Aug. 5, 1969 C. F. FORSLUND 3,459,125

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 1

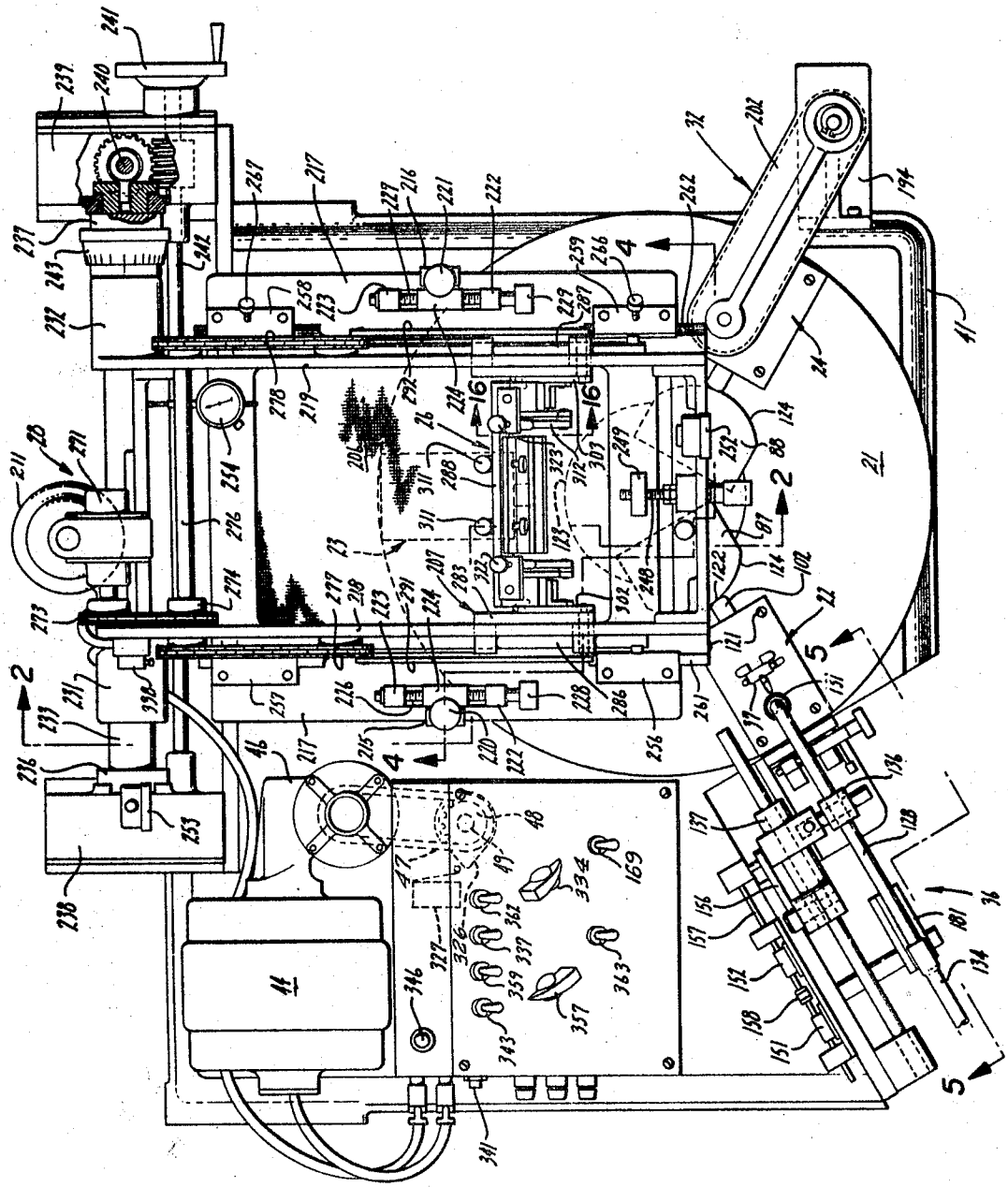


Fig. 1

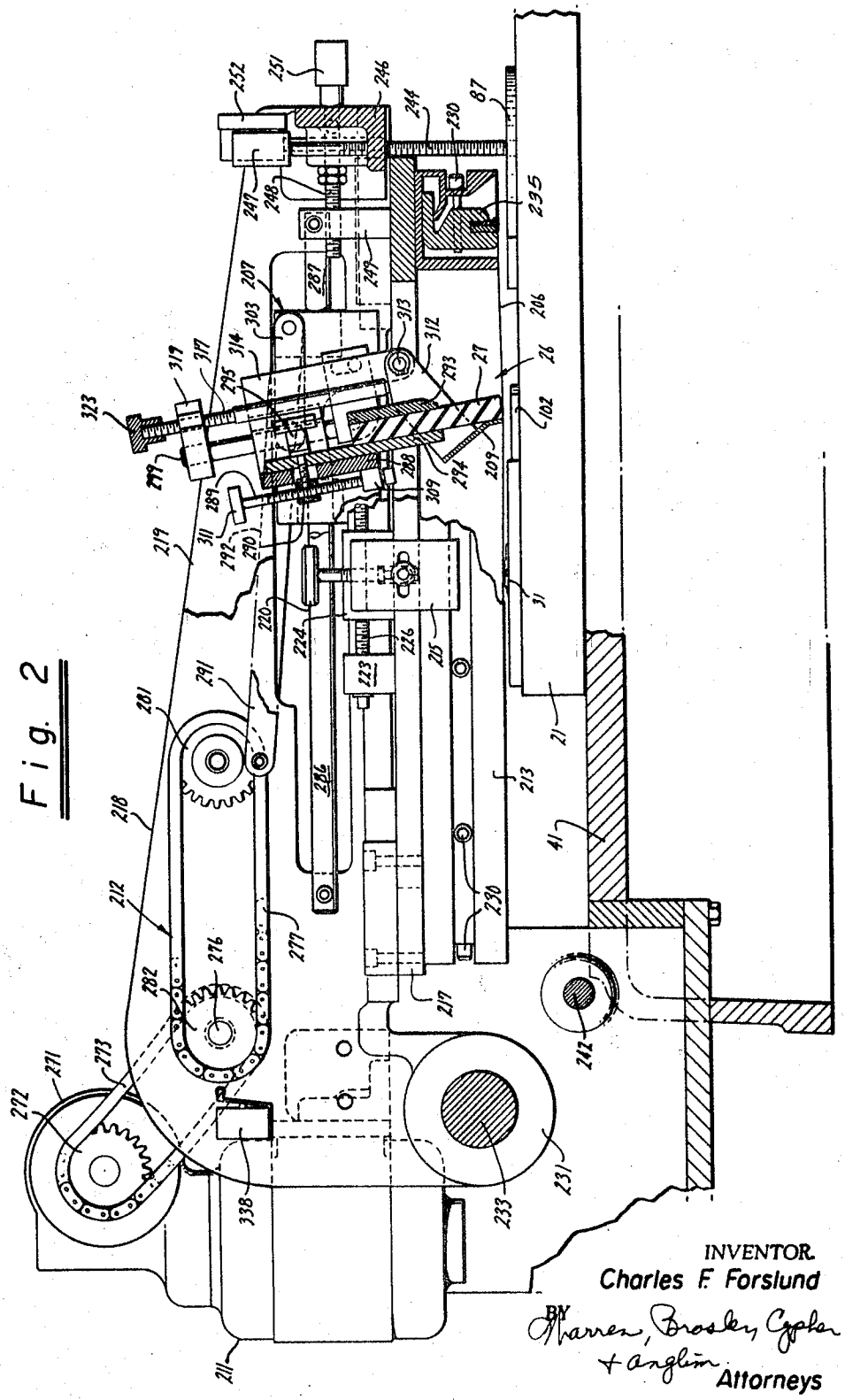
INVENTOR.
Charles F. Forslund
BY Warren, Brosler, Cypher & Anglin.
Attorneys

Aug. 5, 1969 C. F. FORSLUND 3,459,125

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 2

Fig. 2



INVENTOR.
Charles F. Forslund
BY Warren, Brosley, Cyphar & Anglim
Attorneys

Aug. 5, 1969 C. F. FORSLUND 3,459,125

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 3

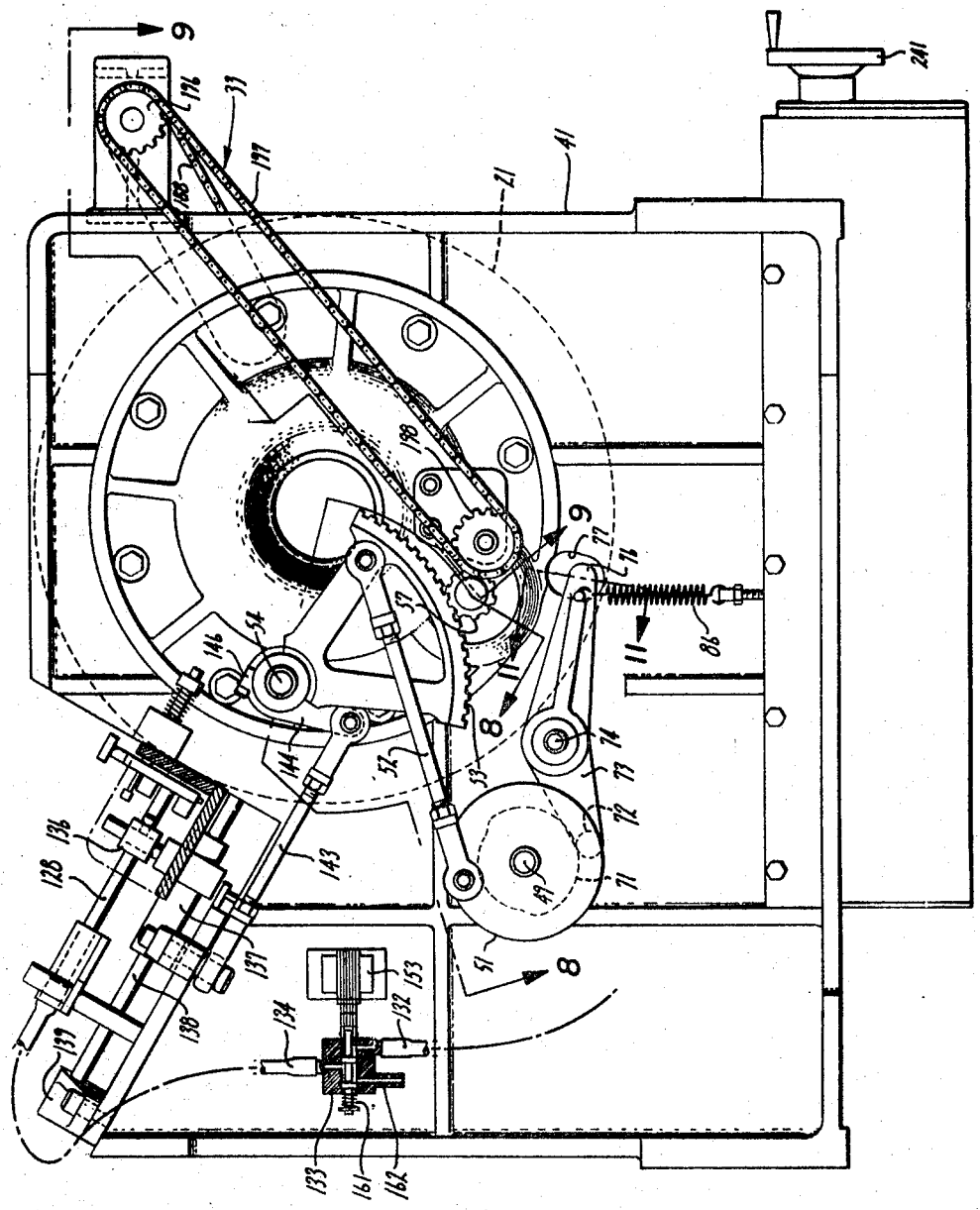



Fig. 3

INVENTOR.
Charles F. Forslund
BY Warren, Brosler, Cypher
+ anglim
Attorneys

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 4

Fig. 16

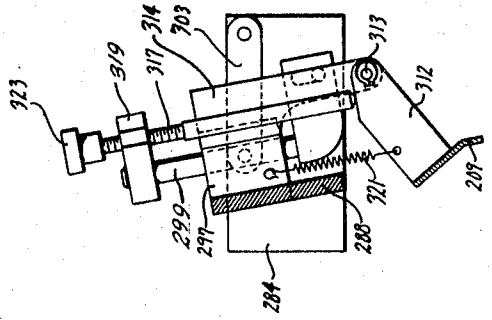


Fig. 4

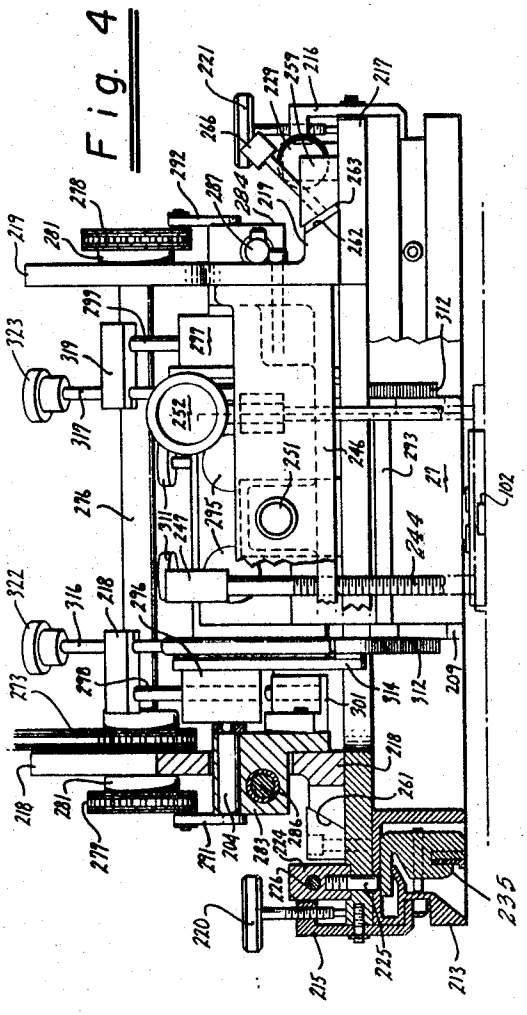


Fig. 12

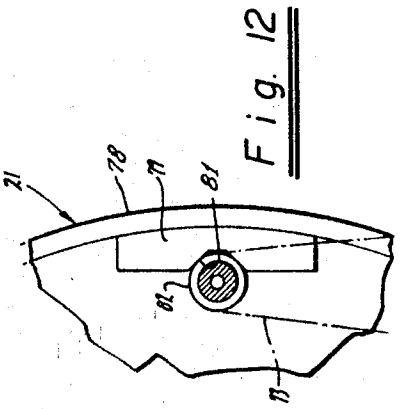
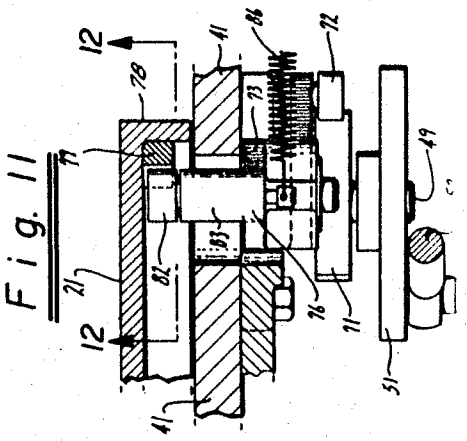


Fig. 11



INVENTOR.
Charles F. Forslund
By Warren, Brosler, Cypher & Anglim.
Attorneys

Aug. 5, 1969 C. F. FORSLUND 3,459,125

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 5

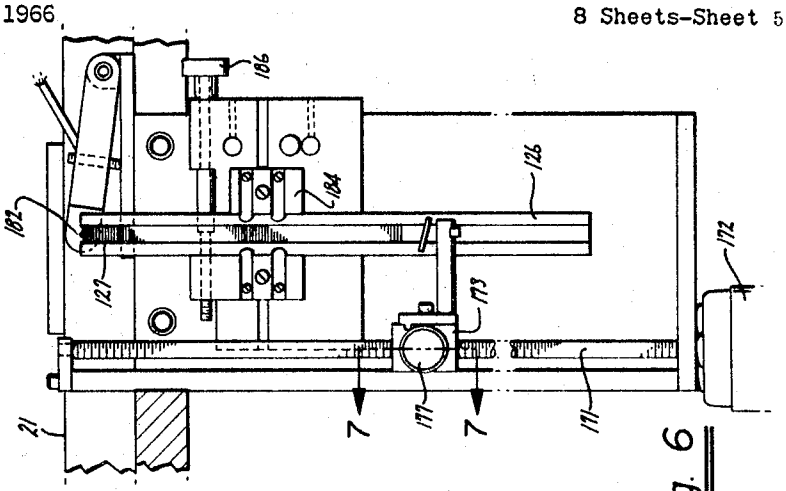



Fig. 6

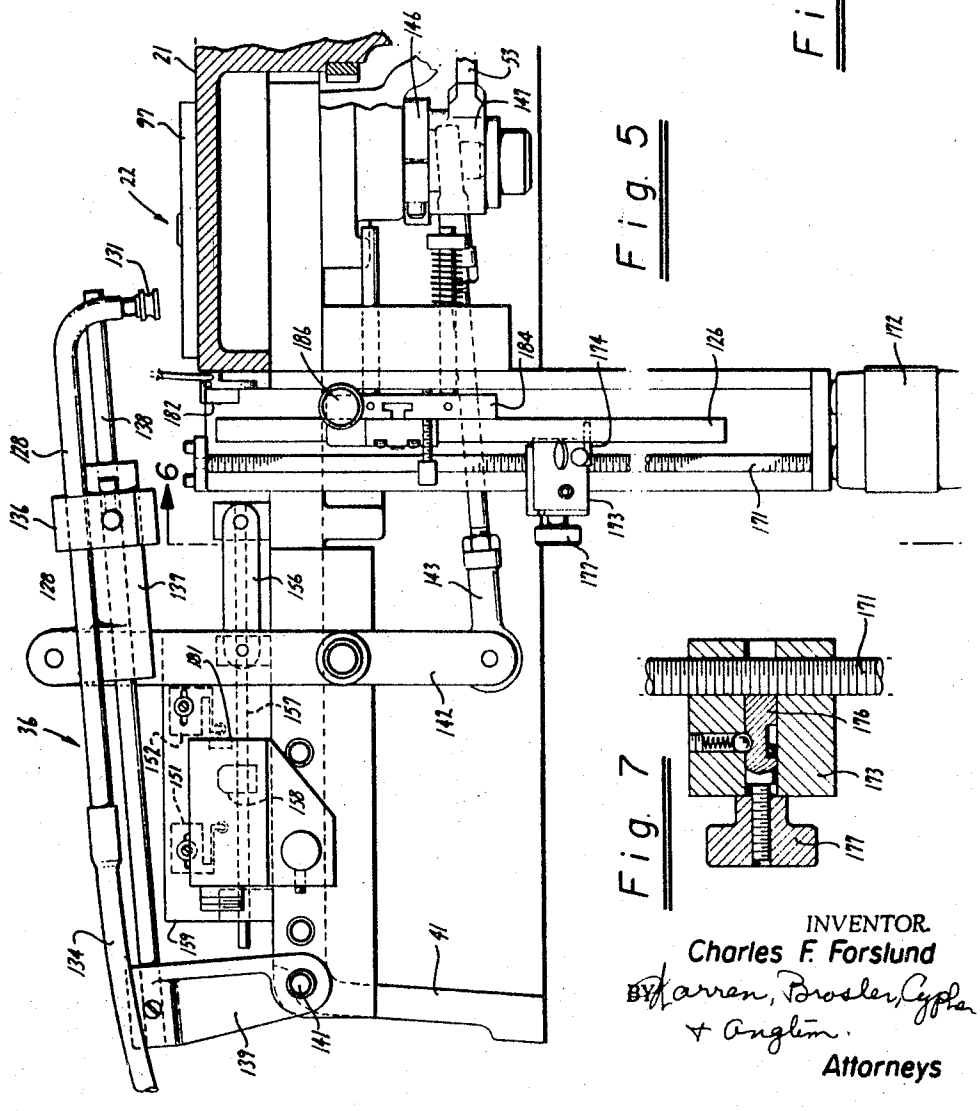



Fig. 5




Fig. 7

INVENTOR.
Charles F. Forslund
BY Warren, Brosler, Cyphers & Anglim.
Attorneys

Aug. 5, 1969 C. F. FORSLUND 3,459,125

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 6

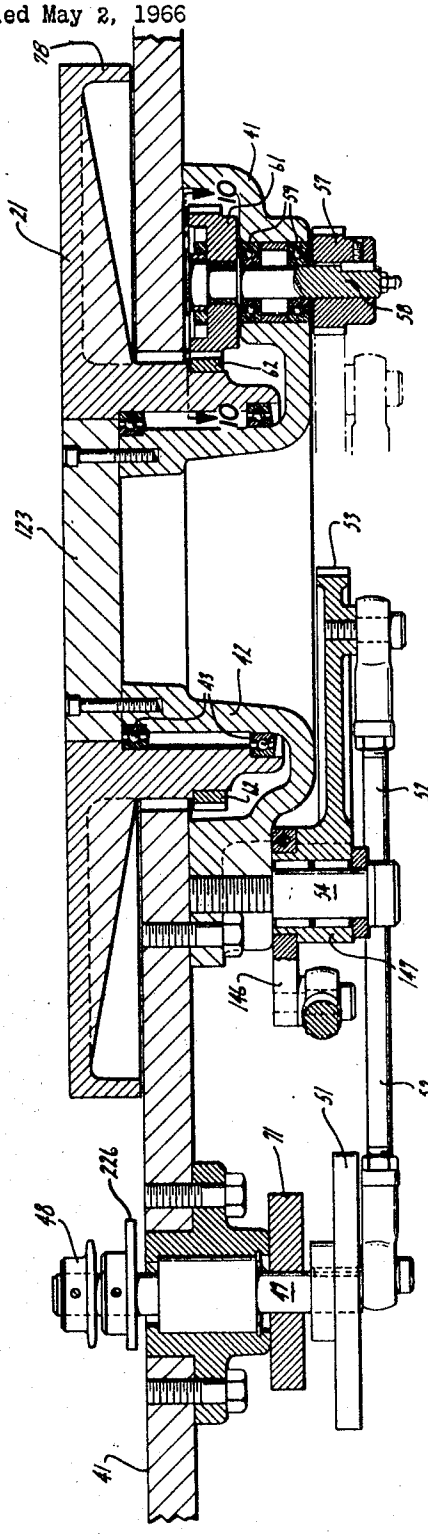


Fig. 8

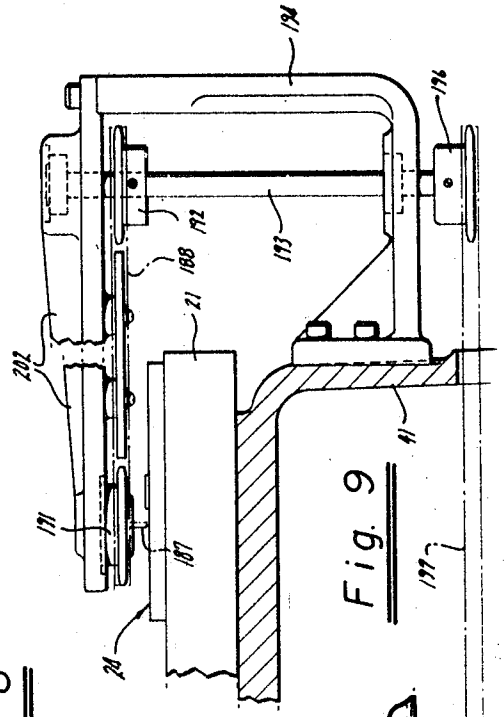


Fig. 9

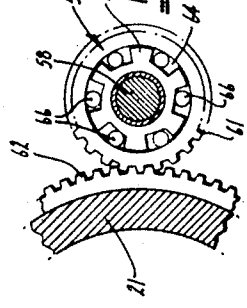
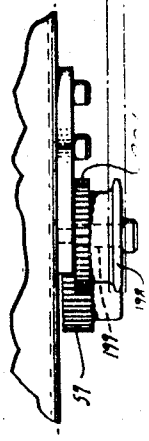


Fig. 10



INVENTOR.
Charles F. Forslund
By Warren, Brosler, Cypher + Anglim
Attorneys

Aug. 5, 1969 C. F. FORSLUND 3,459,125

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 7

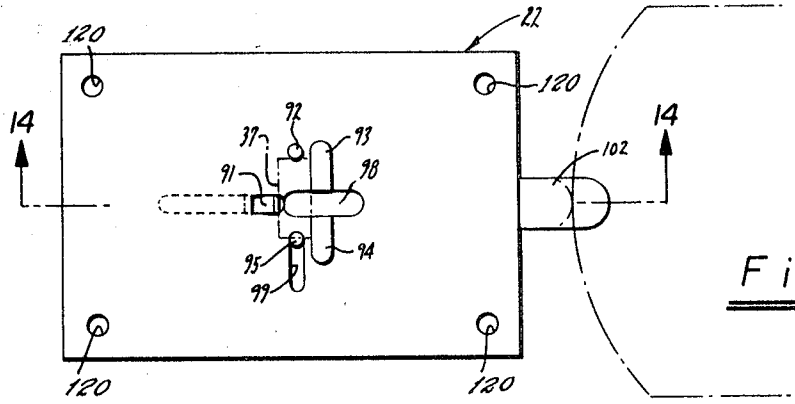



Fig. 13

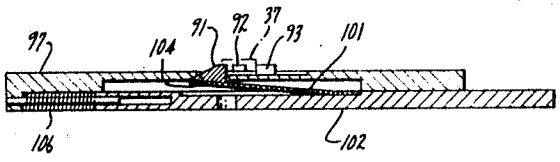



Fig. 14

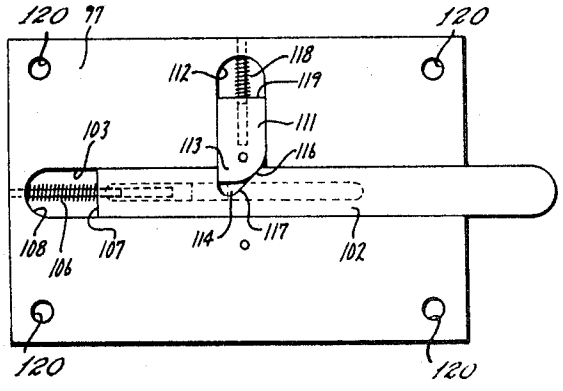



Fig. 15

INVENTOR.
Charles F. Forslund
By Warren, Brosler, Cypher
+ Anglim
Attorneys

SCREEN PRINTING MACHINE

Filed May 2, 1966 8 Sheets-Sheet 8

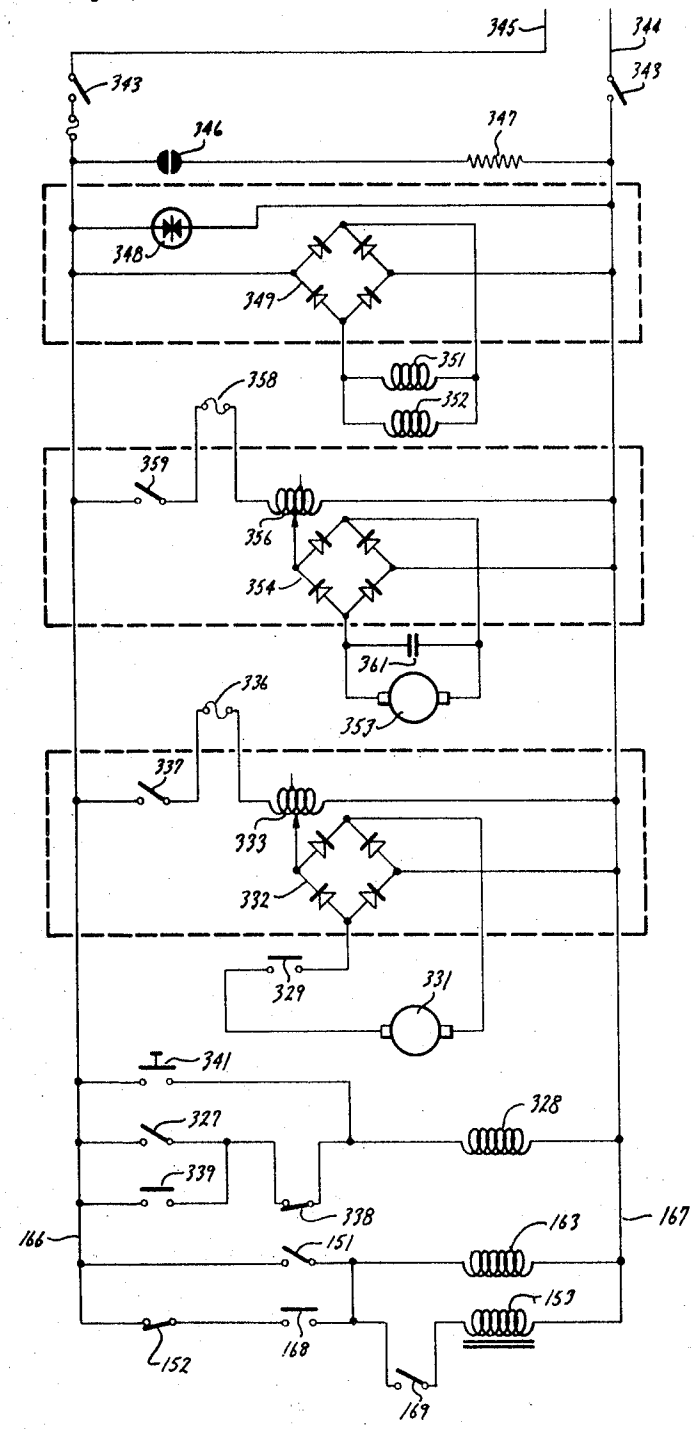



Fig. 17

INVENTOR.
Charles F. Forslund
BY Warren, Brosler, Cypher + Anglim
Attorneys

United States Patent Office 3,459,125 Patented Aug. 5, 1969



3,459,125

# SCREEN PRINTING MACHINE

Charles F. Forslund, 3510 Rubin Drive, Oakland, Calif. 94602

Filed May 2, 1966, Ser. No. 546,841
Int. Cl. B41f 15/26; B41l 21/02
U.S. Cl. 101—35 9 Claims

## ABSTRACT OF THE DISCLOSURE

A machine for imprinting boards, such as ceramic wafers with a squeegee moving over a printing screen. A turntable is formed with circumferentially spaced board receiving, board printing and board delivery stations, and a motor drive mechanism intermittently advances the turntable so that during each rest period the boards on the turntable are located at the several stations. During each rest period, a locking mechanism registers one of the boards at the printing station with the printing screen; pick up means place a new board on the turntable at the receiving station; and an ejector at the delivery station removes the board printed during the preceding rest period. A motor for driving the squeegee is energized during the rest period to move the squeegee over the printing screen and thereby imprint the board at the printing station.

The invention relates to screen printing machines and more particularly to those designed to screen print electronic circuit boards, ceramic substrates, cermets, and the like.

An object of the present invention is to provide a screen printing machine of the character described which will automatically print small parts as above-mentioned with precise repeatability and to very close tolerances as required for microcircuitry and components.

Another object of the present invention is to provide a screen printing machine as described above which will produce parts of high quality in high speed production.

A further object of the present invention is to provide a screen printing machine of the character described which is sturdily built to ensure dependable, trouble-free operation over long production runs.

The invention possesses other objects and features of advantage, some of which with the foregoing will be set forth in the following description of the preferred form of the invention which is illustrated in the drawings accompanying and forming part of this specification. It is to be understood, however, that variations in the showing made by the said drawings and description may be adopted within the scope of the inventiion as set forth in the claims.

Referring to said drawings:

FIGURE 1 is a plan view of a screen printing machine constructed in accordance with the present invention.

FIGURE 2 is a cross-sectional view of the machine taken substantially on the plane of line 2—2 of FIGURE 1.

FIGURE 3 is a bottom view of the machine.

FIGURE 4 is a fragmentary cross-sectional view of the machine taken substantially on the plane of line 4—4 of FIGURE 1.

FIGURE 5 is a side elevation of a portion of the machine as suggested by line 5—5 of FIGURE 1.

FIGURE 6 is a cross-sectional view of the portion of the machine illustrated in FIGURE 5 and is taken substantially on the plane of line 6—6 of FIGURE 5.

FIGURE 7 is a fragmentary cross-section of a portion of the machine shown in FIGURE 6 taken substantially on the plane of line 7—7 of FIGURES 6.



FIGURE 8 is an opened out cross-sectional view of a portion of the machine as seen in FIGURE 3 and is taken substantially on the plane of line 8—8 of FIGURE 3.

FIGURE 9 is a cross-sectional view of a portion of the machine illustrated in FIGURE 3 and is taken substantially on the plane of line 9—9 of FIGURE 3.

FIGURE 10 is a fragmentary cross-section of a portion of the machine illustrated in FIGURE 8 and is taken substantially on the plane of line 10—10 of FIGURE 8.

FIGURE 11 is a cross-sectional view of a portion of the machine as illustrated in FIGURE 3 and is taken substantially on the plane of line 11—11 of FIGURE 3.

FIGURE 12 is a fragmentary cross-sectional view of a portion of the machine taken substantially on the plane of line 12—12 in FIGURE 11.

FIGURE 13 is a plan view of one of the board receiving nests as seen in FIGURE 1 but on a somewhat enlarged scale.

FIGURE 14 is a cross-sectional view of the portion of the machine shown in FIGURE 13 and is taken substantially on the plane of line 14—14 of FIGURE 13.

FIGURE 15 is a bottom view of the board receiving nest as seen in FIGURE 13.

FIGURE 16 is a fragmentary cross-sectional view on an enlarged scale of a portion of the apparatus taken substantially on the plane of line 16—16 of FIGURE 1.

FIGURE 17 is an electrical wiring diagram of the machine.

The screen printing machine of the present invention is arranged with circumferentially spaced board receiving or loading, board printing, and board delivery or ejection stations; a turntable 21 and a plurality of board receiving means 22, 23 and 24 thereon mounted for movement to and between the several stations; screen printing means 26 mounted at the printing station and including a squeegee 27 (see FIGURE 2) and motor drive 28 therefor providing a pass for impressing an appropriate fluid material, herein generally referred to as ink, onto a board 31 positioned in registration therewith; delivery or ejection means 32 removing boards from the board receiving means 22–24 at the delivery station; motor drive means shown generally in FIGURE 3 for rotating turntable 21 and having regular periods of drive and rest for advancing the several board receiving means in steps into successive registration with the printing station; and means phased in its operation with the turntable drive for energizing the squeegee motor drive 28 for effecting a squeegee pass during each rest period.

The several board loading, printing and ejection stations are positioned in equally circumferentially spaced intervals with the turntable mounted for rotation concentrically of the stations, and the several board receiving means 22–24 are mounted in equally spaced intervals on the turntable for simultaneous registration with the station. Accordingly, the loading, printing and ejectoin cycles of the machine may take place simultaneously to permit a high production rate of printed parts. A chain drive 33, see FIGURE 3, is provided for the delivery or ejection means 32 so as to provide a cycle of operation including a pass for removing a board from one of the board receiving means 22–24 located at the delivery or ejection station; and the operation of the chain drive 33 is phased with the turntable motor drive for effecting the board removal pass during each of the rest periods. Similarly, a board feeding or loading means 36, see FIGURES 1 and 5, is arranged to deliver an unprinted board 37 to board receiving means 22 located at the board loading station, and to do so during the rest period of the turntable. Consequently, during this rest period a board is delivered to the turntable at the board receiving station, a board is printed at the board printing station, and a printed board

is removed from the board delivery or ejection station.

The machine is here mounted on a base casting **41** providing a hub **42** upon which the turntable **21** is journalled by means of bearings **43**, see FIGURE 8. Motive power for rotating the turntable is obtained from an electric motor **44**, see FIGURE 1, which has a gear head **46** connected to a drive chain **47** in turn entrained around a drive sprocket **48** mounted on a drive shaft **49**, see FIGURES 1 and 3. At the underside of the base plate **41**, a drive wheel **51** is fitted on shaft **49** and which is in turn connected by a pivoted link **52** to a segmental gear **53** journalled on a stub shaft **54** on base plate **41**. Accordingly, continuous rotation of drive wheel **51** by motor **44** will be accompanied by an arcuate reciprocation of segmental gear through alternate forward and return strokes. Segmental gear **53** has a geared connection to the turntable which includes an overriding clutch **56**, see FIGURE 10, which provides the drive and rest periods of the turntable corresponding with the alternate strokes of the segmental gear **53**. As will be best seen in FIGURES 3 and 8, gear **53** is enmeshed with a pinion **57** mounted on a vertical shaft **58** journalled in bearings **59** carried by base plate **41**. A pinion **61** mounted on the upper end of shaft **58** is enmeshed with a ring gear **62** provided on turntable **21**. Clutch **56** is incorporated in the driving connection between shaft **58** and pinion **61**. As will be seen in FIGURE 10, a ball carrier plate **63** is fastened to shaft **58** for rotation therewith within a cylindrical chamber **64** provided in pinion **61**. A series of balls **66** is mounted in peripheral recesses formed in plate **63** and so shaped as to wedge outwardly the balls **66** into driving engagement with the internal wall of the cylindrical chamber **64** upon rotation of the shaft in a clockwise direction as viewed in FIGURE 10, and to release the driving engagement between the plate and wall in the reverse counterclockwise direction of motion of shaft **58**. Thus, on displacement of segmental gear **53** in one direction, the driving connection is made to turntable **21** so as to provide the drive period, and upon reverse direction of motion of the segmental gear **53** the turntable will be in its rest period.

As an important feature of the present machine, means is provided, as best seen in FIGURES 3, 11 and 12, for locking the turntable against movement with the several board receiving means in positive registration with the several stations of the machine at the conclusion of each of the turntable drive periods and to release the turntable for rotation at the end of each of the rest periods. As will be best seen from FIGURES 3 and 8, a cam **71** is mounted on shaft **49** and engages one end **72** of a bell crank lever **73** journalled at its midsection on a stub shaft **74** provided at the underside of the base casting **41**. The opposite end **76** of the bell crank lever extends into juxtaposition to an opening **77** in the base casting **41** adjacent to a peripheral flange **78** provided on the turntable, see FIGURES 11 and 12. A plurality of indexing blocks **79** equal in number to the number of stations of the machine are secured to the internal face of flange **78** and are each provided with a notch or recess **81** shaped with a taper to receive a roller **82** mounted on the upper end of an arm **83** provided on the end **76** of the bell crank lever **73** and which arm extends up through opening **77**. A spring **86** is connected between bell crank **73** and base plate **41** so as to constantly urge the bell crank in a clockwise direction as seen in FIGURES 3 and 12 thereby urging roller **82** into a nested position in recess **81** so as to provide the locked indexed position of the turntable. Cam **71** is provided with a pair of substantially semi-circular lobes which provides a two-position location of the bell crank with the roller swung outwardly into engagement with recess **81** and with the roller retracted inwardly out of such engagement.

As a further feature of the present machine, each board is firmly gripped in each of the board receiving means for very precise registration with the screen printing means. At the same time, the board receiving means are arranged to open up so as to release the boards therein at the board receiving and board delivery stations. For this purpose, each of the board receiving means **22–24** is provided with displaceable detent means, see FIGURES 13, 14 and 15, which is spring biased to board securing position; and means, see cams **87** and **88**, is provided at the receiving and delivery stations for displacing the detent means to board releasing position. With reference to FIGURES 13–15, it will be seen that each of the board receiving means, here means **22**, is provided with five spaced shoulders or stops **91**, **92**, **93**, **94** and **95**, which are mounted on a supporting plate **97** in an array providing a perimeter support for a board **37** shown in phantom lines as contained between the several stops. In the arrangement as illustrated stops **93** and **94** are spaced apart to provide a passageway **98** therebetween and stop **91** is mounted for movement to and from stops **93** and **94** and also upon movement away from such stops to drop down below the plane of plate **97** so that the delivery means at the delivery station may sweep through passageway **98** and slide the printed boards off from the turntable. It will also be noted that stop **95** is movable in slot **99** to and from stop **92**, and in accordance with the present structure is moved simultaneously with stop **91**. With reference to FIGURE 14 it will be seen that stop **91** is carried at the end of a leaf spring **101** for projecting up through an opening in plate **97**, and spring **101** is carried by a slide arm **102** mounted for reciprocation in a guide way **103** formed in the underside of plate **97**. Stop **91** is formed with a tapered face **104** which co-functions with a tapered edge of the opening in plate **97** through which stop **91** projects, see FIGURE 14, so that upon movement of arm **102** to the left, as seen in FIGURES 13–15, stop **91** will be caused to move downwardly to a position flush with or below the top surface of plate **97** so as to release the board **37** from its clamped position in the stop. It will be noted that in moving downwardly, stop **91** also moves to the left, that is away from stops **93** and **94**; and contrarywise in the return movement of arm **102**, stop **91** raises and moves toward stops **93** and **94** to effect clamping of board **37**. This return movement of arm **102** is here urged by spring **106** mounted in compression between the inner end **107** of arm **102** and the adjacent end **108** of guide way **103**.

Stop **95** is carried by a cross slide **111** mounted in a guide way **112** formed in the underside of plate **97** perpendicular to and intersecting guideway **103**. One end **113** of cross slide **111** is formed to enter a side recess **114** formed in arm **102** and the end and recess are provided with tapered confronting faces **116** and **117** which cofunction to urge cross slide **111** outwardly upon inward movement of arm **102**, thereby carrying stop **95** away from stop **92** simultaneously with the movement of stop **91** away from stops **93** and **94**. A spring **118** is mounted between an end **119** of cross slide **111** and adjacent end of guide way **112** so as to constantly urge slide **111** inwardly, that is, to maintain engagement of surfaces **116** and **117**. Each of the mounting plates **97** is secured to the turntable as by screws **121** mounted through openings **120** in the plate so as to locate the plates in registration with the printing screen when the associated indexing notch **81** is fixed in place by roller **82**.

As will be best seen from FIGURE 1, the board receiving means as illustrated in FIGURES 13–15 are mounted on the turntable so as to position the actuating arm **102** radially so as to locate an inner end **122** of each of the arms in position to engage and be displaced radially outwardly by cams **87** and **88** which are carried by a stationary center plate **123** fixed to the hub **42** of the base casting **41**, see FIGURES 1 and 8. Cams **87** and **88** are located at the board receiving and board delivery stations and are formed with cam surfaces **124** shaped and positioned to engage the inner ends **122** of slide arms **102** as the board receiving means approach the board receiving and board delivery stations so as to move the movable detents **91** and **95** to the open position of the board re-

ceiving means so as to effect receipt and discharge of the unprinted and printed boards.

The machine may be adapted for handling different size boards by simply changing the board receiving means assembly as shown in FIGURES 13–15. In this manner all types of circuit boards including ceramic wafers, substrates, cermets and the like can be handled for microcircuitry and components; and the term circuit board as used herein is intended to include these several items.

Means **36** provides for the automatic feeding of boards or chips to the board receiving nests as the latter arrive at the board receiving station as seen in FIGURE 1. This means, as best seen in FIGURES 1, 3, 5, 6 and 7, comprises a magazine **126** for holding a stack of chips **127**, see FIGURE 6, to be printed and presenting an uppermost exposed chip at the top of the stack adjacent the periphery of the turntable **21** at the receiving station for delivery to the nest for board receiving means **22** thereat; an arm **128** mounted for reciprocation between magazine **126** and the nest **22**; and means, here an air suction tip **131** carried by the arm for picking up the top exposed board at the magazine and releasing the board at nest **22**. The constantly operating vacuum pump or other source of reduced air pressure is connected by conduit **132** to a two-way solenoid operated valve **133** which is in turn connected by conduit **134**, see FIGURE 3, which is connected to one end of arm **128** here in the form of a hollow tube so as to communicate the vacuum source with tip **131** under the control of valve **133** so that the tip is communicated with the source when it is in juxtaposition to magazine **126** for picking up the top exposed chips and the tip is disconnected from the source when it is in juxtaposition to nest **22** for releasing the chips to the board receiving means.

As will be observed, arm **128** is mounted by bracket **136** to a side member **137** mounted for reciprocation on shaft **138** having one end supported in an arm **139** pivoted at **141** to the base plate **41** for arcuate upward and downward swinging of shaft **138** during reciprocation of slide **137** thereon. Slide **137** is here pivotally connected to the upper end of a vertically positioned lever **142** having its lower end pivotally connected to one end of link **143** which has its opposite end pivoted to a crank arm **144** fixed by clamp **146** to the hub **147** of segmental gear **53**, see FIGURES 3, 5 and 8. Accordingly upon reciprocation of the segmental gear, vacuum pick-up tip **131** will be carried reciprocally between the top of the magazine and the chip receiving nest **22**; and the forward movement of the tip, that is from the magazine to the nest is effected during the rest period of the turntable while the reverse movement from the nest to the magazine is effected during the drive period of the turntable.

A pair of micro-switches **151** and **152** is arranged for actuation adjacent the ends of the reciprocating stroke of arm **128** and is connected electrically to solenoid **153** for displacing valve **133**. As will be best seen in FIGURES 1 and 5, liner **142** is connected by link **156** to a slide rod **157** which carries an actuator **158** for reciprocal movement between the actuating arms of microswitches **151** and **152** which are mounted on a supporting plate **159** on the supporting base plate **41**. Valve **133**, see FIGURE 3, is normally biased by spring **161** to a position communicating conduit **134** to atmospheric port **162**. Upon energizing of solenoid **153** the valve spool is displaced to the right as seen in FIGURE 3, placing conduit **134** in communication with the vacuum source conduit **132**.

With reference to the electrical diagram, FIGURE 17 it will be seen that the rearwardly disposed switch **151** is connected in series with a relay coil **163** and power supply lines **166** and **167**. Switch **151** is normally open but is closed by actuator **158** at the retracted position of arm **128** to thereby energize relay coil **163** and close relay switch **168**. Forward switch **152** is normally closed and is connected to supply line **166** and relay switch **168** which is in turn connected back to relay coil **163** so as to hold the relay energized after the closing of switch **151** and until the opening of switch **152**. At the same time relay switch **168** is connected to a manually controlled toggle switch **169** located at the control panel of the machine and to solenoid **153** and supply line **167**. Accordingly, when switch **169** is closed, the closing of switch **151** will cause actuation of solenoid **153** and the holding of the solenoid actuated until switch **152** is opened. Switch **152** is moved to open position by actuator **158** at the forward end of its stroke which in turn de-energizes the relay **163** and solenoid **153** thereby causing valve **133** to shift under its spring bias to drop the chip into nest **22**.

Chips in stack **126** are moved upwardly as the uppermost chip is taken from the top of the stack. This is here effected by a vertically set lead screw **171** which is connected at its lower end for rotation by an electric motor **172**. A nut **173** is threaded on lead screw **171** and is provided with a finger **174** which enters magazine **126** to support the chip stack. Accordingly, upon rotation of lead screw **171** by motor **172**, finger **174** will be carried upwardly in the magazine to raise the stack of chips therein. Preferably, nut **173** may be manually raised and lowered on the lead screw and for this purpose is provided with a slidable thread engaging part **176** which may be moved to and from lead screw **171** by a manually controlled knob **177**, see FIGURE 7.

Energizing of motor **172** to raise the chip stack is under the control of a photoelectric actuator including a light beam source **181** mounted at an elevation to throw a light beam across the top of the chip stack and on to a photosensitive receiver **182**. An appropriate amplifier, not shown, is connected between receiver **182** and motor **172** so that the motor is energized so long as the light beam is received at an aperture at receiver **182** and is de-energized when the uppermost chip intercepts the light beam. Magazine **126** is here carried in a mounting bracket **184** which may be manually adjusted from time to time into precise positions by screw **186**.

The chip delivery means for removing printed chips from the turntable here includes a member **187**, see FIGURE 9, mounted at the delivery station for reciprocation through delivery and return strokes extending between the board receiving means **24** and exteriorly of the turntable for delivery to an external chute or conveyor (not shown). Member **187** is connected to the reciprocating drive means for the turntable for movement of the member through its delivery stroke during the rest period of the turntable and to its return stroke during the drive period of the turntable. The delivery mechanism includes a drive chain **188** to which member **187** is attached and which is entrained around a sprocket **191** mounted in superimposed relation to board receiving means **24** and a sprocket **192** mounted exteriorly of the turntable on the upper end of a vertical drive shaft **193** journalled in a bracket arm **194** fixed to the base plate **41**. A sprocket **196** is carried at the lower end of shaft **193** and is connected by chain **197** to a sprocket **198** mounted on stub-shaft **199** depending from the underside of base plate **41**. A pinion **201** connected to sprocket **198** is enmeshed with pinion **57**, see FIGURES 3 and 9, so that sprocket **198**, and the chain drive connected thereto is reciprocated by the forward and return strokes of the segment gear **53**. The extent of this reciprocation is such as to carry member **187** from a position internally of the chip nest to a position externally of the turntable; member **187** being dimensioned as hereinabove indicated to sweep through the nest and pick up the printed chip and carry it radially across the top face of the turntable to the outside periphery thereof for delivery to a chute or conveyor as may be desired. The reciprocating drive connection is such that the printed chip is removed from the turntable during its rest period. A horizontally extending arm **202** is carried by the upper end of bracket **194** and provides the support for the upper end of shaft **193** and sprocket **191**.

The screen printing means comprises, briefly, a screen

206, see FIGURE 2, mounted for positioning in superimposed relation over the board receiving means 23 at the delivery station; a substantially horizontally reciprocating mount 207 for squeegee 27 positioning the squeegee for reciprocation in superimposed relation over the screen; a flood bar 209 carried by the mount for reciprocation in superimposed relation over the screen; an electric motor 211 and reciprocating drive 212 connected to the mount for displacement thereof through forward and return strokes; and means displacing the flood bar 209 to and the squeegee from the screen 206 during the forward strokes so as to uniformly spread the ink over the screen, and to displace the flood bar from and the squeegee to the screen during the return stroke so as to effect a printing on the chip 31 mounted below the screen. The printing head is constructed substantially in accordance with the disclosure in my co-pending application Serial No. 432.528 for Screen Printing Apparatus and Method filed February 15, 1965, and reference is made to that application for a more complete showing of the corresponding parts.

Screen 206 is here mounted in a frame 213 which is engaged by clamps 215 and 216 to a sub-plate 217 which is in turn mounted on the opposite sides 218 and 219 of a main printing head supporting frame. Clamps 215 and 216 are provided with manually adjustable clamping screws 220 and 221 for easy and rapid attachment and detachment of the screen frame 213 to the sub-plate 217. Horizontally extending lead screws 226 and 227 are each carried in spaced upright supports 222 and 223 on plate 217 and are threaded through and intermediately positioned nut 224 fastened by pin 225, see FIGURE 4, extending through a slotted opening into engagement with the underlying frame 213. Manually engageable knobs 228 and 229 on the lead screws provide fore and aft adjustment of the screen, it being noted that the provision of such screws on the opposite sides of the screen permits both joint and individual adjustment of these sides. Precise adjustment of the screen by lead screws 226 and 227 is effected by loosening clamps 215 and 216 sufficiently to permit relative adjustment between the screen frame and plate 217; and after the desired adjustment has been effected, clamps 215 and 216 are tightened to hold the parts in adjustment. With reference to FIGURES 2 and 4, it will be seen that the edges of screen 206 are secured to supporting members 235 which are set at the four sides of the screen and are in turn mounted within frame 213 and are secured thereto by a series of screen tensioning screws 239.

Mounting of the sub-plate 217 to the undersides of the side arms 218 and 219 of the main printing frame is effected by a plurality of dovetail mounting blocks 256, 257, 258 and 259 mounted in pairs fore and aft of plate 217, and formed to fit in mated engagement with complementary surfaces as seen at 261 and 262 on side arms 218 and 219. Gibs as seen at 263, and tightening screws 266 and 267 therefor as seen in FIGURES 1 and 4 are used to secure plate 217 in place.

The rear extremities of frame sides 218 and 219 are supported in journals 231 and 232 mounted on a cross shaft 233 which is in turn supported at its opposite ends in vertical slide members 236 and 237 carried in vertical guides 238 and 239 supported in upright position on the base frame 41 of the machine. Slides 236 and 237 may be adjusted upwardly and downwardly by a hand wheel 241 so as to carry the rear end of the printing frame upwardly and downwardly to provide proper adjustment with respect to the turntable and chip thereon to be printed. The mechanical connection between hand wheel 241 and vertical slide members 236 and 237 is detailed in my co-pending application above-referred to and includes a geared drive to vertical lead screws 240 in the housing of vertical guides 238 and 239, a common connection being effected for simultaneous operation by transverse drive shaft 242. Transverse adjustment of the rear end of the printing frame may be effected by a micrometer head 243 provided on shaft 233 at the vertical slide member 237.

The forward end of the printing frame may be raised and lowered by a vertical set screw 244 threaded through a front side 246 of the frame and having its lower end supported on the top face of cam 87 and being provided at its upper end with a manually engageable knob 247 for precise adjustment of the elevation of the frame. Fore and aft adjustment of the printing screen may be effected by screw 248 carried by the front side 246 of the frame and threaded through an upright post 249 on sub-plate 217, screw 248 having a manually engageable knob 251 at its forward end for precise manual adjustment. Accordingly, very precise side to side, fore and aft, and up and down adjustments of the screen may be effected. Indicator gauges 252 and 253 are mounted front and rear to show the up and down adjustments of the printing frame; indicator gauge 254 is provided for showing the fore and aft adjustment of the screen; and micrometer head 243 will show the side to side adjustment of the screen.

The present machine operates on what is normally referred to as off-contact type printing in which a normal clearance is used between the screen and the parts to be printed. As the squeegee travels over the screen, it deflects the screen downwardly to the part to apply the ink and contact is established between the screen and the part at the tip of the squeegee. Proper printing pressure can be obtained by use of the adjustments above discussed. As the squeegee passes beyond the end of the part, the screen automatically elevates to its separated position.

With reference to FIGURES 1, 2 and 4, it will be seen that squeegee drive 28 comprises an electric motor 211 which is connected through a gear head 271 to a sprocket 272 connected by chain 273 to sprocket 274 mounted on a transverse drive shaft 276 extending between the side arms 218 and 219 of the main printing head frame. Motor 211 is mounted on a rear section of the frame so that the arms and motor and drive may be swung as a unit around shaft 233 as a center.

A pair of drive chains 277 and 278 is mounted at the outside of arms 218 and 219 and extends generally horizontally with the arms around fore and aft sprockets 281 and 282 as seen in FIGURE 2. The reciprocating mount 207 above referred to here consists of a pair of bushing members 283 and 284 which are slidably mounted for reciprocation on horizontally extending shafts 286 and 287 carried by arms 218 and 219 and which are interconnected by a cross plate 288 for movement fore and aft as a unit. A pair of links 291 and 292 is pivoted at one end to bushing members 283 and 284 and at their opposite ends to chains 277 and 278 so that the continuous motion of these chains around their supporting sprockets will be translated into a reciprocating motion of mount 207.

Squeegee 27 is here mounted between a pair of plates 293 and 294, the latter extending vertically above the top of the squeegee for attachment at its opposite side edges to vertically reciprocating mounting blocks 296 and 297 which are carried for vertical reciprocation upon shafts 298 and 299 supported at their lower ends by brackets seen at 301 in FIGURE 4.

Vertical reciprocation of blocks 296 and 297 and squeegee 27 attached thereto at the ends of travel of mount 207 is here effected by lever arms 302 and 303 see FIGURES 1 and 2, which extend from the pivot shafts as seen at 204 in FIGURE 4 for the forward pivoted ends of links 291 and 292. As will be best seen from FIGURES 2 and 4 blocks 296 and 297 will be displaced downwardly as the rearward ends of links 291 and 292 pass around the forward sprockets 281 in a clockwise direction; and contrary-wise the blocks will be displaced upwardly as the rear ends of links 291 and 292 pass around the rearwardly positioned sprockets 282 in a clockwise direction. Vertical adjustment of squeegee

27 relative to mounting blocks 296 and 297 may be effected by lead screws as best seen at 289 in FIGURE 2 and which are threaded through nut members 290 which are connected to clamping screws 295 carried by the squeegee mounting plate 294, it being noted that the connection is made through slotted openings provided in the back plate 288 of the mount. The lower ends of lead screws 289 are mounted in supporting members as seen at 309 in FIGURE 2; and the upper ends of the screws are fitted with knobs 311 to afford manual vertical raising and lowering of the squeegee.

A reverse reciprocal operation of floor bar 209 with respect to squeegee 27 is effected by mounting the opposite ends of flood bar 209 on lever arms as seen at 312 in FIGURES 2 and 16. These lever arms are pivoted as seen at 313 to the lower ends of bracket 314 mounted on the slide blocks 296 and 297 so that the pivoted ends of levers 312 will be carried up and down with the slide blocks. A pair of vertically set adjusting screws 316 and 317 is threaded through arms 318 and 319 carried by the upper ends of shafts 298 and 299 and extend downwardly to bear at their lower ends on levers 312, see FIGURES 2 and 16, intermediate their pivot point and flood bar 209. The levers are biased upwardly by springs 321 mounted in tension between levers 312 and mounting blocks 296 and 297. Consequently, pivots 313 will move downwardly with the squeegee thus causing levers 312 to fulcrum about the lower ends of screws 316 and 317, under the urging of spring 321 to raise flood bar 209; and contrarywise when pivots 313 move upwardly with the upward movement of the squeegee, levers 312 will be rotated in a counterclockwise direction as seen in FIGURE 16 so as the lower the floor bar 209. Precise setting of the flood bar in its lowermost position upon screen 206 may thus be controlled by manually adjusting screws 316 and 317 and manually engageable knobs 322 and 323 are provided on the upper ends of the screws for this purpose.

Reciprocation of the printing head assembly in properly phased relation to rotation of the turntable and its drive and rest periods is effected by a timing cam 326 mounted on the main drive shaft 49, see FIGURE 1, and which functions to engage and actuate at the proper time in the operating cycle a switch 327 to energize the printing head drive motor 211. Switch 327 as will be seen from the electrical diagram FIGURE 17 is normally open and is momentarily closed by a lobe on cam 326 and which energizes a relay 328 which has one of its normally open contacts 329 connected to a power source and armature 331 of motor 211. The power source is here a full wave rectifier 332 connected to power line 167 and a variable transformer 333 which is used to control the speed of the squeegee drive. An operating knob 334 is provided at the control panel, see FIGURE 1, for operating transformer 333; and the circuit is also controlled by a fuse 336 and a manually controlled master toggle switch 337 connecting the transformer to the other supply line 166, toggle switch 337 also being seen at the control panel in FIGURE 1.

As will also be seen from FIGURE 17, a normally closed switch 338 is connected in series with switch 327 and the relay coil 328; and one of the relay contacts, normally open is connected in parallel across switch 327. Upon closing of switch 327 by cam 326 relay 328 will be actuated to close contacts 329 and 339; and contact 339 will lock the relay in closed position until switch 338 opens. With reference to FIGURE 2 it will be seen that switch 338 is mounted just to the rear of sprocket 282 and in position to be actuated by the rearward end of link 291 as it passes around sprocket 282 in a clockwise direction. Thus, squeegee motor 211 once energized will continue to operate until the printing head assembly is displaced to its left-hand position, as seen in FIGURE 2, where switch 338 will open, thereby de-energizing relay 328 and opening contacts 329 de-energizing the armature 331 of motor 211. A normally open manually operable switch 341 is connected from supply line 166 to relay coil 328 and may be operated from the control panel in order to manually start and stop the printing head assembly for making necessary adjustments in the several parts as hereinabove described. This switch will remain open during the normal automatic operation of the machine.

Referring to the balance of the electrical schematic diagram as shown in FIGURE 17 a master control switch 343 connects power lines 166 and 167 to the supply lines 345 and 344. This switch is located at the control panel as is also a pilot light 346 which shows the power to be on and which is connected across the power lines in series with resistor 347. Also connected across power lines 166 and 167 is a thyrector 348 and a full wave rectifier 349 which supplies power to the field windings 351 and 352 of the turntable motor 44 and the squeegee drive motor 211.

Preferably a manually operable speed control is provided for the turntable drive motor which in turn controls the operating speed of the overall cycle of the machine. As shown in FIGURE 17, power for the armature 353 of the turntable drive motor is received from a full wave rectifier 354 which is in turn energized by a variable transformer 356, the control knob 357 of which will be seen at the control panel in FIGURE 1. Transformer 356 is connected to the power supply line through a fuse 358 and a manually controlled toggle switch 359 which will also be seen at the control panel. A capacitor 361 is here connected across armature 353. Other switches 362 and 363 are provided at the control panel for operating the chip magazine lift motor 172 and for turning on and off of the vacuum pump connected to the vacuum pick-up tip 131 of the feed mechanism.

I claim:

1. In a machine for screen printing circuit boards and including a turntable having a plurality of board receiving means mounted thereon, board loading means and motor operated screen printing means and board ejection means circumferentially disposed of said turntable at board loading and board printing and board ejection stations respectively, motor driven means for rotating said turntable and having regular periods of drive and rest and being correlated with said board receiving means to advance the latter in steps into successive registration with said printing station, and means phased in its operation with said motor driven means for energizing said motor operated printing means for impressing ink onto a board registering therewith, wherein said board receiving means comprises, detent means carried by said turntable for determining the position of said boards thereon and having radially extending arms displaceable radially outwardly to a board releasing position, spring means biasing said arms to board securing position, and camming means at said board loading and board ejection stations for engagement with and outward displacement of said arms.

2. A machine as defined in claim 1, wherein said board receiving means and detent means comprises a plurality of fixed and movable stops positioned for engaging the periphery of said board and said moveable stops being biased for clamping said board, and said arms being connected for displacement of said movable stops away from said board periphery.

3. A machine as defined in claim 2, wherein said stops are mounted for movement of boards radially of said turntable into and out of engagement with said stops at said loading and ejection stations.

4. A machine for screen printing circuit boards and having circumferentially spaced board loading and board printing and board ejection stations which comprises; a turntable and a plurality of board receiving means thereon mounted for determining the position of boards on said table and for movement of said means to said stations; screen printing means mounted on said printing station and including a squeegee and a motor drive therefore providing a path impressing ink onto a board positioned in

registration therewith; ejection means for removing said boards from said board receiving means at said ejection station; a motor driven means for said turntable having a motor and a segmental gear having a geared connection to said turntable and reciprocating drive means connecting said motor and gear for driving said gear through alternate forward and return strokes and a clutch mounted in said geared connection and providing regular periods of drive and rest corresponding with alternate strokes of said gear and being correlated with said board receiving means to advance the latter in steps into successive registration with said printing station; and means phased in its operation with said motor driven means for energizing said squeegee motor drive for effecting said squeegee pass during each rest period.

5. A machine as defined in claim 4, a magazine for holding a stack of boards to be printed and presenting an exposed board at the end of the stack adjacent the periphery of said turntable at said loading station for delivery to said board receiving means thereat, an arm mounted for reciprocation between said magazine and board receiving station, and means carried by said arm for picking up said exposed board at said magazine and releasing said board at said board receiving means, said arm being connected to said reciprocating drive means for delivery of said board to said board receiving means during said rest period and for return movement of said arm during said drive period.

6. A machine as defined in claim 4, means providing a plurality of indexing notches on said turntable circumferentially distributed thereon according to said stations, a roller mounted for reciprocation into and out of seated engagement with one of said notches brought into registration therewith for precisely setting and locking the rotational position of said turntable, cam drive means connecting said roller to said motor for movement of said roller to said seated position at the conclusion of each turntable drive period and withdrawing said roller from said seated position at the end of each rest period.

7. A machine as defined in claim 4, wherein said ejection means comprises, a member mounted at said ejection station for reciprocation through delivery and return strokes extending between said board receiving means and exteriorly of said turntable and being formed and positioned to engage and remove a board during its delivery stroke, said member being connected to said reciprocating drive means for movement of said member through its delivery stroke during said rest period and through its return stroke during said drive period.

8. A machine as defined in claim 7, a chain drive at said ejection station including a sprocket mounted in superimposed relation to said board receiving means and a sprocket mounted exteriorly of said turntable and a chain entrained on said sprocket, said member being carried by and depending from said chain, and drive means connecting said chain drive to said segmental gear for displacing said member through its delivery and return strokes upon reciprocation of said segmental gear.

9. A machine for screen printing circuit boards and having circumferentially spaced board loading and board printing and board ejection stations which comprises, a turntable and a plurality of board receiving means mounted thereon for determining the position of board on said turntable and for movement of said means to said stations, screen printing means mounted at said printing station and including a squeegee and a motor drive therefor providing a pass impressing ink onto a board positioned in registration therewith, ejection means for removing said boards from said board receiving means at said ejection station, motor driven means for rotating said turntable and having regular periods of drive and rest and being correlated with said board receiving means to advance the latter in steps into successive registration with said printing station, means providing a plurality of indexing notches on said turntable one associated with each of said board receiving means, a roller mounted for reciprocation into and out of seated engagement with said notches upon rotation of said turntable for locking the rotational position of said turntable and functioning when in engagement with a notch to locate its associated board receiving means in precise registration with said screen printing means, drive means connecting said roller and motor driven means for movement of said roller to said seated position at the conclusion of each turntable drive period and withdrawing said roller from said seated position at the end of each rest period, and means phased in its operation with said motor driven means for energizing said squeegee motor drive for effecting said squeegee pass during each rest period.

**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 382,637 | 5/1888 | Curtis | 192—45 |
| 521,749 | 6/1894 | Williams. | |
| 1,929,549 | 10/1933 | Glass | 101—408 |
| 1,963,850 | 6/1934 | Johnston | 101—43 |
| 2,966,115 | 12/1960 | Arelt | 101—126 |
| 3,263,603 | 8/1966 | Fuchs | 101—123 |


ROBERT E. PULFREY, Primary Examiner

CLIFFORD D. CROWDER, Assistant Examiner

U.S. Cl. X.R.

101—123, 407; 214—1; 221—211; 269—254