

(19)



**Europäisches Patentamt**  
**European Patent Office**  
**Office européen des brevets**

(11) Publication number:

**0 118 173**  
**A1**

(12)

## EUROPEAN PATENT APPLICATION

(21) Application number: 84300325.2

(51) Int. Cl.<sup>3</sup>: B 65 H 54/38

(22) Date of filing: 19.01.84

(30) Priority: 03.02.83 US 463439

(43) Date of publication of application:  
12.09.84 Bulletin 84/37

(84) Designated Contracting States:  
BE CH DE FR GB IT LI NL SE

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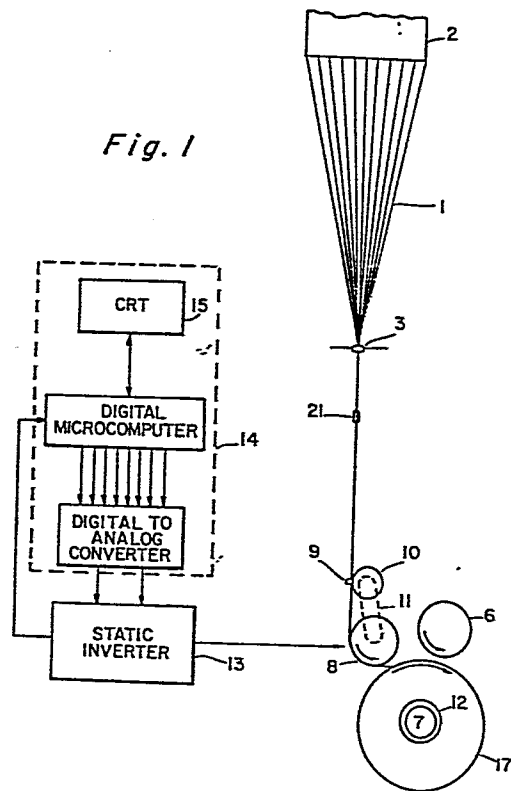
(54) **Apparatus and process for crosswinding filamentary yarn.**

(57) Improved apparatus and method for forming packages of crosswound direct-spun yarn, such as partially oriented polyester yarn. The method permits the consistent winding of large packages which have low banding defect level and can be unwound more readily in subsequent processes such as false twist texturing. The apparatus comprises specific digital microcomputer systems (11), for controlling the traverse rate of a grooved roll winder (8). The process comprises controlling the traverse rate of the grooved roll (8) in a specific manner, dependent upon the properties of the yarn being wound.

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Fig. 1



APPARATUS AND PROCESS FOR CROSSWINDING  
FILAMENTARY YARN

This invention relates generally to high speed winding of yarn packages comprising melt-spun yarns crosswound around supporting  
5. tubes, by the type of winding machine which uses a so-called grooved roll to traverse the yarn as the yarn is wound around the package. More particularly, it relates to improved and versatile apparatus and process for winding yarns comprising filaments by winding machines of the type in which an inverter is used to control the rotational  
10. speed of the grooved roll. It also relates to the improved large yarn packages thereby obtained, which improved packages have less tendency to result in yarn breaks during subsequent yarn unwinding and processing operations.

Textured filamentary yarn is conventionally manufactured  
15. by false twist texturing so-called partially oriented yarn (POY). A POY feedstock package typically consists of continuous filament POY crosswound around an inner supporting tube. The continuous filaments frequently have noncircular cross-section, rather than round cross-section, and a wide range of deniers and filament counts and  
20. spin finishes, for reasons that are well known in the art. It is well known that yarn breakage during the texturing operation results in economic loss for obvious reasons. It is also well known that such yarn breakage is most often associated with so-called "bad package build" of the packages most prone to yarn breakage. Further,  
25. it is well known that yarn packages which contain "ribboning" tend to have bad package build for unwinding purposes. "Percent Banding Level" is the term used in the trade to denote the percentage of all feedstock packages which have a threadline break due to "ribboned" yarn which has slipped into a position of lower helix angle, and is  
30. detected during the falsetwist texturing operation. The yarn on a package is said to "ribbon" whenever a helix of yarn is in direct side-by-side contact with the helix of yarn in the immediately preceding yarn layer, for the obvious reason that such a package gives the visual impression that a broad ribbon of yarn has been wound  
35. therearound. Ribboning has been found to be a major indirect cause

of yarn breakage in unwinding feedstock packages of POY consisting of polyester filaments with slick spin finish thereon, particularly when such packages have been wound by a yarn winder that uses a grooved roll to traverse the yarn as the yarn is wound around the package. Ribboning problems also increase as yarn denier increases. One such winder that uses a grooved traverse roll is the well known commercially used Barmag SW 46SSD Winder, described hereinafter in Example 1.

Theoretically, under various simplifying assumptions,

10. ribboning occurs in a yarn wind-up system at critical package diameters. A critical package diameter occurs whenever there is a ratio of simple integers between the bobbin speed in revolutions per minute and the traverse guide frequency in cycles per minute. The calculation of ribbon zones is easily made under these assumptions

15. and their location for the SW 46SSD winder is presented in one of the Figures. Under these circumstances the helical path of the yarn on the bobbin is exactly repeated. When ribboning is permitted to persist for more than a few seconds, the build-up becomes unstable. This, in turn, frequently leading to difficulties in unwinding large

20. packages during subsequent processing. Various techniques well known as "ribbonbreaking" (or "antipatterning") have been developed in an attempt to prevent ribboning from occurring for a long period. For example, in one method, the traverse frequency is made to oscillate between an upper and a lower limit. The ultimate aim of this

25. oscillation is to avoid a constant speed operation of the traverse, thereby minimizing conditions favorable for ribbon formation. Also US Patent 3 799 463 discloses a process for winding yarn into a cylindrical-bodied substantially flat-ended package by traverse winding layers of helical coils of yarn on a surface-driven package

30. is improved by not only breaking ribbon formation by the known waveform (minor modulation of inverter output to the traverse motor) from a preset point, but also modulating the set point to create a major modulation having a minor modulation superimposed along or within the modulated set point waveform. The major modulation has

35. a period of about 0.25 to 2 minutes and an amplitude of about 2 to

12 percent. US Patents 3 638 872 and 3 241 779 are also addressed to ribbon-breaking techniques.

- On a winder equipped with a conventional traverse system without a grooved roll (eg a traverse guide driven by traverse cam),
5. ribbon-breaking is often accomplished by varying the traverse inverter output frequency (generally  $\pm 1-2.5\%$ ) around a specified base frequency over a specified time period (1-8 sec). When plotted, the inverter output frequency and resulting traverse speed will both produce a sinusoidal wave. In the case of the Barmag SW 46SSD Winder,
  10. however, the addition of the grooved roll to the traverse system substantially increases the total mass of this system. The increase in mass increases the rotational inertia of the traverse mechanism, making it more resistant to speed changes as directed by a sinusoidal inverter output signal. To compensate for the increased mass, an
  15. "inertia compensation" or so-called "P-jump" potential is commercially supplied by Barmag with the traverse inverter. The P-jump is an instantaneous change in inverter frequency at the reversal points of maximum and minimum frequency. This instantaneous change in frequency results in a more rapid speed change of the traverse, and
  20. helps to compensate for the rotational inertia of the traverse system. P-jump is specified in terms of a percentage of the total traverse amplitude with maximum to minimum frequency being 100%. Unfortunately, however, this technique imposes excessive strain on the inverter, particularly as period of modulation is decreased and
  25. P-jump and amplitude of modulation are increased. Even so, trial and error techniques permit selection of traverse setup factors which will reduce constant speed grooved roll operation for a limited variety of roll speeds, modulations, base frequencies, periods and P-jumps.
  30. An article of background interest is "Situation Report on High-Speed Spinning at the Start of the Eighties" by Dr Gunter Schubert in "International Textile Bulletin", March 1980, pages, 229-258, particularly Section 4.2 "Controlled Thread Tension" and Section 4.6 "Running-Off Problems". More recently, at the October 1982
  35. Greenville show, Barmag demonstrated a new type of ribbon-breaking

system, called "Ribbon Free Random Wind" (RFR). The system is based upon using two inverters (rather than a single inverter) for a bank of Barmag winders, and uses timing switches on each winder to change backwards and forwards from one inverter to the other, thereby

5. temporarily increasing the traverse speed to jump through the theoretical critical diameter ribbon points. Further information about the RFR system can be found in Barmag's booklet "Information Service NR 23" October 1982, particularly at pages 8-9. Also, pages 11-14 of the Barmag booklet discusses "Use of Microprocessors in the
10. Man-Made Fiber Industry", but does not disclose or suggest the invention described and claimed hereinafter.

In contrast to the forementioned prior art, it has now been surprisingly discovered that greatly improved yarn packages can be consistently produced by using a microcomputer system to feed a

15. predetermined programed electrical frequency signal into the inverter that controls the speed of the grooved roll, without introducing unacceptable variability into the yarn (such as denier variability and orientation variability). Large packages with diameters greater than 300 mm can be made with low percent banding level, even with
20. slick yarns that are particularly prone to band. Further, use of the microcomputer provides a high degree of flexibility in plant operating conditions that permits large and appropriate changes in grooved roll speeds to be determined experimentally and implemented commercially, whenever yarn properties such as coefficient of friction
25. are changed for other reasons.

According to the present invention, there is provided an improved apparatus for winding filamentary yarn onto tubes (12) to form crosswound packages (17) of filamentary yarn, the winding apparatus comprising means (6) for rotating the tube, yarn supply

30. means, and grooved roll means (8) for traversing the yarn in reciprocating manner as the yarn is being wound onto the tube, the traversing means also comprising a static inverter (13) for controlling the frequency of the traverse cycle during the winding operation, characterised in that there is provided in combination

35. therewith a programed digital microcomputer (11) and means for feeding

an electrical output signal from the microcomputer (11) to the inverter (13), whereby the microcomputer continuously controls the frequency of the traverse throughout the winding of the package according to a predetermined program.

5.           The means for feeding an electrical output signal from the microcomputer to the inverter may comprise a digital-to-analog converter. This converter may comprise means for converting a 12 bit digital input value into an analog output voltage. The microcomputer may comprise a programme comprising a variable ramp
10. function, at least one variable time delay and a modulation function with variable parameters. The minimum value of the variable ramp function is preferably less than 0.94 of the maximum value of the variable ramp function, more preferably less than 0.89 and most preferably less than 0.84.
15.           According to the present invention, there is further provided an improved process for forming packages of direct-spun yarn by spinning continuous filaments and crosswinding the spun filamentary yarn onto tubes at speeds in excess of 10,000 ft/min (3048 m/min) by traversing the yarn as it is pulled onto the pre-existing portion
20. of the package, and by controlling the frequency of the traverse cycle by means of a static inverter, characterised by (i) programing a digital microcomputer system (11) with a predetermined program, and (ii) feeding a predetermined compatible electrical signal from the microcomputer system (11) to the inverter (13).
25.           The process may comprise varying the frequency of the electrical signal to the inverter in accordance with the sum of a varying ramp function and a modulation function. It may comprise feeding a varying ramp function which essentially decreases during at least most of the winding of the package by an amount that is at
30. least 6 percent of the value of the ramp function used for winding the inner layers of yarn. The ramp function may be modulated in an amount of 1 to 3 percent at a frequency within the range 1 to 20 seconds. At least 20 traverse mechanisms may be controlled with a single common inverter, the ramp function being increased during the
35. winding of the outermost portion of the packages and the full packages

being team doffed during the period of increasing ramp function.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

FIGURE 1 is a partial semi-schematic view in side elevation  
5. of one embodiment of the process of the invention on a single position.

FIGURE 2 is a partial semi-schematic view of the control system of one embodiment of the invention as applied to controlling simultaneously eighty Barmag crosswinders.

10. FIGURE 3 is a simplified front elevation view of a prior art Barmag grooved roll.

FIGURES 4A - 4D are graphs of some grooved roll speeds used in the Examples, expressed as percent overfeed, on a time basis (and inherent package diameter basis) during the winding of yarn packages  
15. according to the invention. The graphs are not strictly to scale.

FIGURE 5 is a graphical presentation of calculations, made under certain simplifying assumptions, of critical yarn package diameters at which integer ribboning should occur with the specific apparatus used in the Examples of the invention and the Comparative  
20. Examples.

FIGURE 6 is a partial schematic diagram of the so-called "team-doff" system of the invention, wherein a single microcomputer-controlled inverter is used in conjunction with 80 yarn winders.

FIGURE 7 is a partial schematic diagram of a dual inverter  
25. system of the prior art for controlling traverse rates on grooved roll cross-winding machines.

FIGURE 8 is a partial schematic diagram of Barmag's RFR system for controlling traverse rates on grooved roll winding machines.

30. The nature of the preferred embodiments of the invention is best understood by the Examples contrasted with the Comparative Examples hereinafter. Such Examples are not intended to limit the scope of the invention.

#### EXAMPLE 1

35. Crosswound packages of octolobal polyester POY were made

according to the improved process described below. The banding level (defined below) of these packages was generally less than 1 percent, in contrast to corresponding prior art packages having a banding level of at least about 3 percent.

5. The process used was essentially in accordance with Figures 1, 2 and either 4A or 4B or 4C in all the variants of Example 1.

- Figure 1 is a partial semi-schematic view in side elevation of a single position (or unit) for melt-spinning polyester multifilament yarn, and continuously winding the melt-spun yarn in the form of crosswound packages by means of a yarn winder having a grooved roll to traverse the yarn as it is wound into package form. Molten poly(ethylene terephthalate) polymer was conventionally formed into noncircular octolobal filaments (1) by extruding the molten polymer through 33 holes of a spinneret in a conventional melt-spinning head (2). The extruded filaments were conventionally quenched with cooling air by quenching means, had spin finish applied to them by conventional finish applicator (3), air interlaced conventionally by interlacer (21) and wound into package form at about 11,500 ft/min (3505 m/min) by means of an otherwise conventional Barmag Model SW 46SSD Class II Winder except for the microcomputer programed traverse speed of the invention. The fully wound packages (17) had diameters within the range 300-350 mm and lengths of about 250 mm, in general accordance with package dimensional pictures and data in Barmag literature on the forementioned Barmag winder page 12 line 27.

- Even though such Barmag Winders are well known in the art and fully described in Barmag's trade literature such as "SW4S; SW46S", obtainable from American Barmag Corporation, 1101 Westinghouse Boulevard, Charlotte, NC 28217, some description of the machine and its characteristics is given below.

- The Barmag SW 46SSD winder was designed for the production of POY packages with random wind at high take-up speeds. Figure 1 illustrates the relative location of the winder's drive roll (6) chuck (7) and traverse system including two yarn-contacting components, a grooved roll (8) and traverse guide (9). The drive

## 8.

- roll and traverse mechanism of the winder are built into a joint housing (not shown) and fastened to a vertically movable slide (not shown). Contact is made between the chuck and take-up head by lowering the drive roll/traverse assembly onto the chuck. The drive
5. roll/traverse assembly is pneumatically weight balanced by means of opposing low friction cylinders (not shown). While the POY package is building, constant pressure is exerted by the drive roll on the yarn package. This pressure is adjustable. The drive roll has a ground, hard, chromeplated, polished surface and is driven by a
10. synchronous motor mounted inside the roll. The threadline is in the traverse guide (9) throughout the entire stroke, and the guide is moved back and forth by a traverse cam (10).

- Since reversal of the traverse guide (9) is somewhat slow, a grooved roll (8) is arranged below the traverse cam. The threadline
15. wraps around the groove of the grooved roll with an approximately 90° wrap, and is subsequently placed on the package with a very small reversing radius. The whole traverse system is driven by a three phase induction motor (not shown) mounted inside the grooved roll. The traverse cam is driven by the grooved roll motor via a gear belt
20. (11).

The chuck (7) supplied with the winder is a manual type with spring loaded fingers (not shown) holding the cardboard tube (12) in place during operation.

- All winder controls, with the exception of motor operation
25. (drive roll and grooved roll), are pneumatically operated in well known manner (not shown). In general, it has been found that 218 denier/33 filament octolobal POY requires exceptionally uniform head pressure, except that during chuck acceleration greater head pressure is provided via an auxiliary air cylinder (not shown).

30. Theoretical calculations were made, under certain simplifying assumptions, to determine the critical yarn package diameters at which integer ribboning should occur with the specific apparatus. The results of these calculations are shown graphically in Figure 5, and were derived in the following way.

35. The following simplifying assumptions were made. Firstly,

- the shape of the package is that of a true cylinder. Secondly, the yarn is printed onto the package surface at absolutely constant helix angle, along the length of the package. Thirdly, the linear surface speed of the package is identical to the linear surface speed of the drive roll (DRS). Fourthly, the system provides a so-called absolutely constant yarn "% overfeed", defined as follows in terms of grooved roll speed (GRS) and drive roll speed (DRS):

$$\% \text{ overfeed} = 100 \frac{(\text{GRS} - \text{DRS})}{(\text{DRS})}$$

10. Once the foregoing assumptions have been made, it can be readily shown mathematically that:

$$D_{PN} = \frac{D_{GR} \times R_{GR}}{N \left(1 + \frac{F}{100}\right)}$$

15. where:  $D_{PN}$  is the package diameter at the N:1 ribbon zone;  
 $D_{GR}$  is the grooved roll diameter at the yarn-contacting point;

$R_{GR}$  is the grooved roll revolutions per double stroke;

N is the number of ribbon turns on the package;

20. F is the % overfeed of the grooved roll;

and L is the stroke length of 250 mm.

For example,  $D_{PN}$  equals 270.0 mm when: N is 4;  $D_{GR}$  is 108 mm;  $R_{GR}$  is 11; and F is 10. This is shown on Figure 5 as point "A".

25.

In practice, the foregoing simplifying assumptions do not conform to actual winding conditions on the barmag winder, equipped with a so-called AGR 11 grooved roll. Such grooved roll is similar in principle to that shown in Figure 3, except that there are 11

30. revolutions of grooved roll for each double stroke. Figure 3 is similar to that shown in Barmag literature, where is is accompanied by the following legend: "All take-up heads of series SW4 are equipped with yarn length compensation to even out the differences in yarn length in the traverse motion triangle. The yarn length
35. compensation contributes also to uniform yarn quality and excellent

package build-up. It is achieved by a special shaping of the grooved roll. The yarn tension in the traverse motion triangle is kept almost constant".

- While the Barmag winder may be well adapted for winding
5. certain types of yarn under certain winding conditions, experiments showed that the amount of harmful ribboning present in the packages, expressed as a percentage of all package rejected for banding, was highly dependent upon the frictional characteristics of the yarn being wound. It was also noted that the frictional characteristics of the
10. yarn impact upon the validity of all the foregoing four simplifying assumptions.

- Table 1 below summarizes some data obtained in practising variants of the invention. It shows the "banding level" significantly depends upon yarn properties as well as the specific overfeed program
15. that is used to control the actual rotational speed of the grooved roll throughout the package build. "Banding level" is the number of packages with unacceptable "bands" therein, expressed as a percentage. The bands result from slippage of "patterned or ribboned" yarn into a position of reduced helix angle. The overfeed/time
20. relationships that were used are shown in Figures 4A-4C. They were obtained by means of a separate inverter (shown as 13 in Figures 1 and 2) for each winder, with each of these inverters being controlled by a microcomputer (shown as 14 in Figures 1 and 2). The individual inverters drove the traverse motors (not shown) on the winders. The
25. microcomputer consisted of a commercially available Intel SBC 80/20-4 single board Digital microcomputer connected with a commercially available Adac 735-SBC Digital-to-Analog Converter Board, whose output was fed to the static inverter. The inverter was a commercially available 3 horse power static inverter manufactured by PTI Controls,
30. Inc. The Digital output signal from the microcomputer was used to control the frequency of the output signal from the static inverter to the traverse motor. In addition, a cathode ray tube (15 of Figure 1) was used to examine and change various parameters associated with the traverse speed control program.

35. In all the Examples, the microcomputer program consisted

11.

of two speed control functions: firstly, a long term "ramp" function which controlled the average percent overfeed, F, over say 30 seconds; and secondly, a short term "modulation" function which provided continuous wave modulation above and below the ramp overfeed. The

5. amplitude and period and shape of the combined wave were varied by the microcomputer, and the CRT was used to set the parameters, by techniques that would be well known to one of average skill in the art. Results were obtained as in Table 1.

TABLE 1

| 10. | EX<br>NO | YARN<br>TYPE | FINISH<br>TYPE | % RAMP<br>OVERFEED<br>RANGE | MODULATION   |                 | %<br>BANDING<br>LEVEL |
|-----|----------|--------------|----------------|-----------------------------|--------------|-----------------|-----------------------|
|     |          |              |                |                             | AMP<br>(± %) | PERIOD<br>(SEC) |                       |
| 15. | 1A       | 218/33*      | H              | 14 - 5                      | 2            | 4               | < 0.3                 |
|     | 1B       | 218/33       | M              | 14 - 5                      | 2            | 4               | < 0.3                 |
|     | 1C       | 303/33*      | M              | 20 - 8                      | 2            | 4               | < 3                   |
|     | 1D       | 225/33*      | L              | 25 - 8                      | 2            | 4               | < 0.3                 |

20. \*In Examples 1A, 1C and 1D the yarn was air interlaced in conventional manner between the finish applicator and the winder.

- In Table 1 above, three yarn types (218/33, 303/33, and 225/33 octolobal POY yarns) and three finishes that differed in relative friction (H having the highest, M having a medium, and L having the lowest frictional characteristics) are shown. For each
25. product the same modulation is used, ie  $\pm 2\%$  amplitude and a 4 second period. The initial and final percent overfeeds are shown to define the ramp function. The function has been optimized (relative to Comparative Example 2) in order to provide lower banding levels for each combination of finish and yarn type. Each value of % banding
30. level shown in Table 1 was based upon a large enough sample size such that differences were statistically significant. During the trials, it was noted the optimum conditions for one type of yarn and finish combination were quite unsuited for the winding of other yarns. It is believed that the reason for this is associated with the frictional
35. characteristics of the yarn, both along the yarn and transverse to

the yarn. It was further noted that on occasion ribboning occurred at package diameters significantly different from the critical package diameters calculated according to the standard assumptions above.

Surprisingly, the large variations in overfeed used during the package

5. build (in Figure 4A-4C) did not appear to cause corresponding variability in yarn properties, such as variability in yarn denier, tenacity and elongation. In view of this, it is believed to be unnecessary to use additional yarn hauloff godets (not shown in Figure 1) between the finish applicator and the traverse guide. Of course,
10. such intermediate godets could be used if desired.

The data shown in Table I was based upon sequential trial-and-error techniques, and such techniques would have to be used in determining the optimum overfeed program for each type of yarn to be wound. Nonetheless, some interesting points, and perhaps

15. guidelining principles, may be derived from examining Figures 4A-4C. Under all three programs the percent overfeed decreases during the package build. This, in turn, results in yarn winding tension increasing during package build. Avoidance of excessive winding tension in the inner layers of yarn perhaps results in a softer core
20. capable of elastic compression when further wound with outer layers of yarn under higher tension. Avoidance of insufficient winding tension in the outer layers of yarn and a softer core together, perhaps help prevent the just-laid yarn in the outermost layer from migrating along the length of the package from its position as
25. originally printed by the grooved roll. Furthermore, lower helix angles result as the traverse speed is decreased. This in combination with the higher threadline tensions may have two further positive effects. Ridges of yarn which build during patterning are not as high and have less of a tendency to slip creating fewer wind off
30. faults.

In addition, it should be noted, in at least some of these Examples, a general system layout was used as shown in Figure 2 for a bank of 80 Barmag winders. It will be noted that a host microcomputer was used to perform supervisory functions over

35. each of the 80 satellite microcomputers in a conventional manner.

EXAMPLE 2 (COMPARATIVE)

- Crosswound packages of octolobal polyester POY were made with commercially available Barmag Winders in general accordance with Example 1, but without using the microcomputer programmed traverse speed of the invention. In particular, "modulated constant ramp" traverse speeds were selected from those available on commercially available Barmag equipment prior to the introduction of RFR in 1982. Table 2 below summarizes the % banding levels obtained for various yarns under various winding conditions. In general, it appeared that these packages tended to be more saddle-shaped than those of Example 1.

TABLE 2

| 15. | EX<br>NO | YARN<br>TYPE | FINISH<br>TYPE | OVERFEED                    |              |                 | %<br>BANDING<br>LEVEL |
|-----|----------|--------------|----------------|-----------------------------|--------------|-----------------|-----------------------|
|     |          |              |                | % RAMP<br>OVERFEED<br>RANGE | MODULATION   |                 |                       |
|     |          |              |                |                             | AMP<br>(± %) | PERIOD<br>(SEC) |                       |
| 20. | 2A       | 218/33*      | H              | 15                          | 2            | 4               | 2.5                   |
|     | 2B       | 218/33*      | M              | 15                          | 2            | 4               | 13                    |
|     | 2C       | 303/33       | M              | 14                          | 2            | 4               | 100                   |
|     | 2D       | 225/33*      | L              | 13                          | 2            | 4               | 44                    |
|     | 2E       | 225/33*      | M              | 15                          | 2            | 4               | 24                    |

- \*In Examples 2A, 2B, 2D and 2E the yarn was air interlaced conventional manner between the finish applicator and the winder.

Clearly, these Comparative Examples provided highly unsatisfactory banding levels as compared with corresponding variants of Example 1 for the same yarn type.

30. EXAMPLE 3

- After the promising results obtained in Table 1 had been obtained, experiments were performed to determine whether pre-existing plant facilities could be used as an interim solution on a so-called "team doffing" system which system would require only a single microcomputer controlled inverter for a bank of 80 Barmag Winders,

rather than a single inverter for each winder.

Figure 4D is a graphical representation of the microcomputer controlled overfeed of the 80 Barnag winders that were used in tandem.

5. During team doffing, doffing full packages and donning empty tubes on all 80 winders was performed during a 30 minute period within the zone D-D of Figure 4D, by using more operators than would normally be required for random doffing. As a result, the programed overfeed varied from package to package, depending upon the particular point of doffing/donning within Zone D-D.

From Table 3 below it will be noted that this team doff system reduced the banding level to around 0.8% (as compared to about 2.5% for Comparative Example 2A).

TABLE 3

15.

20.

| EX<br>NO | YARN<br>TYPE | FINISH<br>TYPE | % RAMP   |       | MODULATION   |                 | %<br>BANDING<br>LEVEL |
|----------|--------------|----------------|----------|-------|--------------|-----------------|-----------------------|
|          |              |                | OVERFEED |       | AMP<br>(± %) | PERIOD<br>(SEC) |                       |
|          |              |                | INITIAL  | FINAL |              |                 |                       |
| 3A       | 218/33*      | H              | 11       | 8     | 1            | 8               | 0.8                   |
| 3B       | 218/33*      | M              | 11       | 8     | 1            | 8               | 0.5                   |

In Examples 3A and 3B the yarn was conventionally air interlaced between the finish applicator and the winder.

25. It will, of course, be appreciated that such team doffing system appears to be only an interim solution. The system does not work satisfactorily under conditions where there are frequent breaks in the spinning threadlines or frequent melt-spinning pack changes. Further, a team doffing system is incompatible with many automated doffing systems, including those in which a single robot is used to handle sequentially packages from a whole bank of 80 winders.

30.

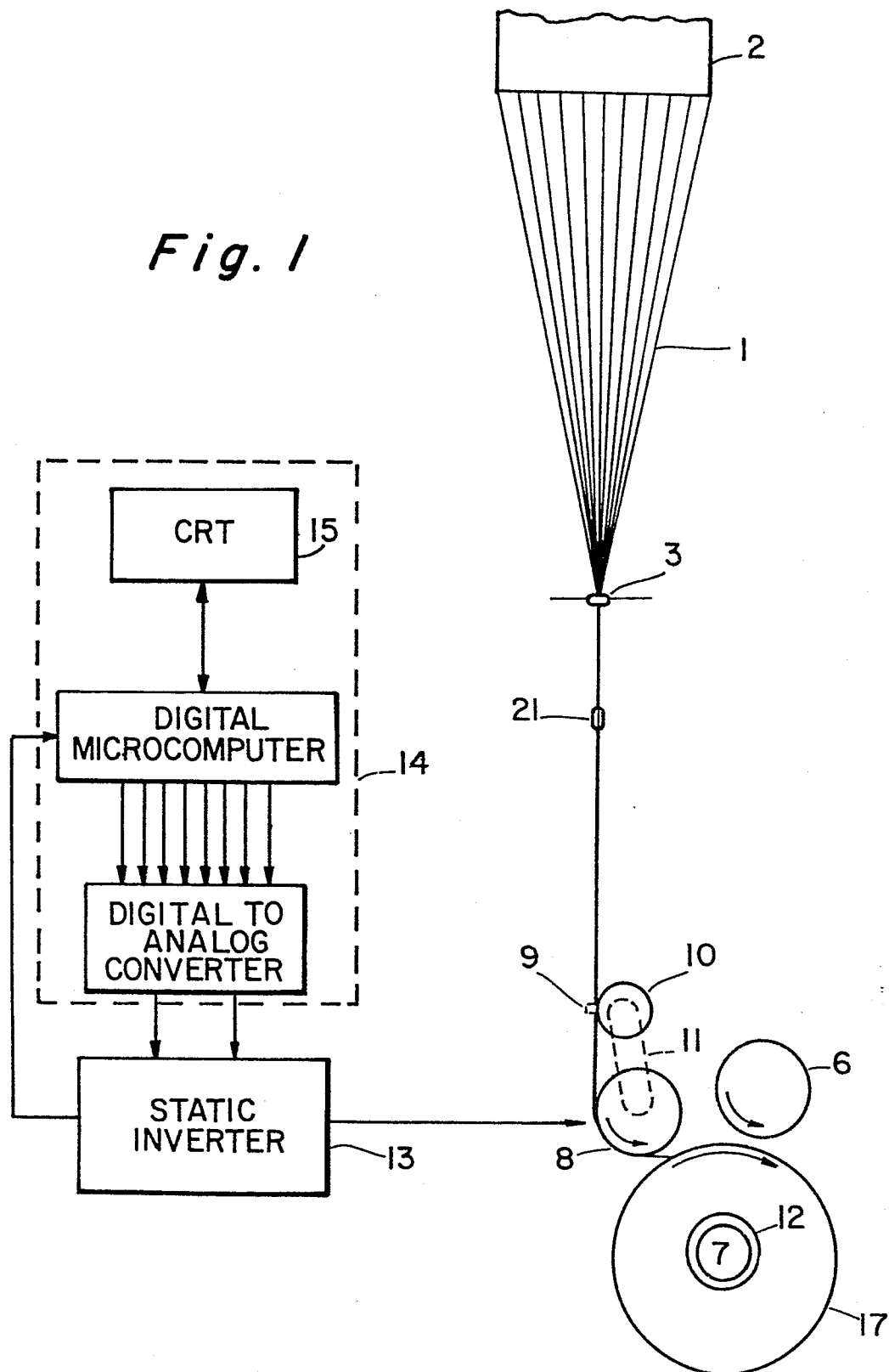
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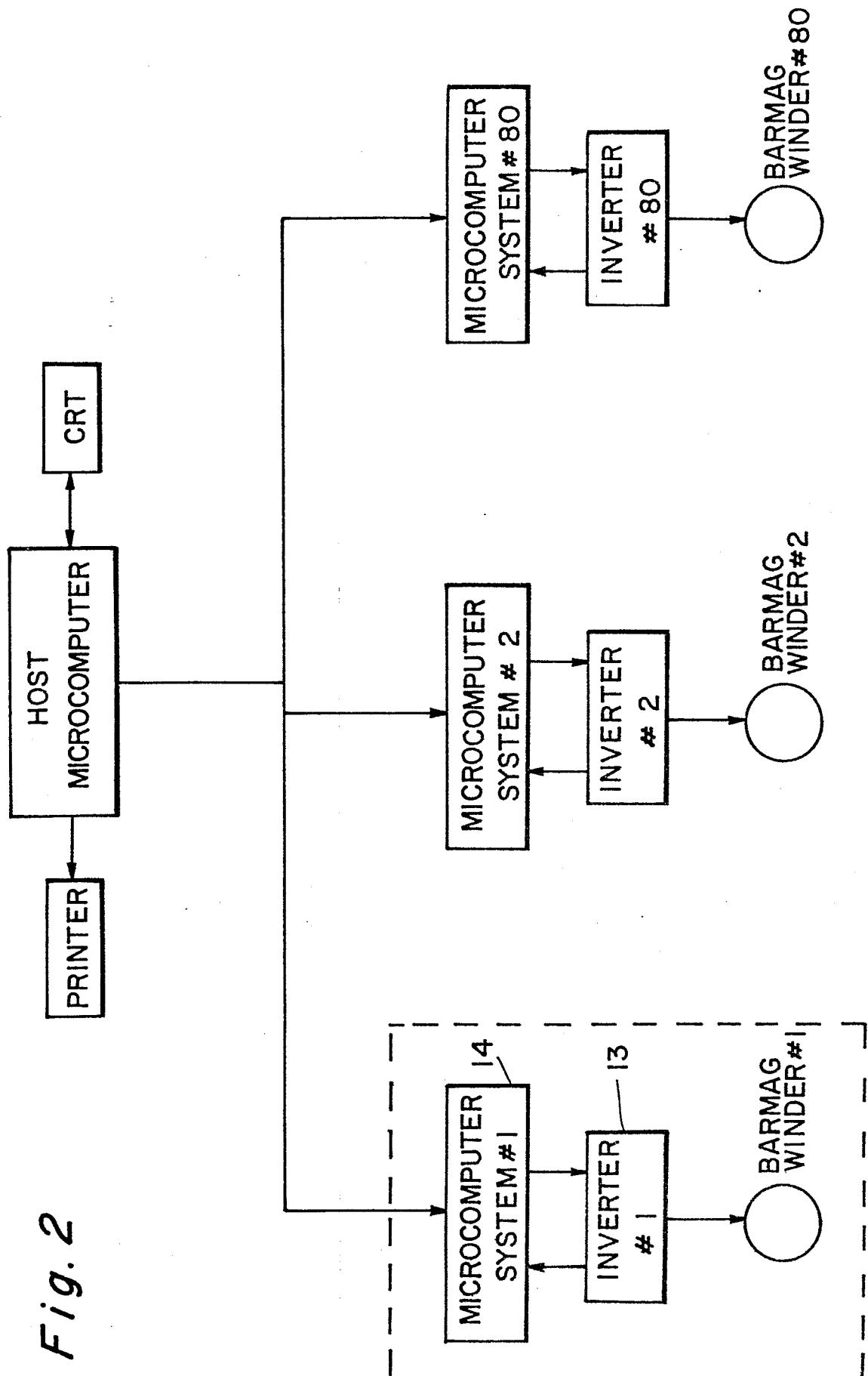
1. Improved apparatus for winding filamentary yarn onto tubes (12) to form crosswound packages (17) of filamentary yarn, the winding apparatus comprising means (6) for rotating the tube, yarn supply
5. means, and grooved roll means (8) for traversing the yarn in reciprocating manner as the yarn is being wound onto the tube, the traversing means also comprising a static inverter (13) for controlling the frequency of the traverse cycle during the winding operation, characterised in that there is provided in combination
10. therewith a programmed digital microcomputer (11) and means for feeding an electrical output signal from the microcomputer (11) to the inverter (13), whereby the microcomputer continuously controls the frequency of the traverse throughout the winding of the package according to a predetermined program.
15. 2. The apparatus of claim 1 wherein the means for feeding an electrical output signal comprises a digital-to-analog converter.
3. The apparatus of claim 2 wherein the digital-to-analog converter comprises means for converting a 12 bit digital input value into an analog output voltage.
20. 4. The apparatus of claim 1 wherein the microcomputer comprises a program comprising a variable ramp function: at least one variable time delay; and a modulation function with variable parameters.
5. The apparatus of claim 4 wherein the variable ramp function's minimum value is less than 0.94 of the variable ramp
25. function's maximum value.
6. The apparatus of Claim 5 wherein the variable ramp function's minimum value is less than 0.89 of the variable ramps function's maximum value.
7. The apparatus of Claim 5 wherein the variable ramp
30. function's minimum value is less than 0.84 of the variable ramp function's maximum value.
8. An improved process for forming packages of direct-spun yarn by spinning continuous filaments and crosswinding the spun filamentary yarn onto tubes at speeds in excess of 10,000 ft/min (3048
35. m/min) by traversing the yarn as it is pulled onto the pre-existing

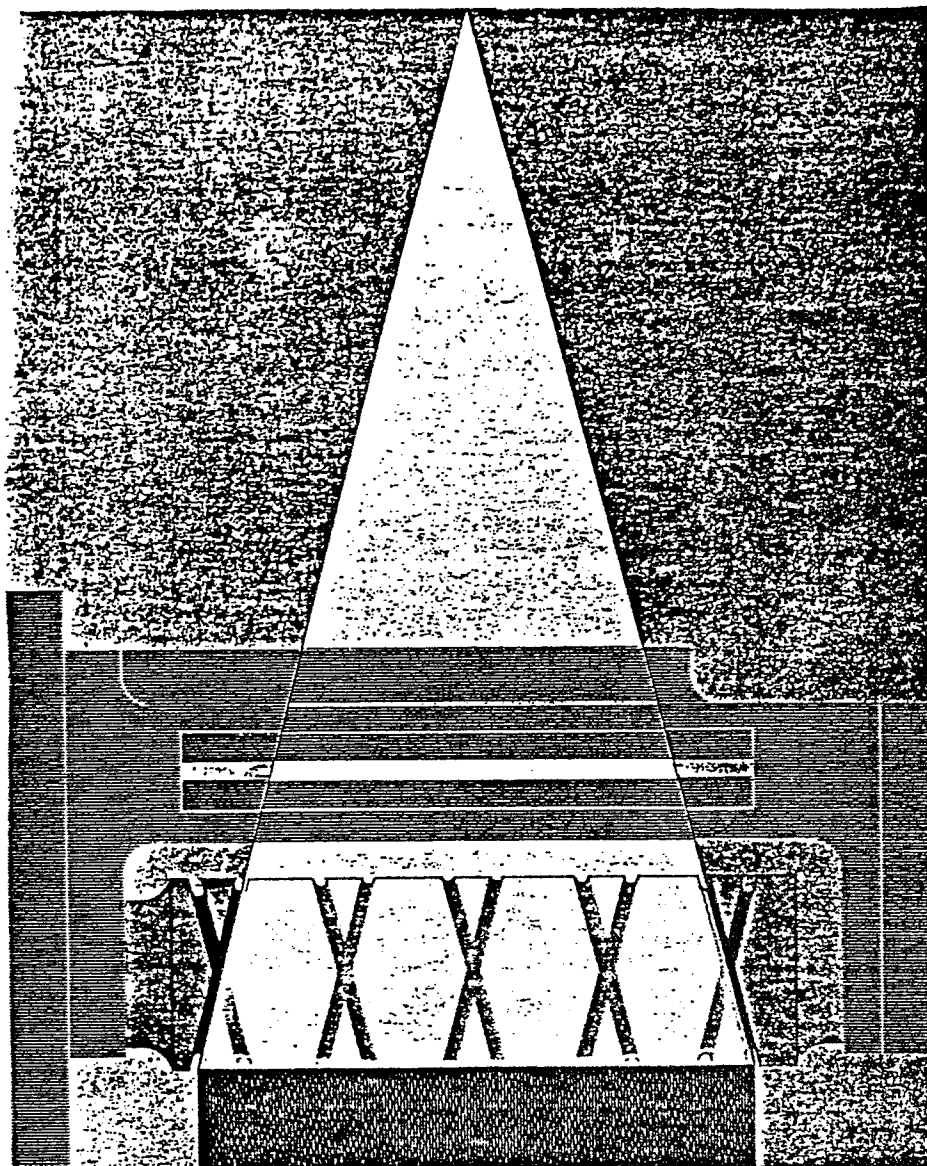
16.

- portion of the package, and by controlling the frequency of the traverse cycle by means of a static inverter, characterised by (i) programming a digital microcomputer system (11) with a predetermined program, and (ii) feeding a predetermined compatible electrical signal
5. from the microcomputer system (11) to the inverter (13).
9. The process of claim 8 which comprises varying the frequency of the electrical signal to the inverter in accordance with the sum of a varying ramp function and a modulation function.
10. The process of claim 9 which comprises feeding a varying
10. ramp function which essentially decreases during at least most of the winding of the package, by an amount that is at least 6 percent of the value of the ramp function used for winding the inner layers of yarn.
11. The process of claim 10 which comprises modulating the ramp
15. function in an amount of 1.3 percent at a frequency within the range 1 to 20 seconds.
12. The process of claim 10 which comprises controlling at least 20 traverse mechanisms with a single common inverter, and increasing the ramp function during the winding of the outermost portion of the
20. packages, and team doffing the full packages during the period of increasing ramp function.

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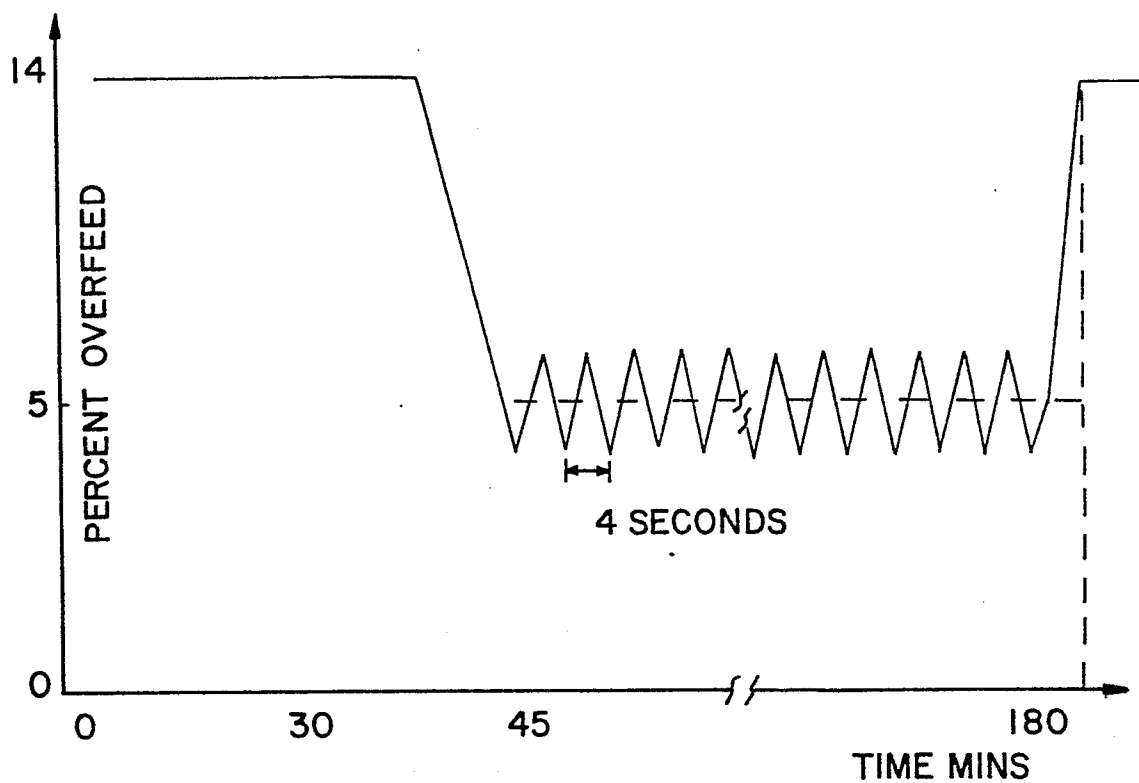
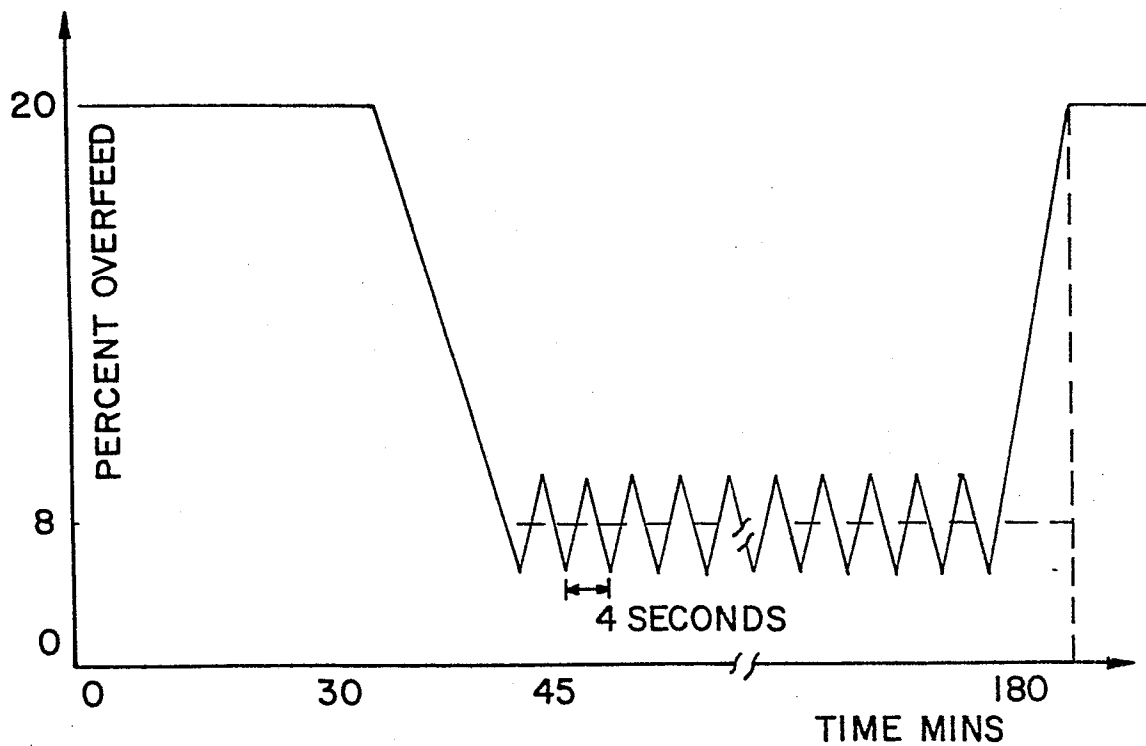
*Fig. 1*



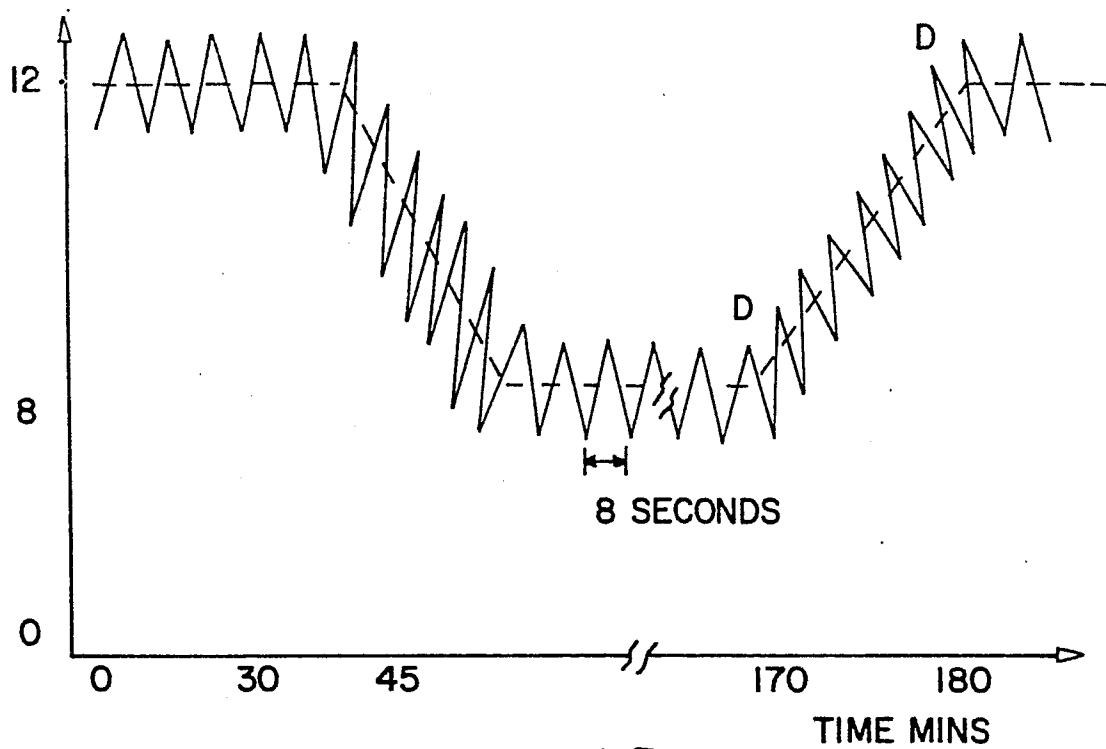
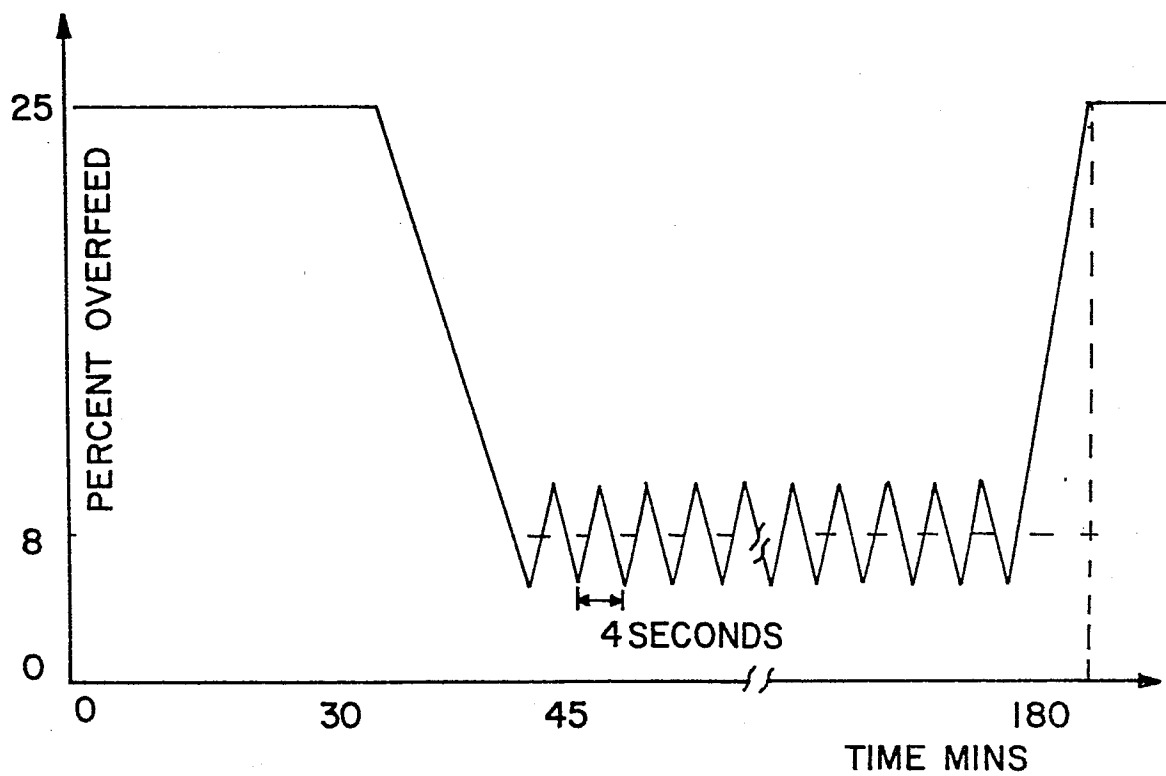


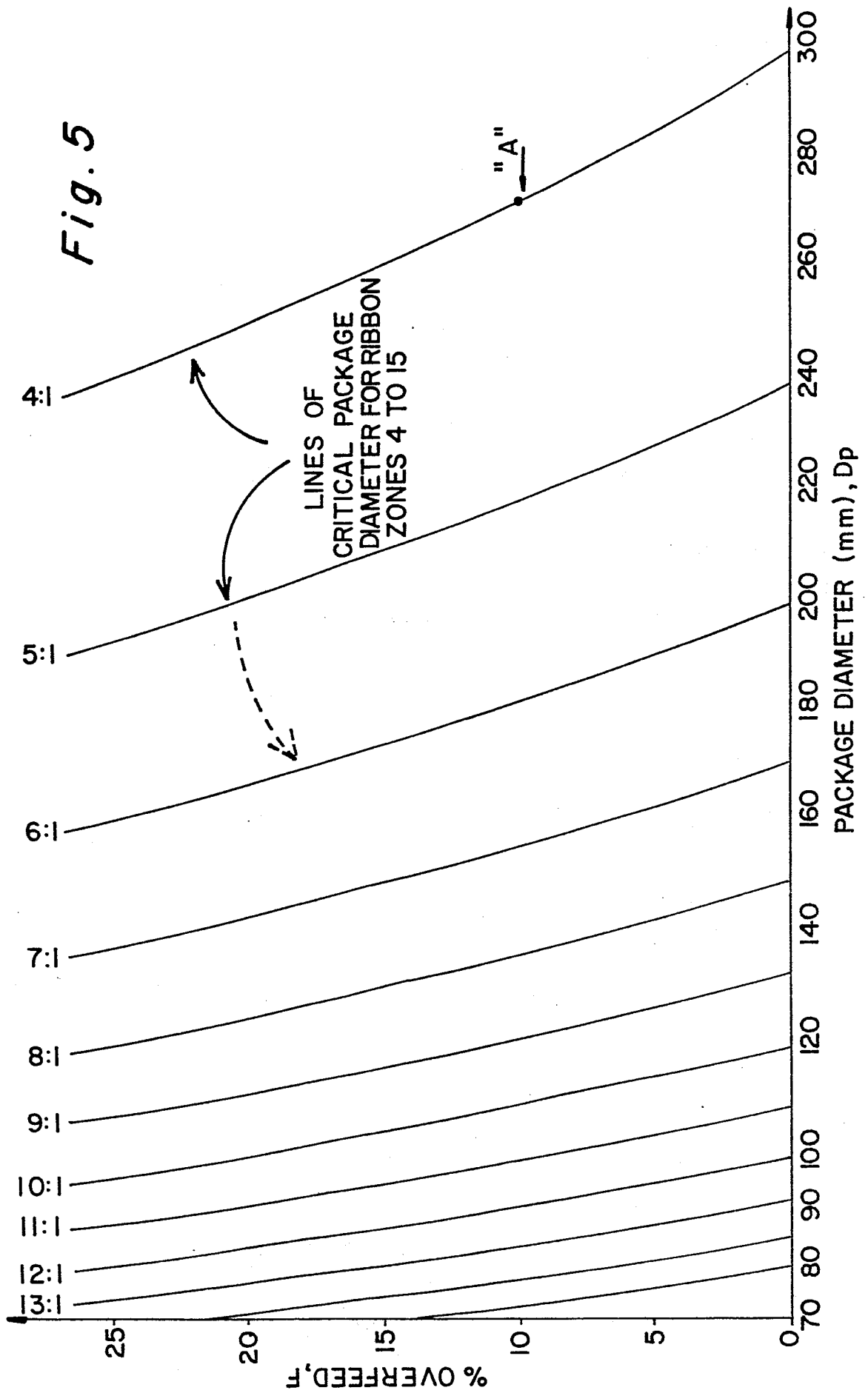
*Fig. 3*  
(PRIOR ART)

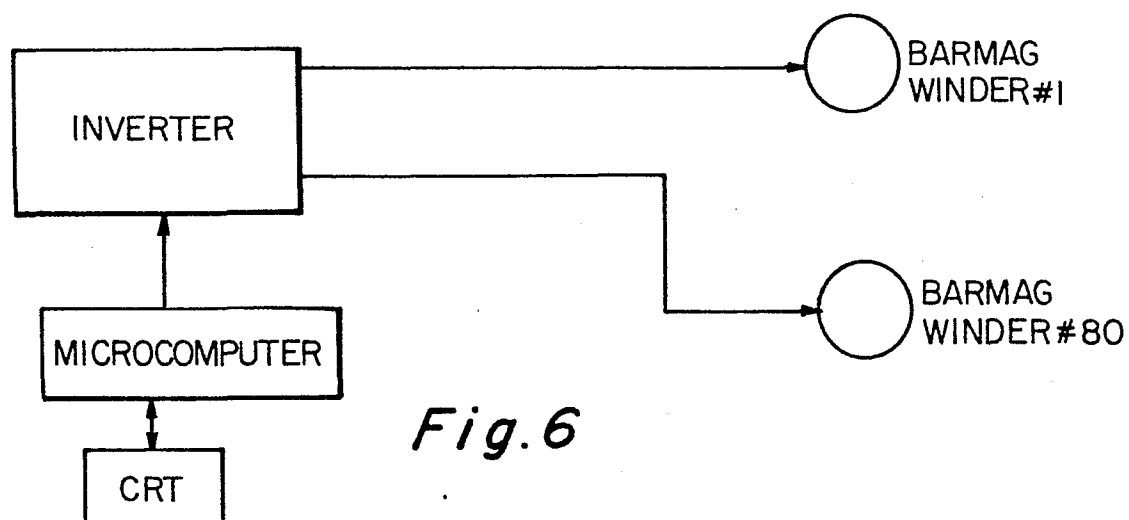
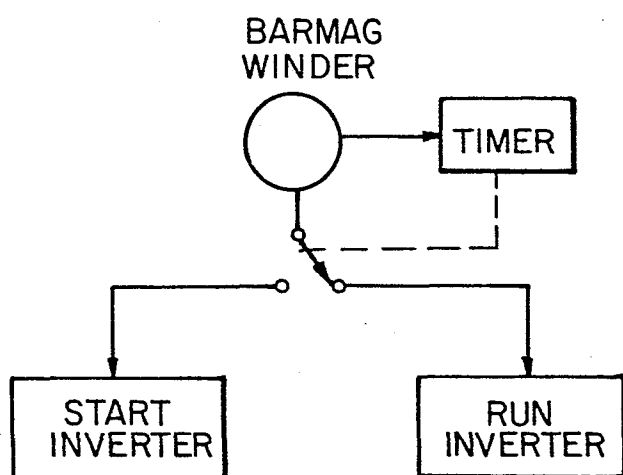
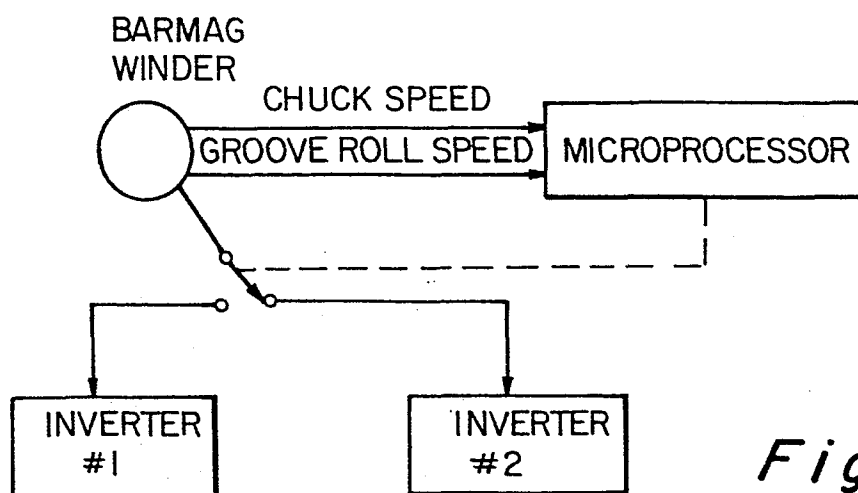
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*Fig. 4A**Fig. 4B*

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*Fig. 4D**Fig. 4C*



*Fig. 6**Fig. 7*  
(PRIOR ART)*Fig. 8*



| 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. <sup>3</sup> )       |
| A                                                                                                                                                                                                                       | DE-A-2 544 337 (JOY MANUFACTURING)<br>* Whole document and in particular pages 3,8,18; figure 1 * | 1,8                                                                                                                                                                                                                                                                              | B 65 H 54/38                                                     |
| A                                                                                                                                                                                                                       | ---<br>US-A-4 146 376 (OWENS CORNING FIBERGLASS)<br>* Columns 4-6 *                               | 1,8                                                                                                                                                                                                                                                                              |                                                                  |
| A                                                                                                                                                                                                                       | ---<br>EP-A-0 068 720 (MONSANTO CO.)<br>* Whole document *                                        | 1,8                                                                                                                                                                                                                                                                              |                                                                  |
| A                                                                                                                                                                                                                       | ---<br>US-A-4 269 368 (OWENS CORNING FIBERGLASS)<br>* Columns 7-20; figures 3,6 *                 | 1,8                                                                                                                                                                                                                                                                              |                                                                  |
| D,A                                                                                                                                                                                                                     | ---<br>US-A-3 638 872 (DU PONT DE NEMOURS)<br>-----                                               |                                                                                                                                                                                                                                                                                  | TECHNICAL FIELDS SEARCHED (Int. Cl. <sup>3</sup> )<br><br>B 65 H |
| The present search report has been drawn up for all claims                                                                                                                                                              |                                                                                                   |                                                                                                                                                                                                                                                                                  |                                                                  |
| Place of search<br>THE HAGUE                                                                                                                                                                                            |                                                                                                   | Date of completion of the search<br>15-05-1984                                                                                                                                                                                                                                   | Examiner<br>DEPRUN M.                                            |
| <b>CATEGORY OF CITED DOCUMENTS</b>                                                                                                                                                                                      |                                                                                                   |                                                                                                                                                                                                                                                                                  |                                                                  |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                   | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br><br>& : member of the same patent family, corresponding document |                                                                  |