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54 Yarn partial dyeing.

57 An apparatus 12 for the production of novel variegated dyed effects including space dyed effects of yarns 10 comprises at least one spray nozzle 20 connected to a source of dye liquor 22. A nozzle 20 is also connected to a source of compressed air switchable by means of solenoid valves 36, 38 to provide at least two air flow rates whereby to alter the rate of application of dye liquor to the yarn. A number of compartments or tanks containing dye liquor and respective nozzles may be supplied so that a wide variety of dyeing effects are available.

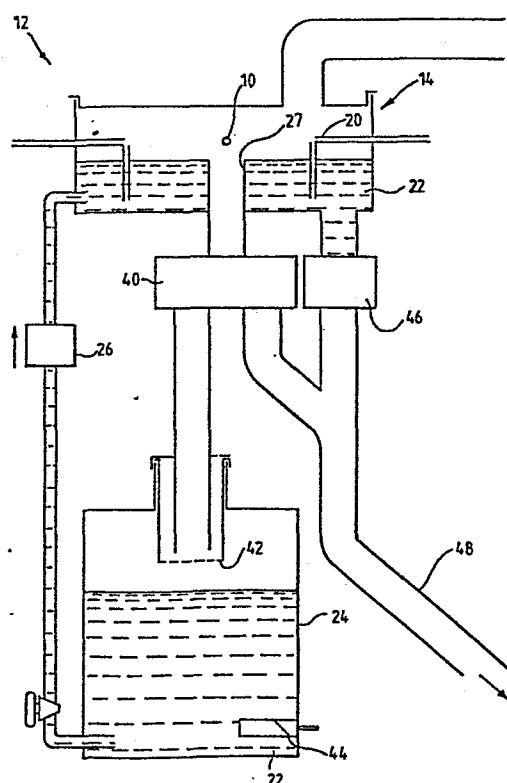


Fig.1a.

TITLE MODIFIED
see front page

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YARN DYEING

This invention relates to a method and apparatus for producing novel variegated dyed effects on yarns including space dyeing effects.

Space dyeing is the name given to the dyeing of yarns in successive
5 lengths of different colours so that multicoloured effects are obtained in a fabric woven or knitted from the yarns so dyed. There are many methods of space dyeing but these divide into two principal techniques: roller printing and spraying. Further
10 subdivision may be made according to the form the yarn takes during the dyeing process, for example whether it passes the dye application zone as continuous parallel ends of yarn or is in hank form.

The invention concerns the space dyeing of continuous ends of yarn by a spraying technique. Apparatus for space dyeing has not
15 hitherto found widespread usage since firstly it is generally expensive and any particular type of apparatus will normally only produce a limited number of novelty yarns. The total sale of such yarns is not likely to be great, and these will be dictated by considerations of fashion, meaning that the machine may
20 be idle for long periods of time. Furthermore most techniques of space dyeing produce periodicity in the colours applied, which can lead to the defect of 'phasing' patterns when knitted or woven into a fabric. This is particularly severe with single or double feeder knitting machines such as fully fashioned frames.

25 The invention seeks to provide an apparatus for the space dyeing of yarns by a spray technique which is relatively inexpensive, is capable of producing a wide range of novelty effects, and reduces or overcomes the defects of hitherto available machines.

According to the present invention there is provided an apparatus for the space dyeing of yarns which comprises at least one spray nozzle connected to a source of dye liquor, the nozzle being connected to a source of compressed air switchable to provide at
5 least two air flow rates whereby to alter the rate of application of dye liquor to the yarn.

Preferably, there will be more than one spray nozzle, and each will be associated with a source of dye liquor of a different colour. Normally, three spray nozzles will be provided since
10 virtually any desired colour combination can be produced by three different coloured dye liquors.

At least one of the spray nozzles should be switchable between two different air flow rates, and preferably all are, but only some may be switchable. In addition, some or all of the nozzles may
15 also be switchable into an 'off' mode. One convenient way of providing two or more air flow rates is to provide compressed air at two or more different pressures. Another way would be to have air at constant pressure and two or more nozzles of different bore, or means for altering the bore size of a single nozzle.

It has been found that the use of a relatively low air flow for spraying the dye liquor from the spray nozzles results in a
20 spattering effect of small spots of dye liquor being deposited on the yarn. Use of a relatively higher air flow creates a more solid effect, approaching a solid shade. Thus by switching
25 from one pressure to another with a given nozzle different effects may be produced and, when more than one spray is used with more than one coloured dyestuff, such effects may be alternated or overlaid as desired and as described more fully hereinafter.

In order to overcome the problem of periodicity, the switching between
30 different modes of operation may be accomplished in a random manner, for example with the use of a random electronic signal generator. A particularly useful random generator is the 'Mark/Space' generator

described in our UK Patent No. 1495748. This device can generate a 'Mark' signal and a 'Space' signal alternately each of a random period, but each settable with limited of for example between 0.1 and 9.9 seconds. Thus, for example the 'Mark' signal could be set
5 at between 4 and 6 seconds, when it will produce a random length signal between those limits, and the 'Space' signal could be set at between say 2 and 4 seconds, when the generator will produce a random 'Space' signal within these limits. For further discussion of the construction and operation of the device reference is directed
10 to our UK Patent No. 1495748. The random Mark/Space signal may be used to turn one or more nozzles on and off, to alternate one or more nozzles between the high and low pressure settings, to alternate between successive nozzles of different colours, or any combinations of these settings. Thus, the apparatus of the
15 invention is capable of producing a large number of novelty yarn effects.

As an alternative to the use of a dedicated Mark/Space generator unit, it is possible to employ a computer to generate two or more random signals. The computer may also be employed to control the
20 system generally and to store data relating to given yarns and/or pattern sequences. In order to contain expense it has been found that a single board dedicated microprocessor, for example the SB-1 unit made by Kemitron Electronics Ltd. and based on the Z-80 8-bit processor, may be employed to advantage. With this unit it has
25 been found possible to increase the number of randomly-generated signals within pre-programmed limited from 2 to 12 (or more if required), and provide a separate set of random signals for each of three nozzles.

While reference has been made to 'space dyeing', the apparatus of
30 the invention is capable of producing a wider variety of variegated effects than is normally encompassed by this term; the term 'space dyeing' as used herein is to be construed accordingly.

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The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Figures 1 (a) to (c) are diagrammatic views of an apparatus in accordance with the invention;

5 Figure 2 illustrates a control program flow chart; and

Figure 3 is a table of effects available.

Referring to the drawings, it can be seen that a yarn 10 is continuously passed through an apparatus generally designated 12 which in this case comprises three compartments or tanks 14, 16 and 18 each provided with a pair of respective spray nozzle units 20.

5 Each compartment is maintained with a supply of dyestuff 22 of a desired colour, the level of which is maintained by means of a respective reservoir 24 which feeds the compartment through a suitable pump arrangement 26, and a liquor return weir 27.

Each nozzle unit 20 comprises an air jet 21 and a tube 23 in communication with the dyestuff 22 in its respective compartment. The
10 dyestuff is sprayed towards the yarn 10 by means of a compressed air supply fed by respective conduits 28, 30 from pressure regulators 32, 34 and through solenoid valves 36, 38 to the jets 21. The
15 regulator 32 feeds the conduit 28 with air to first, higher, pressure and the regulator 34 feeds the conduit 30 with air to second, lower, pressure from a common compressed air supply.

The mechanical operation of the device in figure 1 is as follows. The yarn 10 (illustrated as a single yarn although a number of
20 yarns may be passed simultaneously through the device) is drawn through the device at a speed typically in the order of 400 m/min. Each of the compartments 14, 16, 18 carries a dye of a different colour and each of the sprays 20 sprays the yarn 10 with its own dyestuff as the yarn passes through the apparatus in accordance with the programme more fully described hereinafter. The dye-
25 stuffs may then be fixed on the yarn by, for example, steaming, for example for a time of 2½ minutes, and then, if necessary, the yarn may be dried before or after winding on to a suitable package.

The dye liquor in each of the compartments 14, 16, 18 is maintained at its correct level by means of the overflow weir 27 which, in
30 normal operation, drains via a drain/reservoir valve 40 back to the reservoir 24 through a filter 42 to keep the dye liquor clean. A

- 6 -

low level detector 44 is located toward the bottom of the reservoir 24 and warns the operative when dye liquor is becoming dangerously low so that it can be replenished. The rate of pumping of the pump 26 should be greater than the maximum delivery of the spray units 20 to ensure that the level within the compartments is maintained constant.

A separate drain valve 46 is provided connected to a waste tube 48 which also connects to the drain/reservoir valve 40. When it is desired to drain a compartment, for example to change the colour of dye liquor, pump 26 is switched off and drain valve 46 opened to drain the liquor in the tank to waste. The liquor supply tube 25 is disconnected from the reservoir 24 at the stopcock 27 and re-connected to a water supply. Drain/reservoir valve 40 is switched to waste and the pump turned on to fill the tank 14 with water. Drain valve 46 is closed. The sprays 20 operate to clean the sides and lid of tank 14. Drain valve 46 is then opened to drain the waste water. This flushing procedure may be repeated a number of times. The reservoir 24 is disconnected and removed and replaced with a further reservoir with fresh liquor.

The whole apparatus may be controlled by a dedicated single board computer such as the SB-1 unit referred to above. A decimal key pad may be provided to programme yarn data into the computer and a display on a visual display unit or a dual line 40 character alpha numeric dot matrix LCD may also be provided. Figure 2 illustrates a typical flow chart of the control programme for the computer. Each pair of sprays 20 in the compartments 14, 16, 18 can be turned off, supplied with high pressure air through the valve 36, or supplied with low pressure air through the valve 38. Since there are three compartments this gives twenty-seven different states,

for each of the possible time segments and these are illustrated in tabular form in figure 3. In addition, the computer employed may be programmed to give signals of random type duration within pre-programmed upper and lower limits to any one or any combination of the effect codes listed in figure 3. Thus the number of pattern sequences is virtually infinite. The computer has inbuilt memory which may be extended by use of suitable hard memory peripherals, such as a disc drive, in which the details of a particular yarn and particular patterning routine may be stored. Thus, to repeat a particular patterning sequence one need only call up the relevant memory location.

The use of high and low air flow rates according to the regulators 32 and 34 enables a wide variety of effects to be obtained. The exact values of pressures for both high and low modes is easily determined empirically and would depend on many practical factors such as the nature of the compressed air supply available, bores of the connecting conduits, viscosity of the dye liquor, bore of the spray jets, and so forth. However, a low pressure setting would generally produce a spattering from the jet which results in a 'spotted' or 'mottled' effect on the yarn, whereas a higher pressure setting would normally produce a more solid shade. Naturally settings within a wide range of values can be employed, and indeed, if desired in any particular case the 'high' 'low' settings could be identical or even reversed.

A larger or smaller number of compartments may be employed. Three is a convenient number since using the three primary colours of dye liquor virtually any colour combination desired may be produced.

A suitable dye liquor for the dyeing of chlorine/Hercoset treated wool yarns consists of a reactive dye and auxiliaries according to the following recipes:

	<u>gm. Kg⁻¹</u>
Procion Blue MX3G dyestuff	20
Urea	50
Irgapadol PE wetting agent	10
Antifoam RD	2
5 Manutex RSB thickener	10
Sodium Carbonate to pH 9.0	
Water to 1 Kg.	

The dyestuff Procion Blue MX3G may of course be replaced by any suitable dyestuff. Furthermore,

10 any form of textile yarn may be employed and the type of dyestuff chosen accordingly.

Consider, for example, that a yarn is designed in which three different colours are required to begin at the same point on the yarn. If all three spray units are switched on together the appearance of the yarn will be of first one colour coming in, then
5 the second and finally a blend of all three. This is due to the separation of the points of application of the three colours. The length of yarn between the point at which the first colour comes in and the point at which the third appears is equal to distance $2D$ (see Figure 1b). To minimise this overlap as effects are changed,
10 the tanks may be placed as close together as possible.

However, this overlap problem between consecutive effects is avoided by switching the spray units sequentially with a time separation equal to t where:

$$t = \frac{D}{V} \quad \begin{array}{l} D = \text{spray unit separation} \\ V = \text{yarn velocity} \end{array}$$

15 This will be achieved by programming the yarn speed into the computer, which will then output all control information to the spray units with the required time difference. With this modification the separation between the tanks is not important. It would be better in this case for the tanks to be a greater distance apart
20 (e.g. 10 cm or more) for ease of maintenance and cleaning. The tanks are always mounted separately to avoid contamination. Excess dye liquor carried out of a tank along with the yarn, through the guide holes, will tend to be thrown clear before the yarn enters the next tank.

EXAMPLES

25 Any combination of colours may be used in the three application tanks and one or two may be left empty if required. For the following examples, however, we will consider only one case where three primary colours have been used:

- 10 -

Tank 1 (14) - Red
 Tank 2 (16) - Yellow
 Tank 3 (18) - Blue

The following notation will be used for effects:

5 A1 (36) A2 (38)
 ON (1) OFF (0)spots of colour
 OFF (0) ON (1) -----relatively solid colour
 OFF (0) OFF (0) no effect

As a general rule, spots of effect are best produced by a liquor with
 a higher viscosity than one used for relatively solid colour. If
 10 both spots and solid colour are being applied in the same tank (during
 different time segments) then the pressure at A2 will be higher than
 that at A1.

1) Firstly we will examine a typical effect:

 purple mottled pale green
 15 v _____ v _____ v

The valve settings for this effect would be:

Time Segment	Red		Yellow		Blue	
	A1	A2	A1	A2	A1	A2
1	0	1	0	0	1	0
2	0	0	1	0	1	0

20 2) In order to design a yarn on the system, a yarn designer is
 likely to first draw out the required effect, break this down into
 the constituent components and finally translate these into the
 required effect codes. For instance, suppose a repeating rainbow
 effect is desired, this could be shown as a nine segment repeat:

red reddish yellowish yellow yellowish bluish blue bluish reddish
 orange orange green green purple purple
 v v v v v v v v v

which becomes



and hence

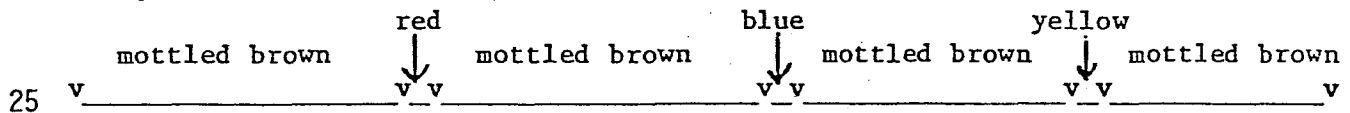
Time Segment	Red		Yellow		Blue	
	A1	A2	A1	A2	A1	A2
1	0	1	0	0	0	0
2	0	1	1	0	0	0
3	1	0	0	1	0	0
4	0	0	0	1	0	0
5	0	0	0	1	1	0
6	0	0	1	0	0	1
7	0	0	0	0	0	1
8	1	0	0	0	0	1
9	0	1	0	0	1	0

Which is finally translated into effect codes (See Figure 3) as follows:-

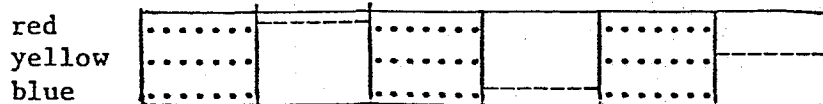
Time segment	1	2	3	4	5	6	7	8	9
Effect Code	5	18	17	4	12	9	2	11	14

In this example, similar time limits may be chosen for each segment, eg. 0.5 to 1.0 seconds.

3) A 'flash' effect on a predominant base shade might be:



which comprises:-



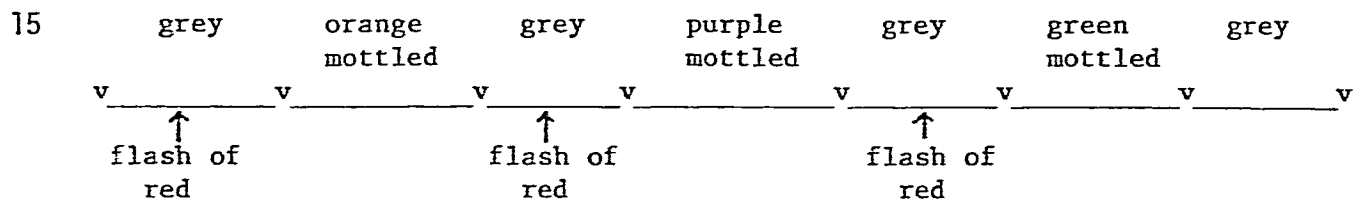
5

Time Segment	Red		Yellow		Blue	
	A1	A2	A1	A2	A1	A2
1	1	0	1	0	1	0
2	0	1	0	0	0	0
3	1	0	1	0	1	0
4	0	0	0	0	0	1
5	1	0	1	0	1	0
6	0	0	0	1	0	0

Hence: Time Segment 1 2 3 4 5 6
Effect Code 27 6 27 2 27 4

- 10 Typical time limits: Segments 1, 3 and 5: 5 - 9.9 secs
Segments 2, 4 and 6: 0.1 secs

4) The base shade may be the original yarn shade, in which case no dyestuff is applied along these sections. For instance on a yarn spun from ^{new} top dyed to a pale grey we may require:-



which comprises



taking the maximum twelve segments:-

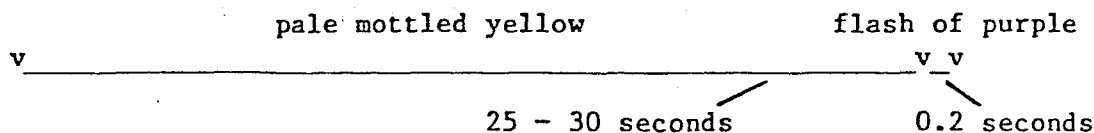
Time Segment	Red		Yellow		Blue	
	A1	A2	A1	A2	A1	A2
25 1	0	0	0	0	0	0
2	0	1	0	0	0	0
3	0	0	0	0	0	0
4	1	0	1	0	0	0
5	0	0	0	0	0	0
30 6	0	1	0	0	0	0
7	0	0	0	0	0	0
8	1	0	0	0	1	0
9	0	0	0	0	0	0
10	0	1	0	0	0	0
35 11	0	0	0	0	0	0
12	0	0	1	0	1	0

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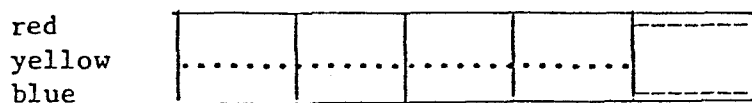
ence: Time Segment: 1 2 3 4 5 6 7 8 9 10 11 12
Effect Code : 1 6 1 19 1 6 1 15 1 6 1 13

Typical time limits: Segments 1, 3, 4, 5, 7, 8, 9, 11, 12 : 2 - 4 secs
Segments 2, 6, 10: 0.1 - 0.3 secs

- 5) If time segments longer than 9.9 secs are required, two or more adjacent segments may have the same effect. For example, consider a two colour effect with very long lengths of base and short flashes of contrast colour:-



- 10 This can be produced as follows:-



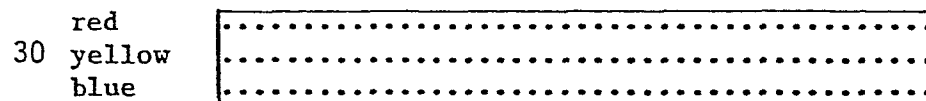
So we have a 5 segment repeat:-

Time Segment	Red		Yellow		Blue	
	A1	A2	A1	A2	A1	A2
1	0	0	1	0	0	0
2	0	0	1	0	0	0
3	0	0	1	0	0	0
4	0	0	1	0	0	0
5	0	1	0	0	0	1

Time segment : 1 2 3 4 5
Effect Code : 4 4 4 4 10

- Time Limits: Segments 1, 2, 3 : 8 secs
Segments 4 : 1- 6 secs
Segments 5 : 0.2 secs

- 6) The system can also be used for producing continuous colour effects. Tweed effects consisting of tiny flecks of colour are particularly successful. For instance, an all-over mottled brown:-



Which is a one-segment effect:

Time Segment	Red		Yellow		Blue	
	A1	A2	A1	A2	A1	A2
1	1	0	1	0	1	0

- 35 Time Segment: 1
Effect Code : 27

The value of the time limit setting does not matter since the effect repeats continuously.

Thus the apparatus of the invention specially in the preferred form embodying computer control is simple to set up and use and production is likely to be more consistent with few opportunities for error.

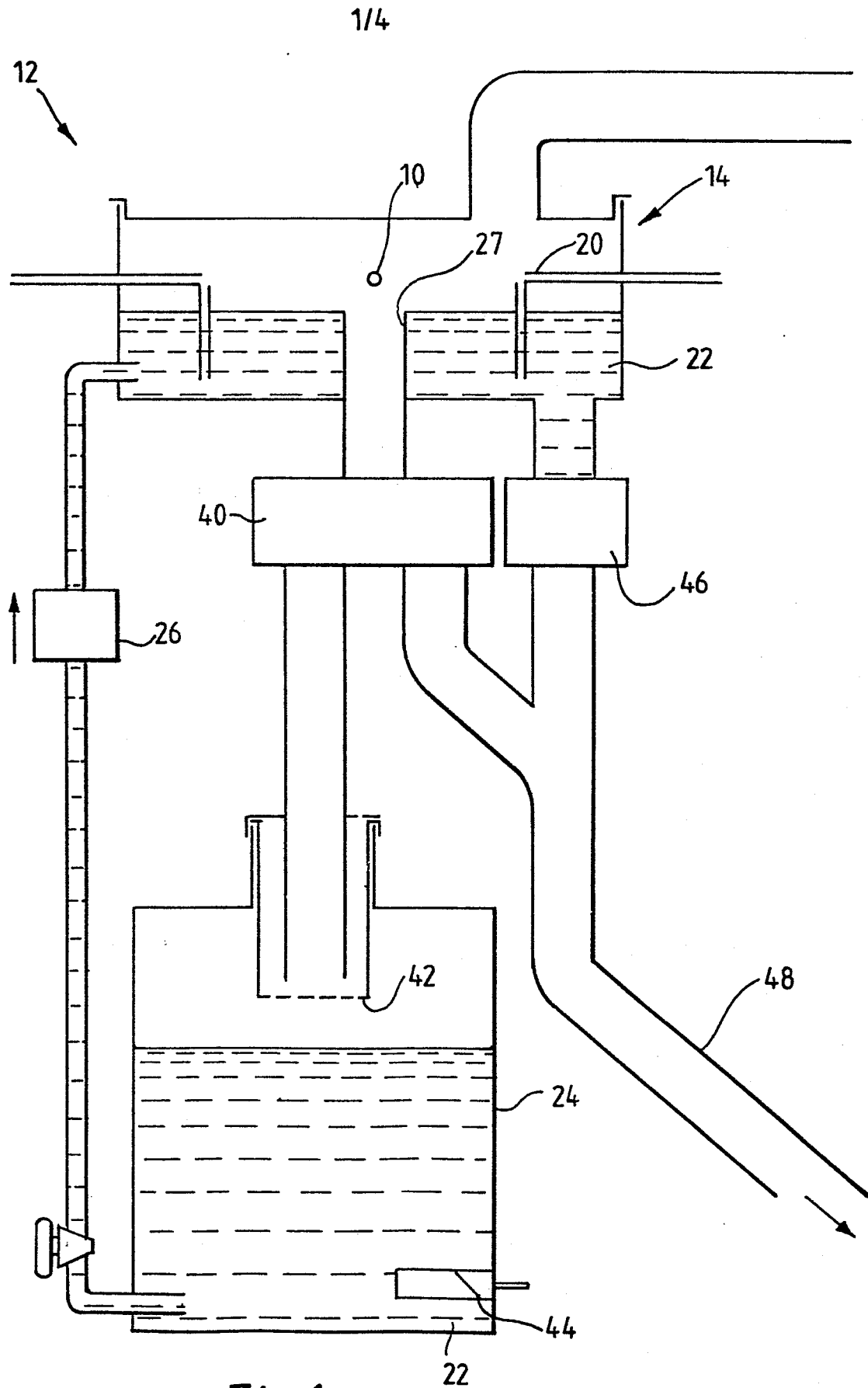
Maximum flexibility in the choice of pattern sequences is available to

5 the designer and yet the capital cost of the apparatus can be maintained at a relatively modest level.

CLAIMS

1. An apparatus for the space dyeing of yarns which comprises at least one spray nozzle connected to a source of dye liquor, the nozzle being connected to a source of compressed air switchable to provide at least two air flow rates whereby to alter the rate of application of dye liquor to the yarn.
5
2. An apparatus as claimed in claim 1 in which a pair of spray nozzles is directed one at either side of the yarn passing thereby.
3. An apparatus as claimed in either of claims 1 or 2 in which there are three sets of spray nozzles each connected to a separate source of dye liquor of a different colour.
10
4. An apparatus as claimed in any one of claims 1 to 3 in which the or each nozzle is connected by respective solenoid valves to two conduits fed from a common high pressure compressed air supply via regulators such that one conduit is maintained at a higher regulated air pressure than the other.
15
5. An apparatus as claimed in any one of claims 1 to 4 in which switching between different modes of operation is accomplished in a random manner by the use of randomly electronically generated signals.
- 20 6. An apparatus as claimed in claim 5 in which the signals are generated randomly between preset upper and lower time limits.
7. An apparatus as claimed in either of claims 5 or 6 in which the randomly generated signals are generated by a dedicated single board computer.

8. An apparatus as claimed in claim 7 in which the computer also controls the operating sequence of the apparatus and stores data relating to patterning sequences.
9. An apparatus as claimed in any one of claims 1 to 8 in which
5 there is more than one set of spray nozzles each connected to a respective source of dye liquor each being spaced apart to prevent contamination of one dye liquor by the next adjacent dye liquor.
10. An apparatus as claimed in claim 9 in which each set of nozzles is operated with a time delay related to the yarn speed
10 and separation of the sets of nozzles so as to prevent gaps in, or overlapping of, the liquors applied to the yarn.
11. An apparatus as claimed in any one of claims 1 to 10 in which the dye liquor may be directed to drain and a source of flushing water supplied to clean the apparatus.



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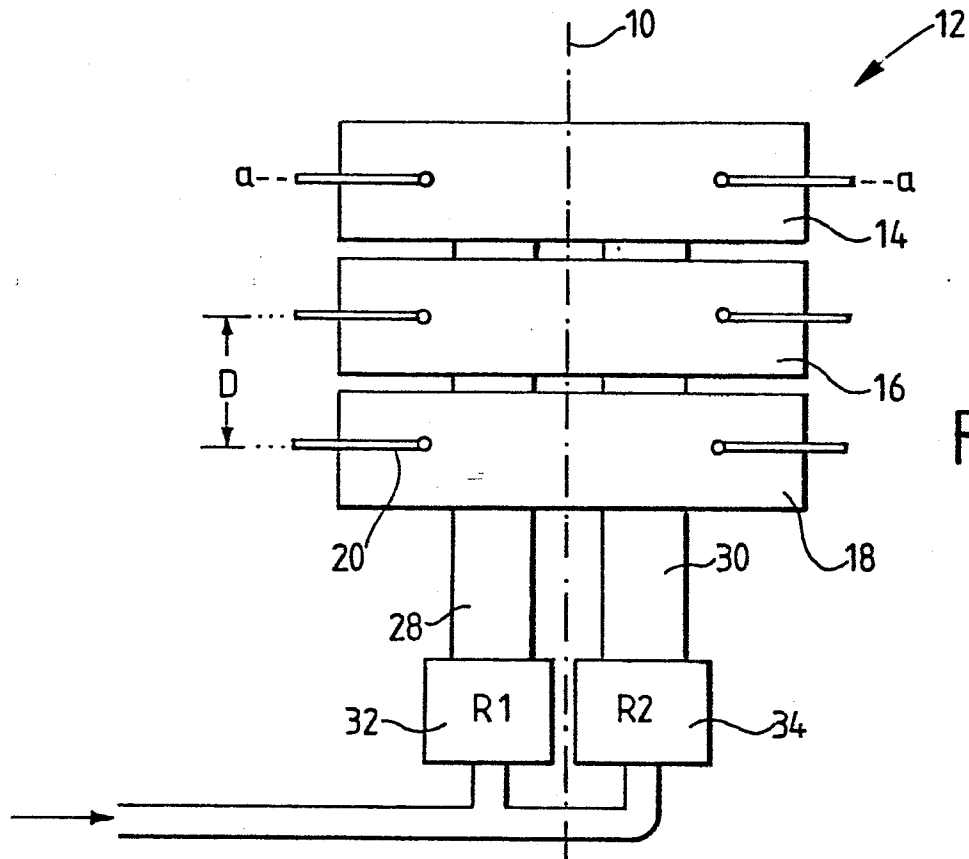


Fig.1b.

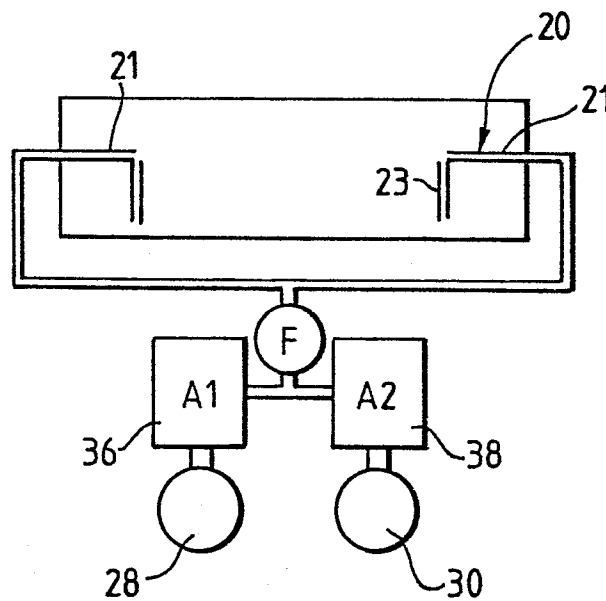


Fig.1c.

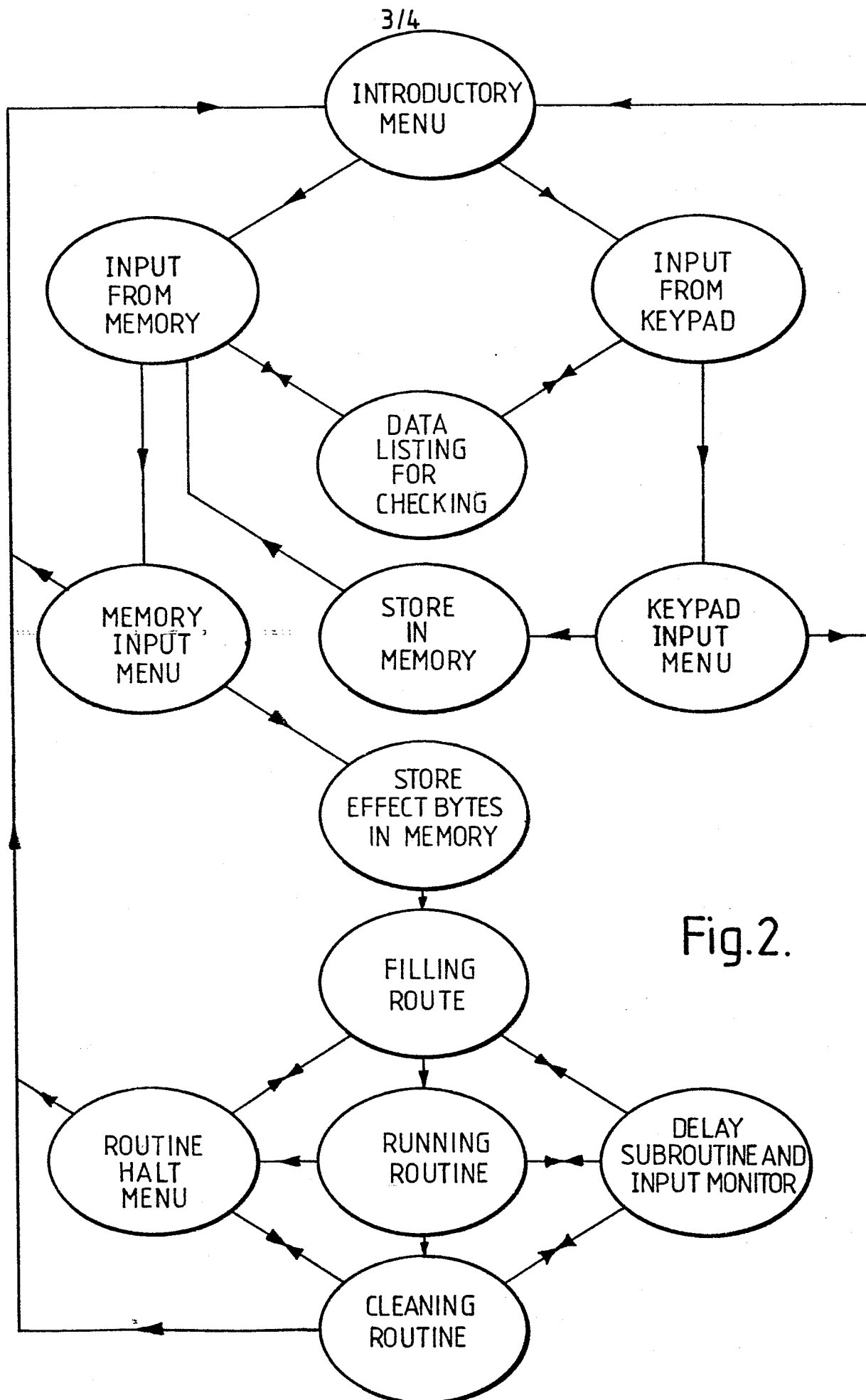


Fig.2.

Fig. 3.

Tank one A1 A2	Tank two A1 A2	Tank three A1 A2	Decimal equivalent of binary value O/P to port	Effect Code
000001000100010101010	000010001000100010011001100	0100001111000000000011110000	0	1
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	1	2
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	2	3
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	4	4
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	8	5
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	16	6
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	32	7
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	5	8
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	9	9
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	17	10
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	33	11
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	6	12
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	10	13
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	18	14
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	34	15
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	20	16
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	36	17
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	24	18
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	40	19
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	07	20
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	12	21
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	37	22
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	25	23
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	41	24
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	22	25
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	38	26
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	26	27
000001000100010101010	000010001000100010011001100	001000000000111100000000001111	42	



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	US-A-4 202 189 (MILLIKEN) *Whole document, particularly column 3, lines 58-67*	1-9	D 06 B 11/00
X	--- FR-A-1 414 221 (VEB HALBMOND-TEPPICHE) *Whole document, particularly page 3, right-hand column, middle*	1-9	
X	--- FR-A-2 172 667 (FMC CORPORATION) *The whole document*	1-4, 9	
Y		5-8	
Y	--- FR-A-2 226 819 (VAN DELDEN) *The whole document*	5-8	TECHNICAL FIELDS SEARCHED (Int. Cl. 3) D 06 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 23-03-1984	Examiner PETIT J.P.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	