United States Patent [19]

Jaffa

[11] **3,889,595**

[45] **June 17, 1975**

[54] **CONTINUOUS ROTARY SCREEN PRINTING METHOD AND APPARATUS**

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[73] Assignee: **Precision Screen Machines Inc.,** Hawthorne, N.J.

[22] Filed: **July 3, 1972**

[21] Appl. No.: **268,522**

[52] **U.S. Cl.** **101/116;** 101/118; 101/126; 101/129; 101/181; 242/58.4

[51] **Int. Cl.** **B41l 13/16;** B41f 15/10; B41f 15/24

[58] **Field of Search** ..... 101/116, 182, 115, 181, 101/126, 120, 129, 119, 228, 178, 248, 219, 416 A; 226/113, 114, 118; 242/58.1, 58.4, 75.3

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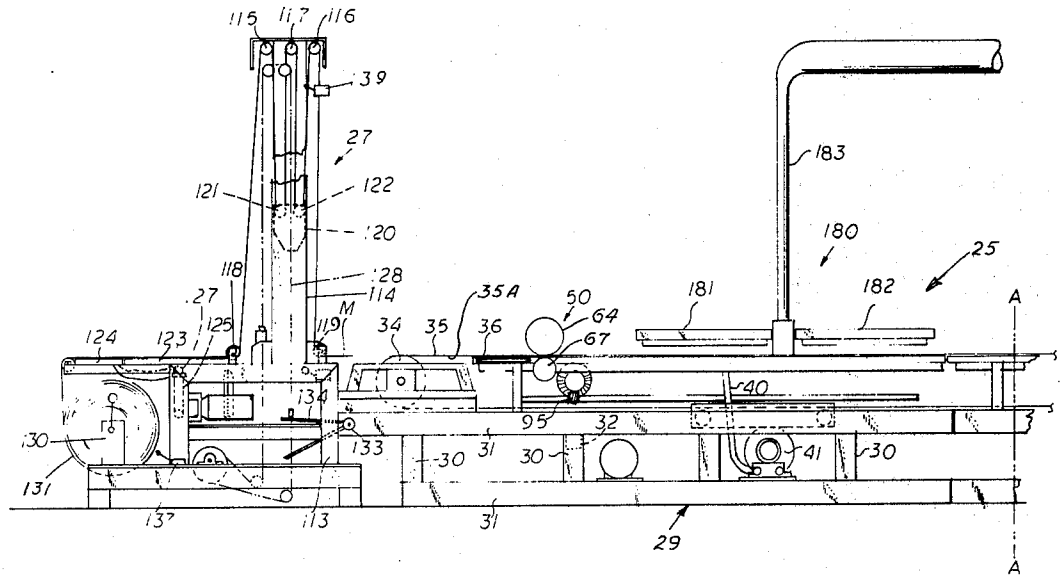
Primary Examiner—Edgar S. Burr
Assistant Examiner—R. E. Suter

[57] **ABSTRACT**

This disclosure is directed to a method and apparatus for screen printing in which a continuous sheet or web of material to be printed is advanced in the direction of feed relative to a rotating cylindrical printing screen to effect a continuous screen print in which both the rotation of the screen and the direction of feed of the material is reversed a predetermined amount each time the screen printing operation is interrupted for any reason. Upon commencing a successive printing operation, the method and apparatus operate to lower the printing screen as it rotates in a printing direction onto the advancing material so that the rotating screen effects registration with the advancing trailing edge portion of a previously printed portion of web to effect an overprint of the previously printed surface resulting in the avoidance of any smearing and/or waste between successive screen prints. The method and apparatus further contemplate a feed and unwind system operatively associated to facilitate splicing of successive rolls and/or effecting the removal of successive rolls of printed material without interruption of the printing operation.

11 Claims, 22 Drawing Figures



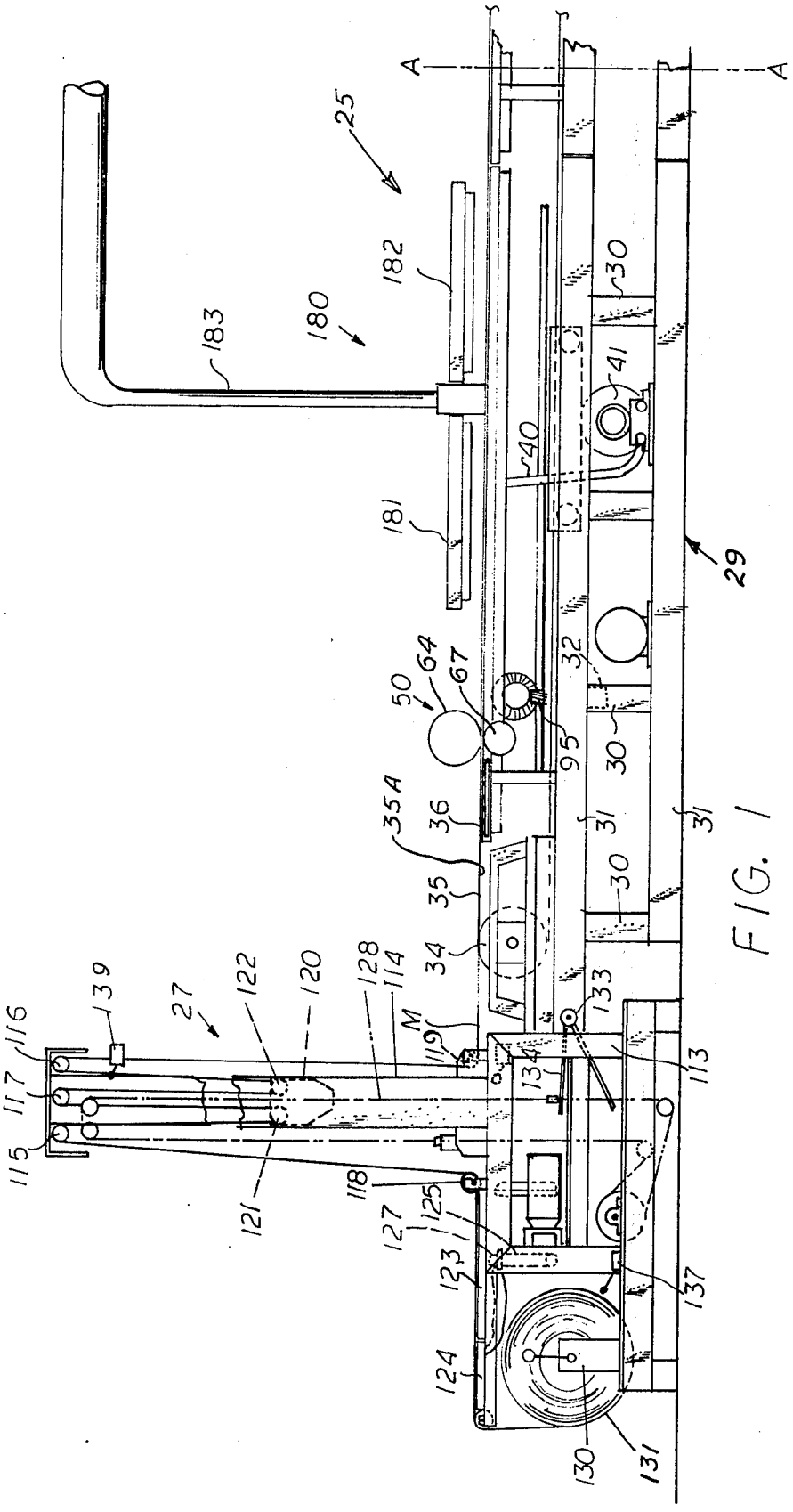

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FIG. 1

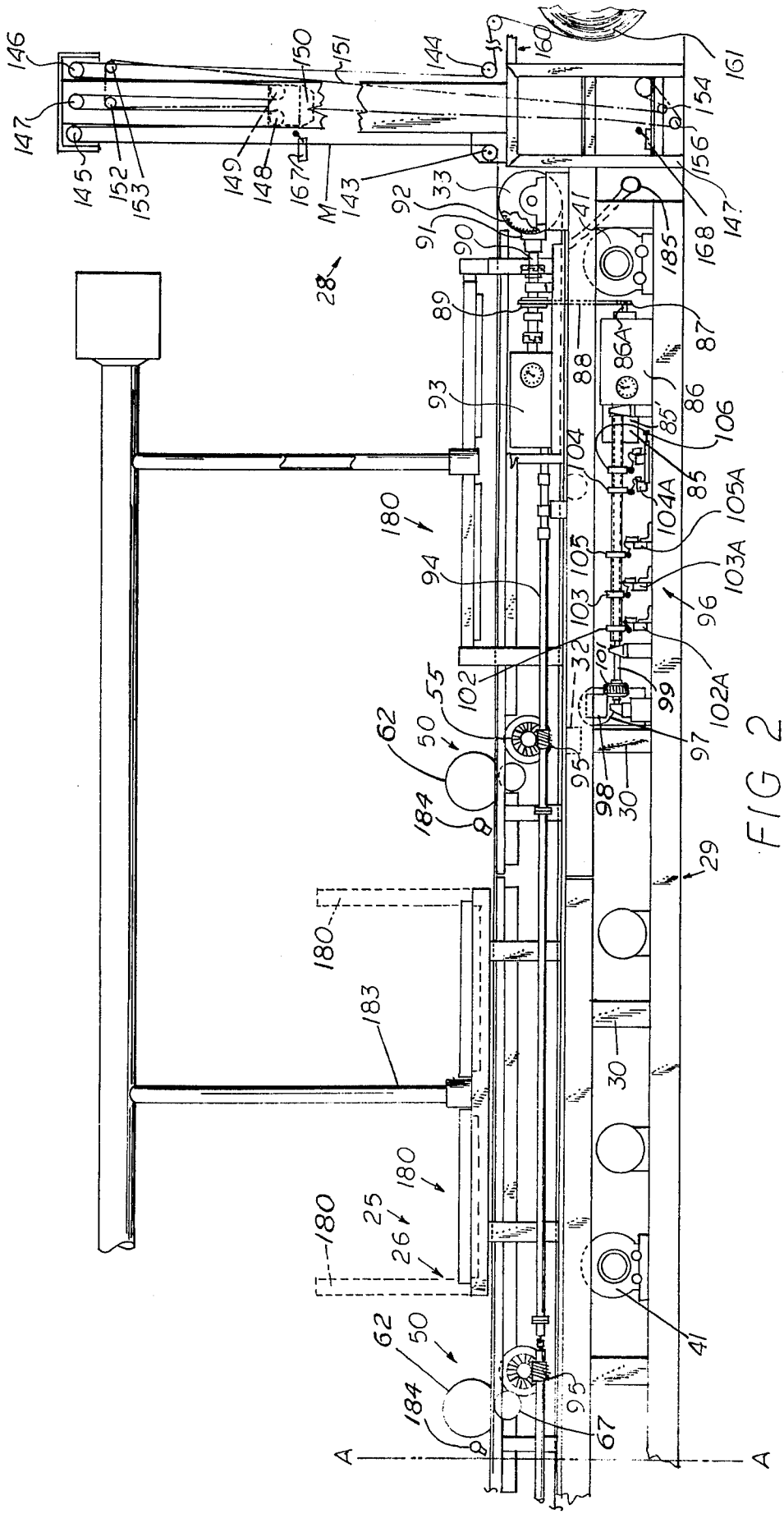
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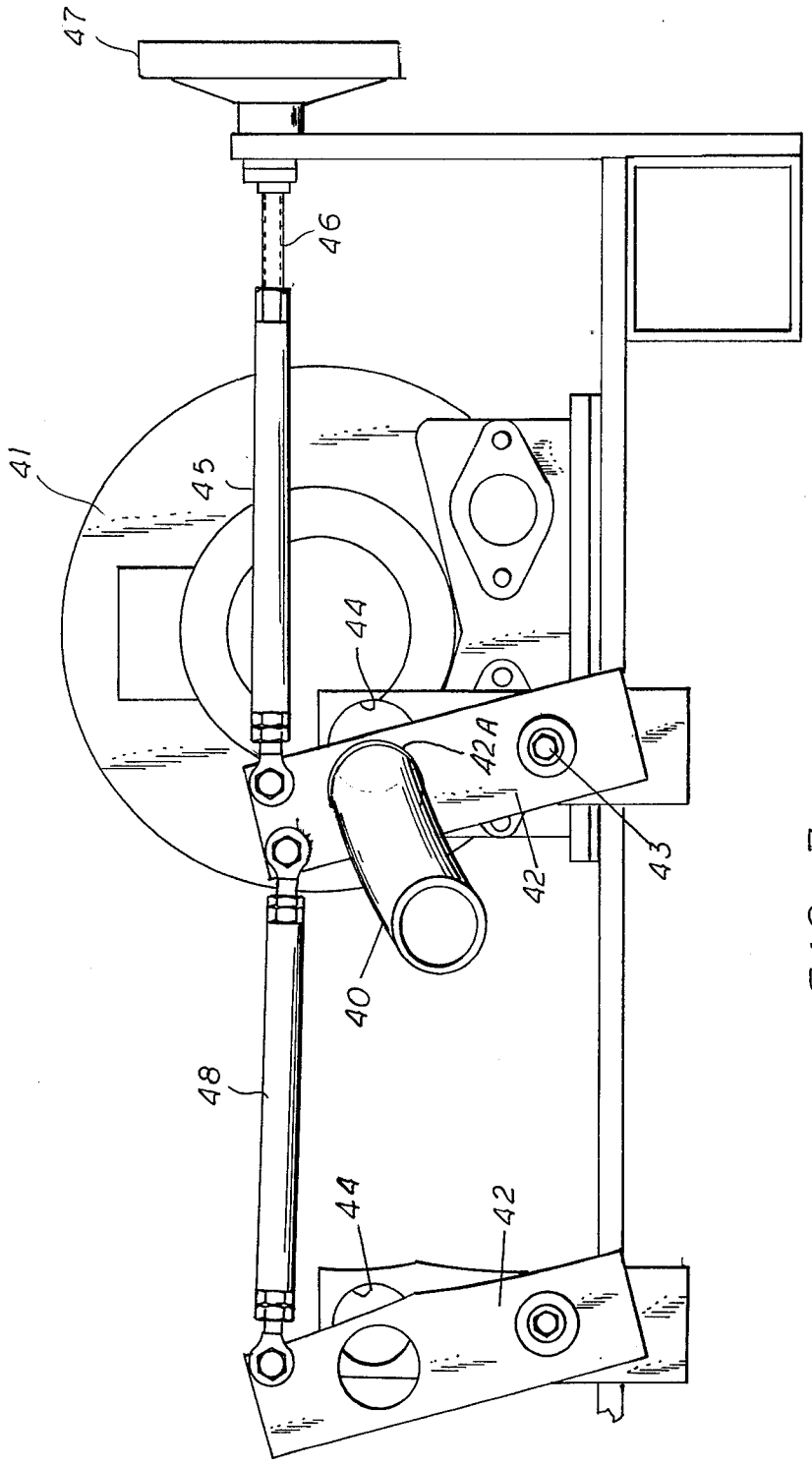
FIG 2



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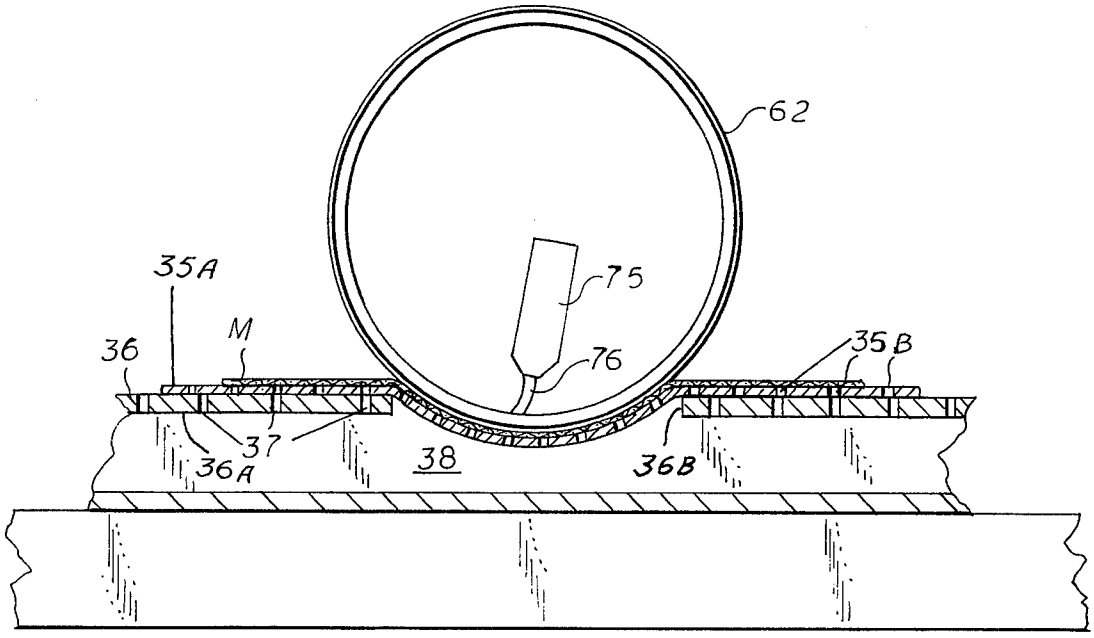

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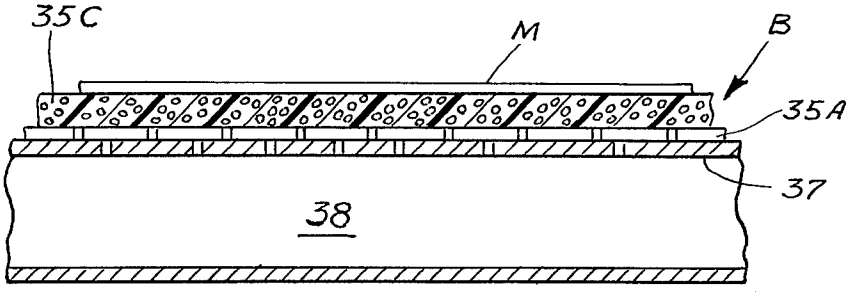

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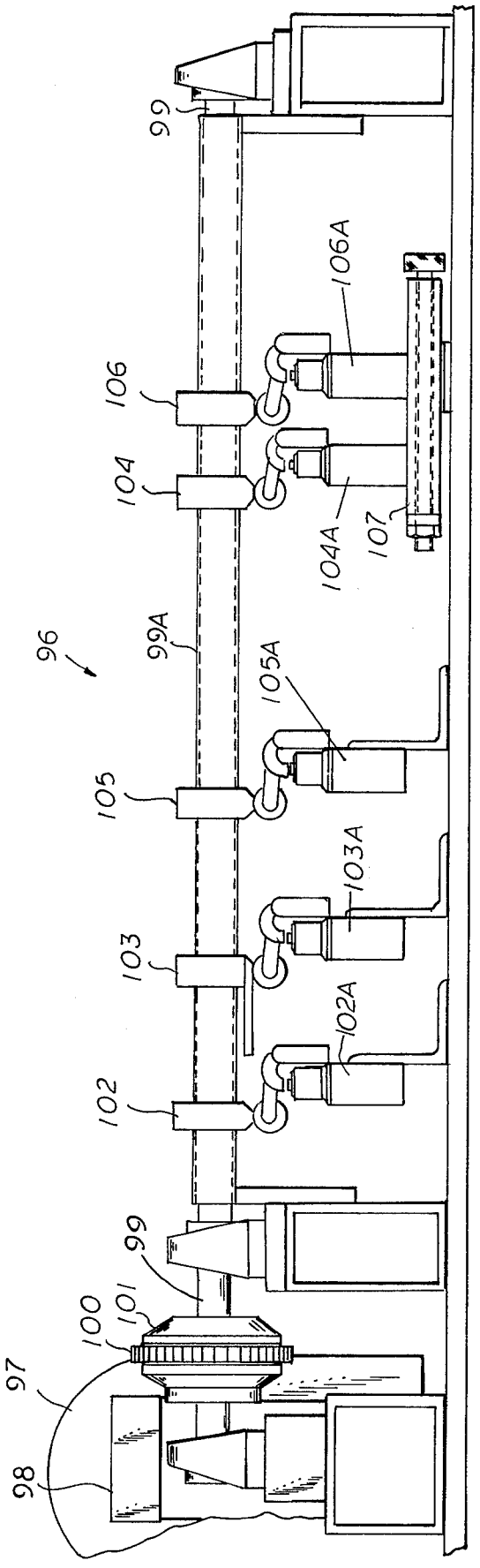
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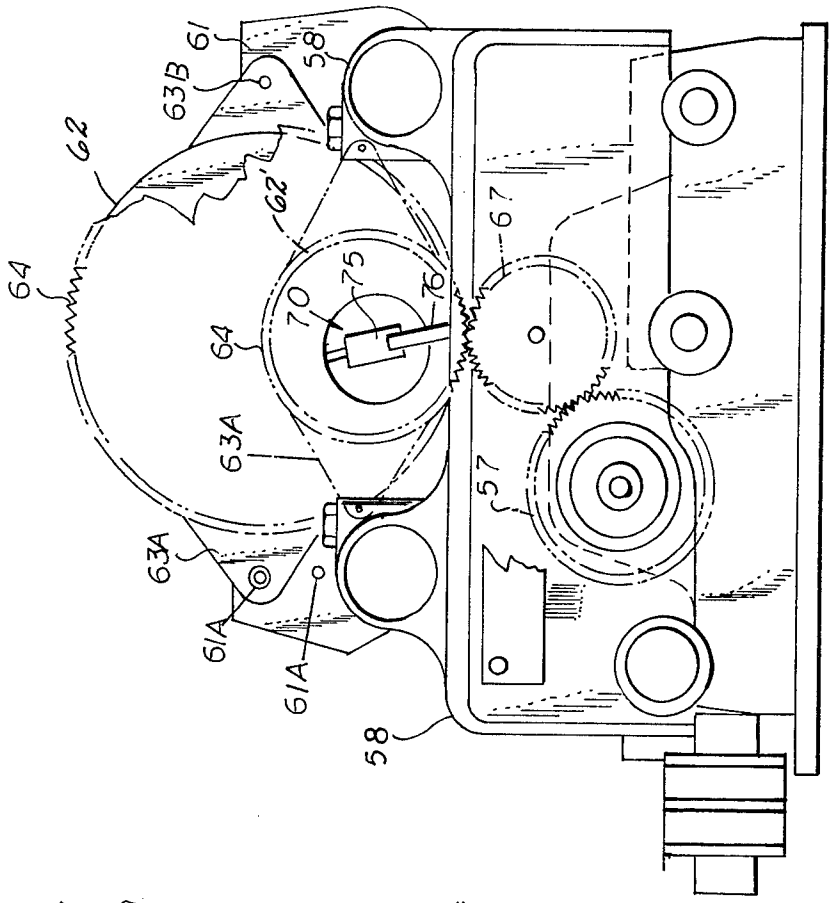
FIG. 5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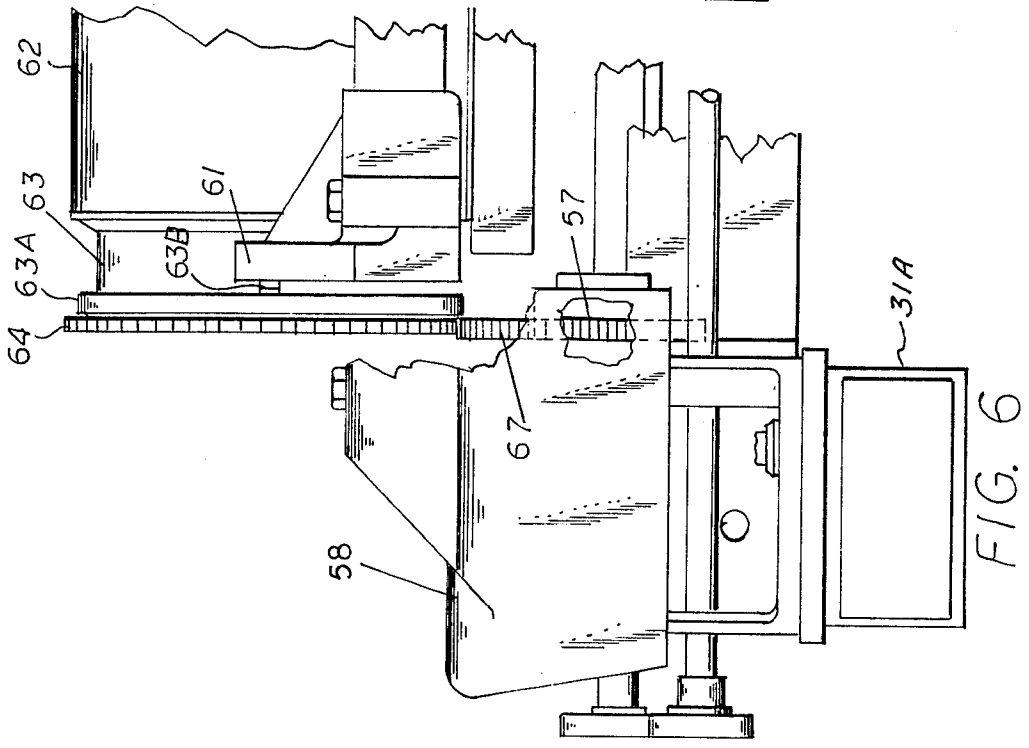
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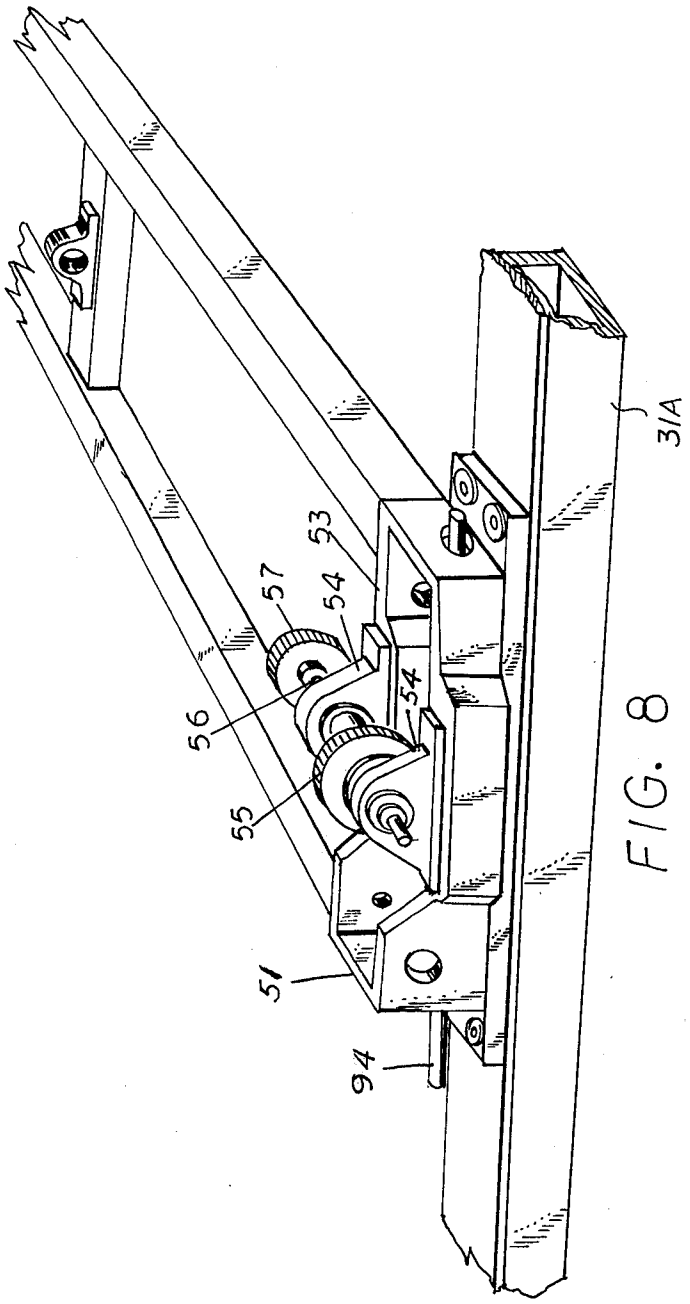
FIG. 6



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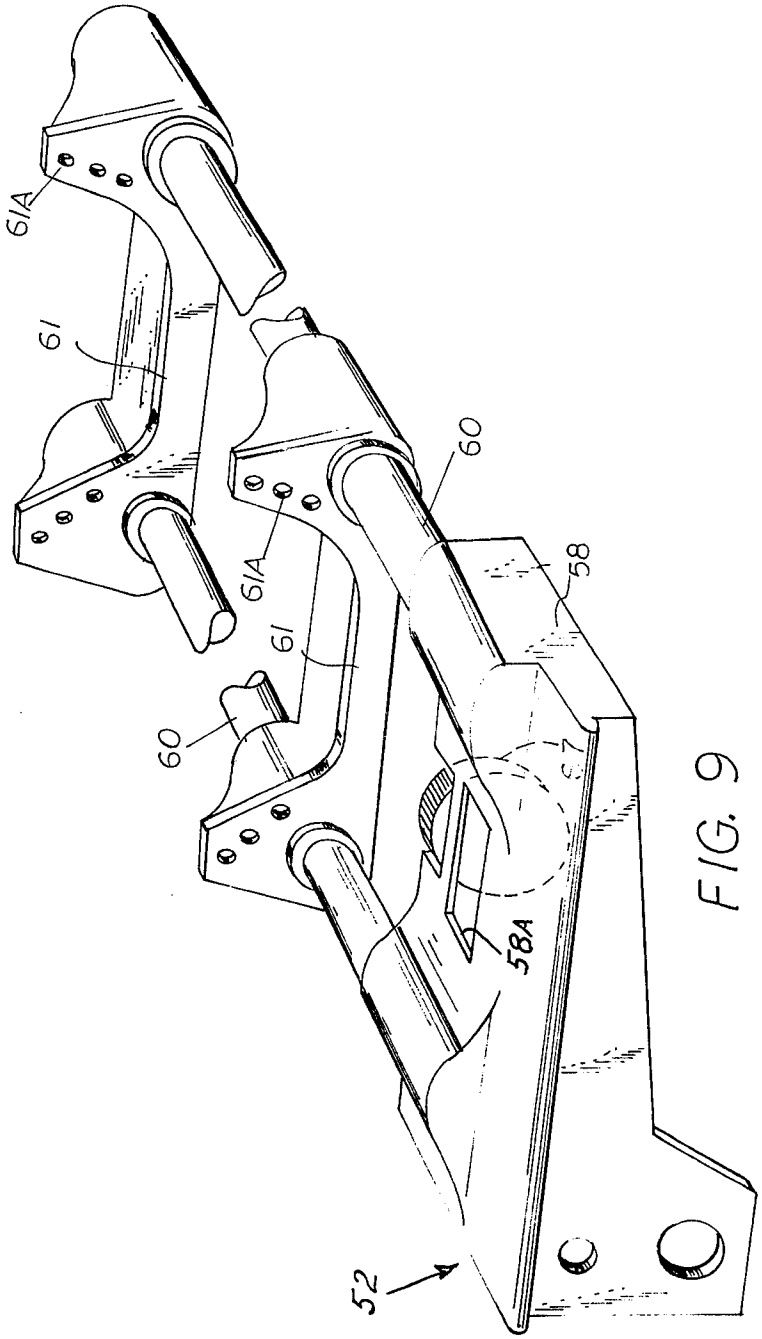

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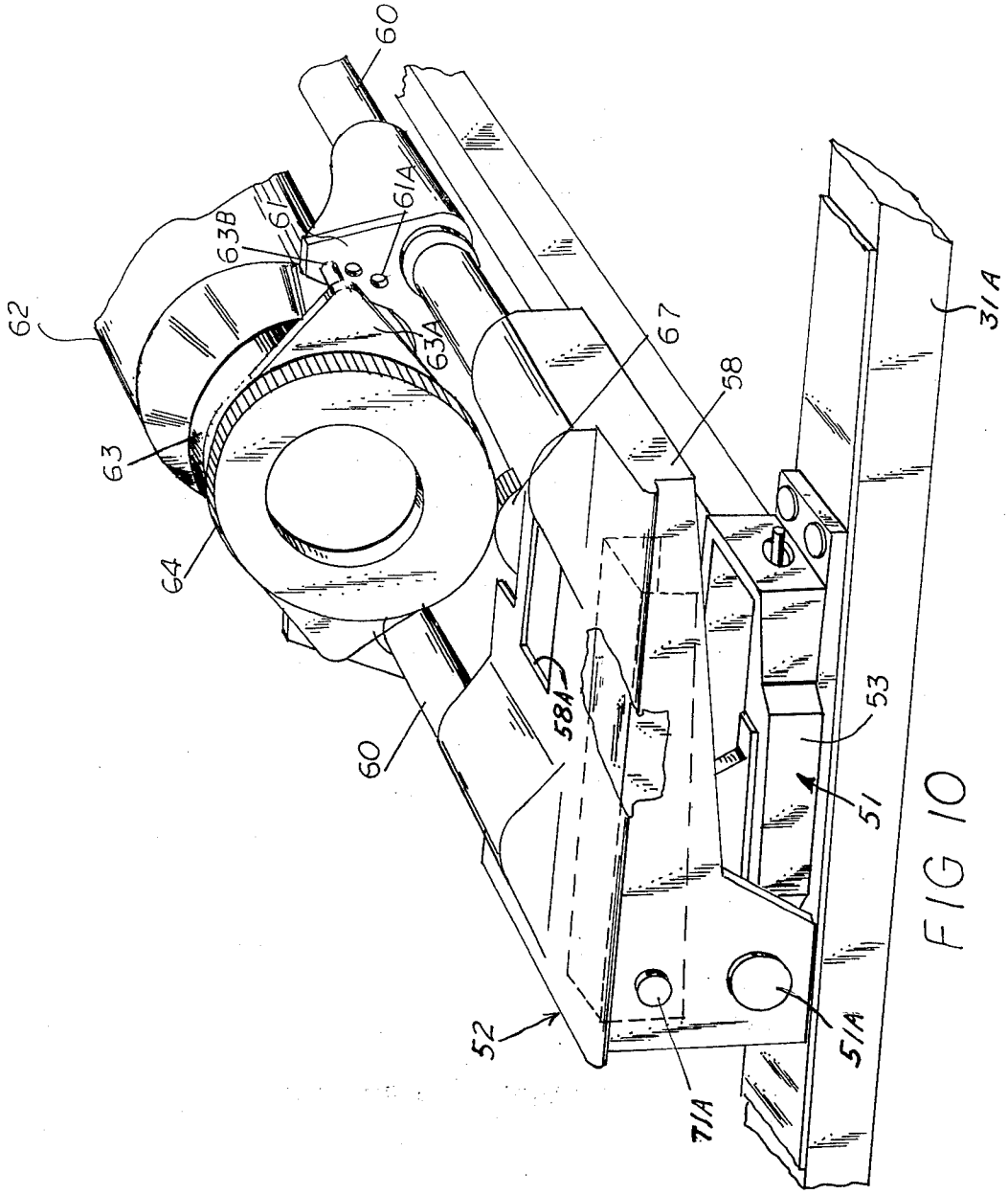

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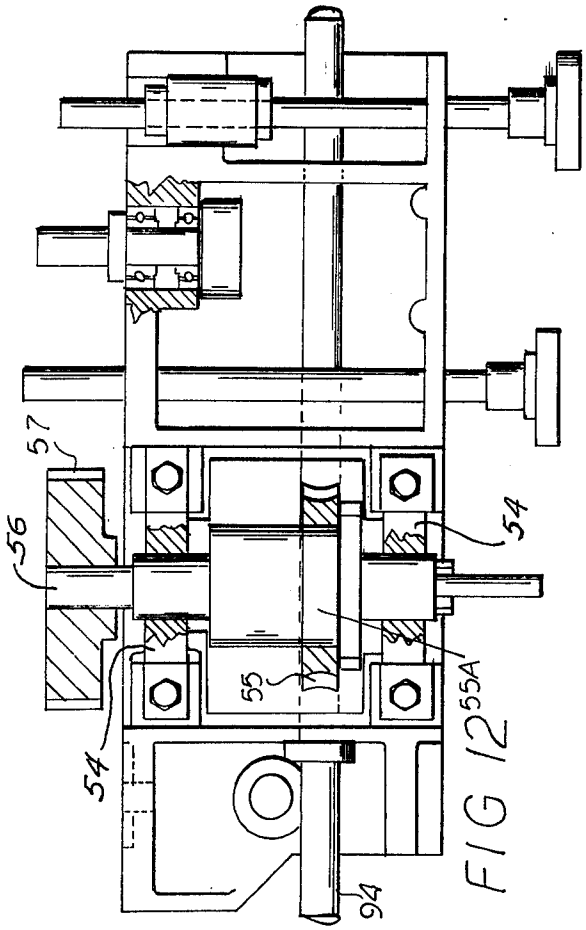

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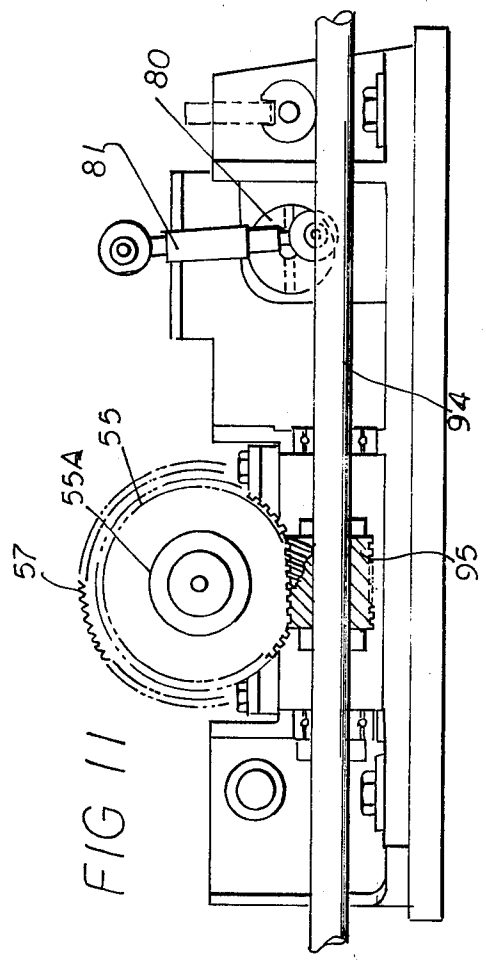
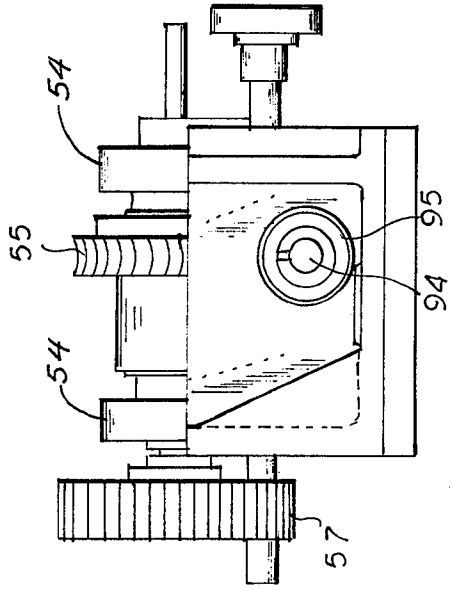


FIG 11



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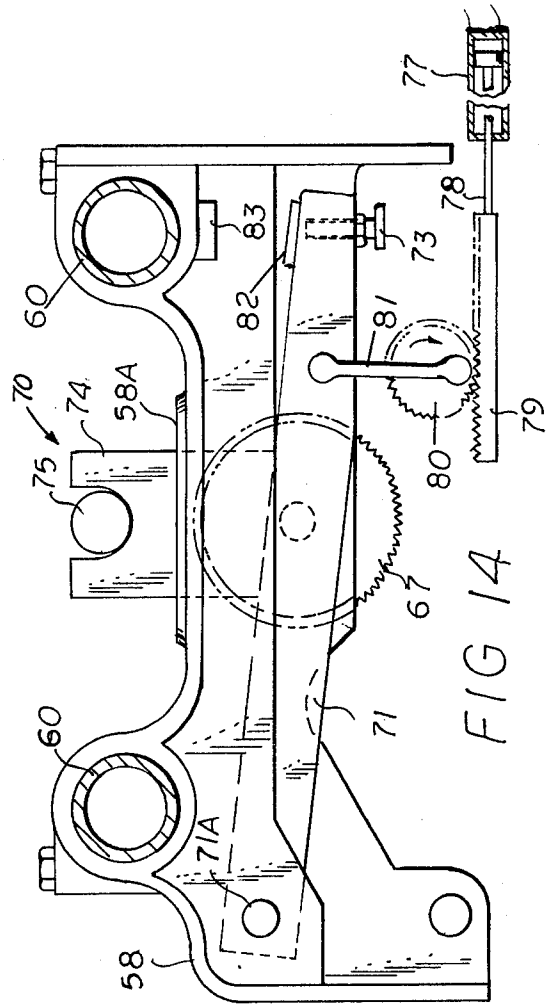

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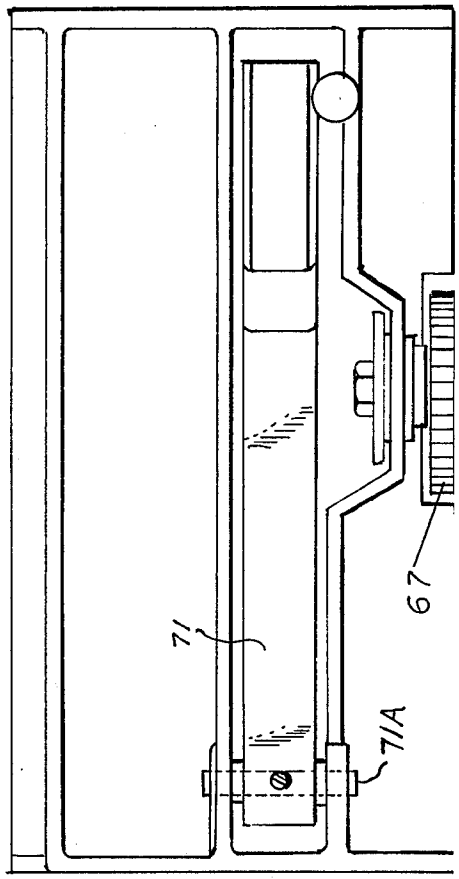
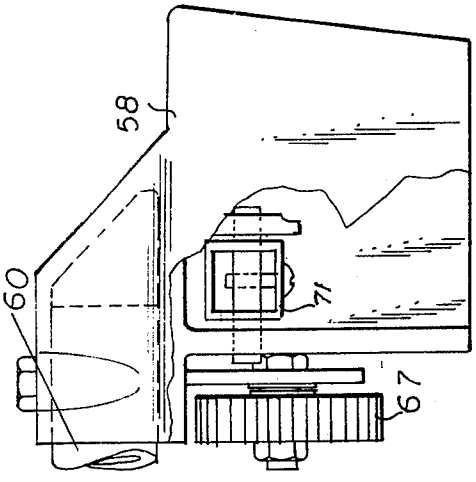


FIG. 15



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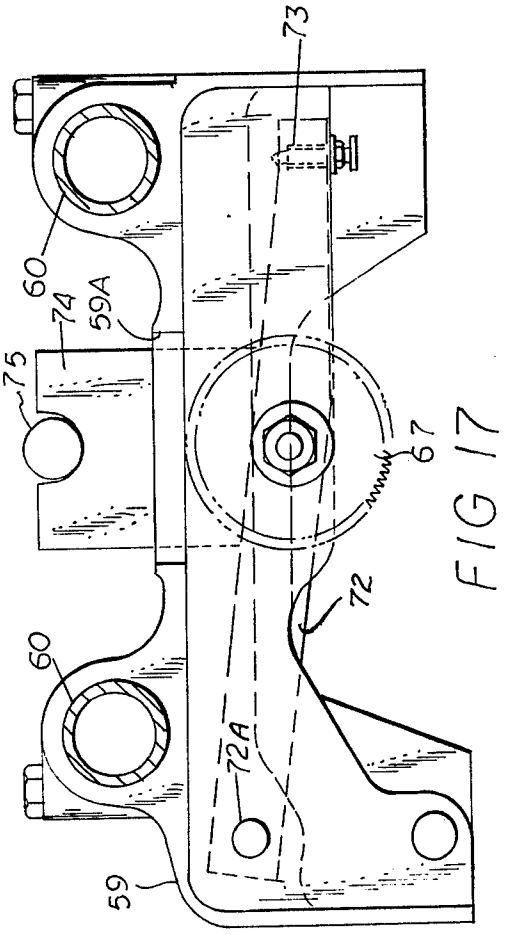

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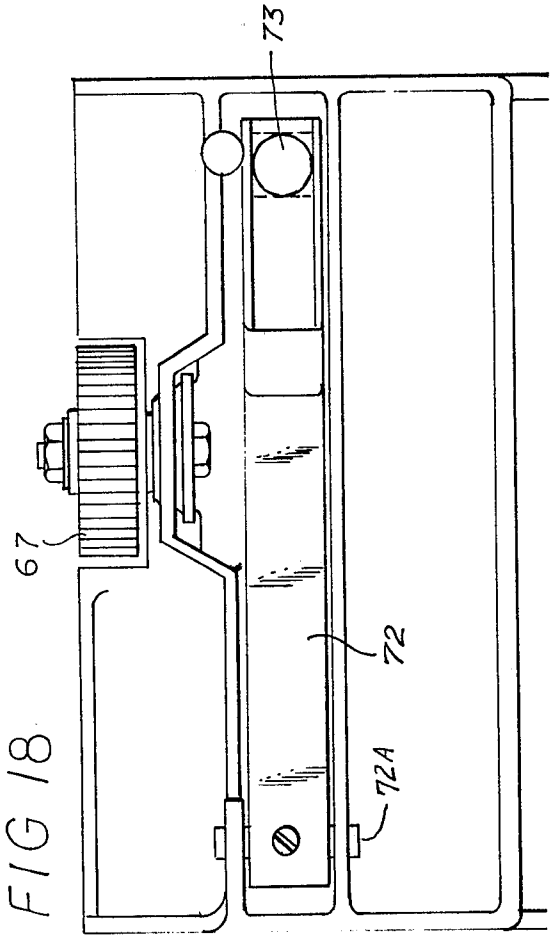

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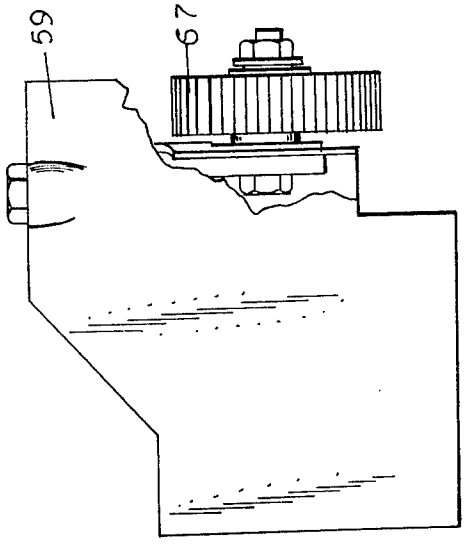

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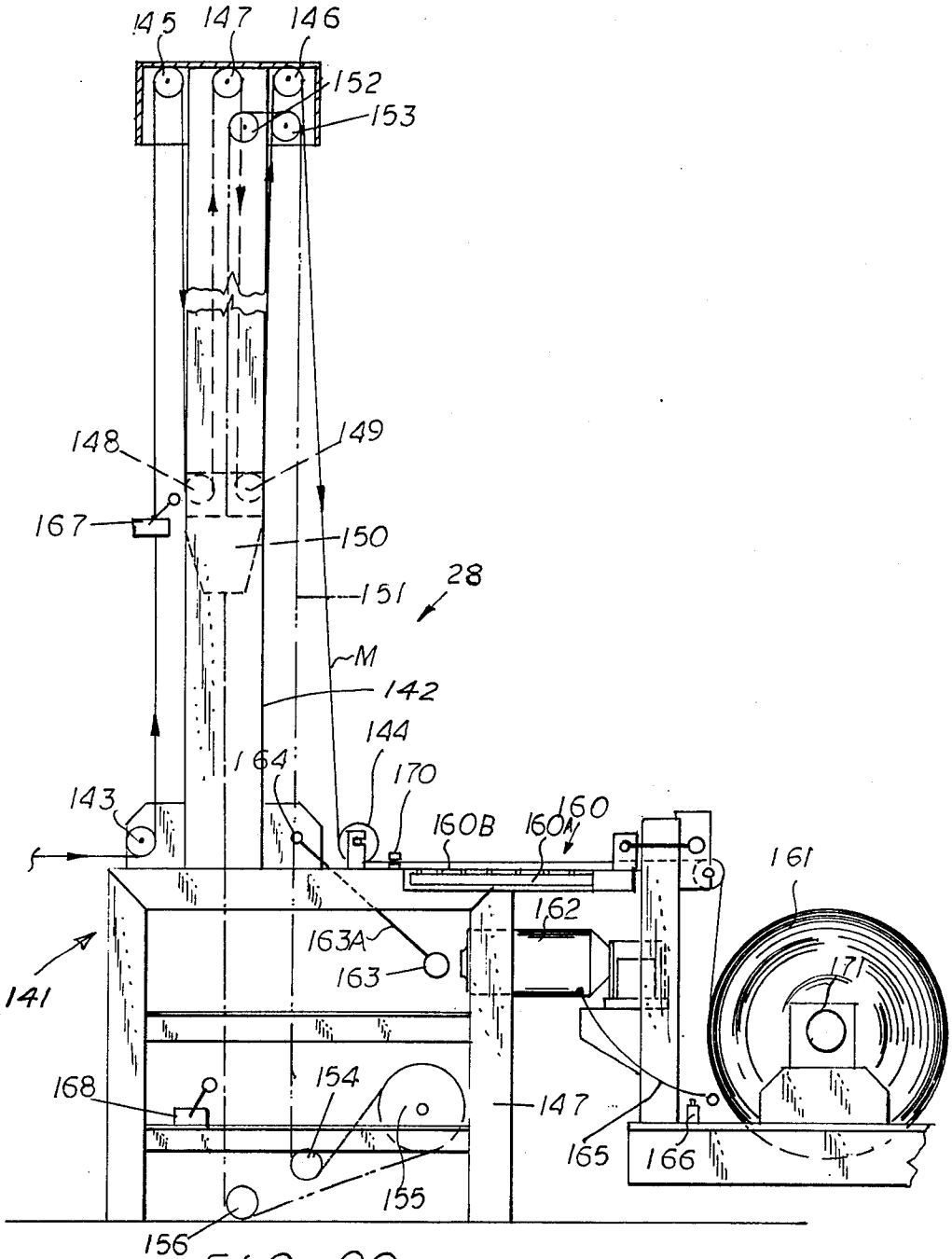
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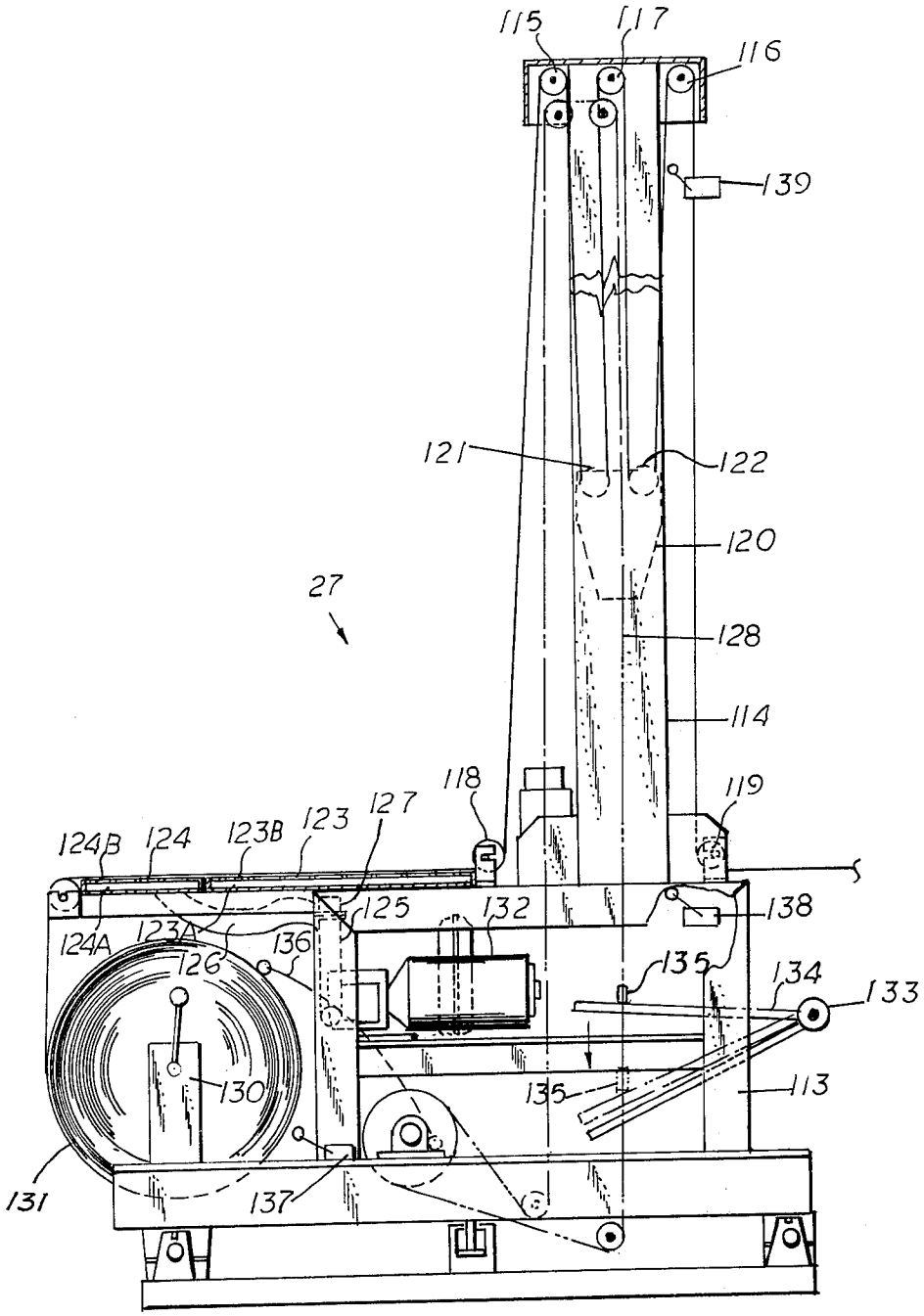
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FIG 21

CONTINUOUS ROTARY SCREEN PRINTING METHOD AND APPARATUS

PROBLEM AND PRIOR ART

Heretofore, considerable difficulty has been encountered in effecting proper registration between successive printing operations in the event the printing operation was interrupted for any reason, e.g., when changing rolls either at the feed end or take-off end of the operation. This was due to the extreme difficulty encountered in effecting proper registration of the rotary printing screen and the end of the preceding print, whenever the operation was restarted. With the known method and apparatus, invariably a smear or blurr would result between successive printed portions of the web each time the printing operation was stopped and then recommenced. Thus each time the known rotary screen printers were stopped for any reason, some portion of the web of printed material was lost due to waste created by such blurring or smearing.

Another difficulty noted with existing rotary screen printing methods and apparatus is that the point at which the rotary printing screen means contact with the material being printed is backed up by a generally hard surface. For this reason the printing occurs at a line contact which limits the amount of ink or dye deposited and/or penetration thereof into the material being printed.

Still another difficulty encountered in rotary screen printing is the need for securing the material to the printing bed as it is being printed so as to insure positive registration and to minimize shrinkage and particularly when the printed sheet is made of plastic, e.g., vinyl webs or sheets.

Also with known printing methods and apparatus, it was heretofore necessary to stop the printing operation each time a new supply of material was required to be fed to the machine and/or removed therefrom. Because of these stoppages the problem of registration and waste between successive prints is further aggravated.

OBJECTS

An object of this invention is to provide a method and apparatus for rotary screen printing in which registration between successive printed portions of a continuous strip or web is assured without the effect of smearing or blurring.

Another object os this invention is to provide a method and apparatus for rotary screen printing continuous webs and sheets in which the deposit of ink and/or penetration thereof on the material being printed is enhanced.

Another object is to provide a method and apparatus for rotary screen printing in which the material and the screen is reversed in relative predetermined relationship in the event the printing operation is interrupted for any reason.

Another object of this invention is to provide a method and apparatus for rotary screen printing a continuous web or sheet in which the material is positively held in place throughout the printing cycle of operation to insure positive registration and to eliminate shrinkage during the printing thereof.

Another object is to provide a method and apparatus of rotary screen printing in which a new supply of material and/or a supply of printed material may be readily

spliced or unspliced without effecting any interruption of the printing operation.

Another object is to provide a method and apparatus for rotary screen printing a continuous web or sheet in which the printing bed and/or the printed portion of the material is cooled so as to enhance the overall printing operation.

BRIEF SUMMARY OF THE INVENTION

The foregoing objects and other features and advantages of this invention are attained by a rotary screen printing method in which a continuous strip or web or material to be printed is fed to and supported on an endless printing bed or blanket whereby the material is firmly adhered thereto, e.g., in the case of a non-porous material by a negative pressure acting thereon. A rotary printing screen having a stencilled portion and associated squeegee is lowered onto the material whereby the ink is forced through the stencilled portion of the screen by relative movement between the screen and squeegee. The printing is effected by rotation of the printing screen relative to the moving printing bed and material which are connected in synchronous driving relationship.

Upon the termination of the printing operation for any reason the squeegee is first lifted out of contact with the screen slightly in advance of the printing bed and material coming to a full stop. The screen is then lifted away from the material being printed resulting in a minimum of any ink or dye being forced through the screen to leave any demarcation mark. Upon the printing bed coming to a complete stop, both the printing bed and material supported thereon together with the rotation of the printing screen are reversed a corresponding amount in synchronous timed relationship, a predetermined amount.

Upon starting up of the printing operation, the screen is lowered onto the material to engage the trailing edge portion of the previously printed section. In doing so the rotation of the screen and the linear movement of the printing bed or blanket and material thereon being synchronized for movement in the printing direction effects an overprint between successive prints and thereby results in a positive registration therebetween.

To enhance color penetration and/or the deposit of color on the material, a surface area contact is provided between the printing portion of the screen and the material and its printing bed. This is attained by allowing the material to circumscribe a circumferential surface portion or area of the printing screen during a printing operation.

To minimize any interruption of a printing operation the changing of the supply of material and/or the removal of a supply of printed material is effected by splicing and/or unsplicing of the sheet as the printing opertion is being conducted. This is attained by providing an accumulation of material at the beginning and end of the printing operation which enables the printing operation to continue as the changeover in supply is effected.

The apparatus by which the continuous screen printing method may be automatically performed comprises a machine frame having an endless printing bed or blanket thereon upon which the material to be printed is supported and advanced through the printing cycle. The printing bed is perforated or porous and overlies a vacuum table which is subjected to a residual nega-

tive pressure during a printing operation to firmly adhere thereto the material being printed.

One or more rotary printing screens and associated squeegees are supported along spaced intervals on the machine from above the printing bed. Each of the rotary screens and associated squeegees is mounted for relative movement so as to be lowered and raised between a printing and non-printing position.

A reversible variable speed drive means is operatively connected to the printing blanket and the respective printing screen to effect the synchronous drive thereof. A programming means is operatively connected to the drive means for sequencing the operating components and the reversibility of the drive means so that upon the termination of a printing operation the travel of the printing blanket and the rotation of the screen is gradually reduced and then reversed a predetermined amount. Upon restarting the printing operation the printing screen can thus be lowered onto the trailing edge of the preceding printed portion of the material to cause an overprint in registration with the previously printed portion.

Between printing screens there is disposed suitable heaters for effecting a drying of the inks or dyes between screen prints. The heaters are pivotally mounted to pivot to an inoperative position when the machine is stopped to eliminate any overheating during machine stoppage. Between the heater and the next succeeding printing screen there is disposed a means to cool the portion of the web printed by the preceding rotary printing screen.

To provide surface contact between the printing screen and the material being printed to increase the amount of ink deposited or the amount of penetration, a means is provided to permit the material being printed to conform to a circumferential surface portion or area of the printing screen during a printing operation. The arrangement is such that the amount of available surface contact provided beteween the printing screen and the web can be varied within predetermined limits.

The apparatus further includes a web feed and take-off system operatively associated with the printing portion of the apparatus to enable successive rolls of web material to be spliced and unspliced without interruption in the printing operation. Each of the respective web feed and take-off systems includes an accumulator for accommodating a predetermined amount of material so as to enable a printing operation to continue for a predetermined amount of time sufficient to make the necessary splice between successive rolls.

FEATURES

A feature of this invention resides in the provision of a method and apparatus of continuously printing a continuous sheet of web material in which accurate registration is effected between successive prints upon an interrupted printing operation by effecting a reversal of the printing bed and associated rotary screen a corresponding predetermined amount.

Another feature residies in the provision of a screen printing method and apparatus in which registration of successive printing portions upon interruption is attained by effecting an overprint between successive printed portions of the continuous web.

Another feature resides in a method and apparatus of screen printing wherein the material being printed circumscribes a circumferential surface portion of a rotary printing screen during a screen printing operation.

Another feature resides in the provision of a residual vacuum means for maintaining the continuous web of material to the printing bed throughout the printing operation.

Another feature resides in the provision of a drive means for the printing bed or blanket and associated rotary printing screen which effects a slowing down of the respective movement thereof in the direction of feed as the printing operation is stopped and thereafter effecting a reversal in the movement of the printing bed and rotary screen a corresponding amount.

Another feature resides in the cooling of the printed material before passing under a rotary screen.

Another feature resides in the provision of a screen printing method and apparatus having a feed and take-off system which permits uninterrupted printing during changeover between material supplies.

Another feature resides in the provision of a continuous rotary screen printing machine in which the synchronization of the printing bed or blanket and the associated rotary screen is effected by two variable speed drives operatively associated with a programmer motor means.

Another feature of this invention resides in the provision whereby the rotary printing screens can be readily raised and lowered between a printing and non-printing position without requiring any disengagement of their driving connections.

Another feature of this invention resides in the provision of utilizing a porous printing blanket.

Another feature of this invention resides in the provision of utilizing a foraminous covering over the surface of the printing blanket to create a soft printing surface which provides for a uniform distribution of the negative pressure forces being applied thereto.

Other features and advantages will become more readily apparent when considered in view of the drawings and specification in which:

FIG. **1** is a sectional view of the left hand portion of a screen printing machine embodying the invention.

FIG. **2** is a sectional view of the right hand portion of the apparatus of FIG. **1**.

FIG. **3** is an enlarged detailed view of the vacuum pump to control the residual negative pressure in the table portion of the apparatus.

FIG. **4** is an enlarged detailed sectional view illustrating the contact area of the screen relative to the material.

FIG. **5** is an enlarged detail of the programming means.

FIG. **6** is a fragmentary end view of the rotary screen.

FIG. **7** is a side view of FIG. **6** illustrating the mounting for various diameter screen heads.

FIG. **8** is a perspective view of the lower head or base assembly of the rotary printing head.

FIG. **9** is a detailed perspective view of the upper head assembly.

FIG. **10** is a detailed perspective view of a portion of the printing head assembly.

FIG. **11** is a side view detail of the printing head drive.

FIG. **12** is a plan view of FIG. **11**.

FIG. **13** is an end view of FIG. **11**.

FIG. **14** is a side view of the upper front portion of the head assembly.

FIG. 15 is a bottom view of FIG. 14.

FIG. 16 is an end view of FIG. 14.

FIG. 17 is a side view of the upper rear portion of the head assembly.

FIG. 18 is a bottom view of FIG. 17.

FIG. 19 is an end view of FIG. 17.

FIG. 20 is a side view of the in-feed accumulator.

FIG. 21 is a side view of the take-off accumulator.

FIG. 22 is a sectional view of a modified printing blanket construction.

DETAILED SPECIFICATION

This invention is directed to an improved method of continuously screen printing an uninterrupted sheet or web of material. The material to be printed is taken from a roll supply and fed to and supported on a movable printing bed or blanket. The material is held fast to the printing blanket in a manner so as to assure positive registration and to avoid shrinkage. If the sheet or web to be printed is a porous or fabric material, the sheet is adhesively secured to the movable printing bed or blanket. Non-porous material, such as vinyl plastic sheets, are secured to the movable printing bed or blanket by subjecting the sheet to a residual negative pressure. This is attained by providing the printing blanket with a series of small perforations or holes and passing the blanket over a perforated table top which is subjected to a negative pressure.

The printing blanket and material supplied thereon is then passed under one or more rotary printing screens which are adapted to be moved between a raised non-printing position and a lowered printing position. In the printing position the rotary screen printing screen is rotated in contact with and in synchronization with the linear movement of the material relative thereto to effect the printing of the material.

To enhance the amount of ink or dye deposited on the material and/or to enhance the penetration of the ink or dye onto the sheet, the surface area of contact between the printing screen and the material is enlarged by providing a cushioning effect at the point of contact, thereby enabling the material to conform to a circumferential portion of the printing screen depending on the degree of softness of the cushioned area.

On passing the printing screen the printed portion of the material is heated to enhance drying of the inks or dyes; and thereafter passed in printing relationship with a next succeeding rotary screen. In the printing of vinyl plastic the heated or dryed portion of the printed fabric is thereafter cooled by blowing cooling air thereat immediately prior to advancing the printed sheet through the succeeding printing operation, e.g. during a multiple color printing operation. Sufficient cooling air is applied to the heated or dryed portion of the printed sheet to cool the material to a temperature below 120°F. To reduce any build-up of heat in the printing blanket, it too may be subjected to a cooling by directing cooling air thereto at a point beyond the last of the printing screens.

To avoid interrupting the printing operation, the material from the successive roll supplies is spliced together so that a continuous uninterrupted sheet is printed. This is attained by accumulating a supply of the material to be printed to provide the required amount of material which can be printed during the time necessary to effect a splice between the end of the material from one roll supply and the lead end of a succeeding supply roll. Also the removal of a supply of printed material may be effected without interrupting the printing operation by providing for an accumulation of printed material to occur upon completion of the printing operation for a period of time necessary to effect the removal of the printed supply.

In the event the printing operation is to be stopped for any reason the squeegees associated with the respective screens are first lifted out of contact with the screen before the movement of the material in the direction of feed has come to a complete stop. The screen is then lifted off contact from the material whereby a minimum of color is forced through the screen to create any mark. With the screen off the material, the rotation of the screen is reversed and the printed material is backed up a corresponding amount.

Upon commencing the printing operation again the printing screen and associated squeegee is lowered onto the printing surface so as to make contact with the trailing edge of the preceding printed portion of the sheet. In doing so the screen or screens are again rotated in the direction of printing as the material is also being advanced from its backed up position in synchronization with the rotation of the screen and with the screen being lowered into printing position to effect an overprint with the trailing edge of the preceding printed area of the material. In this manner any smear or blurring between successive printing operations is avoided as the screen and material are in register. To avoid any overheating of the material in the interrupted printing operation, the heaters are moved to a position to deflect the heat away from the material.

The foregoing method may be automatically performed by a screen printing apparatus **25** disclosed in the drawings. Referring to FIGS. **1** and **2**, the screen printing apparatus **25** comprises a screen printing portion **26**, an infeed accumulator portion **27** and a take-up accumulator portion **28**. The printing portion **26** comprises of a suitable frame structure **29** formed by a plurality of spaced upright leg portions **30** interconnected by longitudinally extending, and transversely extending frame members **31** and **32** respectively to define a substantially rectangularly shaped frame assembly.

Journalled adjacent the respective end portions of the frame assembly **29** are a pair of end rollers **33, 34** over which an endless belt or printing blanket **35** is threaded. The arrangement is such that the upper flight **35A** of the printing blanket **35** defines a movable printing bed or blanket for supporting thereon the material M to be printed.

Disposed immediately subjacent the upper flight **35A** of the printing bed or blanket **35** is a table top **36** which is fixed to and supported on the frame structure **29**. The table top **36**, as seen in FIG. **4** comprises a hollow structure to define therein a negative pressure chamber **38** which is substantially coextensive the length of the table. The upper surface **36A** of the table top **36** is provided with a plurality of holes or apertures **37** extending therethrough so as to be disposed in communication with the negative pressure chamber **38**.

The printing blanket or bed **35** is also provided with a series of perforations **35B** throughout the surface area thereof so that during the operation of the machine the upper surface of the blanket or bed **35** is brought under the influence of the negative pressure applied to the negative pressure chamber **38**.

In lieu of a perforated printing blanket 35A, a porous or foraminous printing blanket may be used. The porous printing blanket has the advantage in that the printed material will not show the perforation outlines which may occur when a perforated blanket is utilized. Also a porous type blanket functions to more uniformly disperse the negative pressure being drawn thereon. Reference to FIG. 22 there is shown therein a modified printing blanket construction in which foraminous material, e.g., polyurethane, having open cellular structure 35C is bonded to the upper surface of the perforated printing blanket 35A. The modified blanket B of FIG. 22 supports the material M to be printed and provides a soft surface therefor through which the negative pressure can be readily utilized to hold a non-porous material M, e.g., a vinyl sheet or web to the upper surface of the foraminous material 35C.

The negative pressure chamber 38 of the table top 36 is operatively connected through suitable conduits 40 to a series of vacuum pumps 41 which, when actuated, will subject the pressure chamber 38 to a negative pressure or vacuum. The respective vacuum pumps 41 are supported on a frame platform below the table at spaced intervals along the length of the frame. In this manner the respective sections of the table top 36 are serviced by their own vacuum pump 41.

Each of the vacuum blowers or pumps 41 is provided with means whereby the amount of residual vacuum or negative pressure imposed in the associated vacuum chamber may be controlled or varied. Referring to FIG. 3, the means for controlling the amount of residual vacuum or negative pressure imposed on the respective sections of the table 36 includes valve plate 42 which is pivotally mounted about a pivot 43 adjacent to the negative pressure outlet 44 of the vacuum pump 41. The valve plate 42 is provided with an opening or collar 42A to which a flexible conduit 40 is connected. The other end of the conduit 40 connects with the vacuum chamber 38. Connected to the free end of the valve plate is a linkage 45 which is threadably connected to a threaded adjusting shaft 46, and a handle or turn knob 47 is connected to the free end of the adjusting shaft 46. The arrangement is such that by effecting rotation of the control handle 47, in one direction or the other, the opening 42A of the valve plate is moved into and out of communication with the vacuum outlet opening 44 of the vacuum pump accordingly. Thus the intersecting cross-sectional areas of the conduit connection 42A with the negative pressure outlet 44 of the valve determines the amount of negative pressure which is being drawn on the associated section of the vaccum table 36. As seen in FIG. 3, an interconnecting link 48 interconnects the adjacent valve plates 42 of the respective vacuum pumps, so that the adjustment of each valve plate 42 may be effected simultaneously by the turning of the control handle 47.

Thus the degree or amount of negative pressure being drawn along the length of the vacuum table can be readily controlled by a single adjustment of the control handle 47.

Mounted on the frame 29 to extend transversely thereof are one or more printing heads 50. The respective printing heads are spaced at predetermined intervals along the length of the frame structure 29. It will be understood that the number of printing heads may be varied depending upon the colors and/or type of designs being printed.

Each printing head 50 is similarly constructed and comprises a lower head or base assembly 51 and an upper head assembly 52. The lower head assembly 51 comprises a pair of base castings 53, each being oppositely disposed and supported on the opposed upper frame members 31A. Rotatably journalled between suitable trunnion supports 54 on one of the base castings only is a driving worm wheel 55.

As best seen in FIGS. 11, and 12, the worm wheel 55 is operatively associated with a harmonic phase control unit 55A which permits for a full 360° index adjustment of a cylindrical or rotary printing screen as will be hereinafter described. The output shaft 56 of the harmonic phase control 55A has connected thereto a driving gear 67. A similar driving gear 57 is journalled to the opposed base casting. Pivotally connected about the opposed lower base castings 51 at 51A is the upper head assembly 52. The upper head assembly includes opposed upper head castings 58, 58 which are pivoted to the respective lower base castings 53, 53. Extending transversely between the respective upper head castings 58–59 are a pair of interconnecting support rods 60. Connected between the support rods 60 are a pair of screen support yokes 61–61 arranged for supporting therebetween a cylindrical stencilled printing screen 62.

As best seen in FIG. 6, the printing screen 62 comprises a cylindrical sleeve portion which is stencilled to define a given design to be printed. An end collar 63 is connected to each end of the cylindrical screen 62, with a gear 64 connected to the end collar for effecting the drive of the screen as will be hereinafter set forth. A screen holder 63A rotatably supports the respective end collars 63 on the screen yoke 61. As best seen in FIG. 10, the screen holder 63A is provided with pin means 63B which are arranged to be received in appropriate retaining apertures 61A formed in the yoke 61.

The screen gears 64, when supported between yokes 61—61, are disposed so as to be in meshing arrangement with an idler gear 67 rotatably journalled to the respective upper head castings 58, 59. The idler gears 67 are in turn arranged to mesh with the screen driving gear 57. As will be hereinafter described the idler gears 67 are arranged to roll about the periphery of the driving gears 57 in meshing relationship therewith so that the upper head assembly, in moving the printing screen between a lowered printing position and a raised inoperative printing position moves without causing any disengagement of the gears of the drive train which includes gears 57, 67 and 64. Thus, the screen 62, as will be hereinafter described is always maintained in gear or in synchronization with its driving means.

Referring to FIG. 7, it will be noted that screens 62, 62′ of varying size and/or diameters may be suitably supported between screen yokes 61—61. As seen in FIG. 7, there is shown in dotted or phantom line, a showing of how a smaller screen 62′ may be substituted for the larger screen 62 illustrated by the solid line showing. In either event the driven screen gears 64, 64′ of the respective screens 62, 62′ are arranged to mesh with the intermediate idler gears 67. The arrangement is such that varying size screens 62, 62′ can be readily interchanged, depending upon the shape or repeat of agiven design.

Operatively associated with each printing head 50 or screen 62 is a squeegee assembly 70. Referring to FIG. 14, the squeegee assembly 70 includes a pair of pivot-

ing arms 71, 72, each of which is pivoted at one end about pivot 71A, 72A to its respective upper head casting 58, 59. The other end of the respective pivoting arms 71, 72 is provided with a limit stop 73 in the form of a thread adjusting screw; which can be readily adjusted to limit the downward movement of the screen and associated squeegee, as will be hereinafter described.

Mounted on each arm 71, 72 intermediate the ends thereof, and arranged to extend upwardly through an opening 58A, 59A formed in the respective upper head castings 58, 59 is a squeegee holder support 74. A squeegee holder 75 and associated squeegee blade 76 is supported between the support holders 74—74. As seen in FIG. 7, the squeegee blade 76 extends longitudinally through the cylindrical screen and is arranged to engage the inner circumferential portion of the screen to force the color therethrough during a screen printing operation.

Means are provided for effecting the movement of the respective screens 62 and their associated squeegee blades 76 between a raised inoperative or non-printing position and a lowered or operative, printing position. The operation of the screen 62 and associated squeegee 76 is such that when the machine or screen printing operation is stopped for any reason, the squeegee blade 76 is first lifted up or out of contact with the screen. The screen 62 is then lifted away or off the material M being printed. Upon restarting the printing operation the screen 62 is first lowered into printing position and thereafter the squeegee blade 76 engages the screen to commence the printing. Thus there is provided a limited loss of motion between the squeegee and its associated screen.

This operation or movement of the screen 62 and squeegee blade 76 between raised and lowered positions is attained by means of a piston and cylinder assembly 77. The piston rod 78 of the assembly 77 is connected to an operating rack 79 which is in meshing relationship with an eccentric or gear sector 80. A crank arm 81 is eccentrically interconnected between gear sector 80 and the pivoting arm 71 which supports the squeegee holder support 74 and associated squeegee holder 75 and squeegee holder 76.

In operation it will be noted that whenever the piston and cylinder assembly 77 is actuated the displacement of the rack upon extension of the piston rod 78 will effect rotation of the gear sector 80 to effect a displacement of the crank arm 81. As gear sector 80 is rotated clockwise as viewed in FIG. 14, the crank 81 will effect upward displacement of the pivot arm 71 and its associated squeegee holder 74 and blade 76. Slightly before the arm 81 approaches its high point, the stop 82 engages abutment 83 of the upper head casting 58, 59 whenever continued upward displacement of the crank arm 81 and arm 65 will effect a lifting of the upper printing head assembly 58, 59 and screen supported thereon off the material M.

Upon lowering of the upper printing head assembly 58, 59, a reverse movement is effected. That is, as the rack 79 is moved to the right as viewed in FIG. 14, the crank arm 81 is moved to its lowered position whereupon the printing head 58, 59 is lowered to effect contact between the screen and the material, whereupon continued downward movement of the crank arm 81 and connected pivoting arm 71 to its low point, as determined by stop 73, brings the squeegee blade 76 into contact with the screen 62.

As will be hereinafter described the control of actuation of the piston and cylinder assembly 77 for timing the raising and lowering of the screen 62 and associated squeegee 76 between a printing and non-printing position is effected by the actuation of a suitable micro switch which is wired into the control circuit of the machine. It will be understood that the piston and cylinder assembly 77 controlling the actuation of the screen and associated squeegee may be either hydraulically or pneumatically operated with the micro switch controlling a solenoid valve which controls the flow of activating fluid to and from the cylinder of the assembly 77. The drive means 85' for effecting the drive of the printing bed or blanket 35 during a printing operation, in timed or synchronous relationship to the rotation of the respective printing head screen 62, comprises a main reversible motor 85 which is suitably mounted on the machine frame. The output shaft of the main motor 85 is coupled to a variable speed transmission unit or harmonic phase control unit 86 of a known construction. The output shaft 86A of the variable speed transmission unit 86 has a sprocket 87 connected thereto which is connected in driving relationship by a flexible chain drive 88 to a slip clutch 89, which couples the drive shaft 90 of the printing blanket 35 to the drive of the screen 62.

The printing blanket drive shaft 90 extending to one side of the clutch 89 has connected to the end thereof beveled gear 91 which is disposed in meshing relationship with the driven gear 92 of the end roller 33. On the screen drive side of the slip clutch 89 there is operatively connected thereto a second variable speed transmission unit 93. The output side of the transmission unit 93 is connected or coupled to a common drive shaft 94 for driving the respective printing head screens 62. As shown, a plurality of worm sectors 95 are spaced along the common drive shaft 94, each worm sector 95 being disposed into meshing relationship with a driving worm wheel 55 of the respective printing head screens 62.

Operatively associated with the variable speed control unit 86 of the main motor 85 is a programming means 96 for sequencing the operating cycle of the machine. The programming means 96 comprises a reversible motor 97, the output shaft of which is connected to a suitable gear reduction unit 98. The output shaft of the gear reducer unit 98 is connected through a slip clutch 101 in driving relationship to shaft 99 which is coupled to the input of the variable speed transmission unit 86. The drive shaft 99 is effected by means of a flexible chain drive 100 coupling the output shaft of the reducer unit 98 and the slip clutch 101. As best seen in FIG. 5, the shaft 99 is provided with a section 99A which has spaced therealong a series of cam actuators 102, 103, 105, 104, and 106 in predetermined relationship of activating various micro-switches 102A, 103A, 105A, 104A, and 106A for sequencing the operation of the respective machine components as will be hereinafter described. For example, a cam actuator 102 is mounted for movement on the screw sector 99A for actuating a micro switch 102A to effect a reversal of the motors as will be hereinafter described when engagement is effected therebetween. Another cam actuator 103 is provided for effecting actuation of a microswitch 103A controlling the operation of the screen 62

and associated squeegee assembly **70.** Still another cam actuator **104** operates a micro-switch **104A** to effect actuation of heater **110** as will be hereinafter described. Another cam actuator **105** is spaced along the worm screw **99A** to activate a micro-switch **105A** for effecting a slow down of the belt **35** and screen printing speed as will be hereinafter described, and a switch actuator **106** is provided for effecting the control of a high speed micro-switch **106A**, the latter of which may be adjusted or set relative to the cam actuator **106** by means of an adjusting screw **107.** The programming means **96** is arranged to control the speed of the main drive motor **85.**

This is attained by having the program motor **97** and the main drive motor **85** wired in a control circuit so that both are energized when a start button is actuated. The operation of the program motor **97** effects the drive of the screw section **99A** which will sequence the operating components in a predetermined manner as will be described in the operation of the apparatus **25.** The operation is such that the shaft **99** of the program means **96** connecting to the input of the variable speed control unit **86** will gradually cause an increase in the speed of the main motor **85** until a predetermined operating speed is attained. When the speed of main motor **85** reaches operating speed, the program motor **97** is shut down. It will be understood that the speed of the belt **35** and the rotation of the printing screens **62** are timed or synchronized through the operation or coupling of the variable speed transmission units **86** and **93** to one another. The coupling of the two units **86** and **93** is such as to maintain the speed of the belt or blanket **35** slightly greater than that of the printing screens **62.** This slight difference in relative speed between the blanket and the screen eliminates back lash in the drive gears, and enhances registration.

To stop the operation of the machine **25** for any reason, a stop button is wired into the control circuit so that when depressed, the program motor **97** is energized to rotate in a reverse direction. The coupling of the program means **96** to the variable speed control unit **86** is such that the main motor **85** will be gradually slowed down to "0" speed. The coupling of the variable speed control unit **86** to the variable speed control unit **93** will effect a corresponding slow down of the screens **62** accordingly. In doing so the worm screw **99A** will cause the cam actuators to effect an inverse actuation of the machine operating components, such as the raising and lowering of the screen and squeegee.

A time delay means is included in the control circuit so that when the speed of the printing blanket **35** and screens **62** passes through its 0 speed, the main motor **85** is reversed to back up the printing belt **35** in a direction opposite to the direction of speed a predetermined amount, e.g., 24 to 36 inches. The coupling of the variable speed control unit **86** to the variable speed control unit **93** will cause the printing screens **62** to also be rotated in an opposite direction a corresponding amount. Upon the expiration of the predetermined time delay effecting the back-up of the printing blanket **35** and printing screens **62,** both the main motor **85** and the program motor **97** are de-energized or shut off.

Adjacent one end of the printing portion **26** of the apparatus **25** there is provided an infeed accumulator **27** through which the material M to be printed is fed or supplied to the printing blanket **35** during a printing operation. The infeed accumulator **27** comprises a frame structure having a pair of opposed upright stanchions **114.** Mounted between the upright stanchions **114** adjacent the upper end thereof are a pair of transversely extending idler guide rollers **115, 116** and a fixed upper transverse accumulator roller **117.** Adjacent the base portion of the upright stanchion members **114** is an inlet guide roller **118** and outlet guide roller **119.** Movably mounted between the uprights of the stanchions **114** is a dancing carrier **120** arranged to be moved between a raised and lowered position. The carrier **120** has rotatably journalled therein transverse carrier rollers **121, 122.** An endless chain drive **128** is connected to the carrier **120** to control the up and down movement of the carrier **120** which is under the influence of the tension of the Material M as will be described.

Mounted on the accumulator frame **114** adjacent the inlet end thereof is a vacuum holding table **123** and a vacuum splicing table **124** slightly spaced from one another. Each of the vacuum tables **123, 124** is provided with a vacuum chamber **123A** and **124A** and each chamber is operatively connected in communication with a negative pressure source, as for example, a vacuum pump **125.** As best seen in FIG. **21,** flexible conduits **126** and **127** connect the outlet of pump **125** to each of the respective vacuum tables chambers **123A, 124A.** The upper surface of the vacuum tables **123,** 124 are each provided with perforations or holes **123B, 124B** which communicate with the associated vacuum chambers **123A, 124A** of the respective tables. Immediately adjacent the vacuum holding table is the inlet guide roller **118** about which the material to be printed is threaded. Thereafter the material is threaded over accumulator rollers **115, 121, 117, 122** and **116** as indicated in FIG. **21.**

Mounted on the frame beneath the vacuum table is a supply roll support **130** having means for removably receiving and supporting a supply roll **131** of material to be printed. A drive is provided for the supply **131** to facilitate unwinding of the material M during a printing operation. The supply roll drive is in the form of a D.C. drive motor **132** which is suitably connected in driving relationship to the supply roll **131.** The supply roll drive motor **132** in turn is connected into the operating circuit of the machine by means of a potentiometer **133** whereby the speed of the unwinding supply roll is coordinated to the operating speed of the machine. That is as the diameter of the supply roll **131** diminishes, the speed of the drive motor **132** increases. As seen in FIG. **21,** the potentiometer **133** is governed by an arm **134** which is acted upon by an actuating bar **135** extended between the endless chains **128** of the dancing carrier **120.**

There is also provided a means for notifying an operator when the material on the supply roll **131** is about to exhaust. This is provided by a feeler indicator **136** which engages the periphery of the roll **131.** Thus as the diameter of the roll **131** diminishes to a predetermined point, the feeler arm **136** will actuate a microswitch which will energize an audio signal, e.g., a bell or horn. In the event the audio signal is not heeded, the further diminishing of a predetermined amount of material M will cause the feeler arm **136** to activate another micro-switch **137** which will shut off the supply roll driver motor **132.** When this occurs, the M threaded over the accumulator rollers **115, 116, 117,** 121, 122 begin to tension, causing the dancing rollers **121** and **122** to ascend. Upon ascending a slow down

micro switch **138** is first activated to slow down the machine whereupon continued operation will cause a second micro switch **139** to be activated to shut down the entire printing operation. The stop switch **139** is wired into the circuit so as to reverse the program motor **97** to first reduce the speed of the main drive motor **85** to slow the speed of the belt **35** and screens **62** to 0 speed, and then to reverse the direction of the belt **35** and screens a predetermined amount as hereinbefore described. It will be understood that as the program motor **97** is actuated, that the same will effect the drive of the worm screw shaft **99A** to sequence the operation of the screens, squeegees and heaters to an inoperative, non-printing position.

During normal operation the dancing rollers **121,** 122 are located at the lower end of the upright stanchion members **114.** The arrangement is such that when it becomes necessary to effect a changeover in the supply of material, the vacuum pump **125** is activated to subject the holding table **123** to a negative pressure so that the end portion of the material M is held fast thereto. When this occurs the material M is prohibited from advancing through the infeed accumulator **27.** Because of this, a web tension is applied to the material M causing the dancing carrier **120** and its rollers **121, 122** to move in an upward direction as the printing machine is still operating and calling for material M. The slow down micro-switch **138** interposed adjacent the upright stanchions of the accumulator is thus actuated when the dancing rollers reach a predetermined height to effect a slow down in the printing operation. Upon striking the slow down micro-switch **138** the machine will reduce speed to a preselected setting, and will continue to operate at the preselected low speed so as to allow a predetermined time interval to effect a changeover of the supply rolls. While the time interval can be readily adjusted and varied, a two minute time interval is deemed sufficient to effect the changeover of the supply rolls. In the event the material changeover is not completed in that period of time, the dancing rollers will at a predetermined high point actuate a safety stop switch **139** located adjacent the upper end of the stanchion member to effect a complete shut down of the machine. Upon actuation of switch **139,** the machine is slowed down and reversed as hereinbefore described.

The manner in which the material is threaded over the guide rollers and accumulator rolls of the infeed accumulator, a sufficient amount of a predetermined number of linear feet of material is made available to enable the machine to continue the printing operation during changeover of supply rolls and thereby avoid unnecessary stoppage of the printing machine. Further, it is to be noted that by effecting a reduction in the operating speed of the machine upon actuation of the micro-switch **138,** that additional time may be made available for effecting the change of the rolls. It will be understood that an alternate arrangement may be made by providing an additional accumulation or slack of the material M in the accumulator by the inclusion of additional rollers so that a greater number of linear feet of material can be accommodated. For example, the folds of material in the accumulator may be doubled whereby sufficient material may be stored to effect a changeover without necessitating a slow down in the printing operation.

With an exhausted roll removed and new supply roll of material mounted on the supply roll supports **130,** the end of the new supply is fed over onto the vacuum table **124** whereupon the negative pressure applied to table **124** will tend to hold the lead end of the new supply thereto. With the lead end of the material of the new roll supported on the vacuum table **124** and the trailing end of the preceding roll held fast to the holding table **123,** the respective adjacent ends of the two sheets are secured or spliced together to form a continuous web. With the two ends joined, the negative pressure on both the holding table **123** and the vacuum of splicing table **124** is released. Under normal conditions this splicing occurs while the printing operation is being performed. Upon restarting of the drive motor **132** of the supply roller the material again feeds through the accumulator to achieve a normal feeding speed with the printing operation continuing under normal operating conditions. As the printing operation continues, dancing rollers **121, 122** of the accumulator will tend assume their normal position as the supply roll is being normally driven to the required material to the printing speed of the machine.

Connected to the outlet end of the machine is a take-off accumulator **28** which is somewhat similar to the infeed accumulator **26,** except it operates in a reverse manner. As shown, the take-off accumulator comprises a frame structure **141** having a pair of transversely spaced uprights **142** connected thereto. Guide rollers **143, 144** are mounted on the frame **141** adjacent the base portion of the uprights, to guide the material M to and from the accumulator **27.** Connected to the upper end of the uprights are idler guide rollers **145** and **146** over which the material is adapted to be threaded. A fixed accumulator roller **147** is transversely extended between the opposed stanchion or upright members **142** adjacent the upper end thereof between guide rollers **145, 146.** A movable dancing carrier **150** having rollers **148** and **149** is supported between the uprights for movement between a raised and lowered position. Attached to the dancing carrier **150** is an endless chain **151** threaded over suitable idler rollers **152, 153, 154,** 155 and **156** for controlling the up and down movement thereof.

The printed material M coming off the printing machine is threaded under guide rollers **143** and over guide rollers **145.** The material is then serpentined over the dancer rollers **148, 149** and over the fixed accumulator roller **147.** The material M is then guided under the base roller **144** and over a take-off table **160** to the take-off roll **161.** The take-off roll **161** is directly driven by a D.C. motor **162** the speed of which is contolled by a potentiometer **163.** A bar actuator **164** is extended between opposed portions of the endless drive chains **151.**

In normal operation the dancing carrier **150** is arranged to ride high in the accumulator. During normal operation a bar actuator **164,** carried between chains **151,** is operatively engaging a potentiometer actuator **163A** whereby the speed of the motor **162** driving the supply roll can be controlled by the sensing of the tension on the material so that as the diameter of the supply roll is increasing as the printed material is being wound thereon the speed of take-off roll is reduced accordingly. If desired the take-off roll **161** is also provided with a sensing feeler **165** to sense the amount of printed material being wound thereon. The sensing

feeler **165** operates to activate an audio signal to warn an operator when a change in the take-off roll should be made. In the event an operator fails to heed this signal, a second switch **166** is actuated by the sensor **165** to stop the take-off roll drive motor **162.** In the event the drive motor **162** of the take-off roll stops, the tension on the material being printed is lessened causing the dancing rollers to lower to accommodate the material coming off the printing blanket **35.**

The take-off accumulator **28** is also provided with a slow down switch **167** wired into the circuit to slow down the printing operation when actuated. The arrangement is such that the slow down switch **167** is actuated by the dancing carrier **150** when it has descended a predetermined amount.

If the changeover is not completed, or the drive motor **162** of the take-off roll is not restarted, continued down movement of the dancing carrier **150** will activate a stop switch **168** when the carrier **150** has reached its lowest limit. Actuation of the stop switch **168** will effect a shut down of the printing operation.

The take-off table **160** is constructed with a vacuum chamber **160A** and perforated top to hold fast thereto the material passing thereover when the vacuum on chamber **160A** is activated. In operation the vacuum to the take-off table is manually controlled and is activated when an exchange of take-off rolls is required.

To effect a changeover in take-off rolls **161,** the take-off roll drive motor **162** is de-energized to stop the take off roll. Also the vacuum to the take-off table **160** is activated. Actuation of the vacuum causes the material to be held fast thereto. With the tension on the material thus relieved the dancing carrier **180** begins to lower causing the printed material coming of the printing machine to accumulate in accumulator **28.**

A cutter **170** is operated to cut the material whereupon the take-up roll **161** wound full with printed material can be removed; and an empty take-up spool repositioned on the roll supports **171.** Thereafter the vacuum on table **160** is released and the free end of the material wound to the empty spool. The drive motor **162** is restarted to effect the drive of the take-up spool to continue the winding of the printed material thereon. As tension is again placed on the material M, the dancing carrier will assume its normal operating position. In the event the dancing carrier **150** activates the slow down switch **167** during the changeover period, the start button is wired so that upon actuation thereof the speed of the machine can be gradually brought up to normal operating speed.

As previously described, an alternate construction would be to provide for additional accumulator rollers in the take-off accumulation to increase the folds of material accumulating therein. In this manner the machine can be continually operated at its normal operating speed throughout the changeover time.

Disposed between adjacent printing screens **72** there are provided heating means **180** which may be either electrically or gas fired. Each heating means in the illustrated form of the invention, comprises a pair of heating platens **181,182** which are pivotally mounted for movement between a horizontal operative position and an inoperative vertical position. The respective heater platens through the interconnection of suitable linkages can be simultaneously pivoted between operative and inoperative position. The actuator for the heater platen **181, 182** may comprise a piston and cylinder assembly, the piston of which is operatively connected to the operating linkage to effect the pivoting of the heaters. The operating piston and cylinder assembly is in turn controlled by the switch **104.** The arrangement is such that the heater platens **181, 182** are pivoted in inoperative position whenever the printing operation is terminated for any reason.

To carry off any undesirable fumes, an exhaust duct **183** is arranged adjacent the heaters **180.** In the event a plastic sheet is being printed a means is provided to effect cooling of the printed portion of the printed sheet after passing the heaters **180** and before passing under the next succeeding printing head **62.** The cooling means comprises a cold air conduit **184** extending transversely of the printing blanket immediately upstreamwise from the screens **62.** The conduit is provided with a series of nozzles for directing cooling air onto the printed material. In this manner the temperature of the plastic web can be maintained at a temperature below that at which the material softens, and thereby avoid the creating of a sticky surface which would tend to adversely effect the rolling action of the screens.

In another form of the invention a woven polyester printing blanket may be substituted for the perforated blanket described. With a woven printing blanket the printing surface is rendered porous and can be utilized for printing either a porous fabric material or a non-porous plastic sheet. Thus the woven blanket permits the vacuum table to be used for either fabric or plastic. The utilization of the vacuum table when printing with fabric results in a greater penetration of the printing inks. This is because the penetration is enhanced due to the tendency of the negative pressure drawing the printing inks into the fabric.

To further secure a fabric to such woven blanket, means may be provided for applying an adhesive coating thereto, the adhesive being washed off as the printing blanket travels over the end roller **33.**

The operation of the apparatus thus described is as follows:

A supply or roll of material **131** is supported on the roll support **130** of the infeed accumulator **27** with the leading end of the material threaded about the rollers of the infeed accumulator **27,** as hereinbefore described. The lead end of the material to be printed is then supported on the printing bed or blanket **35.**

To effect a screen printing operation a start button located in a control panel, suitably located, is actuated. Actuation of the start switch energizes both the programmed motor **97** and the main drive motor **85.** The arrangement is such that the programmed motor **97** through its drive shaft **99** coupled to the variable transmission unit **86** will gradually increase the speed of the main drive motor **85** to bring the printing blanket **35** to operating speed. In bringing the main motor **85** to operating speed, the worm screw portion **99A** of shaft **99** will sequentially cause the screen and associated squeegee to be lowered into printing position. Also a heater **180** is lowered to operating position. That is, as the program motor **97** is bringing the main drive motor **85** up to speed it will effect a sequential operation of the screen **62,** squeegee **76** and heaters **180** by displacement of the cam actuators **103, 104** to actuate switches **103A** and **104A** controlling the operation of the printing head and heaters. The actuation of the main drive motor **85** will effect the drive of the printing blanket **35**

in the direction of feed gradually until operating speed of a printing operation is achieved. As the screens **62** are driven through a drive shaft **94** which is synchronized to the speed of the printing belt through the coupled transmission unit **93** during a printing operation, the screens rotate in time relationship to the movement of the material supported on the printing blanket.

The supply roll **131** is driven by a D. C. motor under the control of a potentiometer **134** which is governed by the tension of the material being pulled through the infeed accumulator **27.**

Each of the rotary screens **62** is independently operated upon by a piston and cylinder assembly **77** operating on a rack **79** meshing with the gear sector **80** and crank arm **81** for effecting the raising and lowering thereof with its associated squeegee **76.** In operation, the arrangement is such that whenever the printing operation is terminated, the squeegee is first caused to be raised off the screen by the crank **81** causing the pivoting arm **71** of the squeegee assembly **70** to be raised a predetermined amount. Thereafter further rotation of the crank will cause the printing head **58, 59** and screen supported thereon to be raised off the material M. The arrangement is such that the screen gear train **57, 67,** 64 enables the screen to be raised off the material without disengaging of gears **57, 67, 64.** The screens **62** are thus always maintained in timed or geared relationship to the movement of the printing blanket **35.** In accordance with this invention the material in passing under the printing screen **62** during the printing thereof is permitted to conform to a circumferential portion of the printing screen. This is attained by a cushioning effect resulting in a space or slot **36B** defined thereat formed on the surface of the table **36.** Thus wear and tear on the screen **62** is minimized by the cushioning effect attained thereat. Also this effect enables a greater penetration of the ink and/or amount thereof to be deposited on the material. By increasing or decreasing the vacuum about the area of contact beneath the screen **62** as seen in FIG. **4,** the amount of surface area contact permitted between the screens **62** and material M can be controlled. In this manner the amount of penetration of the inks which is permitted for a particular material can be controlled.

As the inlet accumulator **26** is provided with a slow down switch **138** and stop switch **139** the supply roll **131** can be readily changed without effecting a complete shut down of the printing operation. To effect a changeover, a negative pressure is applied to the holding table **123** for securing thereto the trailing end portion of the sheet to prohibit the trailing end of the sheet M from proceeding through the accumulator **26** to the screen printing machine. Because of the accumulation of folds of material in the infeed accumulator, sufficient material is provided for the printing operation to be continued while the changeover in the supply roll or spool is made. During the changeover, the arrangement is such that the speed of the machine can be slowed down in the event that the accumulator dancing carrier **120** is raised to sufficient height to strike the slow down switch. When the slow down switch **138** is actuated the speed of the printing operation is reduced to provide an operator sufficient time to effect the changeover of spools or supply rolls. The leading end of the material of the new roll is then fed over onto the vacuum table **124** which is also placed under a negative pressure. In this manner the leading end of the material of the new roll and the trailing end of the material from the preceding roll can then be secured in end to end relationship and be spliced together so as to effect a continuous web. The feeler indicator **136** engaging the supply roll provides the operator with a warning when a changeover is required. If the warning is not heeded, a second switch **137** is actuated to stop the printing operation when the supply roll reaches a predetermined low limit. To facilitate the undwinding of the material to accommodate the speed of the printing operation, the motor drive **132** of the supply roll is controlled by a potentiometer **133** connected in circuit with the supply roll motor so that the speed of the roll is rendered responsive to the tension of the material threaded over the accumulator rolls.

In the event that the changeover is not made in the time permitted, the tension on the material is increased causing the dancing carrier **120** of the accumulator to activate the stop switch **139** at its highest limit. The stop switch **139** is wired into the control circuit to terminate the printing operation.

When the machine is stopped for this reason or for any other reason, as hereinbefore described, the arrangement is such that the squeegee **76** is first caused to be lifted off the printing screen **62** and thereafter the printing screen follows to raised position off the material to an inoperative position.

The timing of the squeegee lift upon the machine coming to a stop is such that the squeegee blade **76** is lifted off the screen **62** while the belt **35** and material M has still a few inches of travel before it reaches 0 speed in the direction of feed. The screen **62** is then lifted off the material M. As previously described the actuation of the squeegee and screen is effected by the actuation of the piston and cylinder **77** in response to the actuation of the micro switch **130A** of the programming means **96.** It will be noted that as the upper printing head **58, 59** is raised under the influence of the piston and cylinder assembly and associated crank arm **81,** that the gear train **57, 67** and **64** remain always in meshing relationship to maintain the timed relationship between the speed of the blanket **35** and the rotation of the screens **62.** To eliminate backlash in the train of gears **57, 67** and **64,** the timing can be such that the screens are made to rotate at a speed slightly less than the speed of the transmission unit **86** which controls the rotation of drive shaft **90** to the blanket **35.**

The heating platens **181, 182** are also raised to an inoperative position upon the actuation of the programming switch **104A.**

Upon the printing blanket **35** speed being reduced to 0 forward speed, the programming motor will continue to run for a predetermined timed interval to reverse the printing bed or blanket **35** a predetermined distance. The printing screens in the inoperative printing position are also reversed as a result of the coupled transmission units **86** and **93.** A suitable time delay relay is incorporated in the circuit to de-energize the programming motor and main drive motor upon a lapse of a predetermined time interval. Thus in reversing the rotation of the screens **62,** a coating of ink is applied thereto and dripping of the ink onto the material is prohibited. The back up distance of the printing blanket may range between **24** and **36** inches.

Due to the interaction of the program control means the arrangement is such that reversing of the program motor **97** will cause a pivoting of the heaters **181, 182**

to an inoperative position in timed sequence to the raising of the squeegee **76** and the screen **62** to a non-printing relationship.

Upon restarting by actuation of the start button, the program motor **97** and main drive motor are energized whereby the speed of the drive motor **85** is gradually increased to operating speed, whereupon the cycle of operation is repeated.

The program motor upon being energized will effect the sequenting of the heaters **181, 182** and the squeegee and screens to an operative position in an inverse order. That is the printing screen is caused to be first rotated in the direction of printing as it is gradually lowered into contact with the material M on the blanket **35.** The arrangements such that the printing screen **62** will engage a printing portion of the material M in identical registration therewith as both the screen **62** and the material M are being advanced. With both the screens **62** and material M moving as engagement is made, the squeegee **76** is then brought into contact with the screen **62** to gradually build up pressure on the screen necessary to force the color therethrough. The timing is such that the printing operation is commenced before the preceding printed portion passes beyond the screen point of contact with the material M. Thus the new printing is commenced before the demarcation of the previous print has moved beyond the screen. The result is that an overprint in registration with the previously printed area is effected, and thereby any smearing or blurring between successive prints is avoided. Also the arrangement and mode of operation described results in a minimum of stress or strain being imposed on the screens **62.** The movement in registering both the screens **62** and material M in both the forward and reverse direction enables contact to be made in the printing direction before the demarcation of the previous print to result in an overprint which results in no break in the continuity of the design being printed.

In the event that the take-off roll **161** must be removed, the operation of the take-off accumulator **28** is similar to that of the infeed accumulator **26,** except that it will function in a reverse manner. That is, when the take-off roll **161** has been loaded, and requires removal so that an empty spool or core may be substituted therefor, the vacuum on the take-off table **160** is actuated to subject its chamber **160A** to a negative pressure. On application of the negative pressure the portion of the material thereon is held fast thereto; and the material is severed by a cutter **170.** As the severed material is held fast to table **160,** the dancing rollers **148, 149** of the take-off accumulator fall to take up the slack of the material being printed. As the dancing rollers reach a certain level, a slow down switch **167** is activated which will slow down the speed of the printing blanket to provide the time necessary to effect the changeover. If the changeover of the take-off roll **161** is not completed in the time permitted, then the dancing carrier **150,** when it reaches the bottom-most level will actuate the safety stop switch **168** that will terminate the printing operation of the machine by effecting the drive of the program motor to initiate the stopping sequence as hereinbefore described.

In the event that a plastic sheet is being printed, a means is provided for effecting the cooling thereof before the material is driven past the next succeeding screeen printing station. Accordingly, an air conduit **184** is interposed between a heater **180** and the next adjacent downstream printing screen **62** so as to effect the cooling of the sheet M to insure that the temperature of the printing material is below 120°F., prior to passing through the next succeeding printing screen. To eliminate any residual buid-up of heat in the printing blanket, a second cooling means **185** may be interposed on the under side of the printing blanket **35.**

With the apparatus and method described it will be noted that a method and apparatus is set forth wherein a continuous strip of web material can be continuously printed with a minimum amount or need to effect any shut-down of the printing operation. However, in the event that the printing operation must be terminated for one reason or another, the arrangement is such that the entire printing blanket **35** and the material M supported thereon can be backed up a predetermined amount while the printing screen in the non-printing position is also reversed in a direction opposite to the rotation required for printing a corresponding amount, so that upon a restarting of the printing operation the screen is rotated gradually as it is being moved to a printing position as the material is always being advanced at corresponding rates of speed. In doing so the squeegee operating on the printing screen is thereafter lowered to gradually build up the pressure on the screen as the squeegee settles into printing relationship. The timing of the movement of the screen **62** and the advancing of the belt **35** is such that a succeeding print is beginning to be formed before the trailing end of the preceding print passes the printing screen to effect a registered overprinting which avoid the formation of a demarcation point between successive prints or any resulting smearing or blurring thereof. The preceding print is thus readily picked up without leaving any noticeable mark or demarcation in the design which would result in the waste of the material at that point. The gradual build-up of the screen pressure during the printing operation minimizes any smearing or blurring between successive prints. The arrangement is such that both the printing blanket **35** and the material M supported thereon together with the rotation of the screens **62** move in register and synchronization with one another in both the forward and backward directions of movement.

The phase control unit **55A** enables the screen to be rotated through a full 360° in order to set initial registration of the design.

While the present invention has been described with respect to a particular embodiment of the invention it will be readily appreciated that variations and modifications may be made without departing from the spirit or scope of the invention.

What is claimed is:

1. A rotary screen printing apparatus comprising:

a surface for supporting the material to be printed,

a rotating printing screen disposed adjacent said surface,

means for effecting a relative movement of said surface and said screen between a printing and non-printing position,

means for moving said surface and material supported thereon relative to said screen in a direction of feed during the printing thereof,

drive means for rotating said screen in the printing position thereof relative to said surface to effect continuous printing of the material,

means for reversing the direction of travel of said surface and material thereon, upon the termination of a printing operation, and

means for reversing the rotation of said screen in the non-printing position thereof upon the termination of said printing operation,

wherein said means for effecting relative movement of the screen and surface between a printing and non-printing position include timing means for moving said screen into printing position onto the material whereby the screen effects engagement of said material on the trailing end portion of a print thereon in commencing a printing operation to overlap a portion of a preceeding printed portion of the material to eliminate any demarkation between successive prints on said material.

2. The invention as defined in claim **1** and including a second printing screen disposed in spaced relationship to the first mentioned printing screen,

a heating means being disposed between said printing screens, and a cooling means disposed between said heater and said second printing screen for cooling said printed material after the material has passed said heating means.

3. The invention as defined in claim **2** wherein said cooling means includes an air tube having a nozzle means for directing cooling air into said printed material.

4. A rotary screen printing apparatus comprising:

a surface for supporting the material to be printed,

a rotating printing screen disposed adjacent said surface,

means for effecting a relative movement of said surface and said screen between a printing and non-printing position,

means for moving said surface and material supported thereon relative to said screen in a direction of feed during the printing thereof,

drive means for rotating said screen in the printing position thereof relative to said surface to effect continuous printing of the material,

means for reversing the direction of travel of said surface and material thereon upon the termination of a printing operation,

means for reversing the rotation of said screen in the non-printing position thereof upon the termination of said printing operation,

said surface comprising an endless perforated printing blanket,

a vacuum table supporting said blanket and material during a printing operation,

means for drawing a vacuum on said table for maintaining said material fixed in position relative to said blanket, and

said vacuum table including a transversely extending opening disposed below said printing screen whereby said screen sits in said opening when in the printing position so that the printing blanket and material supported on said table may conform to a circumferential portion of the printing screen seated in said opening in the printing position thereof.

5. A rotary screen printing apparatus comprising:

a surface for supporting the material to be printed,

a rotating printing screen disposed adjacent said surface,

means for effecting a relative movement of said surface and said screen between a printing and non-printing position,

means for moving said surface and material supported thereon relative to said screen in a direction of feed during the printing thereof,

drive means for rotating said screen in the printing position thereof relative to said surface to effect continuous printing of the material,

means for reversing the direction of travel of said surface and material thereon, upon the termination of a printing operation, and

means for reversing the rotation of said screen in the non-printing position thereof upon the termination of said printing operation,

an infeeding accumulator discussed adjacent said supporting surface for feeding a continuous strip of material to said surface,

said infeeding accumulator having means storing a supply of continuous material which is feed to said supporting surface for a predetermined time interval to prohibit any interruption of the printing operation during the set of a new supply of material,

said infeed accumulator includes a holding table having a vacuum chamber,

means for drawing a vacuum on said holding table to secure the trailing end portion of a continuous sheet of material to said holding table,

means adjacent said holding table for supporting the leading end of another supply roll of said material to said trailing end portion to facilitate the joining of the leading end and trailing end portions to effect an uninterrupted printing of an indefinite continuous strip of material.

6. The invention as defined in claim **5** and including take-off accumulator disposed at the take-off end of said support surface, said take-off accumulator having means to accumulate a predetermined amount of printed material during the time required to effect a changeover of take-up rolls.

7. A rotary screen printing apparatus for screen printing a continuous strip of sheet material comprising:

a machine frame,

opposed spaced apart and rollers rotatably journalled on said frame,

a suppport table mounted on said frame between said end rollers, said table having a perforated table top,

means defining a vacuum chamber disposed below said perforated table top,

an endless printing blanket threaded over said end rollers whereby the upper flight of said blanket is supported by said table top,

said blanket being provided with a series of perforations extending through the surface thereof to be disposed in communication with said vacuum chamber,

means for drawing a negative pressure on said chamber,

a printing headmeans mounted on said frame, said printing head including a rotary printing screen rotatably journalled thereon, said printing screen extending transversely of said printing blanket,

a squeegee means extending axially of said rotary screen operatively associated therewith to force a printing ink therethrough during a printing operation,

means for effecting relative movement of said screen, squeegee and printing blanket between a printing and non-printing position,

and reversible drive means for driving said printing blanket and rotating said screen in one direction to effect the printing of the material supported when said screen, squeegee and printing blanket are in printing position on said blanket, and for reversing the direction of said printing blanket and rotation of said printing screen when in the non-printing position upon the termination of said printing operation an amount sufficient to effect an overprint portion between successive prints

said reversing drive means includes

a main reversible drive means,

a variable speed control means operatively connected to said main drive means,

said variable speed control means having an output shaft connected in driving relationship to one of said end rolls to effect the drive of said end roller and blanket threaded thereat,

said output shaft of said variable speed control means being operatively connected to a second variable speed control means,

said second variable speed control having an output shaft operatively connected in driving relationship to said rotary screen to effect the direction or rotation of said screen relative to the direction of drive of said blanket,

and a programming means operatively connected to said first mentioned variable speed control means for sequencing the operation of the blanket, screen and associated squeegee between a printing and non-printing relationship.

8. The invention as defined in claim **7** wherein said first mentioned variable speed control means includes an input shaft, and said programming means includes a reversible program drive means,

a shaft having a threaded portion connected in driving relationship with said program drive means,

said shaft being connected in driving relationship to said input shaft of said first mentioned speed control means,

a series of actuators spaced along said screw shaft.

9. A method of continuously screen printing a sheet of material comprising the steps of:

positioning a rotary printing screen having a stencilled portion and an associated squeegee onto the material to be printed in rolling engagement therewith,

printing the material by simultaneously advancing the material to a direction of feed and rotating the printing screen in the printing position thereof relative to said advancing material in predetermined timed relationship,

moving said printing screen and associated squeegee to a non-printing position upon the termination of a printing operation,

reversing the direction of travel of said material a predetermined amount upon the termination of said printing operation,

and reversing the rotation of said screen an amount corresponding to the reverse movement of said material in the non-printing position thereof,

whereby said direction of travel of said material and rotation of said screen in the non-printing position thereof are reversed corresponding amounts in synchronous timed relationship so that in the printing position said screen engages the trailing end portion of a preceeding printed portion of said material to effect an overlap between successive prints so as to eliminate any line of demarkation between successive prints.

10. A method of continuously screen printing a sheet of material comprising the steps of:

positioning a rotary printing screen having a stencilled portion and an associated squeegee unto the material to be printed in rolling engagement therewith,

printing the material by simultaneously advancing the material in a direction of feed and rotating the printing screen in the printing position thereof relative to said advancing material in predetermined timed relationship,

moving said printing screen and associated squeegee to a non-printing position upon the termination of aprinting operation,

reversing the direction of travel of said material a predetermined amount upon the termination of said printing operation,

and reversing the rotation of said screen an amount corresponding to the reverse movement of said material in the non-printing position thereof,

and including the steps of effecting registration between the screen and material on successive printing operations by rotating the screen in the printing direction,

advancing the material in the direction of feed, and lowering said rotating screen into contacting relationship with said advancing material thereby the stencilled portion of said screen coincides with a complementary trailing printed portion of the previously printed material, to effect an overprint portion between successive prints.

11. A method of continuously screen printing a sheet of material comprising the steps of:

positioning a rotary printing screen having a stencilled portion and an associated squeegee onto the material to be printed in rolling arrangement therewith,

printing the material by a simultaneously advancing the material in a direction of feed and rotating the printing screen in the printing position thereof relative to said advancing material in predetermined timed relationship,

moving said printing screen and associated squeegee to a non-printing position upon the termination of a printing operation,

reversing the direction of travel of said material a predetermined amount upon the termination of said printing operation,

and reversing the rotation of said screen an amount corresponding to the reverse movement of said material in the non-printing position thereof,

and including the step of cushioning the material at the point of contact thereof with said screen to increase the area of contact between the moving material and the screen during a printing operation.

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