April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 1

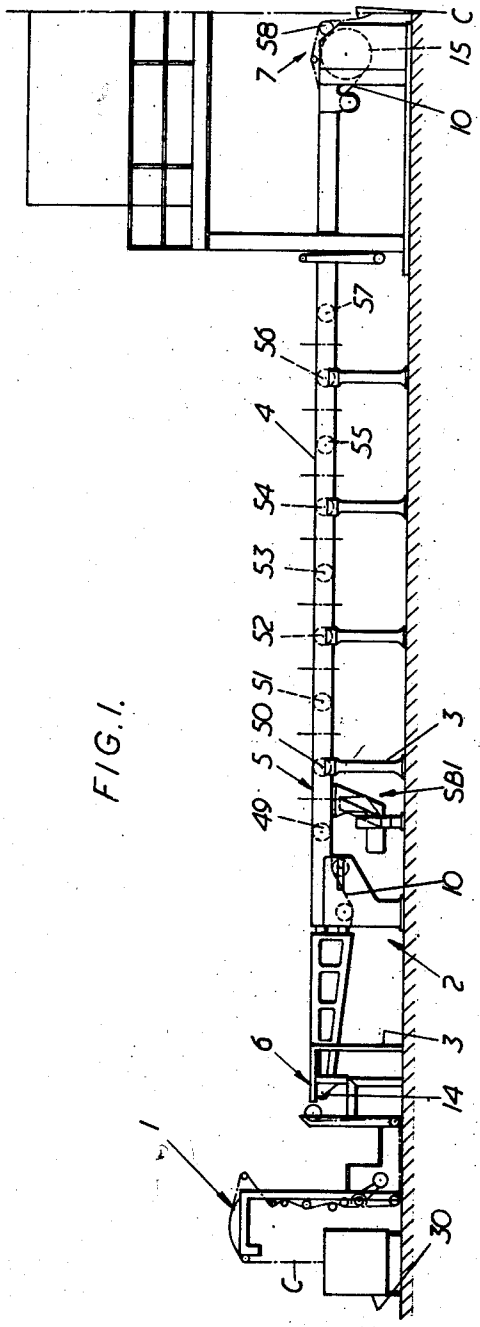


FIG. 1.

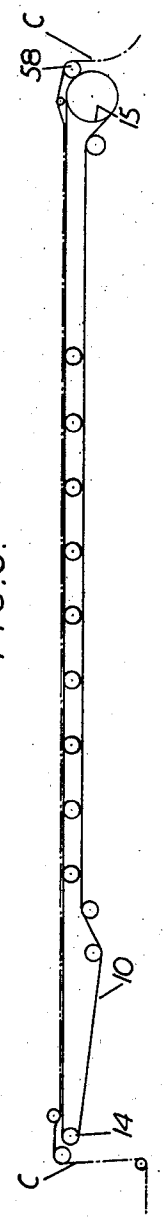


FIG. 6.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler & Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 2

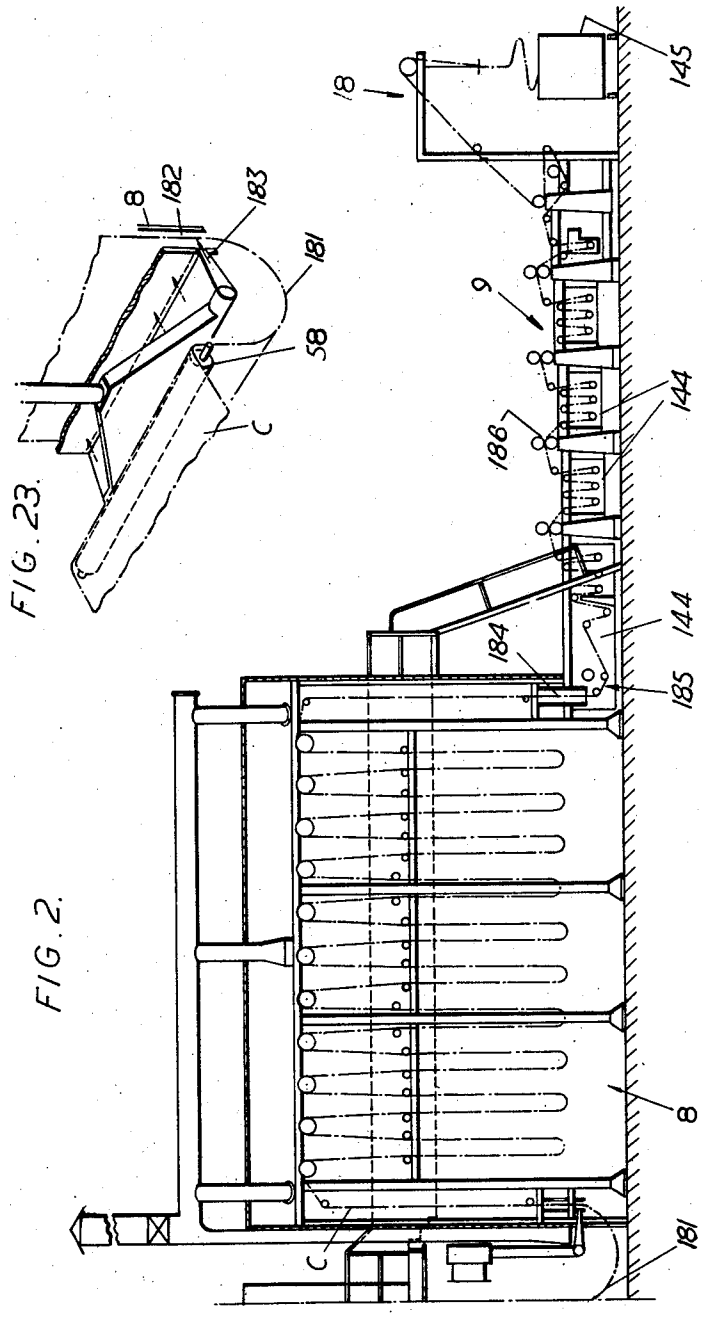


FIG. 23.

FIG. 2.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler & Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 3

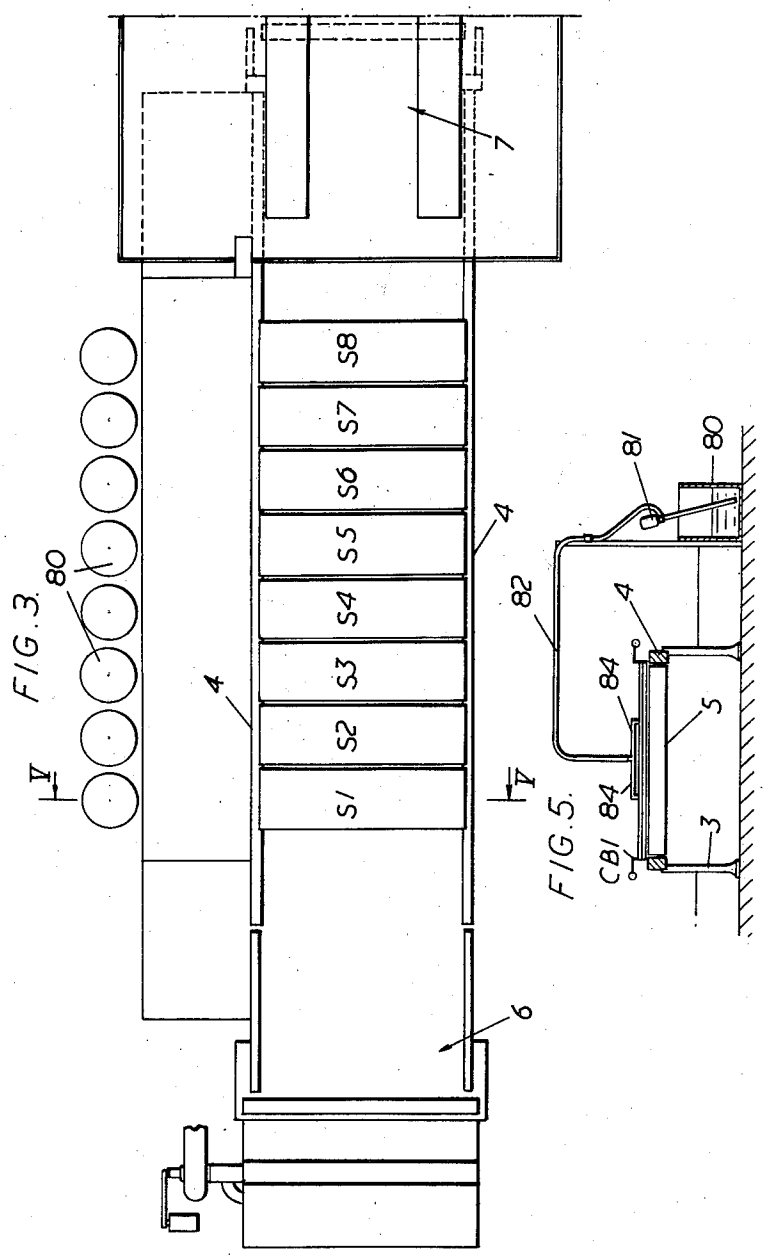


FIG. 3.

FIG. 5.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler & Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 4

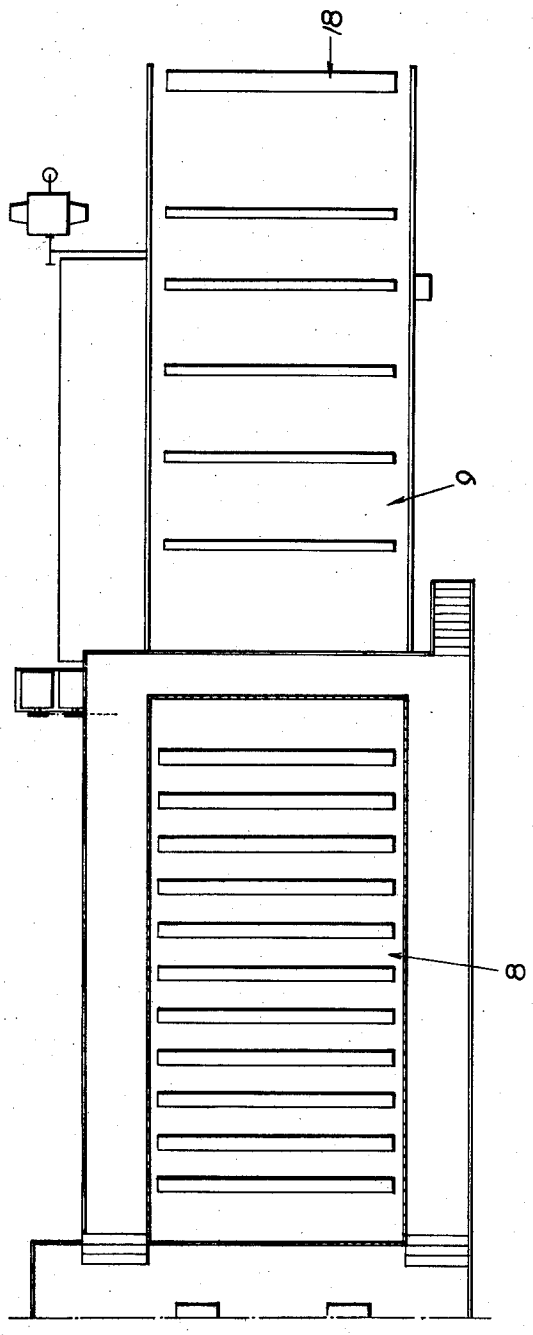


FIG. 4.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler + Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 5

FIG. 15.

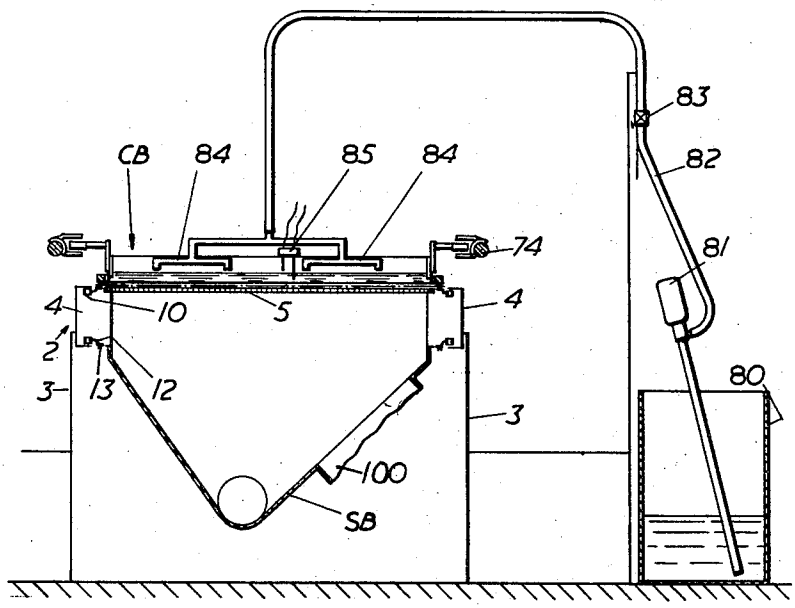
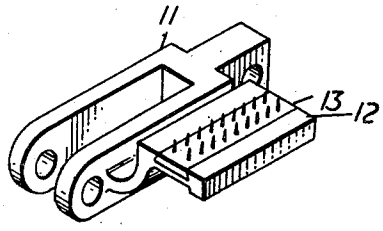


FIG. 7.



Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler + Beveridge *Attorneys*

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 6

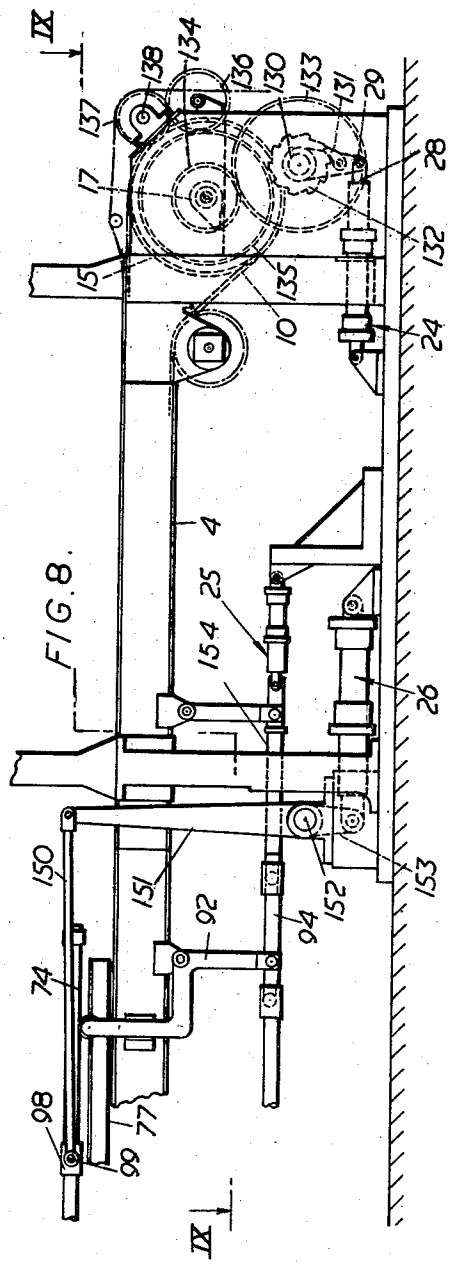


FIG. 8.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Sebenfler + Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 7

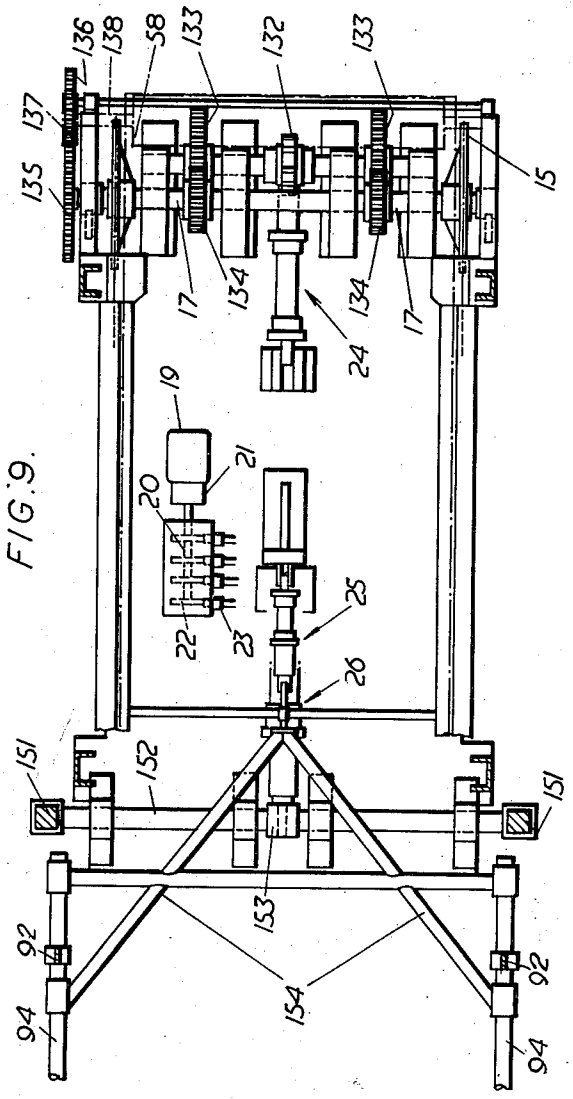


FIG. 9.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler + Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 8

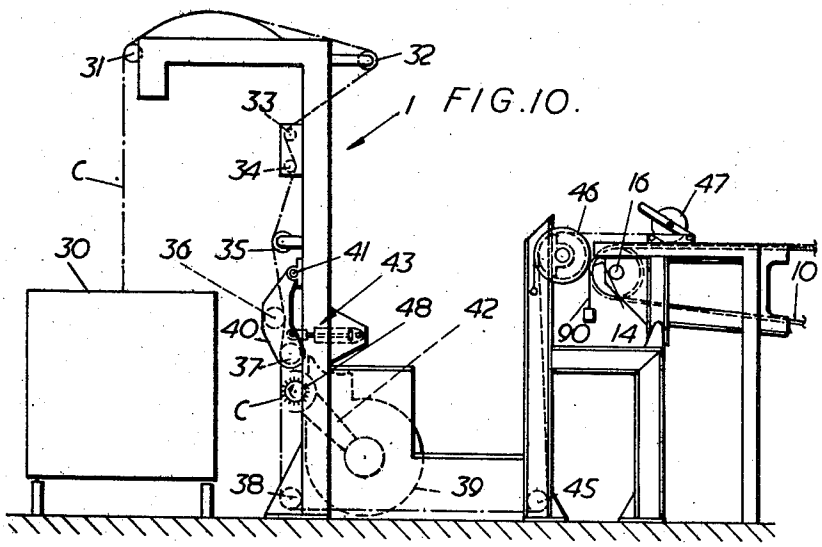


FIG. 10.

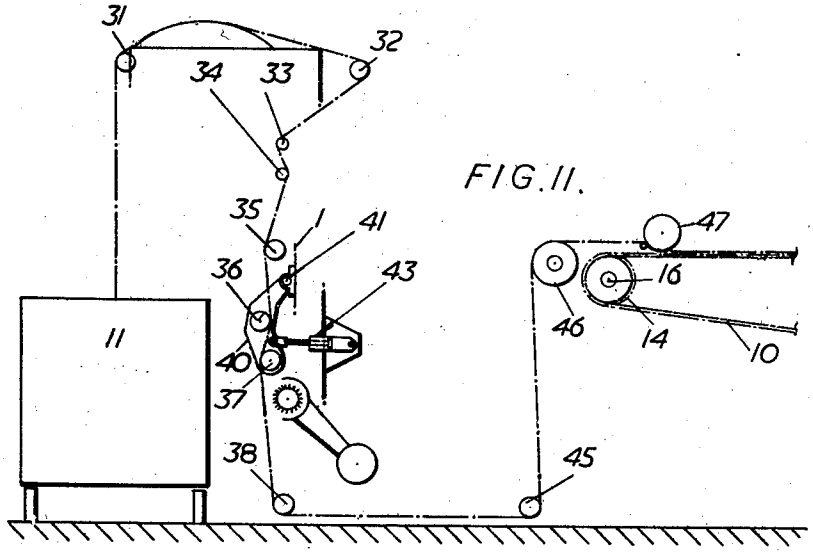


FIG. 11.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler & Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 9

FIG. 12

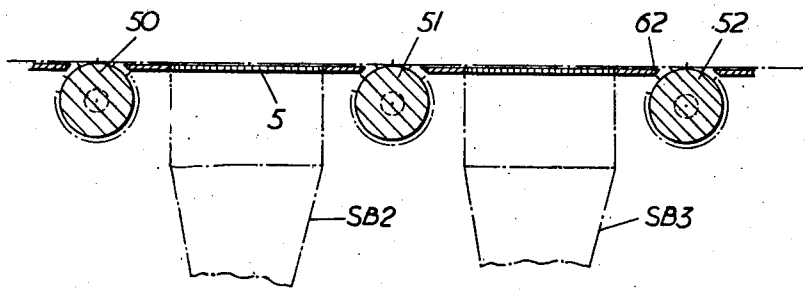


FIG. 13

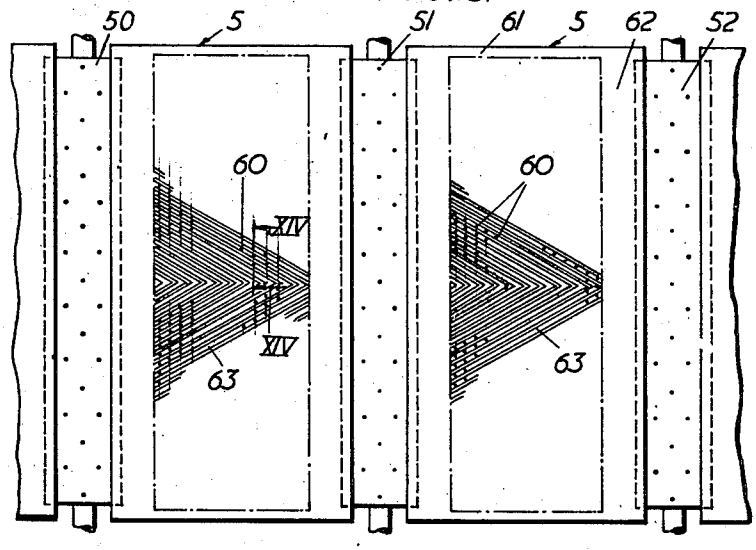
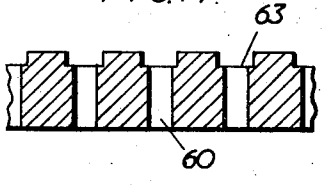


FIG. 14



Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler + Beveridge *Attorneys*

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 10

FIG. 16.

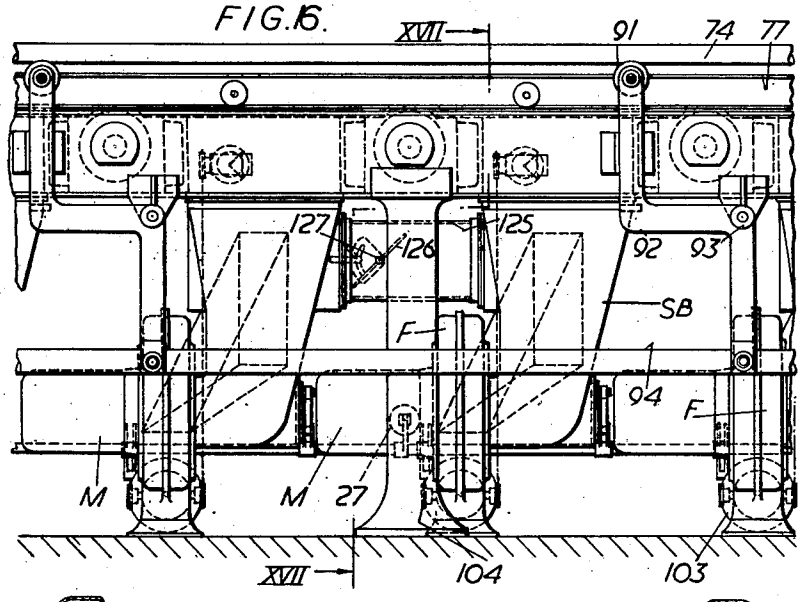
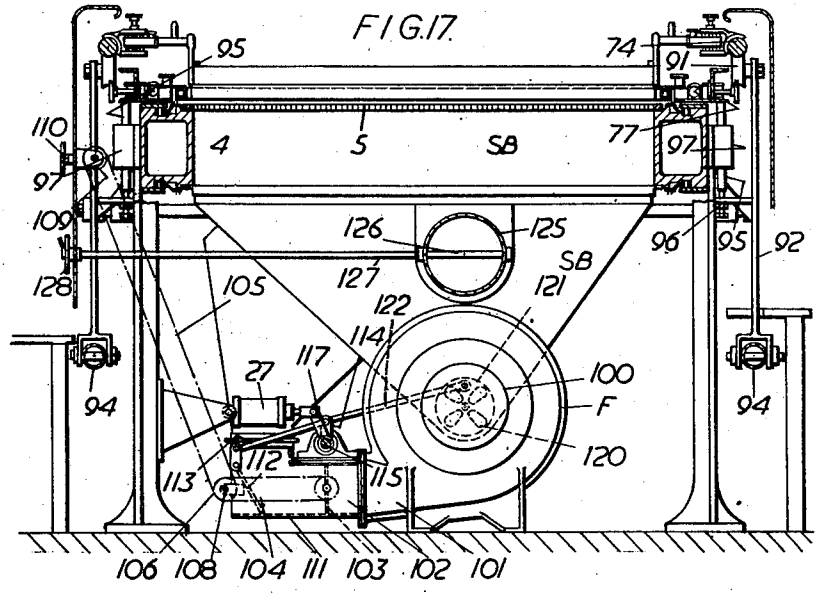


FIG. 17.



Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler + Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 11

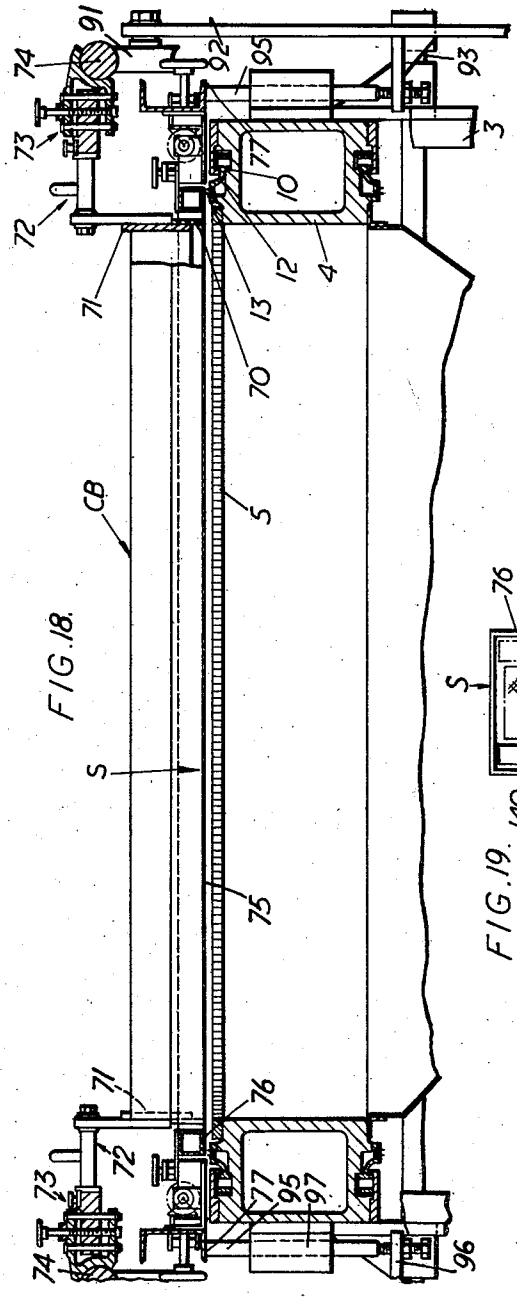


FIG. 18.

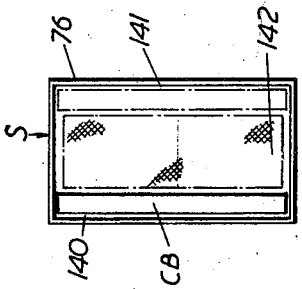


FIG. 19.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler & Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 12

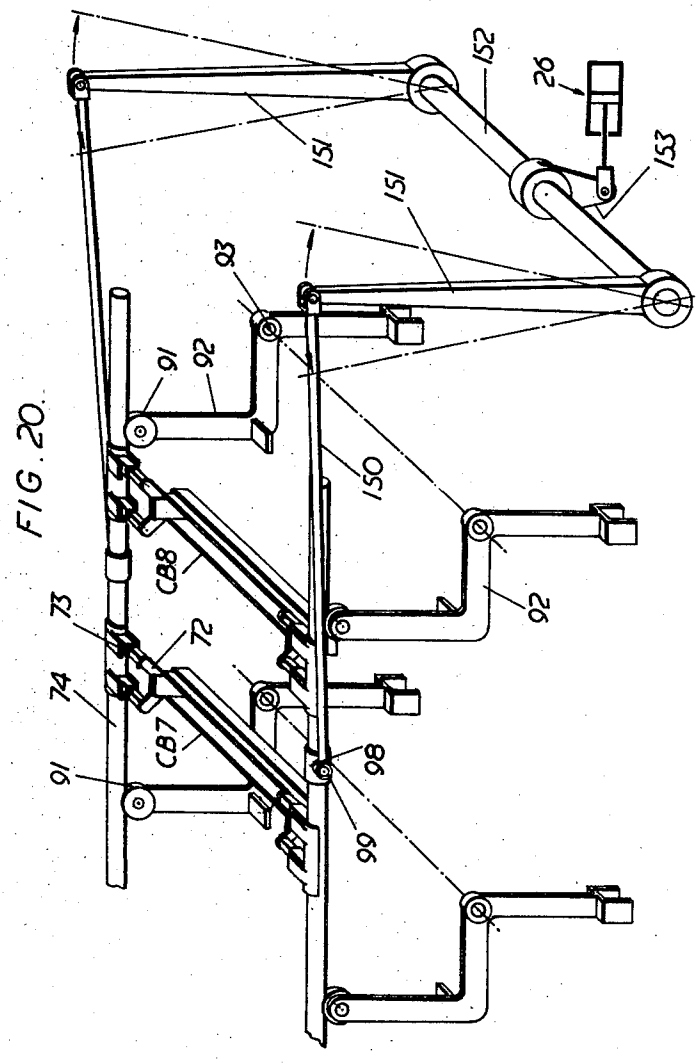


FIG. 20.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler + Beveridge Attorneys

April 21, 1964 T. L. LECKIE 3,129,442

STENCIL PRINTING OF THICK FABRICS

Filed July 13, 1960 13 Sheets-Sheet 13

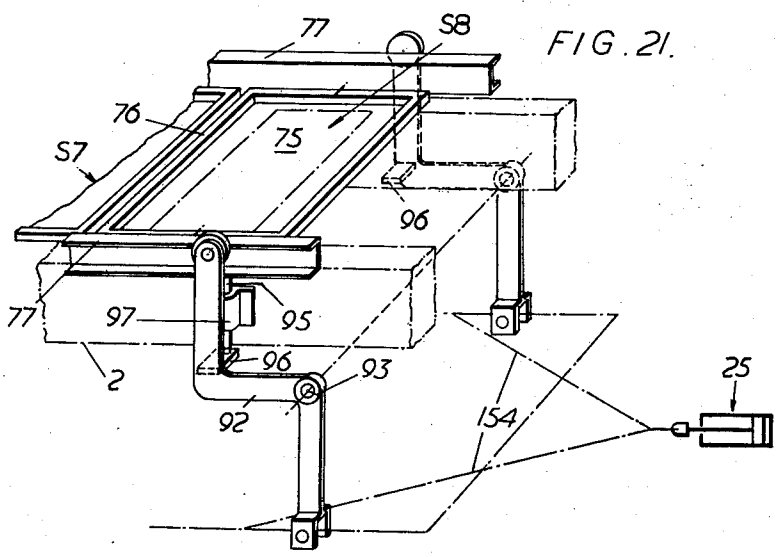


FIG. 21.

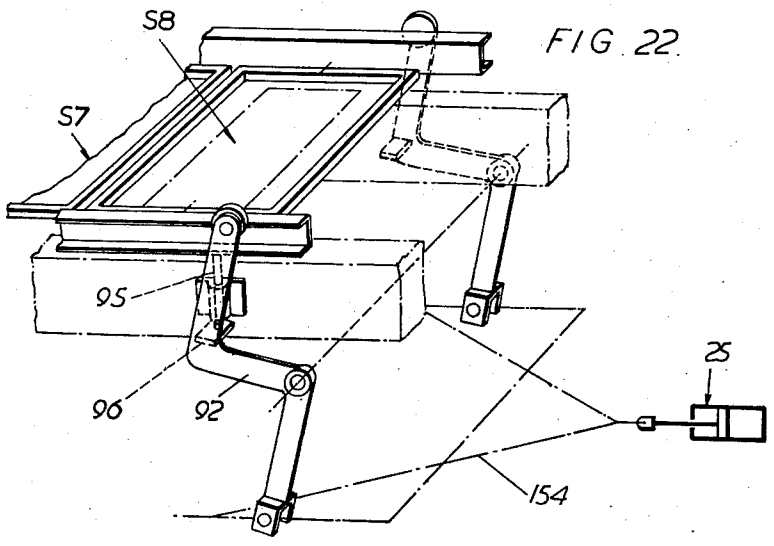


FIG. 22.

Inventor

THOMAS LIDDLE LECKIE

By

Mead, Browne, Schuyler + Beveridge Attorneys

United States Patent Office 3,129,442 Patented Apr. 21, 1964

3,129,442

STENCIL PRINTING OF THICK FABRICS

Thomas Liddle Leckie, Prestwich, near Manchester, England, assignor to The Bradford Dyers' Association Limited

Filed July 13, 1960, Ser. No. 42,655
Claims priority, application Great Britain July 14, 1959
7 Claims. (Cl. 8—149.1)

This invention comprises a process and machine for the printing of thick fabrics in continuous lengths. By thick fabrics I mean fabrics of thickness greater that 1 mm., such as tufted carpets or other pile fabrics (whether the pile is composed of fibres introduced into a fabric base or of yarn pulled out from a woven fabric as in a moquette), or felts, bonded fibre structures or non-woven structures. The invention is particularly applicable to, and will be described with reference to, pile carpets, but it is not limited to these.

Pile carpets, because of their weight and size and the depth of the pile, present printing problems entirely different from those of the printing of ordinary textile materials. In consequence pile carpets have hitherto been made with the use of yarns of different colours, a process which has various drawbacks. It would clearly be advantageous to make the carpet from grey, i.e. natural coloured, yarn and to print it to any desired pattern in a continuous process such that the carpet as delivered from the factory entered a machine and need not be touched by hand until it emerged as a finished printed product. I have produced what I believe to be the first process and machine by which this can be done.

My invention involves the technique of stencil printing, which of course involves movement of the carpet in stepwise fashion through one or more printing stations; this fact introduces some of the problems that arise.

By stencil printing I means printing through a stencil, whether that stencil is an imperforate sheet with free openings in it or is a screen with numerous meshes. As is well known, a pattern is formed by closing some of the meshes in the screen and leaving the remainder open to constitute stencil openings. All the meshes in a screen may be left open if a fabric to be printed should be of uniform colour throughout. The present invention is particularly useful in, and will be described by reference to, screen printing, but stencils with free openings may be used.

The invention includes numerous novel features as such and also a series of steps employed in sequence as a continuous process. These various features and steps will now be described with reference to the accompanying drawings, which show the preferred machine and in which:

FIGURE 1 is a diagrammatic side elevation of the entry end of the whole machine;

FIGURE 2 is a continuation of FIGURE 1 showing the delivery end of the machine;

FIGURES 3 and 4 are diagrammatic plans corresponding to FIGURES 1 and 2 respectively;

FIGURE 5 is a section on the line V—V in FIGURE 3;

FIGURE 6 diagrammatically illustrates a conveyor chain by which a carpet is engaged;

FIGURE 7 is a perspective view of a link of this chain;

FIGURE 8 is a diagrammatic side elevation and FIGURE 9 is a corresponding plan of the delivery end of the printing part of the machine on a larger scale;

FIGURE 10 is a similar elevation of a brushing mechanism and the entry end of the printing part of the machine;

FIGURE 11 diagrammatically illustrates the operation of the brushing mechanism;

FIGURE 12 is a diagrammatic side elevation illustrating the engagement of the carpet by pinned rollers;

FIGURE 13 is a plan corresponding to FIGURE 12;

FIGURE 14 is an enlarged section on the line XIV—XIV in FIGURE 12;

FIGURE 15 is a diagrammatic cross-section through the printing part of the machine on a larger scale;

FIGURE 16 is a side elevation of part of the machine on a larger scale;

FIGURE 17 is a section on the line XVII—XVII in FIGURE 16;

FIGURE 18 is a section similar to FIGURE 17 through the upper part only of the machine on a still larger scale;

FIGURE 19 is a diagram to show the movement of a colour box over a screen;

FIGURE 20 is a perspective view of two colour boxes and mechanism for moving them;

FIGURES 21 and 22 are perspective views of a screen and lifting mechanism in two different positions; and

FIGURE 23 is a perspective view showing a carpet entering the steaming vessel.

The machine shown is designed for printing pile carpets and comprises a brushing frame **1**, two main side frames **2** each composed essentially of uprights **3** and horizontal members **4** spaced apart from one another by a distance greater than the maximum width of carpet to be printed, an entry station **6** to the printing part of the machine, eight perforated carpet supports **5** spanning the side frames **2** and providing eight printing stations, a take-off station **7**, a steaming vessel **8**, a washing apparatus **9** and a withdrawal and lapping mechanism **18**. The printing stations are defined by rectangular screens, S1–8, mounted to move vertically, and above each screen there is a colour box, these boxes being numbered CB1–CB8.

At each side there is an endless conveyor consisting of a stenter chain **10** including links **11** with side flanges **12** having upwardly projecting pins **13** which engage the selvedges of the carpet. The chains **10** pass round sprockets, of which end sprockets **14** and **15** are carried by shafts **16** and **17**, and the shaft **17** is intermittently driven. Whenever the shaft **17** turns the carpet is positively driven by the engagement of the pins **13** with the selvedges.

It is important that the carpet should move through an exact distance at each step. There is an electric motor **19** which runs continuously and drives a cam shaft **20** through a reduction gear **21**. The cam shaft **20** carries cams **22** cooperating with followers **23** that control valves in pipes supplying hydraulic fluid to rams from a source not shown. Each of these rams reciprocates as the valves open and close, in a way that will be well understood by those skilled in the art, and the movements of the rams are timed through the cams to move the various parts of the machine appropriately. This driving mechanism is illustrated diagrammatically in FIGURE 9 and is omitted in the remaining figures for the sake of clarity of them, but three of the rams are shown in FIGURE 8 at **24**, **25** and **26**. A fourth ram is shown at **27** in FIGURES 16 and 17.

The driving mechanism thus described in outline may take any suitable form. All that is required is that the carpet should be moved in exact steps and halted with accuracy; that while the carpet is moving the screen and colour boxes should be stationary and raised above the carpet; and that when the carpet is stationary each colour box should move across the corresponding screen.

The ram **24** drives the shaft **17**. A stem **28** projecting from the ram cylinder is pivotally connected to an arm **29** that is freely mounted on a shaft **130** and that carries a pawl **131**. This pawl engages a ratchet wheel **132** which is fixed to the shaft and at each ram stroke this wheel is turned through one tooth. The shaft **130** carries a gear wheel **133** which meshes with a gear wheel **134** rigid with

the shaft 17. This driving gear is provided in duplicate, one part on each side of the ram 24.

Although the carpet is driven through the stenter chains 10, it is guided by numerous rollers. Each carpet C in turn is brought to the machine lapped in a cart 30 and unwound from it to pass over roller guides 31 and 32 in the brushing frame 1. From the guide 32 it passes over roller guides, 33, 34, 35, 36, 37 and 38. The guides 36 and 37 engage the carpet on its opposite faces and are carried by rocking levers 40, each pivotally mounted at 41 in the frame 1. The other guides in the frame 1 are carried in the fixed members of the frame, and the disposition of these guides as shown in FIGURES 10 and 11 ensures that the carpet is put under suitable tension.

In travelling from the guide 37 to the guide 38 the carpet passes a rotary brush 48 which rotates in the mouth of a suction pipe 42 connected to a fan 39 so that fluff detached by the brush is at once drawn down the pipe and delivered to a collector.

The brush 48 should simply skim the surface of the carpet to remove fluff and lint without deeply penetrating the pile or brushing the carpet while it is stationary. I find that if the pile is deeply brushed fluff is actually brought to the surface, and if the brushing is done as a separate process, i.e. not part of the continuous process of the invention, the fluff is at once brought to the surface or reaches it before the printing takes place. By removing the surface fluff immediately before printing, I leave the surface in a suitable condition for printing and ensure that the screen openings do not become clogged by fluff.

To prevent the carpet being brushed while it is stationary, with the result that some fluff brought to the surface would be still on it during the actual printing, the brush 48 is allowed to rotate continuously and the carpet is kept out of contact with it except when the carpet is moving. It is for this purpose that the guides 36 and 37 are mounted on the rocking levers 40. These levers are connected to the shafts of hydraulic rams 43, and the supply of hydraulic fluid to the opposite sides of the ram pistons is controlled through valves operated by mechanism (not shown) from the cam shaft 20. The levers 40 and therefore the roller guides 36 and 37 are moved in synchronism with the carpet from the position shown in FIGURE 10, in which the carpet is brushed while it is moving, to the position shown in FIGURE 11, in which it is out of contact with the brush while it is stationary.

The brushing of the carpet is effected while the carpet is moving substantially vertically downwards, as it is easier to move the carpet horizontally out of a vertical path than to lift it towards or away from the brush.

The carpet passes from the guide roller 38 round further guide rollers 45 and 46 onto the stenter chains 10. The roller 46 carries pins which engage the under surface of the carpet and is adjustably braked by a belt brake 90 so as to set up tension in the carpet. Two roller brushes 47 force the carpet selvedges onto the pins 13 of the chains 10.

Nine pinned rollers 49–57 are mounted in the side frames 2 so that the upper surface of the support 5 is tangential to the roller surface and the pins project above the support to engage the carpet. The rollers 49 to 57 engage the underside of the carpet over its width and are arranged between adjacent printing stations. Each of these rollers is free to rotate and so is driven by the carpet itself. An end pinned roller 58 is positively driven from the shaft 17 through a gear wheel 135 fixed to the shaft, an intermediate wheel 136 and a wheel 137 fixed to the shaft 138 of the roller 58.

The reasons for using the positive edge drive and the pinned rollers are that the pattern should be printed centrally on the carpet and in line with the selvedge; that a pile carpet is inconveniently heavy and large to attach to a belt; that as suction is applied a solid rubber or similar belt cannot be used and an adequately perforated yet strong enough belt is difficult to produce; and that the problem of preventing centre drag which shows itself in bowing of the weft threads and consequently in unclear printing, and which is acute with so heavy a thing as a pile fabric, is solved by the use of pinned rollers. The braking of the roller 46 and the driving of the roller 58 ensure that the carpet is under tension throughout its width. The freely rotatable rollers 49 to 57 are not essential, but are desirable in a wide carpet.

In travelling beneath each screen S the carpet slides over the corresponding support 5, which is a metal table in which many holes 60 are made to allow suction to be applied to the underside of the carpet through the corresponding suction box SB, there being as many suction boxes (SB1–SB8) as there are screens. The top of each suction box is constituted by a perforated part of the support 5, this part lying within imperforate side edges 61 and end edges 62, the latter bounding the slots in which the rollers 49 to 57 turn. The holes 60 forming the perforations are arranged in rows with the mouths of all the holes of a row lying in a channel 63 and thus communicating with one another. It is found to be advantageous to make these slots form a herring-bone pattern as shown in FIGURE 13. If all the slots run parallel to the warp there is a tendency for the printing to be uneven in tramline fashion. If they all run parallel to the weft there is undesirable resistance to the movement of the carpet. If they are all inclined in the same direction they tend to push the carpet in that direction, but if they are arranged in herring-bone pattern the carpet is kept central.

An important feature of the invention is the use of a free-flowing colouring matter as the printing liquid. In the screen-printing of textile fabrics it is common to use a fairly thick liquid which flows slowly over a horizontal surface and which is forced over the screen by squeegees. The pile of a carpet is usually at least ⅜" deep, and may be as deep as ¾". If the colouring matter is of the usual consistency, it will not penetrate the pile deeply.

The viscosity of printing pastes or colouring matter may be measured by the Redwood method described in "Standard Methods for Testing Petroleum and Its Products" issued by the Institute of Petroleum, on page 665 of the 16th edition dated February 1957. Pastes used in conventional engraved roller printing operations are very thick and may have a Redwood No. 1 viscosity figure at 75° F. of from 20,000 seconds to 100,000 seconds. The free-flowing colouring matter used in this invention is much more fluid and in general has a Redwood No. 1 viscosity not exceeding 3000 seconds at a temperature of 75° F. Suitable colouring matters have been found to have viscosities varying between 25 and 1821 seconds. Colouring matters which have a Redwood No. 1 viscosity in excess of 3000 at 75° F. may be used if desired by heating them to a temperature such that their Redwood viscosity is reduced to below about 3000 seconds.

In screen printing as practised hitherto the colouring matter is commonly forced over the screen and through the openings in it by a squeegee which moves across the stencil. No great difficulty arises so long as the colouring matter is a fairly viscous paste. When, however, pile fabrics and particularly pile carpets are to be printed, I have found it necessary to use the free-flowing colouring liquid (of viscosity little greater than that of water) described above, and this introduces entirely new problems. There is difficulty in holding the colouring liquid in the container, particularly when printing is not taking place and the screen is being lifted to allow the carpet to move forward in step-by-step fashion.

In the present process and machine the colouring matter is supplied to each screen S from a colour box CB. Each colour box is of narrow rectangular shape in plan, extends

completely across the screen from one side to the other and in width is only a small fraction of the length of the screen. Its narrow end walls are formed by plates **71** carried by arms **72** which are adjustable in height through devices **73** themselves secured to lifting rails **74**. Each screen consists of gauze **75** stretched across the underside of a metal frame **76**, and along the side edges the meshes in the gauze are closed. Along the end edges the meshes are also closed over an area at each end large enough to receive the complete colour box. During the printing operation the colour box is moved from one end edge to the other while the screen is stationary, and it is of course necessary to allow the colouring matter to flow freely through the openings in the screen as the box moves but to prevent it from escaping at the end of each printing stroke.

Each colour box has a flexible lower edge formed by rubber strips **70** which make a seal with the imperforate parts of the surface of the screen S, this edge being kept in contact with the screen during the whole of each printing operation and with the imperforate surface at the end of the screen at the end of each printing operation. When the container is in contact with an imperforate end of the screen the colouring liquid is confined within it by the seal.

FIGURE 19 shows a colour box CB on a screen S. The box is shown in full lines over an imperforate part **140** of the screen and in dotted lines in the position it takes up over another imperforate part **141** at the end of a stroke after traversing the part **142** containing the open meshes.

The wider the colour box, the more difficult it is to make the necessary seal and the greater the width of the imperforate surface required at each end of the screen, with resultant increase in the distance between printing stations. A very narrow colour box, on the other hand, involves slow operation of the machine. A very suitable width of colour box is 4 inches.

The colouring matter required for each colour box CB is supplied to that box from a container **80** by a pump **81** through a pipe **82** containing a manually adjusted valve **83** to distributors **84**. An electrical probe **85** responsive to the liquid level is provided in each box and is electrically connected to control the operation of the pump **81**.

Naturally when the screen is lifted to allow the material to move through one step the colour box must be lifted too. It is found in practice that there is some tendency for a screen to sag when lifted, with the result that the seal between it and the flexible edge **70** ceases to be tight. To avoid the risk of colouring matter escaping through this cause between the screen and box the former is moved through a slightly greater distance than the latter. The pressure between the screen and the flexible edge in the raised position is therefore greater than in the printing position, and the risk of liquid seeping through the seal is practically eliminated. If this same high pressure were exerted during the printing, the resistance of the flexible edge to movement over the screen would be so high as to make the movement difficult.

In the machine shown all the screens S are carried by rails **77** one at each side. The screen rails must be able to rise to allow the fabric to move, and the rails **74** must not only be able to rise but also must be mounted to reciprocate to carry the color box over the screen. To enable differential lifting movement to take place, the colour box rails **74** are supported by rollers **91** carried by cranked levers **92** pivoted at **93** and all rigid at their lower ends with operating bars **94**, one at each side. The two operating bars **94** are reciprocated horizontally through inclined rods **154** by the ram **25** when the colour boxes are to be raised, and they rock the levers **92** from the position shown in FIGURES 20 and 21 to that shown in FIGURE 22.

The screen rails **77** are supported by vertical rods **95**

which are raised by cam action when the levers **92** rock to lift the rails **74**. The cams are plates **96** rigid with the levers **92** and bearing on the undersides of the rods **95**, which are themselves guided in fixed open-ended sockets **97**.

When each lever **92** is rocked, the cam plate **96** rises through a distance determined by the length of the middle arm of the lever and the angle of rocking. The roller **91**, being carried at the end of the upper arm, moves upwards through a distance that is the difference between the upward movement of the plate **96** (at the junction of the two arms) and the downward movement of the upper end of the upper arm that results from the movement of that end in a circular path. Therefore the screen is moved further than, and pressed more firmly against, the colour box.

In order to reciprocate each colour box over the screen beneath it, the rails **74** are caused to slide over the rollers **91**. Each is engaged by a sleeve **98** which forms a housing for a pivot pin **99** that enters one end of a connecting rod **150**. The other end of this rod is pivotally connected to a crank **151** on a cross-shaft **152**. This shaft can be rocked through a crank **153** by the ram **26** shown in FIG. 8 and diagrammatically in FIG. 20, the movement of the ram being cam-controlled so that each colour box makes one stroke each time the carpet is halted for printing. The lifting movement of the rail **74** described above is permitted by rocking of the connecting rod **150** with simultaneous slight longitudinal movement of the rail **74**.

Each suction box has a circular mouth **100** in one wall which is joined to the suction side of a centrifugal fan F driven continuously by an electric motor M. The discharge outlet **101** of each fan is connected to a pipe **102** that contains a butterfly valve **103** which can be adjusted through chains **104** and **105** passing respectively over sprockets **106** and **107** on a common shaft **108**, the chain **105** passing also over a sprocket **109** which can be turned by a hand wheel **110**. The pipe **102** discharges air from the fan into a small rectangular box **111**, the top of which opens into the suction box SB. This box **111** has a valve-controlled opening to atmosphere. The valve is a pivoted flap **112** mounted to swing through 45° to form one or other of two adjacent walls of box **111**. In one of its two end position the flap **112** is horizontal and closes the passage from the box **111** to the suction box so that all the air discharged by the fan must flow to atmosphere, and in the other end position (shown in FIGURE 17) the flap shuts the inside of the box **111** off from the atmosphere so that all the discharged air must re-enter the suction box. The flap is moved between its end positions by a pivoted linkage **113** connected to a crank **114** on a cross-shaft **115** which is turned through 45° and back again in synchronism with the printing operations by the hydraulic ram **27** which is connected to another crank **117** on the shaft **115**. The movements of the ram **27** are controlled through the main cam shaft **21**.

Valve-controlled openings **120** are made in the outer side of the casing of the fan F. The valve controlling these openings is an apertured plate **121** mounted to turn in its own plane to bring apertures into or out of register with the openings **120** in the casing. This valve **121** is turned by a rod **122** connected to a further crank (not shown) on the shaft **115**.

During printing the fan discharges to atmosphere through the box **111** and the openings **120** are closed, so that the full suction (controlled by the valve **103**) is applied to the underside of the carpet. When the carpet, which is held and moved by its side edges, is shifted from station to station, the friction between the centre of the carpet and the support **5** tends to cause the weft threads to bow. If this happens, the patterns printed on the carpet in successive printing stations will overlap or otherwise to be thrown out of register. If the suction set up

by the fan is exerted when the carpet is being shifted between stations, then the frictional resistance to movement of the carpet over the support is even greater than before.

It is to avoid such inaccurate printing that the valves 112 and 121 are provided. At the end of each printing operation the suction is destroyed, so that only gravity holds the carpet down on the support, and in fact the suction is replaced by slight positive pressure. To effect this the valves 112 and 121 are changed over, so that the fan discharges into the suction box and circulates air in closed circuit, and a comparatively small amount of air enters this circuit from the atmosphere through the openings 120. An equivalent amount of air then flows upwards through the carpet. This positive pressure is applied when the printing operation is complete but before the carpet moves, and the suction is applied before the beginning of the printing operation.

The risk of inaccurate printing is also counteracted by the rollers 49 to 57, which ensure that the centre of the carpet does not lag behind the selvedges during the printing. The positive pressure set up in the suction box must not be so great as to lift the carpet off these rollers or press it hard against the underside of the screen above it. Preferably there is just enough pressure to set up an air current through the carpet without actually lifting it.

Each printing station has its own fan and suction box but means are provided for interconnecting one box to another or others, so that the suction on one section of carpet may be increased. The suction boxes are interconnected by ducts 125 each controlled by a valve 126 which is mounted on a rod 127 that can be turned through a handle 128.

Air trapped within the pile is largely responsible for the difficulties experienced hitherto in obtaining through printing of a deep pile. For successful printing it is essential both to provide a perforated support such as that shown at 5 beneath the fabirc in order to enable the air to escape and to maintain a substantially constant pressure difference across the screen and fabric during the printing. By means of the suction the air is extracted from the fabric, and thus the liquid colouring matter is enabled to penetrate to the bottom of the pile; the maintenance of a head of the colouring matter ensures that the colouring matter does penetrate the pile deeply; and the maintainence of that head substantially constant ensures that a uniform amount of colouring matter flows to each part of the fabric that must receive it.

Printing can be successfully effected without suction, but then the head of colouring matter must, of course, be greater.

In the printing operation in the machine described, the suction set up in the suction box is effectively applied over a progressively decreasing area of carpet, because the colouring matter acts largely as a liquid seal on the parts of the carpet to which it is applied. The increase in suction would cause the part of the carpet printed at the end of a stroke to be more deeply printed than that at the beginning, i.e. the printing would be uneven. This increase in suction is however compensated for by a decrease in the head of the liquid colouring matter, because the probe 85 does not respond instantaneously to each change in level in the colour box but rather allows the head of liquid to decrease during each printing stroke at substantially the same rate as the suction on the unprinted carpet increases.

If the area that is being printed through a screen is large, e.g. is the background area of the carpet, or if a carpet with a very dense pile is being printed, the decrease in the liquid head may be greater than the increase in the suction, and it may be necessary to supply colouring matter to the colour box during the printing stroke. When this is done the pump 81 when running should deliver the colouring matter at a rate less than that at which it leaves the box so that the liquid head may be allowed to fall to offset the increase in suction.

The variable factors affecting the optimum pressure difference and the permissible departure from it include the area of the carpet subjected to suction, the time during which the colour box is over each piece of the carpet, the viscosity of the colour, the depth of the pile, the density of the pile, and the nature of the fibres. As the viscosity increases, so must the pressure difference increase.

As an example, in printing a substantial proportion of the area of the carpet, e.g. 40%, with a single colour, the pressure difference may initially be equal to 4" water gauge. During the whole printing stroke this should not vary by more than half an inch. With a denser carpet a pressure difference of 8 inches may be required in printing the same proportion of the area, and this should not be allowed to fall below 7 inches. In other words, under these conditions the pressure difference should be constant within 12½% if uniform printing is to be effected.

When, however, only a small proportion of area is being printed with a given colour, the pressure difference may decrease by as much as 20% from an initial value, so it may not be necessary to supply colouring matter to the colour box more often than once in every four or five printing strokes.

Another way of carrying out the invention is to provide a valve-controlled opening in the suction box and to open this progressively as the colour box moves across the screen, while simultaneously maintaining the liquid head substantially constant.

A further way of carrying out the invention, which may be used with advantage with wide carpets, is to employ a suction nozzle which has an opening equal in area to the colour box and which moves with the colour box.

The printed carpet is introduced into the steaming vessel in order to fix the colour. It is found that by steaming the carpet while the colour is still wet, instead of first drying the carpet, much better fastness of colour is obtained.

The printing, steaming and washing-off are part of the complete continuous process, and in order to maintain the correct conditions between the printing machine and the steaming machine a loop is formed in the carpet, and is of such length that the carpet can be fed intermittently into the loop but withdrawn continuously from it. The carpet runs over the pinned roller 58 in the take-off station 7 and forms the loop shown at 181 in FIGURES 2 and 23. It then passes continuously and vertically upwards into the steaming vessel 8. It is important that the pile surface, which is still wet, should not make contact with any hard surface, as this might smudge the colours before they are fixed. The carpet is introduced into the steaming vessel through a slot 182 only slightly wider than the thickness of the carpet so as to minimise the escape of steam, and it is important to keep the recently printed fibres out of contact with the wall of the slot. This is done by subjecting the carpet to an air blast from a nozzle 183 connected to a fan (not shown) as it passes through the slot to force its under-surface against one wall of the slot, and keep its wet surface out of contact with the other wall.

From the steaming vessel 8 the carpet passes into the washing apparatus 9 through a water seal 184. It is agitated by an agitator 185 as it passes into the apparatus, which comprises a series of washing vessels 144. The carpet is moved into and through these vessels by positively driven rollers 186 which rotate continuously. Finally it is lapped into a trolley 145 and conveyed to a drying apparatus. Alternatively it may be dried before being lapped.

I claim:

1. A method of stencil-printing a pile fabric in continuous lengths by moving the fabric horizontally in stepwise fashion through a plurality of printing stations which comprises skimming lint and fluff from the surface of the

fabric while it is moving without deeply penetrating it; printing the fabric in each printing station through a stencil by free-flowing liquid coloring matter passing directly through the stencil from a bottomless container in engagement with the stencil while applying suction to the underside of the fabric so as to maintain an optimum pressure difference across the stencil and fabric, and maintaining said pressure difference substantially constant whereby a penetration of the pile occurs with a minimum of objectionable lateral spreading of the coloring matter so as to produce a commercially acceptable stencil printed fabric; forming a loop in the fabric; moving the fabric forward continuously from the loop; steaming the fabric while it is still wet and fixing the color in it; and passing the fabric through a washing liquid.

2. A method according to claim 1 in which the skimming is effected by causing the fabric to move past a rotary brush, and the fabric is moved away from the brush whenever it stops travelling.

3. The method of claim 1 in which the pile fabric is carpeting.

4. A method of stencil-printing a pile fabric, the improvement which comprises bringing a length of the fabric into position below a stencil and above a perforated support, causing a bottomless container to traverse the stencil in contact therewith while the fabric is stationary, maintaining a body of free-flowing liquid coloring matter in the container, applying suction to the entire area of the stencil during the traversing, the effective head produced by the suction on the underside of that part of the fabric which is being printed increasing throughout the printing stroke, and offsetting the increase in said effective head by reducing the head of the liquid in the container so as to maintain a substantially constant pressure difference across the stencil and fabric during the traversing whereby a penetration of the pile occurs with a minimum of objectionable lateral spreading of the coloring matter so as to produce a commercially acceptable stencil printed fabric.

5. In a method of stencil-printing a pile carpet in continuous lengths in stepwise fashion in a plurality of uniformly spaced printing stations, the improvement which comprises applying free-flowing liquid coloring matter to an area of the carpet in each of said printing stations while the carpet is stationary on a perforated support, subjecting the whole of each area to suction on its underside through the support throughout the application of the coloring matter, destroying the suction at the end of the application of the coloring matter and replacing it by positive air pressure, and moving said carpet horizontally through a distance equal to that between adjacent printing stations while the suction is destroyed and the positive pressure maintained.

6. In a method of stencil-printing a pile fabric, the improvement which comprises bringing a length of the fabric into position below a stencil and above a perforated support, printing the fabric through the stencil by a free-flowing liquid coloring matter passing directly through the stencil from a bottomless container in engagement with the stencil, said printing initially being effected under an optimum pressure difference across the stencil and fabric, and maintaining said pressure difference substantially constant whereby a penetration of the pile occurs with a minimum of objectionable lateral spreading of the coloring matter so as to produce a commercially acceptable stencil printed fabric.

7. In a method of stencil-printing a pile fabric, the improvement which comprises bringing a length of the fabric into position below a stencil and above a perforated support, printing the fabric through the stencil by a free-flowing liquid coloring matter passing directly through the stencil from a bottomless container in engagement into the stencil and applying suction to the underside of the fabric, said printing being effected under an optimum pressure difference across the stencil and fabric for a given fabric while maintaining said pressure difference substantially constant by controlling the suction and the head of the liquid coloring matter whereby a penetration of the pile occurs with a minimum of objectionable lateral spreading of the coloring matter so as to produce a commercially acceptable stencil printed fabric.

References Cited in the file of this patent

UNITED STATES PATENTS

5,480	Coates	Mar. 21, 1848
1,338,785	McGiehan	May 4, 1920
2,008,230	Spooner	July 16, 1935
2,045,783	Lang	June 30, 1936
2,167,179	Joa	July 25, 1939
2,199,342	Johnson	Apr. 30, 1940
2,205,958	McGhee	June 25, 1940
2,236,751	Dine	Apr. 1, 1941
2,321,134	Fleisher	June 8, 1943
2,371,930	Sennino	Mar. 20, 1945
2,421,410	Bucklin	June 3, 1947
2,446,502	Wehrli	Aug. 3, 1948
2,532,471	Wedler	Dec. 5, 1950
2,590,643	Owren	Mar. 25, 1952
2,612,835	Marek	Oct. 7, 1952
2,758,540	Laupman	Aug. 14, 1956
2,862,445	Davey	Dec. 2, 1958
2,923,235	Voeglin	Feb. 2, 1960
2,991,711	Ehrhard et al.	July 11, 1961

FOREIGN PATENTS

518,036	Great Britain	Feb. 15, 1940