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Wills-Moren et al.

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[54] **PATTERNING SYSTEM FOR A MULTI-FEED CIRCULAR KNITTING MACHINE**

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[51] **Int. Cl.**..... **D04b 15/68**

[58] **Field of Search**.... 66/50 R, 50 A, 50 B, 25, 40, 66/42, 36 A, 36 B, 8, 154 A; 137/81.5

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[57] **ABSTRACT**

A multi-feed circular knitting machine equipped with needles selectively raised to different heights by jacks having patterning butts arranged to be acted upon by air-operated selector cams. The latter are in pairs stacked into housings, one in advance of each feed. The two cams of each pair are for raising needles, via jacks, to tucking and clearing heights respectively. To each stack of selector cams there is a block of fluidic elements with sensing orifices in alignment with channels of information carried by a punched tape or an apertured drum driven in time with the machine. The selector cams are pushed forward by low pressure air and retracted by induced vacuum. The jacks are in a cylinder larger than a cylinder accommodating the needles, movement transmitting and amplifying levers being provided between the two whereby short movements of the jacks are converted into longer movements of the needles.

5 Claims, 9 Drawing Figures

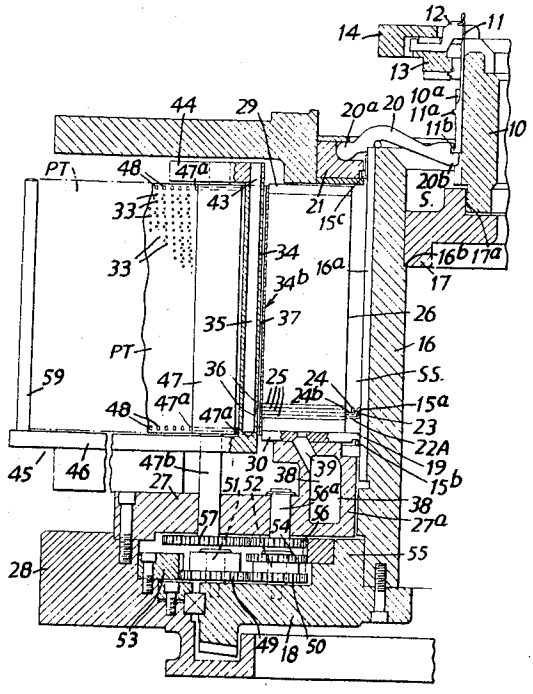
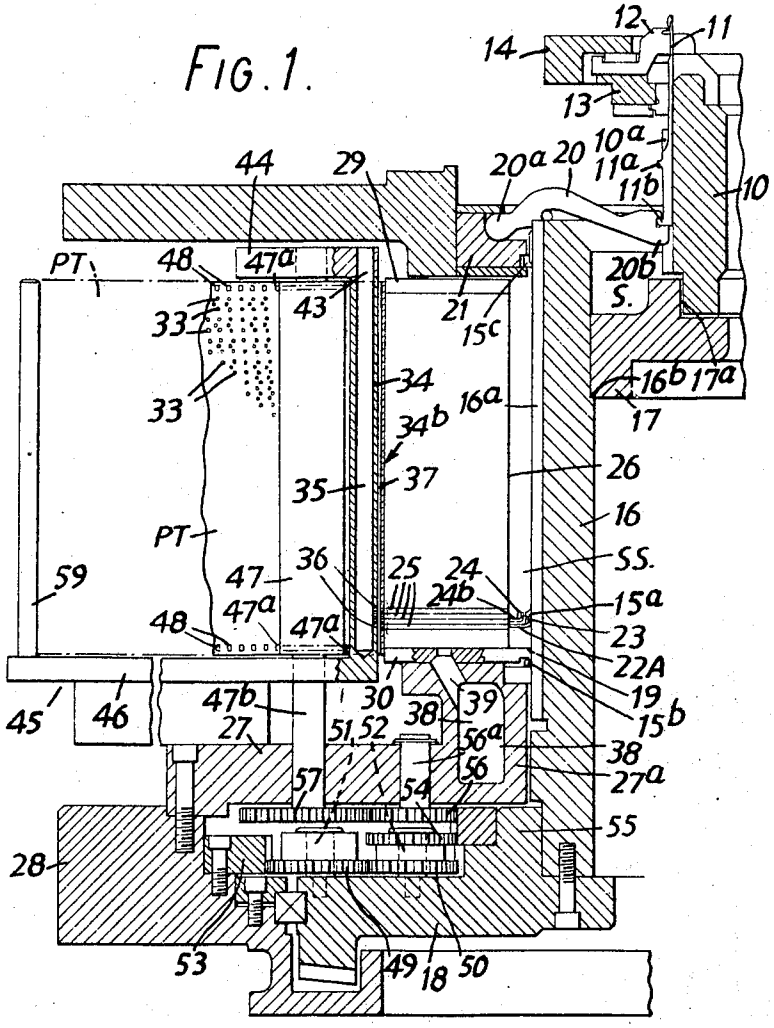


FIG. 1.


12
11
14
13
10a
11a
11b
10
44
29
20a
20
PT
48
47a
43
20b
S.
33
21
15c
34
16a
16b
17a
17
34b
26
35
37
16
PT
SS.
59
36
25
24
24b
15a
47
47a
48
47a
23
22A
19
15b
45
46
47b
27
30
39
38
51
52
56a
38
56
27a
57
54
55
28
53
49
18
50

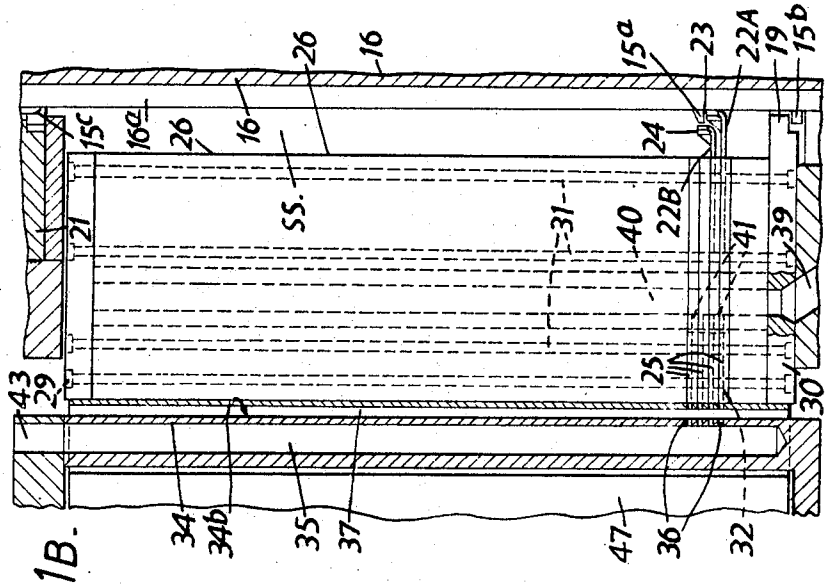

26
16
15a
23
22A
19
15b
15c
16a
26
16
24
55
31
40
22B
41
39
21
43
29
25
30
34
34b
35
37
47
36
32

FIG. 1B.

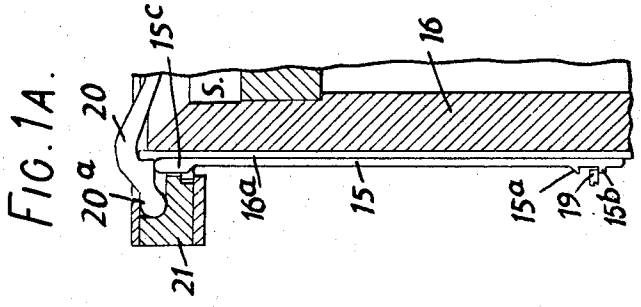
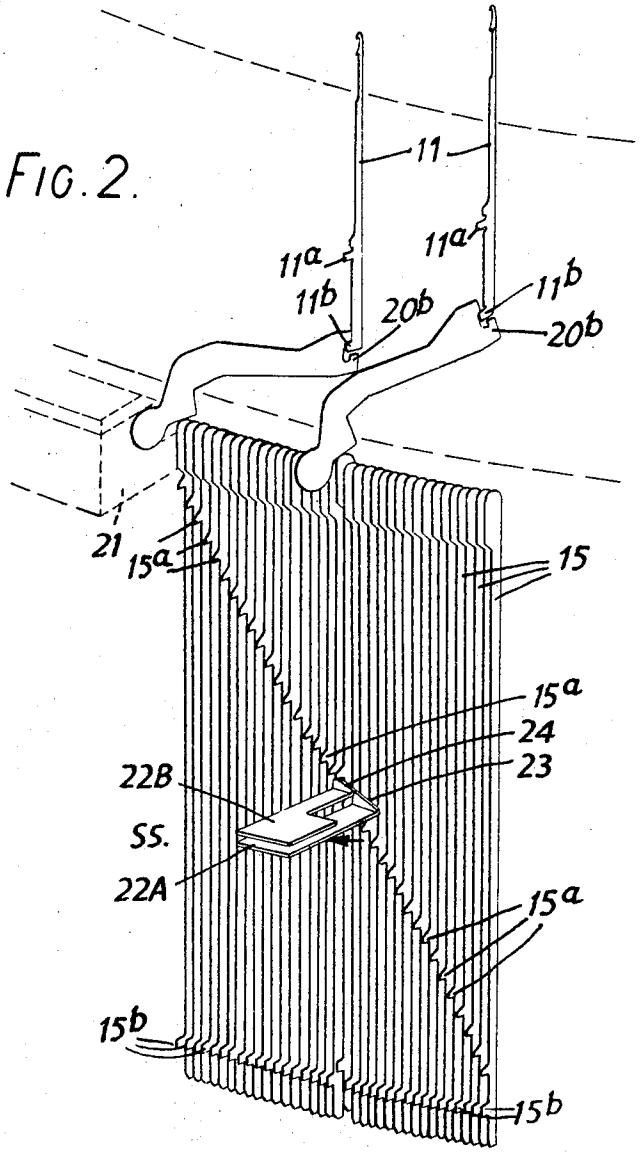

15c
16
20
55
20a
16a
15
15a
19
15b
21

FIG. 1A.

FIG. 2.


11
11a
11a
11b
11b
20b
20b
21
15a
15
15a
24
23
22B
SS.
22A
15a
15b
15b

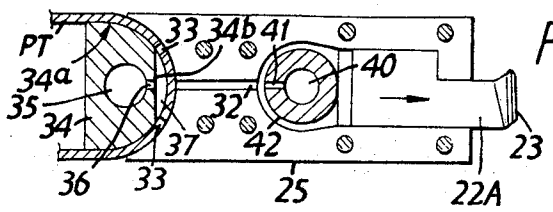


FIG. 6.

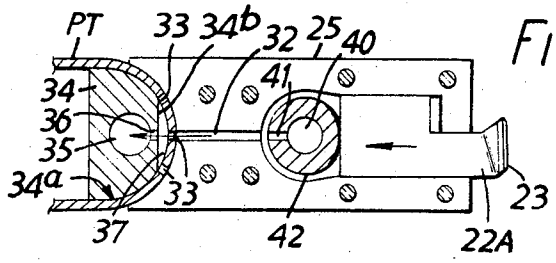
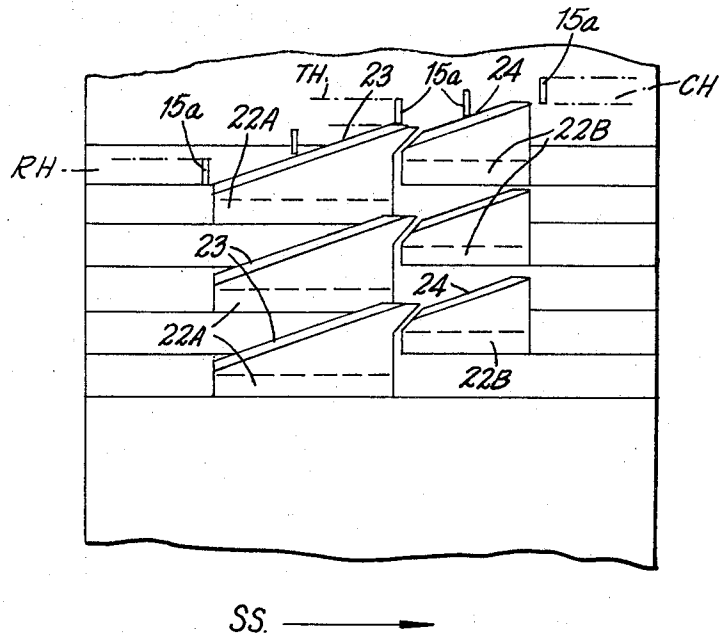


FIG. 7.

FIG. 3.



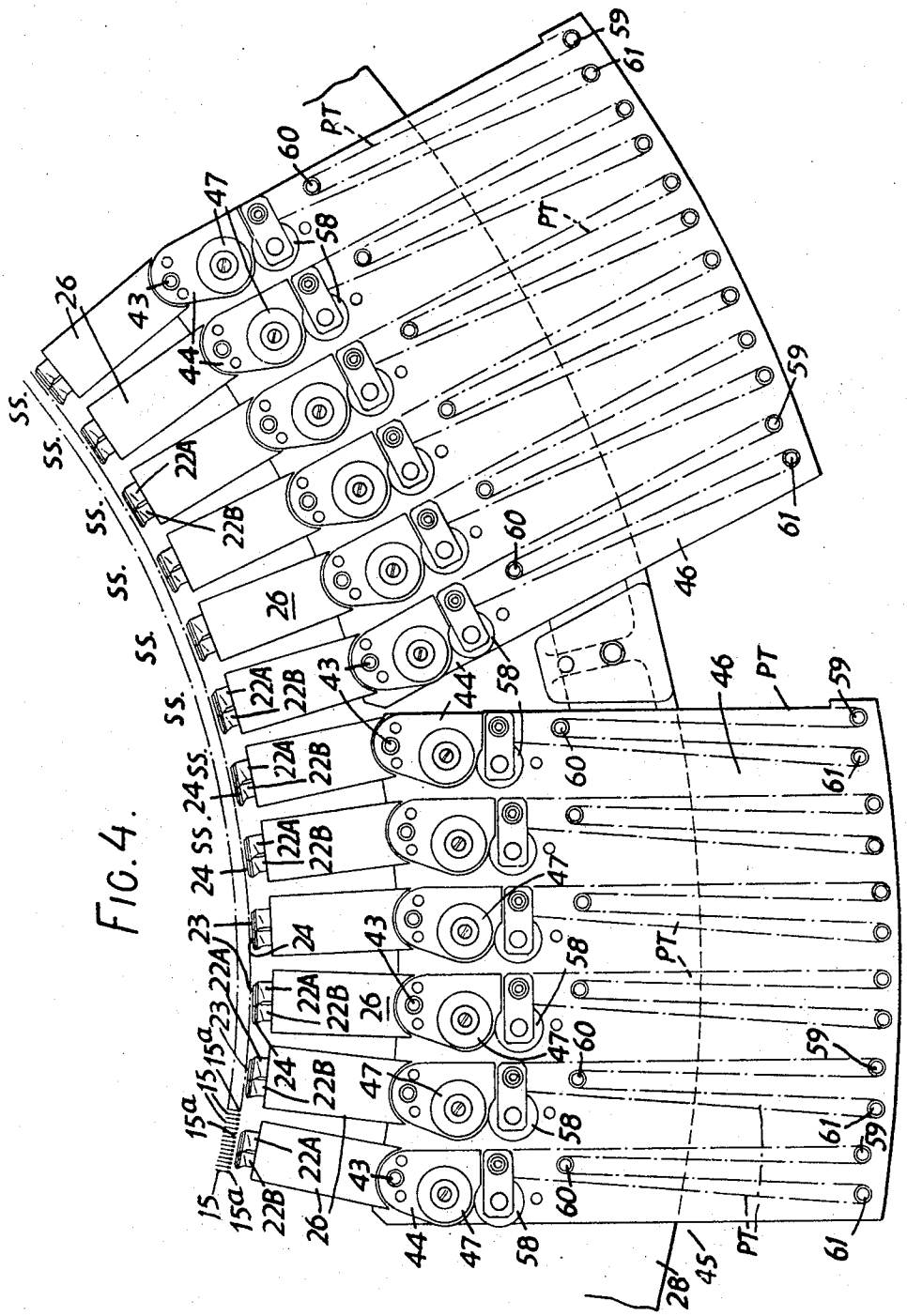


FIG. 4.

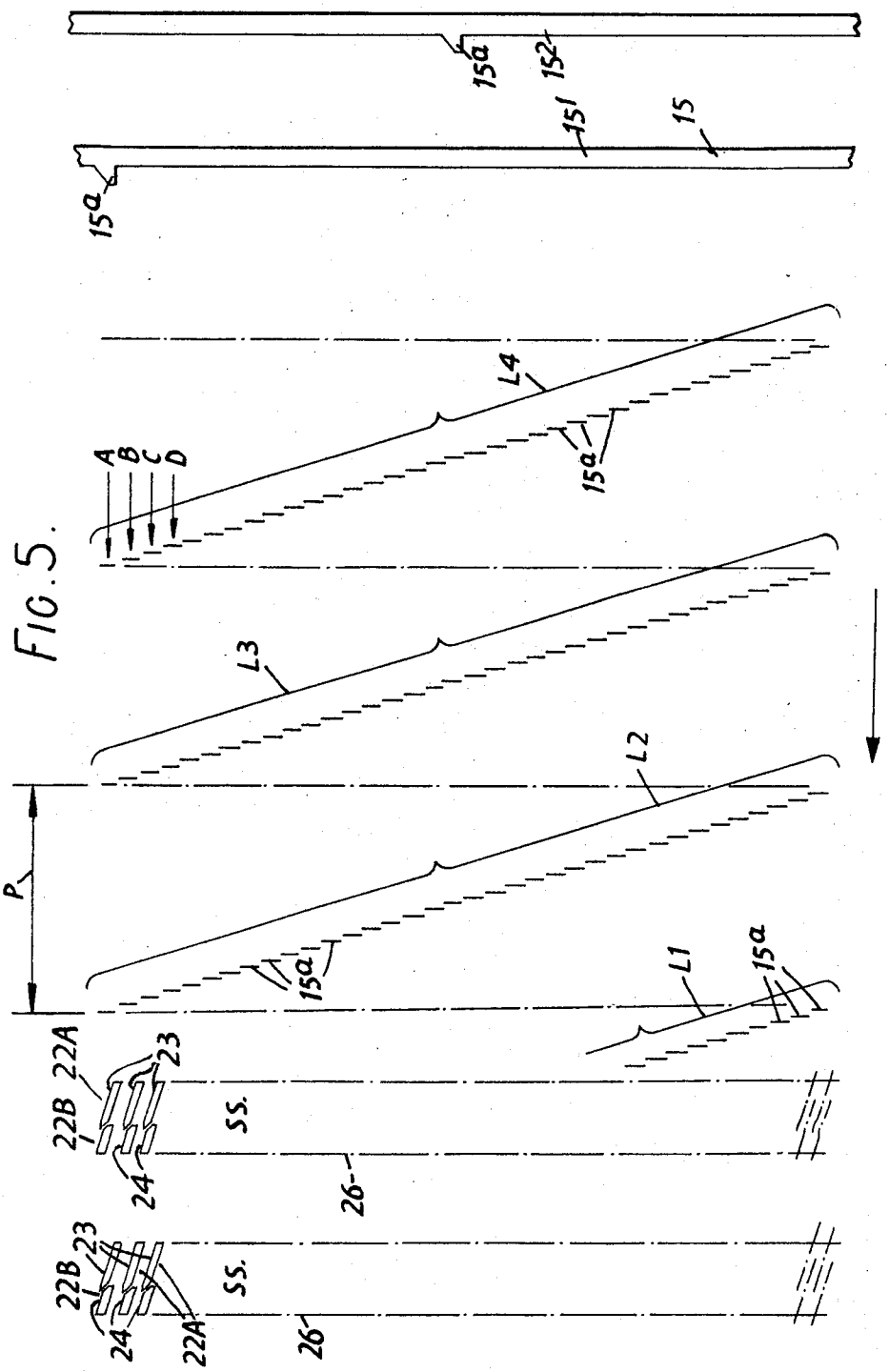

15a
15a
15
15
15a
L4
A
B
C
D
15a
L3
L2
P
15a
L1
15a
22B
22A
23
24
SS.
26
23
22B
24
22A
SS.
26

FIG. 5.

PATTERNING SYSTEM FOR A MULTI-FEED CIRCULAR KNITTING MACHINE

This invention relates to a patterning system for a multi-feed circular knitting machine, and has reference particularly to such a system of the kind comprising, in combination, groups of individually movable selector cam members, one group in advance of each feed, arranged around the knitting head of the machine, individually operable instruments accommodated in tricks of an axially tricked cylinder co-axial with respect to the knitting machine head, said instruments being furnished with patterning butts, one patterning butt per instrument, so disposed in a multiplicity of superimposed planes as to enable them to be operated upon by the selector cam members to effect selective actuation of the instruments, and, for each group of selector cam members, programmed control means functioning at a speed related to that of the machine for selectively operating the said cam members in advance of the relevant feed in accordance with predetermined patterning requirements.

Although there is no limitation in this respect, it is principally the intention that the patterning system of this invention shall be for the selective actuation, under control, of individually operable knitting needles whereby the latter are caused either to knit or to tuck or to non-knit, according to patterning requirements. In this regard, the aforementioned instruments, broadly considered, may be the knitting needles themselves. More usually, however, the butted instruments will be in the nature of needle-actuators, such as jacks or sliders, entirely separate from the needles and, for this reason and where the context so admits, will hereinafter for convenience be referred to as "pattern instruments."

Moreover, it is primarily the intention to apply the invention to a circular multi-feed knitting machine of the rotary needle cylinder type, in which instance the individually operable needles and their actuating pattern instruments move round with the knitting head, whereas the groups of selector cam members and the programmed control means for selectively operating the same are associated or combined with the stationary cam box or shell surrounding the rotary needle cylinder, or superimposed needle cylinders, as the case may be.

It would, however, alternatively be possible to apply the invention to a multi-feed machine of the stationary needle cylinder type, in which case the groups of selector cam members and the programmed control means therefor would be required to revolve together with the annular cam box or shell.

Whilst the invention is applicable to multi-feed double cylinder machines and machines of the cylinder and dial type, it is expected that the principle field of application will be to multi-colour Jacquard single cylinder body machines having cylinders of comparatively large diameter and relatively large numbers of feeds.

As to the disposition of the pattern instrument patterning butts in a multiplicity of superimposed planes as aforesaid, this will usually be such as to enable the patterning butts in any one horizontal plane to be well spaced apart circumferentially; in such an arrangement, the butts on successive pattern instruments are so relatively offset laterally in the superimposed planes as to form right around the machine circumferentially

spaced inclined, i.e., diagonal, lines of butts, the lateral offsetting corresponding, of course, with the pitch of the pattern instruments circumferentially of the machine. But it is considered that other dispositions of pattern instrument butts may be adopted within the broad scope of the invention.

The invention may most advantageously be applied to the particular arrangement of pattern jacks in which these jacks are accommodated in tricks formed in a separate jack cylinder which is co-axial with, but of a larger diameter than the needle cylinder, the butts on the jacks being set out in circumferentially spaced inclined or diagonal lines (hereinafter more fully described) but with the vertical pitch of said butts reduced to such an extent that lifting movements imparted to the pattern jacks by action upon their butts of jack selector cams are less than sufficient to raise the corresponding needles to the heights required. The particular arrangement just described thus essentially also includes the provision, between the pattern jacks in the separate cylinder and the corresponding needles in the needle cylinder, of means of any suitable character, e.g., levers, for transmitting to the needles and simultaneously amplifying the lifting movements imparted to the jacks by the selector cams.

A patterning system of the kind herein referred to applied to a multi-feed circular knitting machine has heretofore often been wholly mechanical. Whilst such a mechanical system enables a wide range of patterns to be produced consistent with a reasonable system cost, its physical space limitations restrict the number of yarn feeds possible and the amount of data that can be contained in the control or programme media or component. This restricts both the rate of output of knitted fabric and the possible pattern area before repeats of pattern are necessary. In order to overcome these limitations, systems have previously been developed using programme media other than mechanical. One example is by use of a programme stored on a film which is read by photoelectric means. The electrical pulses are then used to influence the needle operation by the use of a solenoid for each needle. Such an electro-magnetic system overcomes most of the technical limitations imposed by the mechanical system but is expensive and very complex. Data must be read at a high rate, this again limiting the number of yarn feeds and output rate but allowing the much more comprehensive pattern area than a mechanical system.

The object of the present invention is to provide, in a multi-feed circular knitting machine, a generally improved patterning system of the kind concerned designed not only to increase the patterning potential, but also to permit as many feeds as possible to be incorporated in the machine, thus maintaining a high output rate of patterned knitted fabric, without either necessitating complex data preparation or incurring prohibitive cost.

The improved patterning system according to this invention is characterised in that each of the selector cam members in the group at the selection station in advance of each feed is operable by air pressure, the supply of air under pressure to these members being controlled by an apertured programming element or component movable in timed relation with the rotation of the knitting head of the machine, whereby the selector cam members are operated selectively according to pattern requirements.

In accordance with an important aspect of the invention, there is preferably provided a separate predeterminedly apertured and movable programming element or component and means for reading the same at each selector station. Such a unitary, self-contained system for each feed makes possible extensive patterning potential coupled with high output rates. In this connection it has to be realised that the rate at which information must be read and transmitted to the selector cam members would usually be too great for a central data element or component reading device to be employed. It is considered that development of such a centralised control system although not altogether excluded from the scope of this invention, would probably incur a prohibitively high development cost, with the risk that the resulting equipment, even though technically successful, would be too expensive for the market to accept.

In any event, there are in the preferred embodiment of the invention, provided in each separate programming element or component as many channels of information, i.e., lines of holes predeterminedly interspersed with un-apertured portions, as there are selector cam members in the group at each selector station: this enables relatively low reading speeds to be adopted.

The controlled air pressure system at each selector station may be wholly pneumatic in character, in which instance the movable apertured programming media or component ma itself constitute valve means to control the admission of pressurised air into or the cutting off of such air from conduits in line with the selector cam members of the relevant group. Alternatively, in a pneumatic system, the apertured programming media or components may be used to influence air valves of the diaphragm or any equivalent type.

It is, however, considered that the most suitable air pressure system fot the intended purpose may prove to be a truly "fluidic" one in which there are no moving parts; in such a system, a continuously flowing stream of main pressure air, confined within a conduit, would either be allowed to flow idly past a selector cam member or be diverted for rendering the said member operative by a fluidic switch or an amplifier responsive to a subsidiary low pressure air jet in turn controlled by the presence or absence of a hole in the apertured programming element or component. In other words, the presence of a hole enables a signal, in the nature of an emission, i.e., puff, of low pressure air, to pass to a fluidic switch or an amplifier the output from which operates the selector cam member.

Accordingly, the expression "air pressure system" herein used is intended to be a generic one sufficiently wide to cover any of the foregoing arrangements.

But whatever the precise nature of the air pressure system adopted, a selector cam member may be acted upon by air under pressure either directly or through the medium of a piston or a plunger movable axially within the relevant air conduit. Return of a selector cam member to its inoperative position, preparatory to re-selection after having been operated, may be effected either by fluidic, pneumatic or mechanical means. As examples of mechanical means may be mentioned, firstly, a spring, e.g., of the leaf type, and, secondly, a cam-like protuberance on the needle cylinder designed to push back the selector cam member as a consequence of rotation of the knitting head.

The selector cam members at each selector station may consist either of fulcrummed levers or of rectilinearly movable slides. In either event, the said members may advantageously be banked one above another in a suitable housing located at the selector station, the operative portions of the members being in the nature of inclined cams.

It has previously been stated that the knitting needles are caused either to knit, or to tuck or to non-knit, according to patterning requirements. In this regard, the projection of a selector cam member into its operative position by air pressure may serve, either directly, or through the medium of pattern instruments (with or without associated lift-amplifying means) to raise relevant needles either to clearing height or tucking height so that these needles will either knit or tuck respectively. In such a case, any needles not so raised will non-knit. Broadly considered, however, the arrangement could be reversed so that whilst all needles will normally either knit or some knit and others tuck, only those needles which fail to be raised, by selective retraction of previously operative cam members, will be caused to non-knit.

In order that the invention may be more clearly understood and readily carried into practical effect, specific embodiments thereof will now be described with reference to the accompanying drawings, wherein,

FIG. 1 is a vertical sectional view taken through the knitting head of a circular multi-feed knitting machine of the rotary needle cylinder type, this figure showing a pattern jack in a separate jack cylinder; a lever transmitting to the corresponding needle and amplifying the lifting movement imparted to the said jack by selector cam slides; a bank of fluidic elements with their respective selector cam slides at a selector station; and an apertured programming element in the form of a punched tape,

FIG. 1A is a detail vertical sectional view showing more clearly one of the pattern jacks,

FIG. 1B is a fragmentary portion of FIG. 1 drawn to a larger scale,

FIG. 2 is a detail perspective view showing a pair of the selector cam slides, a succession of the pattern jacks, and two of the needles and of the corresponding intermediate movement transmitting and amplifying levers,

FIG. 3 is a detail inner end view, as seen when looking outwardly from the centre line of the knitting head, of a few of a bank of fluidic elements together with their selector cam slides, and illustrates how these slides elevate jacks to different positions heightwise,

FIG. 4 is a plan view looking down on a few of the banks of fluidic elements and the corresponding control tapes,

FIG. 5 is a developed layout showing, in purely diagrammatic fashion, a few of the inclined or diagonal lines of patterning butts on pattern jacks, pairs of selector cam slides included in the banks at two selector stations and fragmentary portions of pattern jacks,

FIG. 6 is a part-sectional plan view of one of the fluidic elements per se, shown in relation to the punched control tape at the relevant selector station, the selector cam slide of the said element being depicted in its inwardly projected operative position, and

FIG. 7 is a view similar to FIG. 6 but showing the same selector cam slide retracted outwardly to its inoperative position.

Like parts are designated by similar reference characters throughout the drawings.

Referring to FIG. **1**, it will be seen that the illustrated multi-feed circular knitting machine includes a rotary needle cylinder **10** which is peripherally tricked at **10***a* to receive individually slidable knitting needles **11** of the pivoted latch type. Each needle has an operating butt **11***a*. The machine is also furnished, for co-operation with the needles, with outside holding-down sinkers such as **12** which are radially slidable in a horizontally disposed sinker bed **13** and are operated by cams mounted in a sinker cam cap **14.**

For selectively raising the needles **11** there is provided a corresponding circular series of pattern jacks such as that indicated at **15** in FIG. 1A — one to each needle. These jacks are accommodated in tricks **16***a* formed in a separate jack cylinder **16** which is co-axial with, but of a larger diameter than the needle cylinder **10.** At its lower end the needle cylinder **10** seats within a recess **17***a* formed in the top of a ring **17** which in turn fits within, and sits upon an internal shoulder **16***b* formed on, the jack cylinder **16.** The needle cylinder **10** is firmly attached to the ring **17** and the latter is secured to the jack cylinder. The lower end of this jack cylinder has bolted to it the conventional cylinder driving gear **18.** Accordingly, when the gear **18** is driven from the drive source customary in such a machine, the needle cylinder **10** and the jack cylinder **16** will rotate together at the same speed.

Although the size of the machine, the number of feeds with which it is equipped and the rotational speed of the knitting head may vary widely, the particular machine now being described is assumed to have the following specification:

Needles per inch—28
Needle cylinder diameter—26 inches
Cylinder speed—up to 20 rpm.max.
Number of feeds—78

A 30 inch machine having ninety feeds is a practical proposition commercially.

It is convenient here to mention that in FIG. **1** the jack trick **16***a* is shown as being empty so that the form of the trick can be fully seen: for this reason the pattern jack **15** in the next trick is for the most part hidden in FIG. **1** by the relevant trick wall. But in FIG. 1A a pattern jack **15** is fully shown.

As will be seen, the stem of each pattern jack **15** is furnished with only one patterning butt **15***a;* at its lower end each such jack is provided with a butt **15***b* arranged to be acted upon by cams such as **19** by means of which jacks, after being raised, are restored to their original positions for re-selection. The upper end of each pattern jack is increased somewhat in width, from its back edge to its front edge, to provide an abutment **15***c* having a rounded, i.e., semicircular, upper extremity for a purpose hereinafter to be described. The single patterning butts **15***a* on the pattern jacks **15** are provided at different points along their straight stems so that these butts are disposed in a multiplicity of superimposed horizontal planes. The particular disposition of the illustrated butts is such as to enable the patterning butts **15***a* in any one such plane to be well spaced apart circumferentially. That is to say, the butts **15***a* on successive pattern jacks **15** are so relatively offset laterally in the superimposed planes as to present right around the jack cylinder **16** circumferentially spaced inclined, i.e., diagonal, lines of butts, the lateral offsetting corresponding, of course, with the pitch of the pattern jacks circumferentially of the machine. One such inclined line of patterning butts is clearly shown in FIG. **2.** Moreover, three complete inclined lines **L2, L3** and **L4** of patterning butts **15***a* and a part of such a line **L1** are also depicted in FIG. **5.** The pitch P of these inclined lines corresponds with a circumferential distance sufficient to accommodate a succession of 36 of the pattern jacks **15.** Thus, in each inclined line there are 36 patterning butts **15***a*. The direction of cylinder rotation is indicated by the horizontal arrow at the bottom of FIG. **5.** Assuming the patterning butts in each line to be differentiated by virtue of being lettered downwards in the sequence A, B, C, D—, these letters designating the superimposed planes, then the pattern jack 15^1 at the right-hand side of FIG. **5** is shown as having a butt in the top plane A, whereas the jack 15^2 has a butt in the plane R.

Preferably, the vertical pitch of the patterning butts **15***a* on successive pattern jacks **15** is such that the lower edge of the butt on any one jack is spaced vertically from the corresponding edge of the butt on the next jack a distance equal only to the overall vertical dimension of a single butt. In this preferred case, therefore, an individual selected jack can only be lifted a distance equivalent to the vertical pitch of the butts.

Advantageously, the patterning butts **15***a* may, as shown, be of "saw-tooth" form, having horizontal lower edges and upper edges which incline downwardly and outwardly from the stems of the jacks **15.** By virtue of this particular shaping of the butts, inner operative cam portions of selector cam slides (hereinafter to be described) are enabled to be inserted beneath the horizontal lower edges of butts and well into the spaces between butts.

Since each pattern jack **15** is arranged to be lifted only minimal vertical distances, there must, as previously mentioned herein, be provision between the jacks in the separate cylinder **16** and the corresponding needles **11** in the needle cylinder **10** of means for transmitting to the needles and simultaneously amplifying the lifting movements imparted to the jacks by the aforementioned selector cam slides. Conveniently for this purpose there are provided, as shown in FIGS. **1** and **2,** simple, radially extending movement-transmitting and amplifying levers **20** between the upper ends of the pattern jacks **15** and the lower ends of the needles **11.** These levers **20** thus extend across the annular space S between the two co-axial cylinders **10** and **16** of respectively different diameters and are located beneath the customary annular cam box or shell (not shown) surrounding the needle cylinder **10.** The outer end of each of the movement-transmitting and amplifying levers **20** is formed with a near-circular fulcrum **20***a* which is seated in a suitably formed ring **21** combined with the upper end of the pattern jack cylinder **16.** To enable them to avoid interference with the jack cylinder **16,** the pivoted levers **20** may, as shown in FIGS. **1** and **1A,** be of upwardly arched form. In any event, the semicircular upper extremities of the aforementioned abutments **15***c* of the pattern jacks **15** act upon the lower edges of the levers **20** at carefully predetermined points fairly close to the near-circular fulcrum **20***a* so that comparatively small lifting movements of the jacks **15** imparted by the jack selector slides now to be described are magnified into substantially greater heightwise movements of the inner ends of the said levers.

These ends are forked as indicated at **20***b* to embrace and act upon outwardly directed butts **11***b* at the lower extremities of the needles **11.**

The jack selector slides at each selector station SS are arranged in a vertical bank of superimposed pairs. The selector slides of each pair are hereinafter for convenience designated **22A** and **22B.** There are, of course, as many selector stations SS around the knitting head of the machine as there are feeds. Only two of these stations are diagrammatically illustrated in FIG. **5.** The idea is that the operative cam portion of one of the slides, say the slide **22A** of each pair shall have an outwardly directed cam face **23** adapted, by engagement with butts **15***a*, to lift relevant pattern jacks **15** sufficiently to cause corresponding needles **11,** through the medium of the movement-transmitting and amplifying levers **20,** to be raised to tucking height, whereas the operative cam portion of the companion slide **22B** of the pair shall have an upwardly directed cam face **24** which, together with the cam face **23** of the slide **22A,** lifts pattern jacks **15** to an extent sufficiently far to cause corresponding needles to be raised to clearing height. The cam faces **23** and **24** are gently inclined at less than 20° to the horizontal. The butt ends of the slides **22A** and **22B** are, in effect, similar to pistons of air cylinders, In FIG. **3** (as seen looking outwardly from the centre line of the machine), the normal run height of a patterning butt **15***a* is indicated at RH. A butt **15***a* is lifted to height TH by a cam face **23** to position the corresponding needle at tucking height, whereas such a butt is lifted to height CH to position the relevant needle at clearing height preparatory to knitting. In FIG. **1,** the pattern jack is raised only sufficiently to position the corresponding needle at tuck height, the slide **22B** being shown in its retracted position. In FIG. **2,** on the other hand, both of the slides **22A** and **22B** shown are operative, their combined upwardly directed cam faces **23** and **24** having just acted upon the patterning butt **15***a* of the slightly raised pattern jack **15** to position the right-hand needle **11** at clearing height. The left-hand needle in this figure is shown down in its non-knit position.

Of each such pair of jack selector slides, the slide **22A** is longitudinally moved radially inwards into its operative position, independently of the slide **22B** which latter remains stationary. On the other hand, whenever the slide **22B** of the pair is moved radially inwards, the slide **22A** is also caused to move forwardly together therewith. Each slide is arranged to traverse a distance of only 0.1 inch in a radial direction to the machine cylinder.

In the preferred example illustrated in FIGS. **1 – 7,** the major portions of the slides **22A** and **22B** are disposed in superimposed horizontal planes, only the operative cam portions of the said slides having faces appropriately inclined to the horizontal. In this preferred arrangement, whenever the slide **22B** of a pair is selectively moved into its operative position, the companion slide **22A** is as a matter of course, also similarly moved into its operative position.

Alternatively, the selector cam slides in each vertical bank may themselves be in parallel inclined planes with respect to the horizontal so that their operative portions can be in these same planes, the angle of inclination being such as to impart to the jacks **15** the required extents of lift, all as will be hereinafter more fully described with reference to FIGS. **8** and **9.**

Each of the selector cam slides **22A** and **22B** is operable by air pressure, and the air pressure system employed includes fluidic elements **25** each consisting of a single laminate section having an accurately produced cavity to receive one of the said slides. Seventy two of these fluidic elements **25** are stacked one above the other to form a vertical block **26** at each selecting station SS.

Each block **26** is supported upon an upstanding inner portion **27***a* of a fixed annular plate **27** which latter is located near to the lower end of the jack cylinder **16** and is in turn secured upon the fixed bed plate **28** of the machine. The seventy two fluidic elements **25** of each stack are clamped together between upper and lower plates **29** and **30** respectively, long screws, rivets or the like such as **31** being used to produce the clamping effect. The fluidic elements **25** are only 0.75 in. thick, the whole block **26** measuring only 5.40 in. in height. This allows the jack cylinder **16** to be of a reasonable height.

As shown in FIGS. **6** and **7,** each fluidic element has a sensing orifice **32** in alignment with a channel or line of holes **33** punched in a programming element in the form of a punched tape PT. The orifice **32** extends along the median line of the fluidic element. This tape is adapted to be driven at a linear speed corresponding with the rotational speed of the knitting head of the machine, i.e., of the two co-axial cylinders **10** and **16.** The tape PT, moreover, passes around a vertical tape guide **34** which, as shown in FIGS. **6** and **7,** has a mainly convex front face **34***a* with a flat **34***b* thereon, a vertical exhaust duct **35** extending therethrough to practically the full height thereof and a vertical series of as many air exhaust slots **36** as there are selector cam slides **22A** and **22B** in the corresponding bank. Thus, the air exhaust slots **36,** of which there are 72, are disposed one above the other, each of them communicating, on the one hand, with the interior of the vertical exhaust duct **35** common to them all and, on the other hand, with the small vertical space **37** provided between the aforementioned flat **34***b* and the opposed back of the tape. In the upstanding portion **27***a* of the fixed annular plate **27** is formed an annular air chamber **38** which is adapted to be continuously supplied with compressed air at low pressure. Such air may be supplied from a low pressure, high volume turbo-blower which is mounted on the machine. Extending upwardly from the top of the air chamber **38** are air feed channels **39** — one per stack of fluidic elements **25.** Each such air feed channel **39** leads upwardly into the lower end of a vertical air tube **40.** This tube **40** extends upwardly through all of the superimposed fluidic elements **25** and has formed in its wall a vertical series of as many air feed holes **41** as there are selector cam slides **22A** and **22B** in the corresponding bank. The air feed holes **41,** disposed one above another, are in alignment both with the respective sensing orifices **32** and also the corresponding air exhaust slots **36** in the tape guide **34.** The inner end of each orifice **32** communicates with an annular channel **42** formed in the relevant fluidic element **25.** This channel extends partially around the adjacent portion of the vertical air tube **40** and freely communicates with the rear or back edge of the particular selector cam slide carried by the relevant fluidic element **25.** The upper end of each exhaust duct **35** is aligned with a hole **43** (open to atmosphere) provided in a plate **44** constituting a part of a punched tape cassette **45.** At **46**

is represented a base plate of a cassette for, say, six tapes for controlling needle selection at six feeds of the machine.

Presence of a hole **33** in the appropriate channel or line of a punched tape PT causes the relevant selector cam slide to retract in the direction of the arrow in FIG. **7,** whereas no hole causes the same slide to advance in the direction of the arrow in FIG. **6.** The relative sizes of orifice **32** and hole **33,** and the pitch between holes **33,** are arranged so that a continuous row of holes **33** is read as a continuous hole so that the selector cam slide remains retracted. Obviously, a length of tape without holes will cause the slide to remain advanced. The space **37** between the flat **34***b* on the front face of the tape guide **34** and the opposed back of a punched tape PT, which space is segment-shaped in cross-sectional plan (see FIGS. **6** and **7**), ensures that a hole **33** in the travelling tape remains in communication with the vertical exhaust duct **35,** via the relevant air exhaust slot **36,** for a sufficient length of time to enable retraction of the corresponding selector cam slide to fully take place as and when the said hole **33** registers with the corresponding orifice **32.**

Thus, the illustrated air pressure system is such that whenever a hole **33** in a punched tape PT is in such a position as to allow air to escape to atmosphere through an air exhaust slot **36,** the common exhaust duct **35** and the hole **43** at the upper end of the latter, the pressure in the channel **42** between the air feed hole **41** and the back of the relevant selector cam slide falls below atmospheric due to the Venturi effect. The result is that the slide is drawn inwards into its retracted, i.e., inoperative position as shown in FIG. **7.** But as soon as the punched hole **33** passes, so that an unapertured portion of the tape is then blocking the orifice **32,** the pressure of the air issuing through the relevant air feed hole **41** and passing into the annular channel **42** thereupon builds up above atmospheric and the selector cam slide is advanced into its operative position as shown in FIG. **6.**

A single hole **33** in, and an un-apertured blank portion of, a tape causes a tuck selection slide **22A** to move forward. No holes cause both slides **22A** and **22B** to move forward to raise the corresponding needles to clearing height. A double hole in the tape causes both slides of a pair to be retracted so that needles miss.

It will accordingly be appreciated that each selector station has its own punched tape PT, the latter, as shown in FIG. **4,** being in the form of an endless loop. If required, each tape loop can be punched with a different pattern of punched holes. It will accordingly be readily appreciated that a pattern could, if required to do so, extend the full width of the fabric. As previously mentioned, there is in each punched tape PT a separate channel or line of holes **33** for each fluidic element **25** in the corresponding stack. The pitch of the holes **33** along the length of a tape is, in the specific example now being described, .0935 in. Since the machine is equipped with 2,304 needles, there are 64 hole positions per revolution of the cylinders **10** and **16,** i.e., per 5.984 in. of tape. As the machine being described, merely by way of example, has 78 feeds it will be realised that punched tapes of a reasonable and easy to handle length can produce a pattern area of considerable depth.

Each punched tape PT is driven by means of a roller **47** having sprocket teeth **47***a* at each end for engagement in drive holes **48** in the tape margins (see FIG. **1**). At each end of the said roller there are 16 sprocket teeth on a circular pitch of 0.187 in. Consequently, 32 hole positions are traversed past each sensing orifice **32** in a vertical block **26** for each revolution of the corresponding toothed roller **47.** If, therefore, the roller **47** is geared in such a way that it rotates twice for each revolution of the cylinders **10** and **16,** then 64 hole positions will be allowed to pass each sensing orifice **32,** i.e., one signal for each inclined line of patterning butts **15***a*. Manifestly, machines having different needle pitches and different needle cylinder diameters to those hereinbefore specifically quoted will incorporate different gearing or employ different numbers of sprocket teeth — according to requirements.

For convenience of handling and loading, the tapes and their drive and guide rollers are, as previously mentioned, mounted in cassettes **45** in sets of six. Each cassette takes off a drive from the cylinder driving gear **18** which is coupled in the manner depicted in FIG. **1** directly to one of the six toothed drive rollers **47** of the set. The remaining five drive rollers **47** of the set are driven from the first by means of a timing belt (not shown) passing over pulleys mounted on each drive roller spindle.

Each punched tape PT passes between a concave rear face of the relevant vertical block **26** of fluidic elements **25** and the mating convex front face **34***a* of the tape guide **34,** the two being lightly spring loaded together.

Referring again to FIG. **1,** the particular toothed drive roller **47** shown therein is driven from the cylinder driving gear **18** through the medium of a train of spur gearing. This train comprises a pair of intermeshed rotary gears **49** and **50** the axles **51** and **52** of which are fixed in the driving gear **18.** The rotary gear **49** meshes with a stationary gear ring **53** which is secured to the fixed bed plate **28.** The gear **50** is integral and rotatable together with a gear **54.** The latter meshes with a gear wheel **55** arranged to drive a pinion **56.** Lastly, the pinion **56** meshes with a gear **57** secured to the lower end of the spindle **47***b* of the roller **47.** The spindle **56***a* of the pinion **56** rotates, as also does the spindle **47***b*, in the fixed annular plate **27.**

Each toothed drive roller **47** has co-operating therewith a plain guide roller **58,** and three vertical guide pins **59, 60,** and **61** extending up from the relevant base plate **46** are provided for the guidance of each tape loop. Thus, as shown in FIG. **4,** each punched tape PT passes between the relevant rollers **47** and **58,** around the rounded front of the tape guide **34,** then around the guide pins **59, 60** and **61** in that order.

One of the major advantages of the invention is that a control system is attained without moving parts or electrical or electronic circuitry. The only mechanical movement is that which the control system initiates. It is this which leads to simplicity and low unit cost both for the knitting machine pattern programme and the selector units themselves. An air control system has the added advantage that it is self-cleaning: air is discharged through working clearances in the system which helps to disperse dust and lint around the selector units themselves and the knitting elements. Air control also results in a minimum of wear on the operating components within the selector units as they are, in a sense, working on "air bearings."

We claim:

1. A multi-feed circular knitting machine comprising, in combination; an axially tricked cylinder co-axial with respect to the knitting head of the machine; individually operable needle-controlling jacks which are accomodated in tricks in the cylinder and are furnished with patterning butts, one butt per jack, said butts on successive jacks being so relatively offset laterally in a multiplicity of superimposed planes, as to form right around the machine circumferentially spaced inclined lines of the butts, the lateral offsetting corresponding with the pitch of the pattern jacks circumferentially of the machine; groups of individually movable selector cam slides, one group in advance of each feed arranged around the knitting head, and for each group of selector cam slides, programmed control means including an apertured programming element functioning at a speed related to that of the machine for selectively operating the said slides in advance of the relevant feed for effecting selective actuation of the jacks in accordance with pre-determined patterning requirements; the machine being characterized in that the vertical pitch of the said patterning butts on successive jacks is such that the lower edge of the butt on any one jack is spaced vertically from the corresponding edge of the butt on the next jack a distance equal only to the vertical pitch of the butts, whereby an individual jack can only be lifted by any one selector cam slide a distance equivalent to the said vertical pitch; and in that each of the selector cam slides in the group at a selector station in advance of each feed is operable by an air pressure system and the supply of air under pressure to these slides is controlled by said apertured programming element movable in timed relation with the rotation of the knitting head of the machine whereby the selector cam slides are air operated selectively, the air pressure system including fluidic elements each consisting of a single laminate section having therein a cavity to receive one of the selector cam slides, twice as many of these fluidic elements as there are patterning butts in each inclined line of such butts being stacked one above the other to form a vertical block at each selecting station, each fluidic element having a sensing orifice in alignment with a channel or line of information in the apertured programming element.

2. A multi-feed circular knitting machine according to claim 1, said apertured programming element being a punched programming tape, and wherein the sensing orifices detect the presence or absence of holes in said punched programming tape which extends around a vertical tape guide having a mainly convex front face fitted into a concave face of the vertical block of stacked fluidic elements, said tape guide having formed therein an exhaust duct and a vertical series of as many air exhaust slots as there are fluidic elements in the stack, these slots being aligned with the lines of information in the punched tape and communicating with the interior of the exhaust duct common to them all, and wherein a vertical air feed tube in communication with a source of low pressure air extends up through the block of fluidic elements and has formed in its wall as many air feed holes as there are fluidic elements in the stack, said air feed holes being in alignment both with the corresponding air exhause slots and the respective sensing orifices, and the outer ends of the latter terminating in the concave face of the vertical block whilst their inner ends lead into channels freely communicating with the inner butt ends of the selector cam slides in the respective fluidic elements.

3. A circular knitting machine according to claim 2, wherein air under low pressure is fed into the blocks of stacked fluidic elements at the selector stations from an annular chamber formed in a fixed plate which surrounds a rotary cylinder wherein are accommodated the instruments furnished with the patterning butts.

4. A multi-feed circular knitting machine according to claim 1, wherein the selector cam slides in the group at each selector station are arranged in superimposed pairs, the first slide of each such pair having an operative end adapted by engagement with patterning butts, to raise corresponding needles to tucking height only, whereas, the second slide of the pair has an operative end which, together with the operative end of the first slide, causes patterning butts to be lifted sufficiently far as to cause corresponding needles to be raised to clearing height, the arrangement being such that the first cam slide is movable into its operative position independently of the second cam slide, which latter remains stationary, whereas whenever the second slide is rendered operative the first slide is also rendered operative together therewith.

5. A multi-feed circular knitting machine in accordance with claim 1, said apertured programming element being a punched tape, and wherein for driving an endless loop of said punched tape at each selector station there is provided a driveable roller having sprocket teeth for engagement in drive holes in the tape loop, the said rollers at adjacent selector stations being mounted in a removable cassette and wherein at least one of the driveable sprocket rollers in the cassette is driven from a cylinder driving gear through the medium of a train of gearing.

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