United

States of America;

of RONALD MORINO of 11 Raymond Court, Sea Cliff,

New York, United States of America, and

RAYMOND J. KEOGH of 19 Whitehall Drive, Huntington,

New York, United States of America

are the actual inventors of the invention and the facts upon which the applicant

is entitled to make the application are as follows:

The said applicant is the assignee of the actual inventors.

4. The basic application referred to in paragraph 2 of this Declaration

was the first application made in a Convention country in respect

of the invention the subject of the application.

Hartford, Connecticut U. S. A., day of October 1977

Declared at this

Signature of Declarant

George Peter Stephan

To:
The Commissioner of Patents,

SPRUSON & FERGUSON, SYDNEY.
Claim 1. A process for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base, the steps comprising:

(a) feeding a conductor to said base;

(b) engaging the end of said fed conductor between an energizeable stylus and the adhesively activatable surface of the board base at the first of a pair of contact points;

(c) with said end so engaged, energizing said stylus and moving said base and said stylus relative to each other in a predetermined direction;

(3) modulating the energy applied to said stylus proportional to the velocity of said movement to activate said adhesive and adhesively affix said conductor to said base;

(e) monitoring and comparing said feed of said conductor and said relative movement between said base and said stylus; and

(f) generating a control signal when said feed of said conductor and said movement are not in substantial agreement.
Claim 13. The process of claim 11 including the steps of:
(a) monitoring and comparing said feed of said conductor and said movement of said base; and
(b) generating a control signal when said feed of said conductor and said movement of said base are not in substantial agreement.
COMPLETE SPECIFICATION

(KNOWLEDGE OF AUSTRALIA
PATENTS ACT 1952-60

COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE:

Application Number:
Lodged:

Complete Specification Lodged:
Accepted:
Published:

Priority:

Related Art:

Name of Applicant: KOLLMORGEN TECHNOLOGIES CORPORATION

Address of Applicant: C/- CT Corporation, Republic National Bank Building, Dallas, Texas 75201, United States of America

Actual Inventor(s): ROBERT PAGE BURR, RONALD MORINO and RAYMOND J. KEOGH


Complete Specification for the invention entitled:

"IMPROVED METHODS AND APPARATUS FOR MAKING S RIBED CIRCUIT BOARDS"

The following statement is a full description of this invention, including the best method of performing it known to me/us:
ABSTRACT OF THE DISCLOSURE

Improved methods and apparatus for making scribed circuit boards. A conductor is fed to the adhesively activatable surface of a board base which is attached to a movable table. The conductor is affixed to the adhesive surface by means of an energizeable stylus, the energization of the stylus being modulated proportional to the velocity of the table. The feed of the conductor and the movement of the base are monitored and compared and a control signal produced if the conductor feed and base movement are not in substantial agreement. The conductor is positively fed to the board base to eliminate pull on the conductor and substantially reduce the tendency of the conductor to come loose from the board base. The forming stylus has a vertical groove on at least one side which becomes progressively shallower towards the bottom and which has side walls for laterally confining the conductor.

BACKGROUND AND BRIEF DESCRIPTION OF THE INVENTION

This invention relates to wire scribed circuit boards for interconnecting electrical and electronic components as well as methods and apparatus for the manufacture thereof.

It is common practice in the manufacture and assembly of electrical and electronic units to mount electrical and electronic components on preformed circuit boards. Such boards include an insulating base or surface having affixed thereto conductors arranged in patterns to receive and interconnect subsequently added components and to connect such components to each other, to power sources or to ground, as the case may be.
Various techniques have heretofore been employed for making circuit boards. One common technique is by printing. With printing, art work in one form or another must be created. Such art work may define the area upon which conductive metal is to be deposited or the area on a laminate from which metal is to be removed by a subsequent etching operation. In either case, such art work and the related photographic and printing steps are expensive. Furthermore, because of limitations in the thickness of metal which might economically be deposited or laminated and etched, conductivity of printed circuits has, for the most part, depended upon the width of the printed conductor. Hence, each printed conductor requires a relatively wide board area. Such wide board area, taken with the space required between conductors to prevent short circuiting, substantially limits conductor density. Because of such limited conductor density, with recently developed integrated circuits and miniaturized components, it has become necessary, in many instances, to utilize multi-layer or laminated printed circuit boards. This has increased the cost of printed circuit boards.

Recently, techniques have been developed for making circuit boards by scribing or writing wires onto the surface of the board. Such wire scribing is used to replace all or a substantial portion of the printed circuits on circuit boards. In the employment of such wire scribing techniques, certain portions of the conductor pattern, common in a substantial number of boards to be produced, might be printed and the balance of the conductors, such as those for receiving and interconnecting components, might be scribed or written with wire. Apparatus for such scribing is shown and described in

In the apparatus shown and described in the aforementioned patents, insulated wire is written or scribed onto the heat sensitive surface of a base or board. By controlling the apparatus through a program on magnetic tape, paper tape, punch cards or the like, fed through an appropriate control unit, circuit boards can be produced and duplicated. The insulated wire requires a much smaller board area than is required in the printing of the circuit board. Such wire written or scribed boards have been found to be especially suited for use with integrated circuits and miniaturized components.

The wire used for writing or scribing circuits on bases with the apparatus of the above-identified patents is relatively fine. Such wire, as it is written or scribed, is fixed or tacked to the heat sensitive surface of the base with a scriber or tacking head. The head guides the wire and heats or energizes the sensitive surface as the wire is brought into engagement. The continuity and completeness of the circuit board so wire written or scribed can be readily checked in the conventional manner utilized for the inspection of printed circuit boards.

The number, location and compactness of the wire scribed circuits on the circuit board will, of course, depend upon the intended use. Such boards may contain hundreds or thousands of circuits, each circuit being written or scribed on the board with a wire extending between two points. The wire extending between two points may cross over or be crossed over by one or more other written or scribed wires extending
between other points. In extending between points, the written or scribed wire may extend in a straight path or, as commonly happens, such wire may extend for a part of its travel in one direction and in another part of its travel in another direction, usually at right angle to the first direction.

The number and compactness of the wire scribed circuits and the fineness of the scribed wire makes inspection of wire scribed boards to detect loose and incompletely tacked wires difficult. Moreover, the repair and correction of such loose wires, once wiring of the board has been completed, is also difficult. Such loose wires, if undetected and uncorrected, can result in defective boards and interference with and possible damage to processing equipment.

The instant invention provides improved methods and apparatus for producing wire written or scribed circuit boards and eliminates many of the difficulties heretofore encountered in such production and in the inspection of the boards so produced.

In the method and apparatus of the instant invention, the conductor to be written or scribed is fed from a supply source to the scribing head or stylus and such feed is continuously monitored and compared with the length of the base passing the scribing head or stylus for scribing. If the length of conductor fed is substantially less or substantially more than the length of the base passing the scribing head or stylus for scribing, the apparatus is stopped. The specific area of what could otherwise be a defect is, thus, identified. Necessary corrections or repairs can be made and the apparatus can be re-started to complete the board.
The conductor, as it is fed to the heat activatable board surface and scribed with the method and apparatus of the instant invention, is held in engagement with the board surface by the scribing head of stylus. While this is being done, the heat sensitive surface of the board in contact with the wire is heated, preferably by means of an ultrasonic transducer. The energy supplied to the transducer is modulated proportional to the velocity of the table. In this manner the heat is controlled so as to soften and activate the heat sensitive surface in contact with the scribed conductor to receive and bond the conductor to the surface and, at the same time, to avoid overheating and over-softening of the base which could lead to movement or release of the conductor from the base after the scribing head or stylus has passed. In this manner the reliability of the scribed board is increased. In addition, it is no longer necessary to lift the stylus each time the board stops, thereby increasing the speed of the operation.

In earlier wire scribing apparatus, the conductor was pulled from a supply reel by the movement of the board base, thereby stressing the bond between the conductor and the adhesive on the board base. In accordance with the method and apparatus of the present invention, however, the conductor is positively fed to the board surface so as to eliminate the pull on the conductor and substantially reduce the tendency of the conductor to come loose from the base, again increasing the reliability of the scribed board.

The conductor fed to the board is held in contact with the adhesively activatable board surface by a scribing head or stylus while the table and board are moved and the
conductor is scribed. In accordance with the method and apparatus of the present invention the forming head or stylus has a vertical groove or cavity on at least one side which becomes progressively shallower toward the bottom and which has side walls for laterally confining the conductor, thereby reducing tracking errors.

The circuit board blank employed in the method and apparatus of the present invention may be a plain board and through holes might be drilled at the circuit terminals after the conductor circuits have been scribed. Alternatively, the board might be drilled before scribing and, where pre-drilled, through hole connectors might be added before or after scribing. Where the circuit board blank is pre-drilled and through hole connectors, such as by pins, eyelets or through hole plating, are provided before wire writing or scribing, the conductor ends might be connected to the through hole connectors as such wire is written or scribed.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The invention will be more fully understood from the following description of a preferred embodiment, with the appended drawings in which:

Figure 1 is a diagrammatic top plan view showing an arrangement of multiple units of the invention for simultaneously producing multiple scribed circuit boards;

Figure 2A is an enlarged side view, in section, of the upper portion of one of the units of Figure 1;

Figure 2B is an enlarged side view, in section, of the lower portion of the unit of Figure 2A;

Figure 3 is a sectional view taken at 3-3 in Figure 2A;
Figure 4 is a front view, facing toward the feed, of the wire strand feed apparatus of the unit of Figure 2B; Figure 5 is a view of one side of the feed apparatus of Figure 4 with a part of the apparatus open; Figure 6 is a rear view of the feed apparatus of Figure 4; Figure 7 is a view similar to Figure 5 but of the opposite side of the feed apparatus of Figure 4; Figure 8 is a partial sectional view taken at 8-8, Figure 5; Figure 9 is a partial sectional view taken at 9-9, Figure 4; Figure 9A is a sectional view at the end of the apparatus of Figure 9, showing such apparatus in another stage of operation; Figure 10 is a partial sectional view taken at 10-10, Figure 4; Figure 11 is an enlarged partial view of the lower end of the apparatus of Figure 2B showing such end in enlarged detail; Figure 12 is an enlarged view of a portion of the apparatus of Figure 11 showing the stylus and wire strand in enlarged detail; Figure 13 is an enlarged partial sectional view taken at 13-13, Figure 12; Figure 14 is an enlarged view taken at 14-14, Figure 11; Figure 15 is a schematic diagram of a circuit for modulating the energization of the ultrasonic transducer; Figure 16 is a graph of table velocity versus time;
Figure 17 is a pictorial illustration of the modulation of the energization of the ultrasonic transducer; and

Figure 18 is a schematic diagram of a comparator circuit for comparing conductor feed and table movement.

DETAILED DESCRIPTION

Referring to Figure 1, support 2 is mounted in a fixed position, at 4 and 6, above table 8. Table 8 is mounted for movement in the directions of arrows 10 and 12, by reversible electric motors 14, 16, connected, respectively, by worm screws 18 and 20 and nuts 22 and 24 to table 8. In the embodiment illustrated in Figure 1, four identical circuit board blanks 26, 28, 30, and 32 are affixed to the surface of table 8, such as by clamps, not shown, at the edges of the blanks.

Mount 34 is fixed to support 2. In the embodiment illustrated, four identical units, generally designated 36, 38, 40, 42, are mounted one at each of the corners of mount 34. For purposes more fully described hereinafter, the four units are interconnected for simultaneous rotation about their respective vertical axis on mount 34 by chain 44 driven by sprocket 46 and electric motor 48. Idler sprockets 50 and 52 engage chain 44 and maintain the chain in driving engagement with sprocket 46 and units 36, 38, 40, and 42.

Because of the identity, only unit 36 will be described, it being understood that, except for location on fixed mount 34, units 38, 40, and 42 are identical to described unit 36.

Referring to Figures 2A and 2B, the unit of the instant invention includes a hollow tube 51 mounted for
rotation on fixed mount 34 by brackets 52 and 54 and bearings 56 and 58. Collars 60 and 62, Figure 2B, are fixed to tube 51 and, through thrust bearings 64 and 66, support tube 51 for rotation about its axis when chain 44, in meshing engagement with sprocket 68, keyed to tube 51, is driven by motor 48 in the manner to be described.

An electrical slip ring assembly, generally designated 72, is fixed to the upper end of tube 51 by through bolts, one being shown at 74, Figure 2A. In the embodiment illustrated, slip ring assembly 72 includes a plurality of circular electrically conductive rings or discs 76, 78, 80, 82, 84 and 86 insulated, at the bottom, by disc 88 of non-conductive material and, from each other, by non-conductive discs 90, 92, 94, 96 and 98. Through bolts such as 74 engage non-conductive disc 100 to hold the slip rings assembled. At their outer peripheral edges, conductive discs 76, 78, 80, 82, 84 and 86 engage brushes 102, 104, 106, 108, 110 and 112 in brush holders 114, 116, 118, 120, 122 and 124 mounted in fixed position on fixed mount 34.

Electrical insulation liner 130, of non-conductive material, extends axially along the inner wall of tube 51 from the upper tube end, Figure 2A, to just above the lower tube end, Figure 2B. Ultra-sonic energizing coil 132, in liner 130, is connected at one of its ends 134 to conductive ring 80 and at the other of its ends 136 to conductive ring 82. As will be explained in greater detail later herein, coil 132 is energized through ends 134 and 136, conductive rings 80 and 82 and brushes 106 and 108. An ultra-sonic transducer, generally designated 140, has an upper portion 142 of laminated metal extending downwardly through coil 132 in liner
130 of hollow tube 51. A horn section tapers inwardly at 144 into a cylindrical section 146 and terminates in stylus 148.

Wire guide 150, having a base 152 for receiving scribing wire 154 and a cap 156 through which scribing wire 154 passes, is mounted in the end of slip ring assembly 72 forming a closure over the end of tube 51 therewith. For purposes more clearly described later herein, scribing wire 154 passes downwardly through the center of slip ring assembly 72 and into and through bore 158 in tube 51.

Collar 160, Figure 2A, is mounted in fixed position on tube 51 and with "O" rings 162, 164, 166, 168, 170, 172 and 174 forms air tight manifolds at 176, 178 and 180 around tube 51. For reasons more apparent later herein, air manifold 176 connects to bore 182 in tube 51 and is connected by fitting 184 to a source of air pressure, not shown. Manifold 180 connects to bore 190 and is connected by fitting 192 to a source of air pressure, not shown.

Referring again to Figure 2B, support 200 is fixed to tube 51. Stylus and soldering control assemblies, generally designated 202, are mounted to one end of support 200 at one side of stylus 148 and scribing wire feed assembly, generally designated 204, is mounted to the other end of support 200 at the opposite side of stylus 148.

Cylindrical housing 206 encases cylindrical section 146 at the upper end of stylus 148 and is insulated therefrom, for purposes more apparent later herein, by "O" rings 208 and 210 and sleeve 214.

The stylus control assembly includes upper leaf spring 220, connected at one of its ends to housing 206 and at its other end to mount 222 fixed to support 200, and lower
leaf spring 224 connected at one of its ends to housing 206 and, at its other end, to control housing 226 fixed to mount 222. Intermediate its ends leaf spring 224 is connected by piston rod 227 to bellows piston 228 of bellows 230 in air cylinder 232. Coil spring 234 is connected, at one of its ends, to leaf spring 224 and, at its other end, to control housing 226. Coil spring 234, through leaf spring 224 and housing 206, biases stylus 148 out of engagement with the work pieces. By admitting air, under pressure, to cylinder 232, leaf springs 224 and 220, through piston 228 and piston rod 227, are biased downwardly to engage stylus 148 with the work piece. The combined spring actions of leaf springs 220 and 224 and coil spring 234 bias stylus 148 away from the work pieces when air pressure in cylinder 232 is released.

Referring next to Figures 2B, 11, and 12, the soldering assembly, generally designated 240, may be incorporated in and used with the assembly of the invention to solder and join the wire scribed with the apparatus to terminal points on the wire scribed board or the soldering assembly might be omitted and the wires might be joined in a separate operation.

Soldering assembly 240, when incorporated in its preferred embodiment in the apparatus of the invention, includes "L" shaped arm 242 pivoted at 244 to control housing 226 with one of its legs 246 extending upwardly therein, in recess 248. Adjacent its upper end, leg 246 is engaged at one of its sides by compression spring 250 and, at its other side, by piston rod 252 of piston 254 connected to diaphragm 256 in air chamber 258. Air chamber 258 is connected by conduit 260 to air bore 182. Leg 262 of arm 242 is connected by pin 264
to one end of soldering head carrier 266. For reasons more apparent hereinafter, head carrier 266 is spring biased on pin 264 so that, when head carrier 266 is rotated clockwise towards the workpiece and soldering head 268 on carrier 266 engages the workpiece, the spring, not shown, will be tensioned and head carrier 266 will rotate, slightly, on pin 264. Soldering pressure can thus be applied to the joint to be soldered without damage to the workpiece or soldering head.

Referring, now, to Figures 2B, 4, 5, 6, 7, 9, 9A and 10, frame member 300 of wire feed assembly 204 is mounted on support 200. Spaced wire guides 302 and 304 are mounted on frame member 300. Scribing wire 154 passes through guides 302 and 304. A pneumatic wire clamp, generally designated 306, is pivotally mounted at 308 to frame 300 and includes a housing 310, having an outwardly extending cylindrical bayonet 312 mounted thereon and connected thereto by mounting screws 314, Figures 6 and 9, and airtight diaphragm 316, having piston 318 mounted thereon. Piston rod 320 of piston 318 extends axially into bayonet 312. Compression spring 322 is mounted around the piston end of piston rod 320 and is compressed between piston 318 and shoulder 324 on bayonet housing 312. Stop 326 is fixed, by pin 328, to the end of bayonet housing 312, forming a stop-closure at the end thereof. When air, under pressure, is admitted to chamber 330 in housing 310 through inlet 332, diaphragm 316, piston 318 and piston rod 320 are moved inwardly, the end of piston rod 320 engages and clamps scribing wire 154 against stop 326 and spring 322 is compressed. For reasons described in more detail later herein, when diaphragm 316, piston 318 and piston rod 320 are actuated to clamp scribing wire 154 against stop
326, wire 154 is being fed through guides 302 and 304 and pivots wire clamp 306 counter-clockwise around pivot 308. Compression spring 334, mounted in recess 336 in frame member 300, is compressed by the counter-clockwise movement of wire clamp 306 and, when air pressure is released from chamber 330, returns wire clamp 306 clockwise, bringing bayonet housing 312 back into contact with stop 340. For reasons more apparent later herein, stop 340 is threaded into housing and is adjustable therein by knurled handwheel 342 held adjustment by detents 344 and 346, Figure 9.

As best shown in Figures 2B, 4 and 6, electric motor 350, having a motor shaft 352, is mounted on frame member 300. Gear 354 and optical disc 356, of opaque material having equally spaced transparent slots 358, Figure 7, are keyed on motor shaft 352 and are rotated by motor 350, for purposes more apparent later herein. Idler shaft 360, having gears 362 and 364, Figures 4 and 6, keyed thereto is mounted for rotation on frame member 300 parallel to motor shaft 352. Idler gear 362 is in meshing engagement with gear 354 on motor shaft 352 and is driven thereby. Shaft 366, Figures 2B, 5 and 6, is mounted for rotation on frame member 300 parallel to motor shaft 352 and idler shaft 360. Scribing wire drive wheel 368 and gear 370 are keyed to shaft 366 and are driven thereby. As best shown in Figures 2B, 5 and 8, wire drive wheel 368 is grooved around its periphery, at 372, for wedgingly receiving scribing wire 154.

Endless belt 380, Figures 2B, 5 and 8, of flexible material, such as fabric, reinforced rubber or plastic, is mounted on pulleys 382, 384 and 386 mounted, respectively, on shafts 388, 390 and 392, in turn mounted for rotation on belt
frame 394 pivoted, at 396, to wire feed assembly frame member 300. As shown in phantom in Figures 5 and 7, belt 380 is swung out of contact with the surface of wheel 368 and scribing wire 154 by pivoting belt frame 394 about pivot 396. With belt 380 out of engagement, scribing wire 154 can conveniently be threaded into groove 372. With belt 380 locked into engagement with wire drive wheel 368 and scribing wire 154 in groove 372 of wheel 368, gear 398, Figure 2B, keyed to shaft 392, is in driving engagement with gear 370. Thus, scribing wire 154 is wedged into groove 372 by belt 380 and is driven thereby.

For purposes more apparent later herein, the periphery of opaque disc 356, with its equally spaced slots 358, rotates past photocell unit 400, mounted in arm 402 on frame 300, Figures 4, 6.

Referring now particularly to Figures 4, 5, 10 and 11, wire guide head 410, having a wire guide passage 412 for scribing wire 154, is clamped to the end of shaft 414 by clamping screw 416. Shaft 414 is mounted for rotation in frame 300. An "L" shaped actuating arm 418, Figure 10, is clamped to the upper end of shaft 414 by clamping screw 420. Compressed air chamber 422 is connected at 424 to compressed air line 186, Figures 2B and 10. Piston 426, having a piston rod 428 in engagement with one leg of actuating arm 418, is mounted on diaphragm 430 clamped between cover 432 and frame 300. For purposes more fully apparent later herein, compression spring 434, mounted around piston rod 428 and compressed between cover 432 and piston 426 returns piston 426 and diaphragm 430 to retracted position when air pressure in chamber 422 is released. Compression spring 436 mounted
between frame 300 and the other leg of actuating arm 418 biases arm 418, shaft 414 and guide lead 410 to the forward scribing wire feeding position shown in full line in Figure 10. Knife blade 440, Figure 10, is mounted by screws 442 in fixed position adjacent to the wire exit end of guide head 410 and, with guide head 410, when the guide head is rotated to the phantom line position of Figure 10, cuts and severs the scribing wire as scribing of each circuit is completed.

The cut or severed end of the scribed wire is pressed into and affixed to the heat sensitive surface of the base.

As best shown in Figures 12, 13, the side of forming stylus 148 facing guide head 410 has, extending angularly and downwardly toward the bottom end of the stylus, a groove 149 having parallel side walls 149a, 149b. Side walls 149a, 149b, channel and guide the wire, as it is fed into groove 149 at the side of stylus 148 to the tip of stylus 148 where groove 149 is relatively shallow with respect to the wire thickness and the wall of groove 149 is arcuate.

As has been noted, the apparatus of the instant invention might include a soldering assembly such as assembly 240, for soldering and joining the scribed wire to terminal points or the soldering assembly might be omitted and the wire might be soldered and joined in a separate operation after all wire scribing has been completed. Where a soldering assembly and soldering or joining of the wire scribed ends to the terminals as the board is being scribed are employed, it has been found to be of particular advantage to provide a gas blast at the soldered terminals during the soldering. To accomplish this, as best shown in Figure 14, wire guide head 410 is provided, along its opposite sides, with gas passages 444,
446, interconnected to a gas supply at 450. Gas passages 444 and 446 discharge, angularly, toward scribing wire 154 discharged from guide passage 412. Inert gas might be introduced at 450 and discharged through passages 444, 446 to drive off any gases generated when heated soldering head 268 is brought into contact with the scribed wire.

In the operation of the apparatus of the invention, a circuit board blank to be wire scribed is centered on table 8 relative to each of the wire scribing units 36, 38, 40 and 42. All four of the units 36, 38, 40 and 42 may be actuated, each to wire scribe a circuit board blank concurrently with the other units or some of the units may remain inactive while the other of the units are wire scribing boards. In any event, the circuit board blanks to be wire scribed are centered on and fixed to table 8 relative to their respective wire scribing units and all boards are simultaneously moved along "x" and "y" axes relative to their respective scribing units by motors 14 and 16, and worm screws 18 and 20. At the same time, the wire scribing units 36, 38, 40 and 42 are simultaneously rotated relative to board 26, 28, 30 and 32, depending upon the direction of table movement and circuit board wiring. It is obvious, of course, that the scribing units, rather than the base and boards, might be moved and that such movement might be accomplished by the combined movements of the base and units. For example, the base and boards might be moved along one axis, such as the "x" axis, and the units might be moved along the other axis, such as the "y" axis.

Each of the scribing units has its own wire supply such as a wire spool, not shown, and each unit has its own
wire fed, cut-off, scriber, etc. All units that are wire scribings are actuated simultaneously in a manner described later, herein. For purposes of illustration, the operation of one unit is described.

As best shown in Figures 2A, 2B, scribings wire 154 is threaded from the supply, not shown, through guide 150 into and through bore 158 in tube 51 and out of bore 158 into and through guides 302 and 304. Scribings wire 154 is then threaded around wire drive wheel 368, in groove 372, between the walls of the groove and endless belt 380. From grooved drive wheel 368 wire 154 passes through guide 412, into groove 419 in stylus 148, Figure 12, and under the stylus. For reasons more apparent later herein, groove 149 is just a little larger than wire 154, allowing the wire to pass freely therethrough while, at the same time, controlling the positioning and placing of the wire.

At the end of each scribed circuit, the wire scribed onto the circuit board during the preceding scribings is severed from the end of wire 154 in the scribings unit by knife 440, and in a manner later described, a predetermined wire length is fed out of the end of guide passage 412 in guide head 410. Thus, the leading end of scribings wire 154 is under stylus 148 when the scribings unit is at rest.

With the unit at rest and the leading end of scribings wire 154 under stylus 148 the scribings unit is energized. In energizing the unit, table drive motors 14 and 16 are activated, moving table 8 and the circuit board blank thereon in a direction in accordance with a pre-programmed sequence, as will be later described. At the same time that motors 14 and 16 are activated, motor 48, Figure 1, is also...
activated, turning the scribing units, with the stylus 148 thereon, in a direction aligned with the table and circuit board blank movement.

Simultaneously with the activation of motors 14, 16 and 48, air cylinder 232 is energized, advancing piston 228 and piston rod 227 downwardly and, through leaf spring 224, bringing the end of stylus 148 into engagement with the heat sensitive surface of the circuit board blank thereunder. Concurrently, ultra-sonic coil 132 is energized. Scribing wire drive motor 350 is also energized. Thus, wire 154 is fed by wire drive wheel 368 and endless belt 380 through guide head 410, scribing or writing the wire onto the heat sensitive surface of the circuit board blank. High frequency electrical energy is applied through coil 132 to transducer 140 which converts the electrical energy into high frequency vibrations to stylus 148 and wire 154. As wire 154 vibrating at high frequency is brought into contact with the heat sensitive surface of the circuit board blank, wire 154 and stylus 148 activate and soften the board surface, attaching and affixing the scribed wire to the surface of the board. Thus, energy is applied at the interface between the wire or conductor and the board surface to activate the surface, avoiding over and under heating of the surface and adverse effects on the surface and bonding caused thereby.

Once started, the wire writing or scribing continues to the end of the pre-programmed circuit. At the end of the programmed circuit, compressed air is fed to chamber 330, advancing piston 318 and piston rod 320 in bayonet 312 and gripping scribing wire 154 between the end of the piston rod 320 and stop 326. Simultaneously, air under
pressure is fed to chamber 422, advancing piston 426 and piston rod 428 against activating arm 418 to pivot wire guide head 410 clockwise and causing scribing wire 154, being fed through head 410, to be severed by knife 440. While scribing wire 154 is being severed by knife 440, the wire is gripped between the end of piston rod 320 and stop 326. Wire feed motor 350 is stopped but air pressure is momentarily maintained in air cylinder 232, holding stylus 148 in engagement with scribing wire 154 and the heat sensitive surface of the board blank continues to move thereunder on table 8 until the cut, trailing end of the wire scribed in the circuit is heat fixed to the board. Air pressure in cylinder 232 is then released, stylus 148 is raised by leaf springs 220, 224, and ultrasonic coil 132 is de-energized.

After the preceding circuit has been scribed and housing 206 and stylus 148 have been raised the pre-recorded program advances table 8 and the board blank affixed thereto through to the next point where a scribed circuit is to commence. With stylus 148 over the point where the next scribed circuit is to commence, wire drive motor 350 is energized. With the projecting end of scribing wire 154 under stylus 148, air pressure is again fed into air cylinder 232. Piston 228, piston rod 227 and leaf spring 224 move housing 206 and stylus 148 downwardly, bringing the stylus into engagement with the projecting end of scribing wire 154 and the wire into contact with the heat sensitive surface of the circuit board blank affixed to table 8. Table 8 is then moving relative to the stylus and stylus 148 commences scribing the next circuit per the prerecorded program. Air pressure is released from chamber 330 of wire clamp 306,
releasing wire 154. Spring 322 returns piston 318 and piston rod 320 and compression spring 334 returns wire clamp 306 clockwise to its inactive position.

The scribing sequence is repeated for each circuit until all of the circuits in the pre-recorded program have been scribed onto the boards. The completed wire scribed boards are then removed from table 8 and replaced with fresh circuit board blanks. The same pre-recorded program might then be repeated with the fresh board blanks or another pre-recorded program might be employed.

In the apparatus of the present invention, the wire being scribed or written onto the heat sensitive board surface is positioned and fixed to the board by the ultrasonically activated stylus 148. Because of the heat sensitivity of the adhesive layer on the surface of the board blank, the energy imparted to the adhesive layer as the wire is scribed onto the surface must be carefully controlled. In particular, variations in board speed relative to the affixing stylus, as motors 14 and 16 are energized to start, stop and change direction of the table, must be compensated by changes in the ultrasonic energy applied to the stylus.

It has been discovered that the most satisfactory operation is obtained, in the instant invention, when the ultrasonic energy delivered to the stylus is modulated in proportion to the table velocity. Under these conditions, the energy per mil of wire fed and fixed to the board by the ultrasonically activated stylus 148 is approximately constant for all table velocities. Failure to so modulate the ultrasonic power proportional to table velocity can result in severe damage to the adhesive layer and also to the wire.
insulation, in extreme cases. In previous practice of wire scribing techniques, where power modulation was not employed, it was necessary to raise the stylus from contact with the wire while the table and board were as in a stationary state such as during change in wire scribing or writing direction. This raising and lowering of the stylus resulted in uneven and erratic bonding between the wire and adhesive substrate at the start of scribing or writing, at the end thereof and at inflection points in the wire pattern. Moreover, at the inflection points precise location and attachment of the wire to the board was often difficult to obtain. The improvement in uniformity of bonding of the wire to the adhesive layer brought about by practice of the power modulation technique herein described has a further consequence of improving the positioning accuracy of the adhesively bonded wire relative to the board surface at the wire ends and inflection points.

One effective modulation scheme for controlling the ultrasonic power has been implemented in the instant invention by a method of pulse width modulation of the ultrasonic generator output. The ultrasonic generator power supply has a control terminal wherein application of a logic level signal may be applied to enable and disable the generator output.

Referring to Fig. 15, table velocity analog signals are fed from the control circuitry associated with table drive motors 14 and 16, through linear inverters 550 and 552 and resistors 554 and 556 to summing junction 558. This voltage is fed to the base of transistor 592 through an adjustable resistive divider network comprised of resistors 560, 562 and 564.
Unijunction transistor 578, together with variable resistor 586, resistors 582 and 584 and capacitor 576, make up a saw-tooth oscillator in the manner now described. With low voltage on the emitter terminal of unijunction transistor 578, the resistance between base 1 and base 2 of transistor 578 is very high. The voltage across capacitor 576 rises exponentially because of charging current flowing through resistors 586 and 584. When the voltage across capacitor 576 reaches a fixed percentage of the supply voltage, i.e., the intrinsic standoff ratio of the device and usually a voltage in the vicinity of 45 to 50% of the supply voltage, the resistance between base 1 and base 2 and the emitter of transistor 578 suddenly falls to a very low value, quickly discharging the capacitor through the emitter-base circuit. When the capacitor voltage falls nearly to zero, the emitter-base junction resistance again rises to a very high value and capacitor 576 again begins to charge toward the supply voltage. The result is that a saw-tooth voltage develops across capacitor 576 with a repetition rate determined by the time constant of the resistance capacitance network of components 586, 584 and 576. The saw-tooth voltage is applied to the base of the emitter follower circuit comprised of transistor 572 and resistor 579. The voltage developed at the junction of resistors 579 and 570 is a faithful reproduction of the saw-tooth waveform across capacitor 576 but with a much lower source impedance. The frequency of the saw-tooth is typically 200 to 400 Hertz.

The saw-tooth voltage described above is summed with a fraction of the velocity analog signal present in the arm of potentiometer 562. This combined voltage waveform is
applied to the base of transistor 592. Transistor 592, in association with the transistor 602 and resistors 600 and 604 and feedback resistor 590, forms a regenerative amplifier offset from signal common by the voltage across Zener diode 594. If the voltage on the base of transistor 592 is less than about 0.6 volts higher than the Zener diode voltage, transistor 592 will be non-conductive, as will be transistor 602. The collector of transistor 602 will therefore be at ground potential. As soon as the voltage on the arm of potentiometer 562 exceeds a potential greater than the afore-mentioned 0.6 volts above the Zener voltage, transistor 592 begins to conduct. The base of transistor 602 is thereby connected to the Zener voltage which voltage, being at a considerably less positive voltage than the voltage of the emitter, causes transistor 602 to begin to conduct and, hence, its collector voltage rises toward the emitter voltage. The feedback resistor 590, connected between the collector of transistor 602 and the base of transistor 592 feeds back the rising potential which appears on the collector, thereby accelerating saturation of the collector-emitter junction.

Potentiometer 562 is adjusted so that, in the absence of the velocity analog signal, the "on" time of the output during each saw-tooth cycle is zero or close to zero. As the analog velocity signal rises, the regenerative output stage is caused to stay on for increasingly longer fractions of each cycle so that, at full table speed, the "on" portion of the duty cycle approaches 100%, thereby delivering full power to the ultrasonic transducer and stylus through the ultrasonic generator 460.

The modulation of the ultrasonic energy delivered
to the stylus in proportion to table velocity is graphically illustrated in Figures 16 and 17. In Figure 16 table velocity versus time is illustrated. Figure 17 illustrates the modulation of the ultrasonic energy delivered to the stylus through generator 460 at table speeds A, B, C, D, and E of Figure 16. As shown in Figure 17, the duty cycle increases with increasing table velocity.

In the apparatus of the instant invention it has been discovered to be useful to utilize stepping motors as the reversible motors 14 and 16 used to drive table 8 and to connect the motor to table 8 with a worm screw. Thus, each pulse to the motor will move table 8 along the "x" or the "y" axis by, for example, 1 mil or a multiple thereof. Likewise, slots 358 on optical disc 356 are spaced so that each slot corresponds to a unit feed of conductor by electric motor 350 and drive wheel 368, for example, 1 mil or a multiple thereof. Thus, photocell 400 produces a pulse for each unit of wire feed. For purposes of the description which follows, the length of table movement for each motor pulse and the length of conductor unit feed for each optical disc impulse is taken to be 1 mil. In both instances, however, the units may be set for other lengths with equal utility, provided appropriate changes in scaling are made. Likewise, an encoder, such as an optical disc and slots, might be employed with the drive table motors in lieu of the stepping motors and motor drive pulses.

Referring now to Figure 18, with motor 14 or motor 16 energized to move table 8 the motor drive pulses to motors 14 and 16, each indicating 1 mil of movement, are supplied to the input of integrator 640. Pulses from photocell 400, each
indicating 1 mil of conductor feed, are supplied to the input of linear amplifier 620. The output of amplifier 620 is fed to Schmitt trigger 622, the output of which is fed to the input of decade counter 624. Counter 624 is connected in series with decade counter 626. Thus, counter 624 is the "units" counter while counter 626 is the "tens" counter.

The output of units counter 624 corresponding to the fifth pulse received is connected to AND gate 628 while the output corresponding to the ninth pulse is connected to AND gate 630. The output of tens counter 626 corresponding to the tenth conductor feed pulse is connected to AND gate 628 while the output corresponding to the twentieth conductor feed pulse is connected to AND gate 630. AND gate 628 is connected to the set input of flip-flop 632. The reset input of flip-flop 632 is connected to the output of AND gate 646. The output of flip-flop 632 is connected to one input of AND gate 634. The output of AND gate 634 is connected to one input of OR gate 636. The other input of OR gate 636 is connected to the output of AND gate 630. The output of OR gate 636 is connected to control and alarm flip-flop 638.

Still referring to Figure 18, the table drive pulses to motors 14 and 16 are integrated by integrator 640, the output of which is fed to decade counter 642. Counter 642 is connected in series with decade counter 644. Thus, counter 642 is the "units" counter while counter 644 is the "tens" counter. The zero output of counter 642 and the output of counter 644 corresponding to the twentieth drive pulse are connected to AND gate 646. The output of AND gate 646 is connected to the input of delay circuit 648 and to AND gate 634. The output of delay circuit 648 is connected to the
reset terminals of counters 624, 626, 642, 644 and to AND gate 634.

As already noted, in the illustrative embodiment of the invention the apparatus is arranged so that each table drive pulse and each conductor feed pulse is indicative of 1 mil of movement and feed, respectively. For purposes of illustrating the operation of the monitoring system, limits will be set at fifteen and twenty-nine conductor feed pulses or mils of conductor feed for each twenty table movement pulses or mils of table travel. As will be obvious to those skilled in the art, other limits may be employed.

The monitoring system operates as follows. Each fifth conductor feed pulse from units counter 624 and each tenth pulse from tens counter 626, are fed to AND gate 628 which produces an output corresponding to the count "15". Each ninth conductor feed pulse from counter 624 and each twentieth conductor feed pulse from counter 626 are fed to AND gate 630 which produces an output corresponding to the count "29". Similarly, AND gate 646 produces an output corresponding to the twentieth table drive pulse.

Flip-flop 632 is set by the fifteenth conductor feed pulse and reset by the twentieth table drive pulse which, after a suitable delay, also resets all of the counters. Because flip-flop 632 has been reset by the twentieth table drive pulse, flip-flop 632 produces no signal at the input of AND gate 634. Thus, when the delayed twentieth table drive pulse arrives at AND gate 634, no output is produced and alarm flip-flop 638 is not triggered. If, on the other hand, the twentieth table drive pulse reaches flip-flop 632 before the fifteenth conductor feed pulse then flip-flop 632
produces a signal at the input of AND gate 634 which combines with the delayed twentieth table drive pulse from delay relay 648 and, through OR gate 636, triggers control and alarm flip-flop 638. The triggering of flip-flop 638 cuts off the power to table drive motors 14 and 16 and conductor feed motor 350, stopping the apparatus. At the same time, an alarm signal is actuated by flip-flop 638. There is one such monitoring system for each of the scribing units 36, 38, 40 and 42.

As has already been noted, the ninth and twentieth conductor feed pulses are fed to AND gate 630 which, in turn, is connected to OR gate 636 and to control and alarm flip-flop 638. If counters 624 and 626 are not reset by the twentieth table drive pulse, then the twenty-ninth conductor feed pulse will trigger control and alarm flip-flop 638. Normally, however, counters 624 and 626 are reset by the twentieth table drive pulse and AND gate 630 never produces an output at the twenty-ninth counter feed pulse. Thus, if a twenty-ninth conductor pulse occurs before a twentieth table pulse, then the alarm is triggered and the wiring operation is stopped.

Finally, it should be noted that counters 624, 626, 642 and 644 are reset each time the wire feed and table drive are stopped.

The apparatus and processes of the instant invention, while described in connection with a circuit board for interconnecting electrical and electronic components, may also be utilized in scribing boards for interconnecting other types of components, such as optical, pneumatic, hydraulic and similar components. In interconnecting such optical,
pneumatic or hydraulic components conductors other than wires would be employed. For example, with optical components, an optical conductor, such as a coated optical fiber, would be utilized. In the instance of pneumatic and hydraulic components, small diameter conduits would be employed as conductors. As used in the description and in the appended claims it is to be understood that "conductor" is intended to include other conductor means as well as wires.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the inventions claimed.
The claims defining the invention are as follows:

1. A process for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base, the steps comprising:
   (a) feeding a conductor to said base;
   (b) engaging the end of said fed conductor between an energizeable stylus and the adhesively activatable surface of the board base at the first of a pair of contact points;
   (c) with said end so engaged, energizing said stylus and moving said base and said stylus relative to each other in a predetermined direction;
   (d) modulating the energy applied to said stylus proportional to the velocity of said movement to activate said adhesive and adhesively affix said conductor to said base;
   (e) monitoring and comparing said feed of said conductor and said movement of said base and
   (f) generating a control signal when said feed of said conductor and said movement are not in substantial agreement.

2. The process of claim 1 wherein said adhesive is heat activatable and said stylus is ultrasonically energized.

3. The process of claim 1 further including the steps of:
   (a) feeding said conductor to said base;
   (b) monitoring and comparing said feed of said conductor and said movement; and
   (c) generating a control signal when said feed of said conductor and said movement are not in substantial agreement.
The process of claim 1 including the step of fixing said conductor to the second of said pair of contact points.

The process of claim 2 wherein said conductor is severed before being fixed to said second of said pair of contact points.

The process of claim 2 wherein said conductor is fixed to said first and second contact points by means of soldering.

A process for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on a heat activatable adhesive surface of a board base, the steps comprising:

(a) engaging the end of the conductor to be applied between an ultrasonically energizeable stylus and the heat activatable adhesive surface of a board base at the first of a pair of contact points;

(b) with said end so engaged, feeding said conductor to said base while, at the same time, energizing said stylus and moving said base in a predetermined direction;

(c) modulating the ultrasonic energy applied to said stylus proportional to the velocity of said base to activate said adhesive and adhesively affix said conductor to said base;

(d) monitoring and comparing said feed of said conductor to said base and said movement of said base;

(e) generating a control signal when said feed of said conductor and said movement of said base are not in substantial agreement;

(f) fixing said conductor to the second of
said pair of contact points; and

(g) repeating steps (a) through (f) until conductors have been applied between the pre-established contact points in the predetermined patterns.

7. A process for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base, the steps comprising:

(a) engaging the end of the conductor to be applied between an energizeable stylus and the adhesively activatable surface of the board base at the first of a pair of contact points;

(b) with said end so engaged, feeding said conductor to said base while, at the same time, moving said base in a predetermined direction;

(c) energizing said stylus to activate said adhesive and adhesively fix said conductor to said base;

(d) monitoring and comparing said feed of said conductor and said movement of said base; and

(e) generating a control signal when said feed of said conductor and said movement of said base are not in substantial agreement.

8. The process of claim 7 wherein said adhesive is heat activatable and said stylus is ultrasonically energized.

9. The process of claim 8 including the step of fixing said conductor to the second of said pair of contact points.

10. The process of claim 9 wherein said feed of said conductor is deflected and said conductor severed before being fixed to said second of said pair of contact points.

- 32 -
§ 13. A process for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base, the steps comprising:

(a) engaging the end of the conductor to be applied between an energizable stylus and the adhesively activatable surface of the board base at the first of a pair of contact points;

(b) with said end so engaged, energizing said stylus to activate said adhesively activatable surface and adhesively affix said conductor to said base; and

(c) with said end so affixed and with said stylus so energized and in engagement with said conductor, moving said base in a predetermined direction and positively feeding said conductor to said moving base so as to eliminate the pull on said conductor by said moving base and to substantially reduce the tendency of said conductor to come loose from said base.

§ 14. The process of claim § 13 wherein said adhesive is heat activatable and said stylus is ultrasonically energized.

§ 15. The process of claim § 13 including the steps of:

(a) monitoring and comparing said feed of said conductor and said movement of said base; and

(b) generating a control signal when said feed of said conductor and said movement of said base are not in substantial agreement.

§ 16. The process of claim § 13 including the step of modulating the energy applied to said stylus proportional to the velocity of said base.

- 33 -
15. Apparatus for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base comprising:

(a) a table;
(b) means for attaching a board base to said table;
(c) means for feeding a conductor to said base;
(d) an energizeable stylus for engaging the conductor with the adhesively activatable surface of the board base at the first of a pair of contact points;
(e) means for moving said table and said stylus relative to each other in a predetermined direction;
(f) means for modulating and applying energy to said stylus proportional to the velocity of said movement to activate said adhesive and adhesively affix said conductor to said base;
(g) means for monitoring and comparing said feed of said conductor and said movement of said table; and
(h) means for generating a control signal when said feed of said conductor and said movement of said table are substantially different.

16. The apparatus of claim 15 wherein said adhesive is heat activatable and said stylus is ultrasonically energizeable.

17. The apparatus of claim 16 wherein said means for modulating the ultrasonic energy applied to said stylus comprises a variable frequency oscillator.

20. The apparatus of claim 17 further comprising:
(a) means for monitoring and comparing said feed of said conductor and said movement; and
(b) means for generating a control signal when said feed of said conductor and said movement are substantially different.

The apparatus of claim 15 on which said
moving means includes stepping motor means responsive to motor drive pulses and means for generating pulses at a rate proportional to the feed of the conductor.

The apparatus of claim 18 wherein said means for monitoring and comparing said feed of said conductor and said movement comprises counter means for comparing said motor drive pulses and said conductor feed pulses.

The apparatus of claim 15 including means for fixing said conductor to the second of said contact points.

The apparatus of claim 21 including means for severing said conductor before it is affixed to the second of said contact points.

Apparatus for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on a heat activatable adhesive surface of a board base comprising:

(a) a movable table
(b) means for attaching a board base to said table;
(c) means for feeding said conductor to said base;
(d) an ultrasonically energizeable stylus for engaging said conductor with the heat activatable adhesive surface of the board base at the first of a pair of contact points;
(e) means for moving said table in a predetermined direction;
(f) means for modulating and applying ultrasonic energy to said stylus proportional to the velocity of
said table to activate said adhesive and adhesively affix
said conductor to said base;

(g) means for monitoring and comparing said
feed of said conductor and said movement of said table; and

(h) means for generating a control signal
when said feed of said conductor and said movement of said
table are substantially different.

26. Apparatus for applying and fixing continuous
conductors between pairs of pre-established contact points in
predetermined patterns on an adhesively activatable surface
of a board base comprising:

(a) a movable table;

(b) means for attaching a board base to said
table;

(c) means for feeding a conductor to said
board base;

(d) an energizeable stylus for engaging the
conductor with the adhesively activatable surface of the board
base at the first of a pair of contact points;

(e) means for moving said table in a pre-
determined direction;

(f) means for monitoring and comparing said
feed of said conductor and said movement of said table; and

(g) means for generating a control signal
when said feed of said conductor and the movement of said
table are not in substantial agreement.

27. The apparatus of claim 26 wherein said
adhesive is heat activatable and said stylus is ultrasonically
energizeable.

28. The apparatus of claim 27 including:
(a) stepping motor means responsive to motor drive pulses for moving said table; and
(b) means for generating pulses at a rate proportional to the feed of said conductor.

29. The apparatus of claim 28 wherein said means for monitoring and comparing said feed of said conductor and said movement of said table comprises counter means for comparing said motor drive pulses and said conductor feed pulses.

27. Apparatus for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base comprising:

(a) a movable table
(b) means for attaching a board base to said table;
(c) means for moving said table;
(d) an energizeable stylus for engaging the conductor with the adhesively activatable surface of the board base at the first of a pair of contact points;
(e) means for positively feeding said conductor to said base so as to eliminate pull on said conductor by said table and to substantially reduce the tendency of said conductor to come loose from said base while said table is moved in a predetermined direction; and
(f) means for energizing said stylus to activate said adhesive and adhesively affix said conductor to said base.

29. The apparatus of claim 27 wherein said adhesive is heat activatable and said stylus is ultrasonically
energized,

22. The apparatus of claim 20 including means for modulating the energy applied to said stylus proportional to the velocity of said table.

23. The apparatus of claim 27 including:

(a) means for monitoring and comparing said feed of said conductor and said movement of said table; and

(b) means for generating a control signal when said feed of said conductor and said movement of said table are not in substantial agreement.

24. The apparatus of claim 28 including means for fixing said conductor to the second of said contact points.

25. The apparatus of claim 30 including means for severing said conductor before it is fixed to the second of said contact points.

26. Apparatus for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base comprising:

(a) a movable table;

(b) means for attaching a board base to said table;

(c) means for positively feeding said conductor to said base so as to eliminate the pull on said conductor by the movement of said base and to substantially reduce the tendency of said conductor to come loose from said base;

(d) a rotatable head having an energizable forming stylus for aligning and engaging the conductor with the adhesive surface of the board base at the first of a pair of contact points, said stylus having, on at least one side thereof, an inwardly extending cavity which extends in the vertical direction and which becomes progressively shallower.
towards the bottom of said stylus, said cavity having inwardly sloping side walls for laterally confining and guiding said conductor;

(e) means for moving said table in a predetermined direction; and

(f) means for energizing said stylus to adhesively affix said conductor to said base.

24. The apparatus of claim 23 wherein said stylus is positioned at the center of rotation of said head so that said conductor may be scribed around corners as said head is rotated and said table is moved.

25. The apparatus of claim 23 including means for modulating the energy applied to said stylus proportional to the velocity of said table.

26. The apparatus of claim 23 further comprising:

(a) means for monitoring and comparing said feed of said conductor and said movement of said table; and

(b) means for generating a control signal when said feed of said conductor and said movement of said table are substantially different.

27. The apparatus of claim 23 including:

(a) stepping motor means responsive to motor drive pulses for moving said table; and

(b) means for generating pulses at a rate proportional to the feed of the conductor.

28. The apparatus of claim 23 including:

(a) means for modulating the energy applied to said stylus proportional to the velocity of said table;

(b) means for monitoring and comparing said feed of said conductor and said movement of said table; and

29. The apparatus of claim 23 including:

(a) means for monitoring and comparing said feed of said conductor and said movement of said table; and
(c) means for generating a control signal when said feed of said conductor and said movement of said table are substantially different.

43. The apparatus of claim 42 including means for fixing said conductor to the second of said contact points.

44. The apparatus of claim 42 including means for severing said conductor before it is fixed to said second of said contact points.

45. The apparatus of claim 36 including means for positively feeding said conductor to said base so as to eliminate the pull on said conductor by the movement of said base and to substantially reduce the tendency of said conductor to come loose from said base.

46. The apparatus of claim 36 wherein said adhesive is heat activatable and said stylus is ultrasonically energized.

47. A process for applying and fixing continuous conductors between pairs of pre-established contact points in predetermined patterns on an adhesively activatable surface of a board base, the steps comprising:

(a) feeding a conductor to said base;

(b) engaging the end of said fed conductor between an energizeable guide means and the adhesively activatable surface of the board base at the first of a pair of contact points;

(c) with said end so engaged, energizing said guide means and moving said base and said guide means relative to each other in a predetermined direction;

(d) modulating the energy applied to said guide means proportional to the velocity of said movement to activate...
means for monitoring and comparing said feed of said conductor and said movement of said table; and means for generating a control signal when said feed of said conductor and said movement of said table are substantially different.

77. The apparatus of claim 73 including stepping motor means responsive to motor drive pulses for moving said table; and means for generating pulses at a rate proportional to the positive feed of the conductor.

78. The apparatus of claim 73 including means for severing said conductor before it is fixed to said second of said contact points.

DATED this SIXTH day of JUNE, 1979

KOLLMORGEN TECHNOLOGIES CORPORATION

Patent Attorneys for the Applicant
SPRUSON & FERGUSON