United States Patent

Lambert

[15] **3,650,208**

[45] **Mar. 21, 1972**

[54] SCREEN PRINTING MACHINE WITH SINGLE-SIDED RACK-AND-PINION DRIVE

[72] Inventor: **Daryl Gene Lambert,** 1231 West Vista Avenue, Phoenix, Ariz. 85020

[22] Filed: **Nov. 17, 1969**

[21] Appl. No.: **877,322**

[52] **U.S. Cl.** **101/123,** 101/114

[51] **Int. Cl.** **B41f 15/08**

[58] **Field of Search** ..... 317/101 A, 101 B; 200/166; 29/624, 625; 117/212, 38; 101/114, 123, 124

[56] **References Cited**

UNITED STATES PATENTS

3,106,890	10/1963	Schmitt	101/123
2,547,817	4/1951	Frank	101/123
3,477,366	11/1969	Forslund	101/123
2,770,191	11/1956	Holly	101/126
2,704,510	3/1955	Walsh, Jr.	101/123
2,881,700	4/1959	Podgor	101/126

FOREIGN PATENTS OR APPLICATIONS

376,083	5/1964	Switzerland	101/123

Primary Examiner—Robert E. Pulfrey
Assistant Examiner—R. E. Suter
Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

A squeegee holding bar is pivotally coupled to a longitudinally moving squeegee drive bar which extends transversely across an overlying screen, the blank to be printed, and the table supporting the same, and has its pivot axis eccentrically adjustable by separate eccentrics at opposite ends of the squeegee assembly to facilitate complete parallelism between the platen (or blank thereon) and the movable squeegee during machine operation. The transversely extendable movable squeegee drive bar which holds the squeegee assembly is in turn supported at the front and rear by strong, vertically taut bars which are relatively fixed. A longitudinally extending rack is carried on the rear side of the rear squeegee drive support bar, a drive motor is fixed to the drive bar from which extends a spur drive gear in mesh with the rack. On the opposite side of the vertical squeegee support bar, there is a ball bushing assembly whose open face is directed towards the rack to take up the reaction force. The front support bar is F-shaped in configuration to receive within the groove facing the squeegee drive bar, a plurality of roller bearings carried by the squeegee drive bar. The frame assembly which includes the squeegee drive bar may be raised and lowered relative to the table, and, when raised, allows the screen and its support frame to pivot downwardly at one end to facilitate cleaning, removal, and replacement of the screen.

12 Claims, 11 Drawing Figures

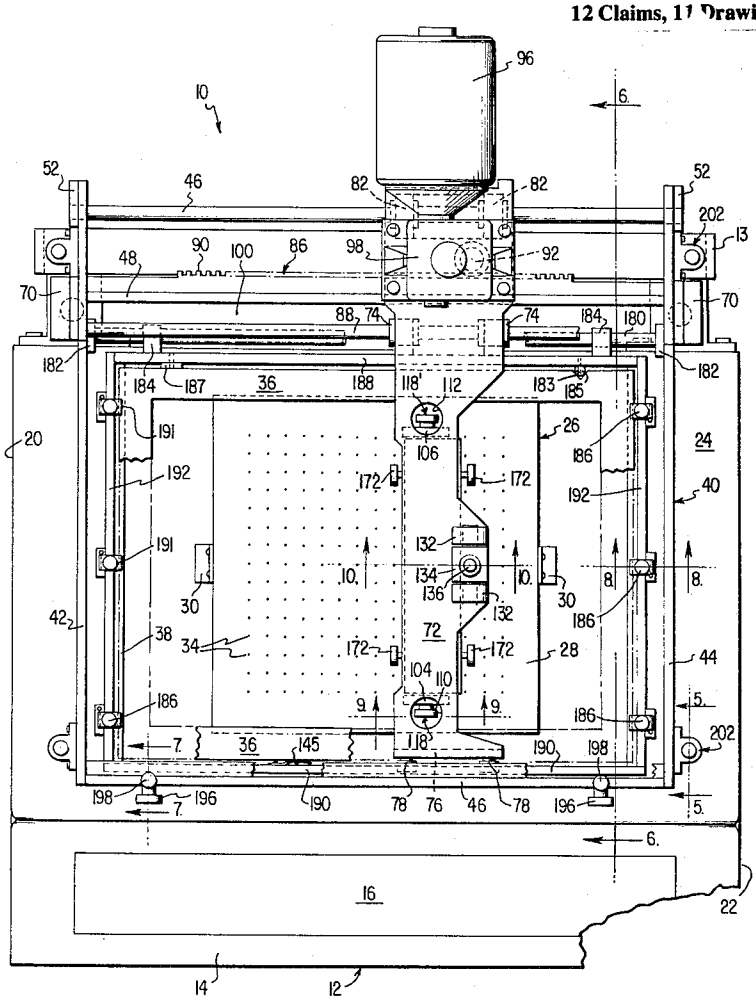
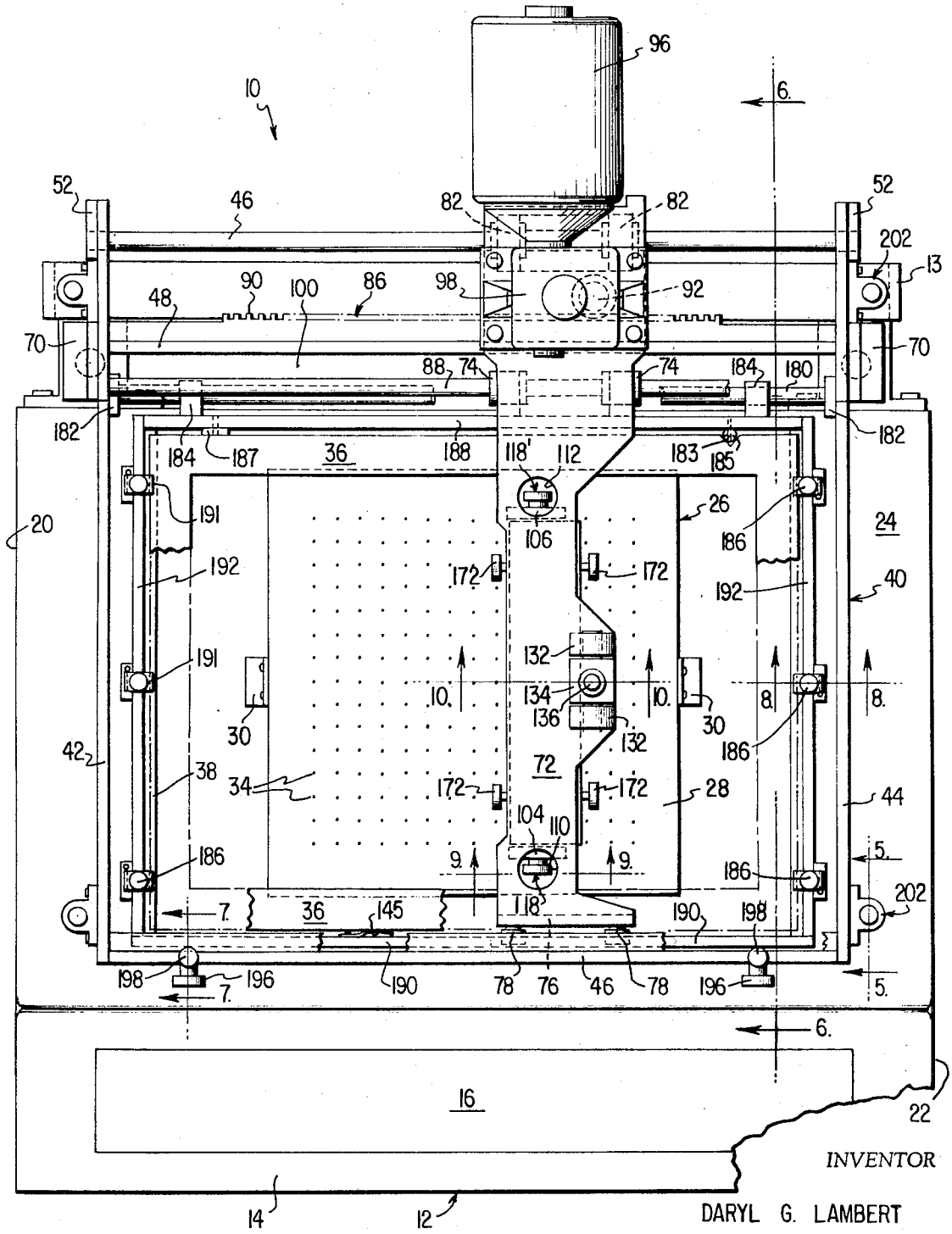


FIG. 1



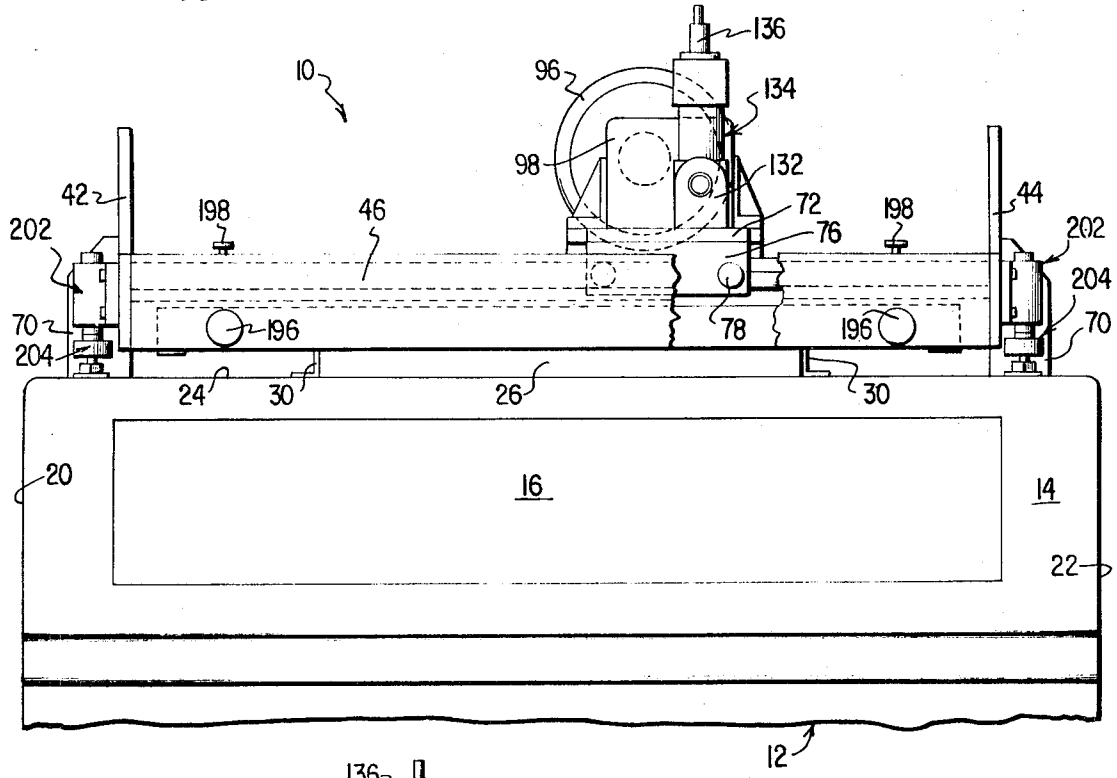
INVENTOR

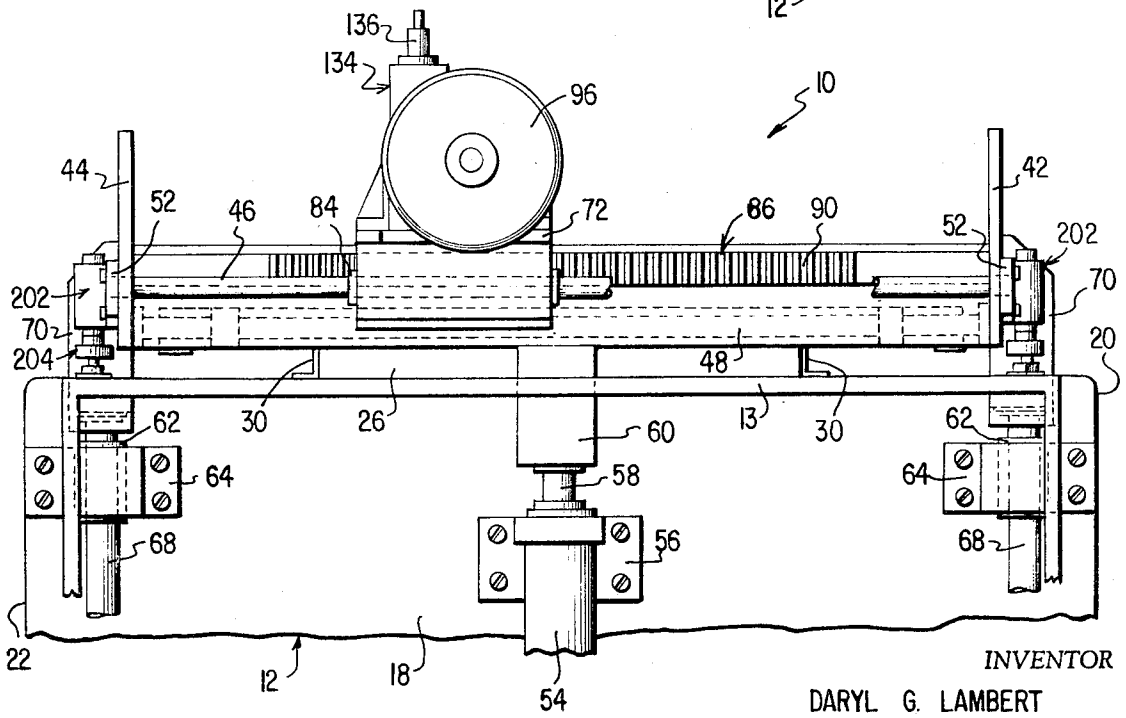
DARYL G. LAMBERT

BY Sughrue, Rothwell, Mion, Zinn & Macpeak

ATTORNEYS.

FIG. 2



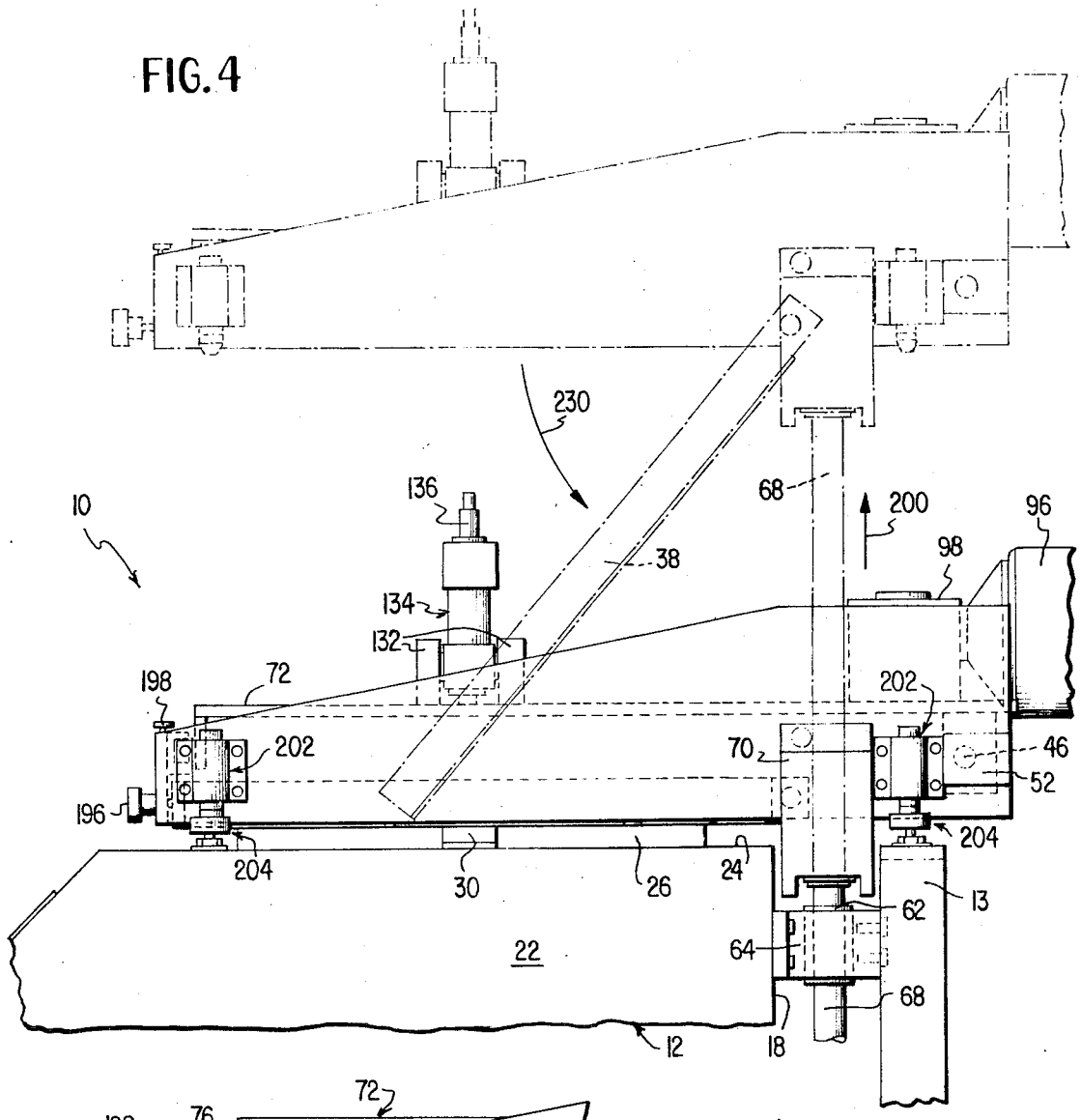


INVENTOR
DARYL G. LAMBERT

FIG. 3

BY Seyfarth, Rothwell, Mion, Zinn & Macpeak
ATTORNEYS.

FIG. 4



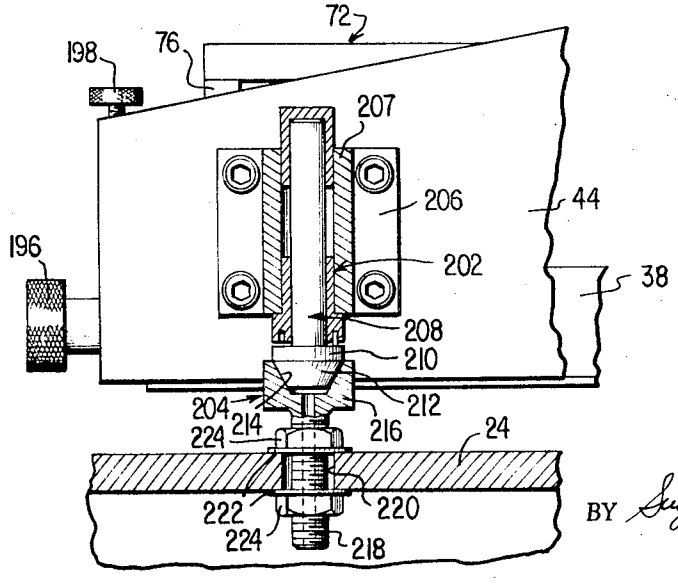


FIG. 5

INVENTOR
DARYL G. LAMBERT

BY Seyfarth, Rothwell, Mion, Zinn & Macpeak

ATTORNEYS.

FIG. 8

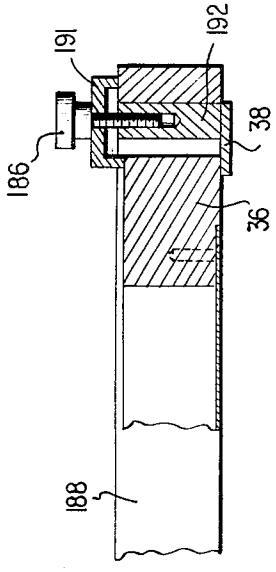


FIG. 6

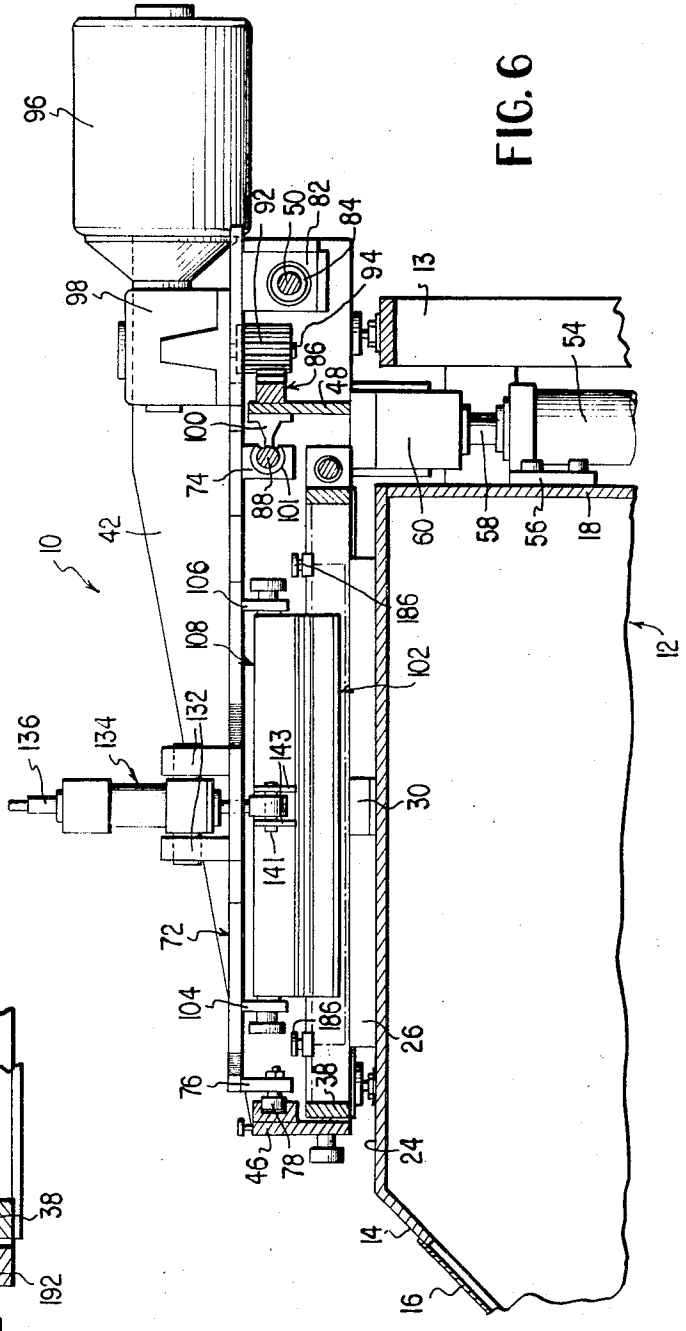
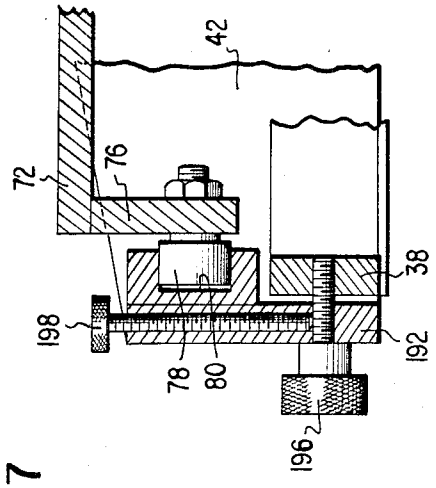


FIG. 7



INVENTOR
DARYL G. LAMBERT

BY Sughrue, Rothwell, Mion, Zinn & Macpeak

ATTORNEYS.

FIG. 9

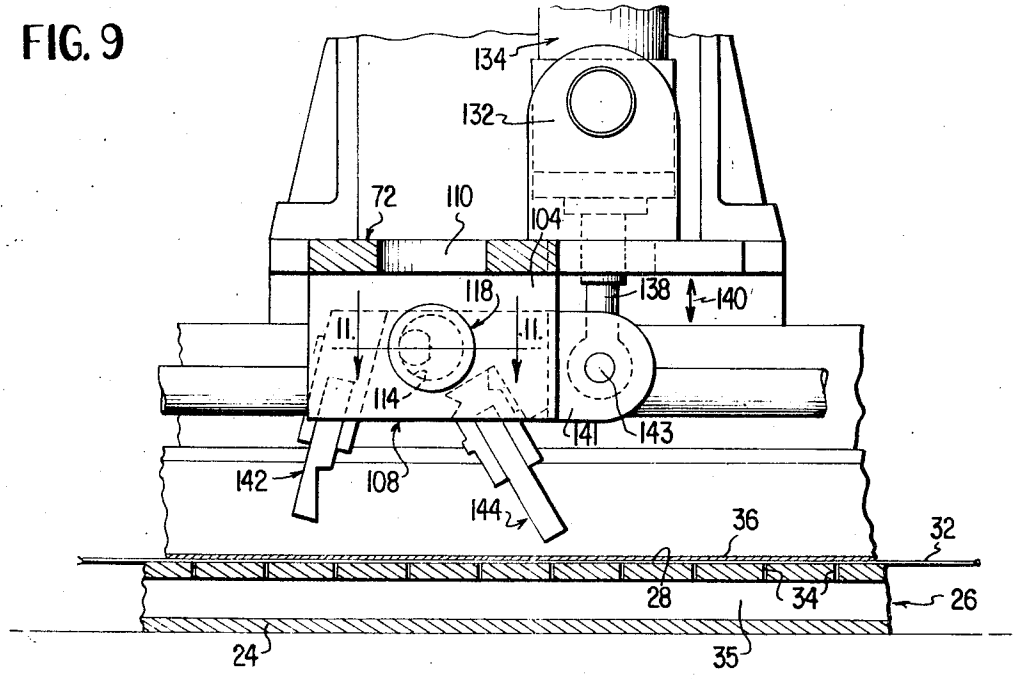
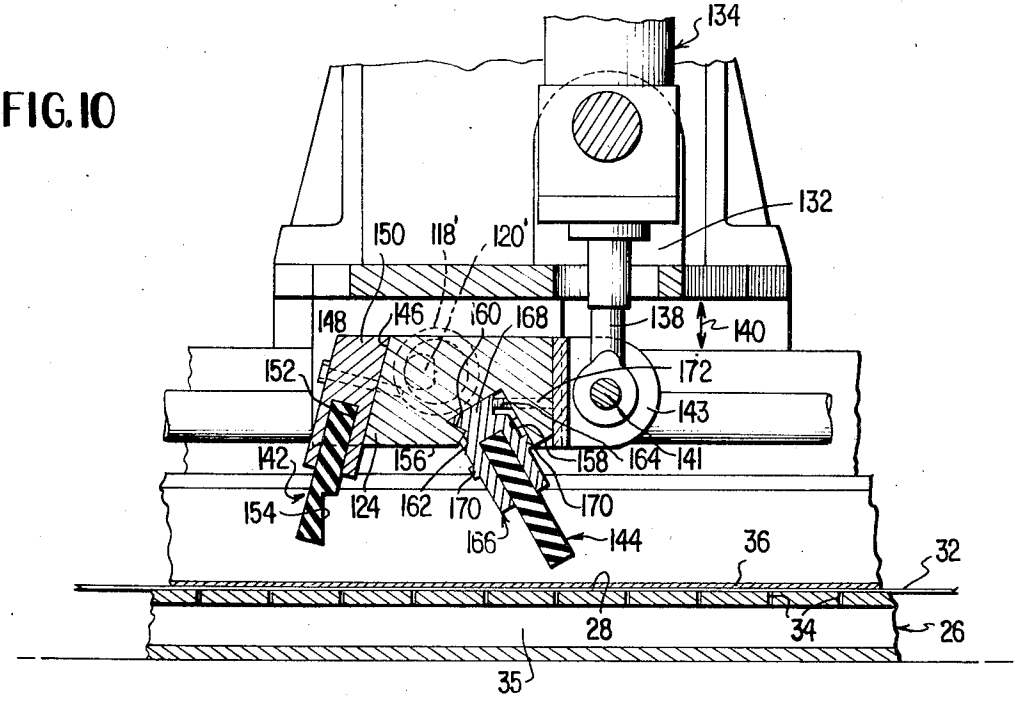


FIG. 10



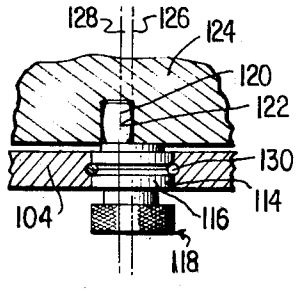


FIG. 11

INVENTOR
DARYL G. LAMBERT

BY Seyfarth, Rothwell, Mion, Zinn & Macpeak

ATTORNEYS

SCREEN PRINTING MACHINE WITH SINGLE-SIDED RACK-AND-PINION DRIVE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to screen printing machines and more particularly to screen printing machines for use in the manufacture of printed circuits requiring extremely close tolerances in the circuit patterns printed on the blanks.

2. Description of the Prior Art

Silk screen printing is a well-established art and basically involves the employment of the platen or table which has a flat surface supporting a planar blank material. A stencil, commonly called a silk screen, overlies the blank and ink is forced through openings in the screen to produce a printed pattern. The present screen printers are highly automated and operate satisfactorily for screen printing of decals, etc.

The electronic industry now uses a great number of printed circuits involving the removal of unprinted metal on a uniform metallic surface carried by the blank, principally by printing resist liquid on localized regions of the blank with the resist preventing removal of the desired localized region of the metallic surfaces. The electrical characteristics of the printed circuit are determined principally by the thickness of the metallic layer remaining and its lateral dimensions. Therefore, the fidelity of the printing, when applying the resist material, greatly affects the quality of the final printed circuit product. In turn, the fidelity of the applied pattern is principally controlled by the relationship between the moving squeegee, the relatively stationary screen and underlying blank receiving the ink.

Historically, most squeegee drive mechanisms have consisted of parallel drive units, i.e., power is applied to either side of the squeegee drive mechanism, generally at the front and rear of the machine, allowing the squeegee to move across the screen to distribute and control the movement of the ink through the screen carrying the pattern. The power being applied to both ends of the squeegee bar requires synchronization which may be achieved either by cam action, chain action, pneumatic arm, and sundry other units. Not only is synchronization important, but it is imperative that equal power be applied at each end of the squeegee blade. Machines in the past, in order to insure proper movement of the squeegee bar and other ink distributing elements across the upper surface of the relatively stationary screen, have required extremely complex and massive supports, fixed to the screen printing table and supported above and spaced from the table top. Such apparatus has greatly interferred with the placement, removal, cleaning and replacement of the individual screens for particular patterns and/or the removal of the printed blank subsequent to screen printing. More importantly, even where synchronization has been achieved, this, in itself, does not insure the proper retention of parallelism between the squeegee blade and the screen underlying the same during the complete longitudinal travel of the squeegee over the table and screen. This is even more complicated where the squeegee is mounted for pivoting about an axis parallel to the plane of the squeegee blade. Further, the maintenance of parallelism or the deliberate tilting of the squeegee blade assembly from side to side has been impossible, especially when the blade assembly includes multiple blades which are selectively pivoted into contact with the underlying screen.

SUMMARY OF THE INVENTION

This invention is directed to an improved screen printing machine and more particularly to the means for adjustably mounting and driving the squeegee blade assembly with the respect to the underlying screen, blank to be printed, and table supporting the same. The squeegee assembly is pivotably supported by a squeegee drive bar which extends across the table and above the screen. Front and rear longitudinally extending, vertically taut relatively fixed bars, support the squeegee drive bar on opposite sides of the underlying screen. A longitudinally extending rack is fixed to the rear support bar, a drive motor is supported on the longitudinally moving squeegee drive bar and has a driven spur gear in mesh with the rack for driving the squeegee drive bar longitudinally in either direction. A ball bushing rod is cantilevered in a highly rigid fashion to the side of the rear vertical support bar opposite that carrying the rack, and a ball bushing circumferentially engages the ball bushing rod with circumferential contact in excess of 180°. The contact surface directly opposes the reaction force between the drive pinion and the rack. At the front of the machine, the front support bar is F-shaped in cross sectional configuration with the longitudinally extending groove facing the end of the squeegee drive bar and receives a plurality of roller bearings carried thereon. Adjustment means allows slight adjustment of the screen supporting frame at that end with respect to the frame assembly. The squeegee drive bar and its driving mechanism is carried by a rectangular frame assembly including the front and rear support bars. In turn, the frame may be raised and lowered with respect to the table and, when raised, the screen support frame is released at one end and pivoted at the other end to incline the same downwardly so that it depends beneath the raised frame allowing access to the same.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of the improved screen printing machine of the present invention;

FIG. **2** is a front elevational view of a portion of the machine shown in FIG. **1**;

FIG. **3** is a rear elevational view of the machine of FIG. **1**;

FIG. **4** is a right hand side elevational view of the machine of FIG. **1** showing the squeegee and screen support frame raised above the table with the screen frame released and inclined therefrom by phantom lines;

FIG. **5** is an enlarged view of a portion of the machine shown in FIG. **4**, partially in section, illustrating one of the locating pins employed in positioning the squeegee and screen support frame with respect to the table;

FIG. **6** is a sectional elevation of the machine shown in FIG. **1**, taken about lines **6—6**;

FIG. **7** is a sectional view of a portion of the machine shown in FIG. **1** taken about line **7—7**;

FIG. **8** is a sectional view of a portion of the machine shown in FIG. **1** taken about lines **8—8**;

FIG. **9** is an enlarged sectional view of a portion of the machine shown in FIG. **1** taken about lines **9—9**;

FIG. **10** is a similar sectional view to FIG. **9**, taken about lines **10—10** of FIG. **1**; and

FIG. **11** is a sectional view of a portion of the squeegee bar assembly showing the eccentric mounting of the squeegee bar taken about lines **11—11** of FIG. **9**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, there is shown an improved screen printing machine **10** of the present invention which comprises a stationary table **12** of cabinet construction including a front panel **14** which may carry controls or the like at **16**, a rear panel **18**, side panels or walls **20** and **22** on the left and right hand sides, respectively, and a flattened table top **24**. While the interior of the table **12** readily carries the components necessary to the operation of the screen printing machine **10**, such as the containers (not shown) for holding the ink and other materials, the present invention is not directed in any way to these features and this portion of the machine has been purposely left incomplete. To this extent, the table top or platen support surface **24** carries a raised platen **26** having a perforated upper surface **28** and is fixed to the table top by L-shaped brackets **30** on either side thereof. Upon the platen surface **28**, which is perforated and to which may be applied vacuum as a hold-down means, is positioned the blank to be printed; in the case of printed circuits, a

laminated sheet having an upper metallic surface. While the blank is not shown in FIG. 1, it is illustrated in the sectional views of FIGS. 9 and 10 at 32 and rests upon platen 26, platen 26 being perforated at 34 to allow vacuum within chamber 35 to hold the blank in position during printing. Overlying the blank material is, of course, a screen 36 which is common to all screen printing operations. The screen itself is indicated as a rectangular element in FIG. 1 by phantom lines, the screen 36 being removably coupled to a hinged screen support frame or chase 38 of box-like configuration which will be described in detail hereinafter.

The present invention is directed principally to the box-like, combined screen and squeegee frame assembly 40 consisting principally of two side frame members 42 and 44 at the left and right sides, respectively, a relatively thick, planar, vertically taut front support bar or F bar 46 and a vertically taut planar rear support bar 48; these members forming the rectangular box frame assembly 40 with their edges being joined. Preferably, these members are formed of light weight metal such as aluminum and are bolted together to provide a rather rigid assembly. The side frame members 42 and 44 extend rearwardly beyond the rear support bar 48 and support an auxiliary bearing rod 47 which extends longitudinally across the machine parallel to rear support bar 48 and is coupled to the ends of side frame members 42 and 44 by coupling elements 52. The screen and squeegee frame assembly 40 may be elevated above the table 12 by a fluid motor 54 which is fixed to the rear panel 18 of the table by coupling member 56. The motor includes an extensible piston rod 58 having its upper end fixed to frame assembly 40 by mounting block 60. The application of fluid pressure, either liquid or gaseous, such as compressed air, causes the piston to extend, as indicated in FIG. 4, to move the frame assembly vertically upward to the phantom line position which, incidentally, allows the screen frame 38 to be released at the forward end of the machine and pivoted to the inclined position shown for facilitating cleaning, removal of the screen or replacement of the same without destroying the set up. At the rear of the machine, there is provided a pair of spaced, sleeve bearings 62 coupled to the rear panel by suitable mounts 64 which in turn slidably support guide rods 68 whose upper ends are coupled to respective left and right hand side frame members 42 and 44 by mounting means 70. Thus, as shown, the frame assembly 40 is adjustably mounted to the rear wall 18 of the table allowing the front and sides to be completely exposed when the frame assembly 40 is at its upper level to facilitate access to both the screen 36 and the platen 26.

A principal aspect of the present invention is the method of mounting the squeegee drive mechanism since in the present design, the squeegee is powered from one side only, thus providing numerous advantages besides low cost and simplicity. The placement of the squeegee drive to one side of the squeegee eliminates alignment and synchronization problems inherent in previous squeegee drive mechanisms requiring parallel drive units on each side of the squeegee drive bar. In this respect, as mentioned previously, the frame assembly 40 includes front and rear vertically taut squeegee mounting or support bars 46 and 48, both members being relatively thick planar bars of high strength metal. This prevents deflection of the transversely extending squeegee drive bar 72 being supported at the front by support bar 46 and at the rear of the table by rear support bar 48. The squeegee drive bar 72 is therefore mounted for reciprocation longitudinally, i.e., from side to side of the machine along a path parallel to support bars 46 and 48. In this respect, the squeegee drive bar 72 is of irregular rectangular configuration and carries, at the rear, inwardly from the rear vertical support bar 48, a pair of open sided ball bushings 74 which depend beneath the drive bar and embrace ball bushing rod 88. At the front end of the squeegee drive bar 72, a depending plate 76 carries a pair of freely rotatable roller bearings 78. The vertical support bar 46 is F-shape in cross sectional configuration, with groove 80 facing roller bearings 78 and receiving the same. Further, at the extreme rear of the squeegee drive bar 72, there are provided a pair of bearing blocks 82 which are fixed to the bottom of the bar 72; the blocks carrying sleeve bearings 84 which are in turn slidably supported on the auxiliary bearing rod 47. Thus, in effect, the squeegee drive bar 72 is mounted for longitudinal movement from side to side on the machine by the three types of bearings 74, 78, and 84.

Driving of the squeegee drive bar 72 from side to side is achieved through the novel employment of a fixed rack 86 which extends parallel to the ball bushing rod 88 but fixed to the rear side of rear support bar 48. The rack 86 is provided with gear teeth 90 which are in mesh with a spur gear 92, which in turn is mounted for rotation about a vertical axis on the vertical drive shaft 94. The squeegee drive bar 72 has fixed thereto at the extreme rear end, a suitable drive motor 96, whose output shaft is coupled to the vertical drive shaft 94 through a gear coupling unit 98. If necessary, unit 98 may also provide the function of gear reduction to reduce the speed of the spur drive gear 92. Not only is deflection of the squeegee drive bar prevented by the employment of front and rear vertically taut support members or bars 46 and 48, but, through the employment of open sided ball bushing rod 88 and the pair of ball bushings 74, the reaction force exerted by the drive gear 92 on rack 86 is adequately and completely taken up by the full surface of ball bushing opposite its open side. Thus, any stresses occurring are taken up by the good side of the bearing. In this respect, the ball bushing rod is coupled throughout its length by a T-shaped rod holding member 100 such that the ball bushing rod 88 is supported in cantilevered fashion throughout its length, providing highly rigid bearing surface for the ball bushings 74. Each ball bushing 74 may be constructed in segmented block form and consists of a semi-cylindrical bearing surface 101 extending in excess of 180° and completely enveloping the exposed cylindrical surface of the ball bushing rod 88 facing the moving squeegee assembly 102, mounted for reciprocation upon the squeegee drive bar 72. As power is exerted to move the squeegee drive bar 72, the force is directed against the rack 86 due to the fact that the spur gear 92 wants to remove itself from the teeth 90 of the rack under the applied power. This causes the favorable side (left hand side in FIG. 6), of the bearing surface 101 in the ball bushings 74 to be used, which is opposite to the open side of the bearing. Thus, in the present arrangement, the bushings may be readily mounted so that deflection occurring in the printing cycle due to the reaction force on the drive mechanism is not dependent upon the structural integrity of a completely surrounded ball bushing.

To reiterate, when the motor is energized and the spur wants to turn the spur gear, by its nature wants to unseat itself out of the teeth of the rack, and it thereby causes the ball bushing to be pressed to the rear of the machine exerting its force against the rack using the good side of the bushing. By using an open bushing, rather than a closed bushing, the structural integrity of the member is used to offset deflection during the printing stroke since the squeegee assembly 102 wants to exert pressure to deflect the squeegee drive 72 bar upward and there is achieved a much stronger and much more standard unit. In fact, in relationship to the maximum squeegee pressure anticipated, there is no measurable deflection to either the front or the rear squeegee support bar 46 or 48.

The front support bar 46 is also unique in this respect since it provides the same structural integrity. The bar 46 in like fashion to bar 48 constitutes a rectangular plate of high strength metal which, as stated previously, is of F-shape cross section to provide the elongated recess 80 for receiving the spaced roller bearings 78. Further, there is no alignment problem between the front and rear support bars because the front support bar is a free riding bar and by using ball bearings 78 to house and limit the vertical action of the squeegee bar due to any downward force on the squeegee blade, the movement of the squeegee drive bar may be limited to an up and down movement to only the necessary tolerance such as one- or two-thousandths of an inch. Thus, with one- or two-

thousandths of an inch being the maximum vertical movement of the unit at the front of the machine, for all practical purposes, there is no vertical movement at all.

The male and female locaters, although primarily used for registration purposes, have another important duty. By turning the threaded female locator **216**, FIG. **5**, it moves up or down. This allows for complete parallelism to be achieved in respect to the platen. Now, if at this time, the screen is not parallel to the platen, then the control knob **196** can be loosened and control knob **198** raised or lowered so as to make the screen parallel to the platen. The F bar is not used to control the vertical adjustment of the screen except as the F bar relates to the platen through the bottoming capabilities of the male and female locaters. Once the F bar is fixed in its proper plane, then the screen can be further raised or lowered through control knobs **196** and **198**.

Referring next to the squeegee assembly **102**, it is noted that the squeegee drive bar **72** is provided with downwardly extending front and rear mounting plates **104** and **106**, for mounting the squeegee holding bar **124** at its front and rear ends respectively, for pivoting; with the pivoting axis being eccentrically adjustable. This arrangement may be best seen by reference to FIGS. **6**, **9**, **10** and **11**. The front mounting plate **104** is preferably bolted to the squeegee drive bar **72** with the squeegee drive bar being provided with an opening **110** partially overlying the same. It is further provided with a second opening **112** partially overlying mounting plate **106** and extending rearwardly therefrom. The front mounting plate **104** is bored at **114** to support enlarged diameter portion **116** of a cylindrical adjusting knob **118**. At the inner end of the adjusting knob, there is provided an eccentric cylindrical extension or pin **120** whose arch is eccentric to the knob axis and whose periphery is suitably curved axially to facilitate positioning of the eccentric pin within bore **122** of the squeegee holding bar **124**. It is apparent when viewing FIG. **11**, that the axis **126** of the adjustment knob **118** is radially offset from the pivot axis **128** formed by the cylindrical eccentric pin **120** carried by squeegee holding bar **124**. Thus, while the squeegee holding bar is mounted for pivoting about pivot axis **128**, this pivot axis is eccentrically positioned with respect to the axis **126** of adjusting knob **118**.

An identical arrangement is provided on the opposite side of squeegee holding bar **124**, at the rear of the squeegee assembly **102**. Mounting plate **106** is provided with an adjustment knob **118'** having an eccentric extension **120'** whose axis is radially offset with respect to the axis of rotation of its adjustment knob **118'**. Both the bore **104** and the enlarged diameter portion **116** of each adjustment knob may be peripherally grooved and an O-ring or the like **130** positioned within each groove to securely locate the knob axially with respect to supporting plates **104** and **106**.

A pair of support brackets **132** extend upwardly from the squeegee drive bar **72** to pivotably support a fluid motor **134**, such as an air cylinder, the air motor being supplied selectively with fluid pressure through inlet **136** to cause motor actuating rod **138** to reciprocate in the manner of arrow **140**. The outer end of the rod is pivotably coupled by pin **141** to ears **143** extending outwardly from the squeegee holding bar **124**. Thus, the squeegee holding bar **124** tends to pivot about the pivot axis **128** defined by respective eccentric pins **120** and **120'**. Depending of course on the position of each eccentric pin, the squeegee assembly **108** may be simultaneously moved up or down, and left or right, which action of course varies the effect of extension and retraction of air cylinder operating rod **138**. Additionally, in screen printing, particularly in its sophisticated application of the process to the electronic industry in the production of printed circuits, it is extremely desirable and sometimes absolutely necessary to maintain parallelism of the squeegee blade in its movement relative to the surface that is being printed. Extremely expensive alignment problems may be avoided and actually eliminated because the squeegee is mounted with an eccentric control so that parallelism may be achieved at setup or at any time thereafter. Further, by rotating respective control knobs **118** and **118'**, two distinct and separate movements may be provided to each end of the screen and the squeegee may readily be angled in its relationship to its movement by as much as 5° to 10°.

This is highly advantageous since it is not necessary to have the rubber blade, that is either flood blade **142** or squeegee blade **144** abruptly coming into contact with the edge of a part being printed upon. This is particularly noteworthy in the area of screen printing involving a process generally known as "a kiss," that is, where the total pressure bottoms just a few thousandths of an inch below the surface upon which printing is occurring. Therefore, any abrupt mounting of the edge of the part by the squeegee could cause a lateral shift of the part which is eliminated when the squeegee blade is brought over the part gradually. This may be likened to driving a car over a railroad track, that is, if the street is angled to the track, one wheel goes over the track at a time and the car rides much more smoothly than if the two front wheels hit the track simultaneously at direct right angles. Secondly, since it is possible to get vertical and horizontal movements by the same eccentric pin, it is easy to maintain parallelism of the squeegee blade to the surface being printed upon. The two eccentrically mounted control units are identical and are on each end of the squeegee holding bar **124** and perform the same function at each end. This allows for independent movement of the ends of the squeegee or flood blade, they do not have to be moved simultaneously or synchronously and further allows deliberate cocking.

In this respect, both the squeegee blade **144** and flood blade **142** are preferably formed at a resilient plastic material such as polyurethane. An important aspect of the present invention is the method of mounting both blades to the squeegee holding bar **124**. The bar **124** is formed of machined aluminum stock or other metal and is provided with an inclined surface **146** to which is coupled by means of mounting screws **148**, a flood blade support block **150**. Block **150** is provided with a rectangular slot **152** which extends the length thereof and within which is positioned the polyurethane flood blade **142**. The blade **142** is generally rectangular in cross section but does include an inclined indentation **154** on the surface facing the squeegee blade **144** to facilitate its function during machine operation.

The squeegee blade **144** is mounted on the opposite side of the pivot axis **128** formed by eccentrics **120** and **120'** and in this case, the bottom surface **156** of the squeegee holding bar is provided with an irregular longitudinally extending recess or groove **158** in the form of an inclined keyway. That is, the side closest to the flood blade and screen is provided with inclined keyway surfaces **160**, **162**, while the side **164** opposite thereto is flat but inclined, rather than being vertical. A specially configured aluminum squeegee blade holder **166** supports the squeegee blade **144** which may be molded therein. The holder **166** in similar fashion to blade support **150** is symmetrical in cross sectional configuration with the inner end **168** being provided with keyway surfaces corresponding to keyway surfaces **160** and **162** of the squeegee holding bar. Further, small projections or protruding ridges **170** extend the length of the mounting element along the outside thereof, such that, when the blade holder is positioned within the keyway slot, one of the projecting ridges **170** readily contacts the flat side wall **164** of the same slot. The projecting ridges form pressure areas since, when the aluminum housing is inserted within the keyway slot **150** and one or more locking screws **172** engage the outwardly inclined key surface to hold the holder within the keyway. It is important to note that the screws **172** do not maintain the squeegee blade holder in its keyway slot under pressure but merely prevent the holder from falling out of the slot, under gravity influence when in the position shown in FIG. **10** since, at this point, the outer edge of the squeegee blade is not in contact with the screen **36**. By actuation of the fluid motor air cylinder **134**, depression of air motor operating rod **138** causes rotation of the squeegee holding bar **108** about the eccentric pivot axis until the squeegee blade contacts the

screen. Reaction pressure forces a pressure ridge **170** into contact with keyway slot side wall **164** and tends to cause the diagonally opposite keyway surfaces **160** and **162** to be pressured by the keyway holder thereby preventing removal under operating pressure. The function of the screws **172** are merely to maintain the blade support **166** in slot **158** when the blade is not in contact with the screen. Of course, the actuation of the air cylinder causing movement of the operating rod **138** upwardly instead of downwardly causes the squeegee holding bar **124** to rotate about the pivot axis **128** defined by eccentrics **120** and **120'** to raise the squeegee blade **144** from the surface of the screen and cause the flood blade **142** to move into contact therewith.

An additional feature of the present invention is directed to the accessibility of the screen mounting to allow the removal and replacement of the screen without adversely affecting the set up in so far as the workpiece or blank material is concerned. Conventionally, in screen printing machines, the screen frame or chase is placed in a master holding frame and bolted into position before set up of the machine; that is, arbitrarily with no respect to the location of the other elements of the machine and the screen may be off in its position by as much as one-fourth of an inch or so. The present invention is partially directed to a screen holding frame which may be separately positioned and is pivotable on one of its mounting axes, preferably at the rear of the machine, so that once the frame assembly **40** is raised above the surface table **24** of platen, **26**, the screen frame or chase **38** may be released to depend at some angle from the now raised frame assembly **40** to facilitate cleaning, removal or replacement of the screen. In this respect, the screen **36** is coupled at both sides, to the screen frame **38** through the employment of a plurality of screen frame adjustment and coupling means **186**. The outer screen frame itself is pivotably mounted on the frame assembly **40** through the employment of a longitudinally extending pivot rod **180** at the rear of the machine positioned just beneath the ball bushing rod **88**. The ends of the rods are coupled to side frame members **42** and **44**, respectively, by coupling means **182** while a pair of hinges **184** are mounted interiorly of the same. The hinges **184** are fixed to the rear screen support frame member **188**, the screen support frame being completed by side frame members **192** and a front frame member **190**. Members **188**, **190** and **192** constitute a screen holding frame assembly or master frame **194** which, while pivotably mounted by means of hinges **184** at the rear, is releasably coupled to the front frame member **46** by a pair of clamping screws **196**. These screws operate on a machine cam so that when the master frame **194** is in the open or drop position for screen insertion, there is a keyway in the screen and a keyway receiver in the master frame so that the screen may be located in this keyway, then brought up into printing position or a position parallel to the printing position, or parallel to the master head of the machine and locked into place.

If there are any final adjustments regarding parallelism, they may be done through the employment of adjustment screws **198** mounted on the top of the F bar. When the adjustment screws **198** are pivoted to the extent that the master frame **194** and especially the front frame member **190** is brought up into the desired position, then the screen locking screws in the master frame **194** may be locked which means that the screen is not locked into a permanent position until it has been moved into its finished printing configuration. This allows for the removal of the screen for cleaning purposes and the reinsertion of the screen or a new screen without destroying the printing set up. Cut into each chase (aluminum frame) is a V notch which seats around a pinned rod **185** affixed to bar **188** on the right side near part **184**. On the left side near part **184** is a flat bar stock **187** affixed to bar **188** of sufficient width and thickness to cause the frame to remain parallel to bar **188** when pressure is applied by a spring **145** located in the center of bar **190** facing the frame. When the screen frame is inserted, it therefore is pushed into the locating V notch causing a consistent location of the frame in the master frame.

Without clamping the screen frame in the master frame by using or turning clamps **186**, the screen is raised and put in printing position by tightening knobs **196**. Only after this has been done are knobs **186** (six of them) clamped at all.

This arrangement allows for the exact repositioning of the screen frame every time it is removed for cleaning or otherwise. It also does not require the master frame to be of such strong and rigid material because the F bar is more than adequate to hold the master frame rigid. In the event the screen frame is not square, locking the knobs **186** after knobs **196** does not cause a rewarping of the frame. With this system the screen frame does not have to be exactly square, but will repeat its location exactly everytime.

Further, under the arrangement of the present invention, the squeegee blades do not have to be removed to get the screen in and out since the squeegee blade remains with the frame assembly **40** in the raised position while the master frame assembly **194** pivots downwardly as indicated in FIG. **4**.

Since the frame assembly **40** is movable vertically as indicated by arrow **200** in FIG. **4** to facilitate screen removal and since it is necessary that parallelism be achieved and maintained for a proper squeegee operation with respect to those components carried by the immovable table **12**, it is necessary to insure proper vertical and horizontal position of the frame assembly **40** with respect to the table each time the frame assembly returns from its raised position or phantom line position to the full line position shown in FIG. **4**. In this respect, the side frame members **42** and **44** are each provided with a pair of male locaters **202** which are received within female locaters **204** carried by the table **12** and vertical support bracket **13**. Each of the male locaters **202** are carried by bracket means **206** and are bolted to the side frames **42** and **44** at positions adjacent the front end and just ahead of the rear panel of the table **12**. The flanged support member **206** carries a cylindrical portion **207** which receives a solid headed pin **208** which is fixedly located with respect thereto. The headed end **210** of the pin **208** is provided with a frustoconical contact surface **212** which is received within a female recess **214** of like configuration carried by the headed end **216** of an adjustable female locater bolt **218**. In this respect, the headed female locater bolts **218** are mounted for vertical adjustment within openings **220** formed within the table top **24**, for instance, in which case washers and nuts **222** and **224** are applied respectively on both sides of the table top to insure fixing the female locater bolts **218** in adjusted position once this position is determined for each of the four locations.

The male and female locaters are positioned on opposite sides of the air cylinder **54** for actuating or lifting the frame assembly **40**. This insures proper positioning of the frame assembly each time it is lowered.

While, as mentioned previously, the present invention is not directed to a complete screen printing machine but rather improvements therein, and since, purposefully, a portion of the necessary apparatus to allow complete operation of the machine is neither shown nor described, it is important only to note the operation of the improved portions of the machine. During operation of the machine, the frame assembly **40** is moved to the raised (phantom line) position of FIG. **4** and the screen frame **194** is released at the front end for pivoting to the position shown as indicated by arrow **230** whereupon screen **36** may be readily inserted therein or the screen cleaned while held in position, or removed for cleaning as desired. The master frame **194** is then returned to its normal position latched in place by clamping screws **196** and, if a blank **32** to be printed is not already placed on platen surface **28**, it may be placed thereon. It is immaterial whether the blank **32** is placed on the platen **26** before or after the screen **36** has been clamped into the screen frame. Vacuum may or may not be employed to hold the blank in position for printing depending of course on the necessity to do so. The means for applying ink to the surface of the screen has not been shown but upon the assumption that ink has been applied, it is important only that the squeegee blade move across the surface of

the screen at a constant velocity, a constant angle with respect to the plane of the screen, and preferably in complete parallelism therewith during the complete stroke across the screen from right to left in FIG. 1. Of course, the tilting in a plane at right angles to the path of movement of the squeegee assembly and any inclination from a position at right angles vertically or horizontally from the path of movement of the squeegee drive bar **70** is made prior to the actual print cycle to produce the desired effect, which action must be closely controlled, especially in the screen printing of printed circuits. As desired, through actuation of air cylinder **134**, the squeegee blade **140** may be rotated out contact with screen **36** and flood blade **142** may be moved into contact therewith. Alternatively, of course, by rotation of eccentric pins **120** and **120'**, both the squeegee blade and the flood blade may have their edges in abutment with the screen tending to trap the ink therebetween and in contact with the screen.

Sophisticated screen printing as used to make printed circuits employs the following functions or steps:

Squeegee blade (a partial hydraulic pump)

Mesh openings (orifices to control ink flow)

Stencil thickness (mechanical dimensions of the emulsion suspended beneath the mesh). This is the stencil cavity or mold.

Vacuum (as a result of the squeegee being pressured, any air is displaced with resist ink material)

Off-contact (the mesh is never in contact with the part to be printed except at the point of squeegee contact—and upon the squeegee passing, the mesh lifts upward immediately following the squeegee and releases the partial vacuum).

Affinity—all screen inks have a greater affinity to the unwetted part being printed as opposed to the prewetted screen stencil, therefore a transfer of ink is achieved.

Since the ink material always preceeds the squeegee blade in its travel across the platen, it must be returned for the cycle to be completed again. This is the primary function of the flood bar, simply to return the ink. It must not be in contact with the mesh during its return stroke, as it would interfere or support the pumping action of the squeegee blade, and is not designed to do so.

The squeegee blade pumps resist ink into the cavity but is restricted or assisted by the arbitrary choice of mesh opening size (orifice). Factors of speed, parallelism, squeegee angle, control the uniformity of the deposited ink over the entire surface being printed. Any variance in these factors would produce a corresponding variance in the ink being deposited.

What is claimed is:

1. In a screen printing machine including a table for supporting blanks to be printed and a screen overlying the blank, the improvement comprising:

a squeegee drive bar extending across said table above said screen and carrying a squeegee assembly beneath the drive bar for contact with said screen;

a pair of laterally spaced relatively thick support bars for supporting said drive bar on opposite sides of said table;

a rack fixed to one of said support bars and extending parallel thereto;

a drive bar motor mounted on said squeegee drive bar and carrying a spur gear driven thereby in mesh with said rack for causing said squeegee drive bar to move relative to said rack, said support bar carrying said rack further carrying a ball bushing rod fixed thereto and extending parallel to said rack, and open sided ball bushing means carried by said squeegee drive bar and embracing said rod with the surface of the rod contacted by said bushing means being the surface most remote from said rack, and the teeth of the rack extending from the surface of said rack which is most remote from said support bar to absorb the reactive force created by opposition to movement of said squeegee assembly over said screen.

2. A screen printing machine as claimed in claim **1**, wherein said rack is fixed to the outside of said one support bar, said ball bushing rod is cantilever supported throughout its length on the inside of said one support bar and said open sided ball bushing means has a C-shaped contact surface which contacts the periphery of said rod in excess of 180°.

3. The screen printing machine as claimed in claim **2**, wherein said other support bar is F-shaped in cross sectional configuration defining an internal groove, and the end of said squeegee drive bar carries at least one roller bearing positioned within said groove and movable therealong.

4. The screen printing machine as claimed in claim **1**, wherein said other support bar is F-shaped in cross sectional configuration with an internal groove within the inside surface thereof, and the end of said squeegee drive bar carries at least one roller bearing positioned within said groove and movable therealong.

5. In a screen printing machine including a table carrying a blank to be printed and a screen overlying the same and a squeegee drive bar horizontally movable across the table and parallel thereto and carrying a squeegee holding bar including at least one blade depending therefrom for contact with the screen, the improvement comprising: mounting plates on each side of the squeegee drive bar extending downwardly toward said screen, aligned circular openings within respective plates, a rotatable cylindrical adjustment knob carried within each opening and means carried by each knob for coupling respective ends of said squeegee holding bar to said cylindrical adjustment knobs at points eccentric of the knob axis; whereby independent rotation of either knob effects simultaneous two-dimensional shifting of the squeegee holding bar pivot axis.

6. The screen printing machine as claimed in claim **9**, wherein said means rotatably couple said blade holder at its end to respective cylindrical adjustment knobs comprising pins eccentrically carried by each cylindrical adjustment knob and axially aligned recesses within opposite ends of said squeegee holding bar to define the pivot axis of the same and receiving said eccentrically positioned pins.

7. The screen printing machine as claimed in claim **5** wherein said squeegee holding bar includes, at each end, aligned cylindrical holes extending partially along the direction of the major axis of said bar, and each rotatable adjustment knob carries eccentrically positioned cylindrical extensions with said cylindrical extensions received within the cylindrical holes of said squeegee holding bar.

8. The screen printing machine as claimed in claim **7** wherein said cylindrical extensions are longitudinally curved to effect line contact between the eccentric extensions and the cylindrical holes receiving the same to facilitate individual adjustment of the support bar pivot axis at each end of the squeegee holding bar.

9. In a screen printing machine including a table carrying a blank to be printed and a screen overlying the same and a squeegee drive bar horizontally movable across the table and parallel thereto and carrying a squeegee holding bar including at least one blade depending therefrom for contact with the screen, the improvement comprising:

mounting plates on each side of the squeegee drive bar extending downwardly toward said screen,

aligned circular openings within respective plates,

a rotatable cylindrical adjustment knob carried within each opening and means said cylindrical adjustment knobs to define a pivot axis for said squeegee holding bar eccentric to the axis of said aligned adjustment knobs;

whereby independent rotation of said knobs effects simultaneous two-dimensional shifting of the squeegee holding bar pivot axis, said squeegee holding bar being further provided with a longitudinally extending keyway slot inclined with respect to the plane of said screen, said keyway slot having its side wall nearest the screen provided with angled, keyway surfaces and having a flat opposite side wall, and wherein said blade is carried by a slotted blade holder, said blade holder having keyway grooves within the sides of the same on the end opposite that carrying said blade, said keyway grooves interfitting

with said keyway surfaces of said slot, and at least one adjustable clamping member carried by said squeegee holding bar for contact with said keyway groove facing said flat side wall after insertion of said blade holder therein and constituting the only means for holding said blade holder within said slot when the blade is out of contact with the screen.

10. The screen printing machine as claimed in claim 9 wherein said blade holder is symmetrical and includes narrow pressure point protruding ridges extending longitudinally along both sides thereof, intermediate of its ends, for contact with the flat side wall of said keyway slot, said ridges constituting the sole areas of application of pressure to the side of said slotted blade holder facing said flat side wall; whereby, when said blade is pressed against said screen, the reaction force tends to pressure the diagonally opposite keyway surfaces.

11. In a screen printing machine including a table, a blank to be printed carried by said table, and a screen overlying the same, and a squeegee holding bar positioned for movement across said screen and parallel thereto, the improvement comprising:

a keyway slot carried by said holding bar facing said screen and inclined with respect thereto, the side wall of the slot nearest the screen including angled keyway surfaces and including a flat opposite side wall, a blade holder including keyway grooves carried on opposite sides thereof adjacent the inserted end for interfitting contact with the keyway surfaces of said slot, and at least one adjustable clamping member carried by said squeegee holding bar for contact with the keyway groove of said holder facing the flattened side wall of said holding bar slot after blade holder insertion and constituting the only means for holding said blade holder within the slot when the blade is out of contact with said screen.

12. The screen printing machine as claimed in claim 11, wherein said blade holder is symmetrical in cross sectional configuration and includes longitudinally extending pressure point protruding ridges along each side of said holder intermediate of its ends for contact with the flat side wall of the blade holder slot after insertion therein, said ridges constituting the sole area of application of pressure to the side of said slotted blade holder facing said flat side wall, whereby; the reaction force, due to contact between the blade and the screen acting on the ridge pressurizes the diagonally opposite keyway surfaces.

* * * * *