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(54) **LOW IGNITION PROPENSITY (LIP) PAPER SMOKING ARTICLES**

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(57) **ABSTRACT**

Apparatus for producing low ignition propensity ("LIP") smoking articles provides independent control of the belt drive transport speed and the cutting head rotational speed in dependence on the relative position of the cutting head blades to the position of the continuous tobacco column on the tape drive, by detecting the presence of synchronizing marks disposed on the outer surface of the tobacco column LIP paper wrapper, thereby controlling cutting of the continuous column to provide registration of the LIP paper's LP bands to their designated location within the finished article's tobacco column.

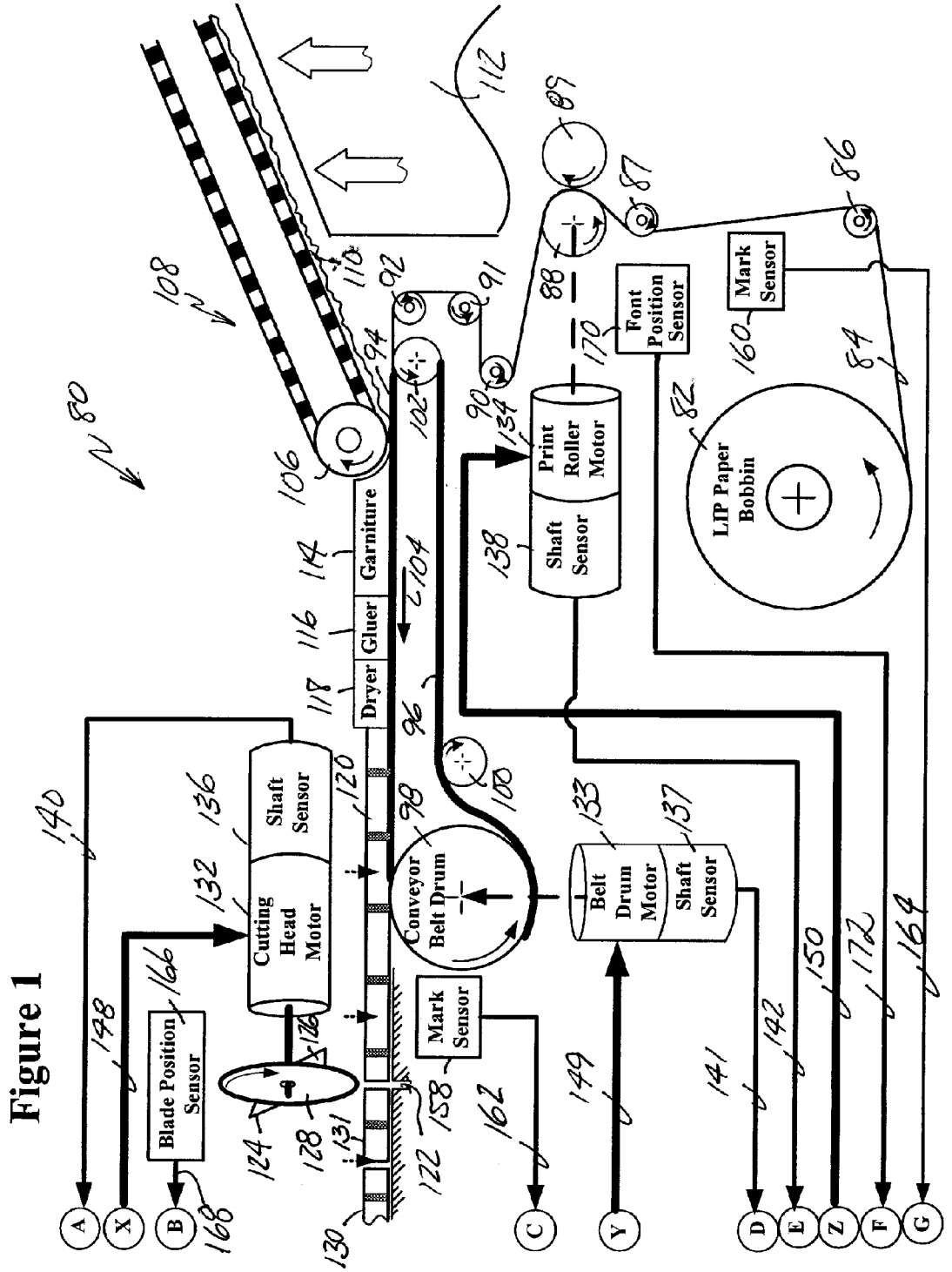


Figure 1
80
108
112
110
92
91
89
88
87
86
94
90
84
82
106
102
104
134
Print Roller Motor
Shaft Sensor
138
Font Position Sensor
170
Mark Sensor
160
LIP Paper Bobbin
Garniture
114
Gluer
116
Dryer
118
96
98
Conveyor Belt Drum
108
133
Belt Drum Motor
Shaft Sensor
137
120
136
Shaft Sensor
Cutting Head Motor
132
140
148
166
Blade Position Sensor
168
124
128
131
122
130
Mark Sensor
158
162
149
141
142
150
172
164
A
X
B
C
Y
D
E
Z
F
G

Figure 2

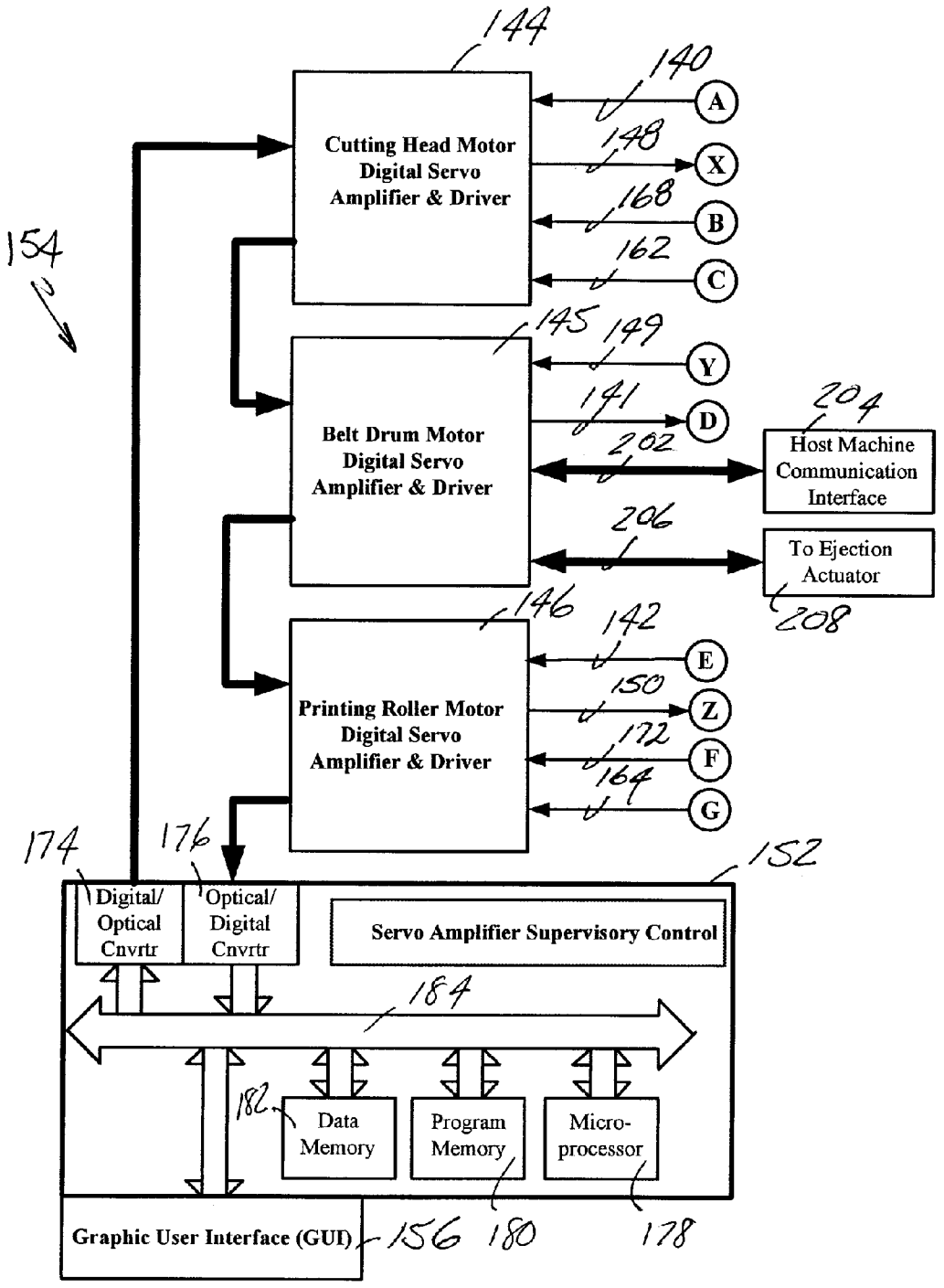

144
140
A
148
X
168
B
162
C
154
145
149
Y
141
D
204
202
Host Machine Communication Interface
206
To Ejection Actuator
208
146
142
E
150
Z
172
F
164
G
Cutting Head Motor Digital Servo Amplifier & Driver
Belt Drum Motor Digital Servo Amplifier & Driver
Printing Roller Motor Digital Servo Amplifier & Driver
174
176
152
Digital/ Optical Cnvrtr
Optical/ Digital Cnvrtr
Servo Amplifier Supervisory Control
184
182
Data Memory
Program Memory
Micro-processor
Graphic User Interface (GUI)
156
180
178

Figure 3

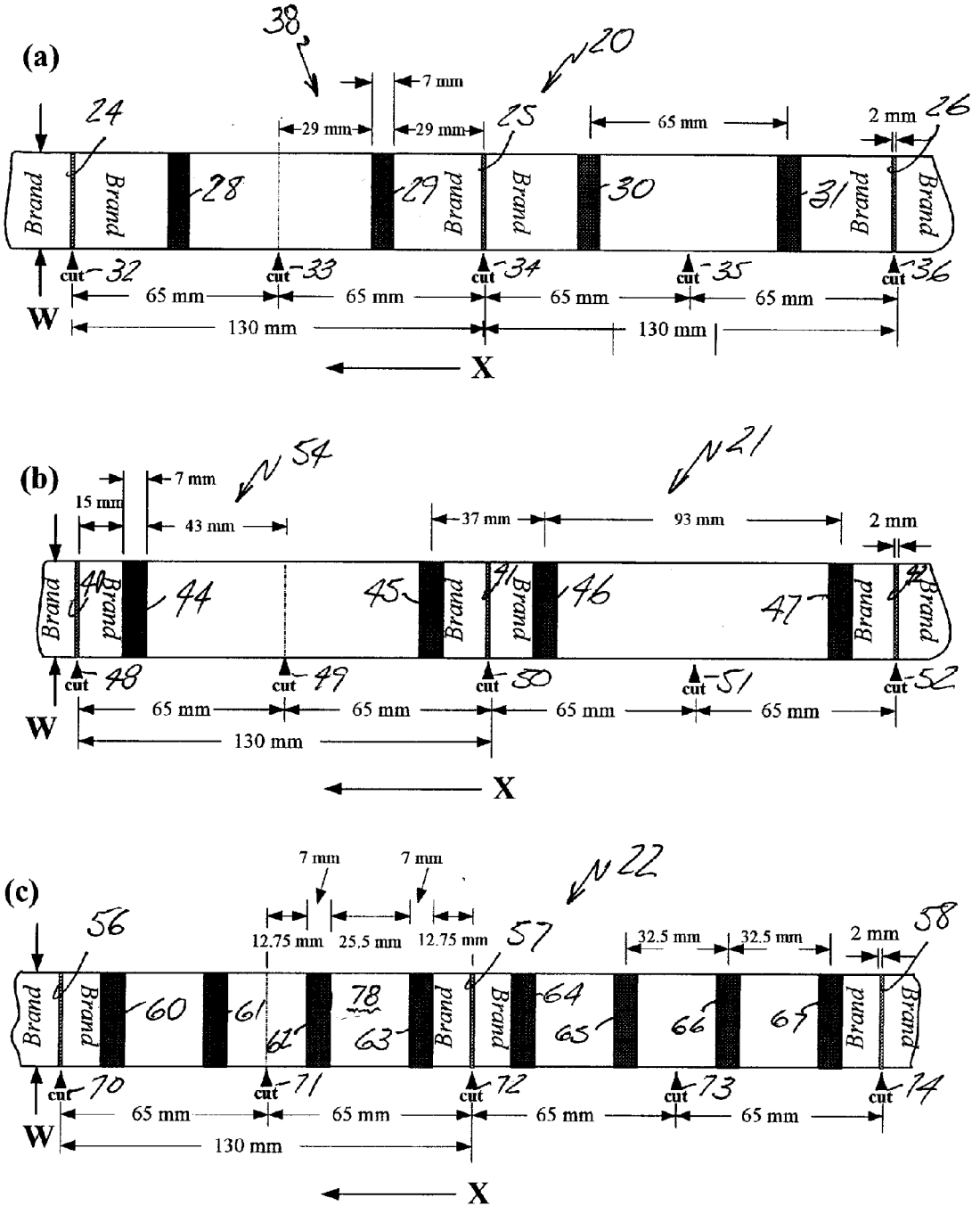

(a)
38
20
7 mm
29 mm
29 mm
65 mm
2 mm
24
25
26
Brand
28
29
30
31
32
33
34
35
36
cut
65 mm
130 mm
W
X
(b)
54
21
7 mm
15 mm
43 mm
37 mm
93 mm
2 mm
40
41
42
44
45
46
47
48
49
50
51
52
(c)
22
7 mm
7 mm
12.75 mm
25.5 mm
12.75 mm
32.5 mm
32.5 mm
2 mm
56
57
58
60
61
62
63
78
64
65
66
67
70
71
72
73
74

Figure 4

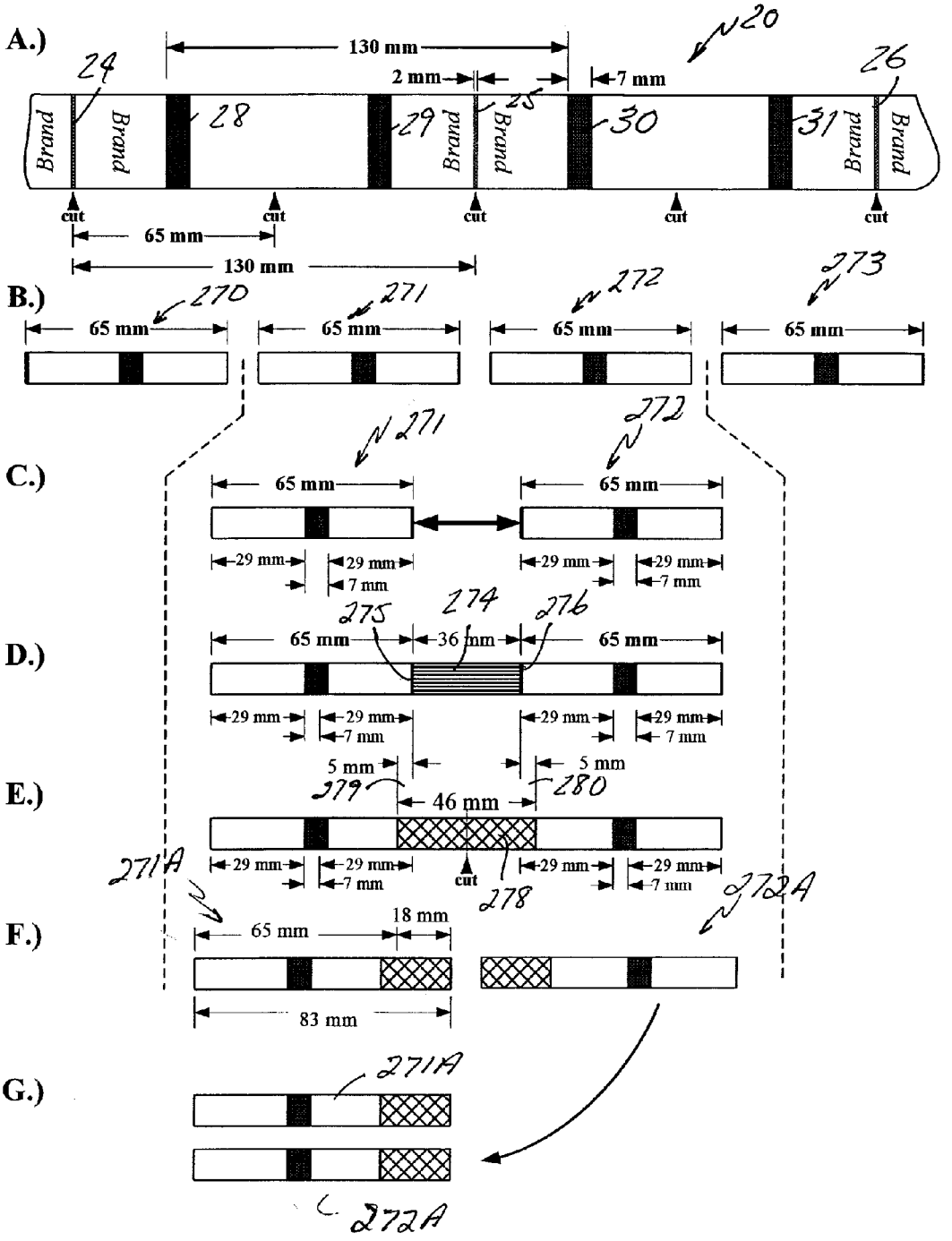

A.)
130 mm
2 mm
7 mm
20
24
26
Brand
28
29
25
30
31
cut
65 mm
130 mm
B.)
270
271
272
273
65 mm
C.)
271
272
29 mm
7 mm
D.)
274
275
276
36 mm
E.)
5 mm
279
280
46 mm
278
271A
272A
F.)
18 mm
83 mm
G.)
271A
272A

Figure 5

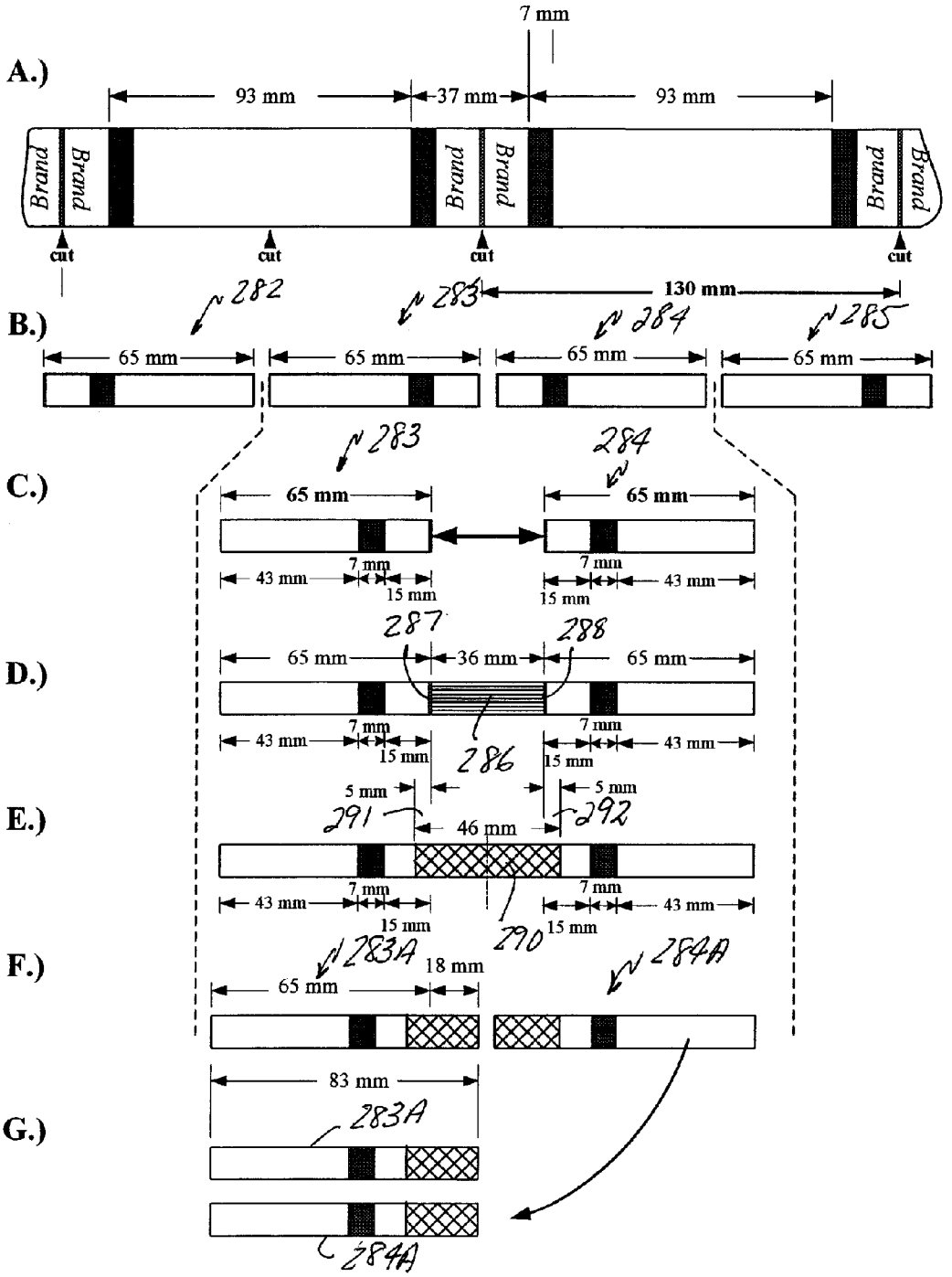

A.)
7 mm
93 mm
37 mm
93 mm
Brand
cut
B.)
282
283
130 mm
284
285
65 mm
C.)
283
284
7 mm
43 mm
15 mm
D.)
287
288
36 mm
286
E.)
5 mm
291
292
46 mm
290
F.)
283A
18 mm
284A
G.)
83 mm

Figure 6

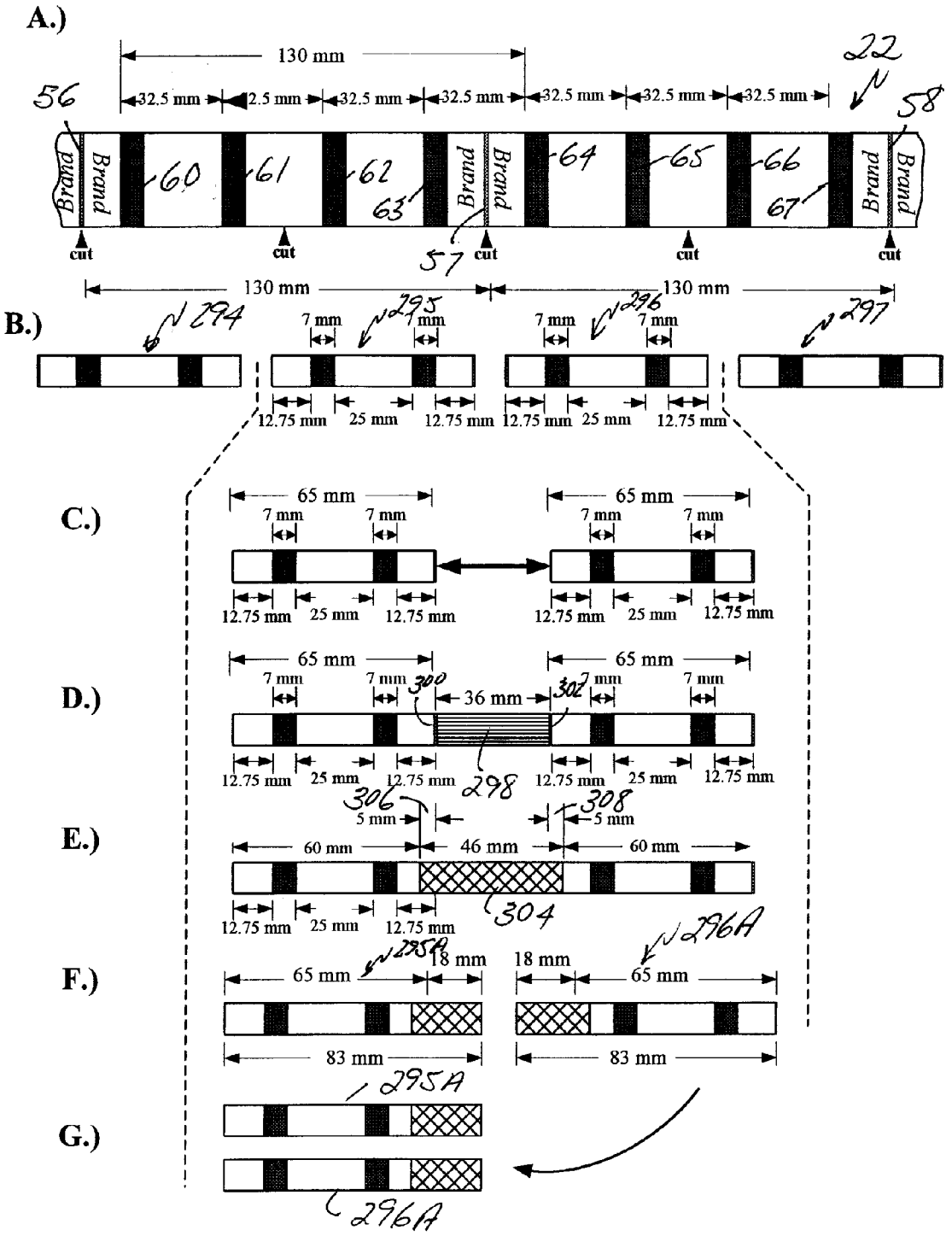

A.)
130 mm
32.5 mm
2.5 mm
32.5 mm
32.5 mm
32.5 mm
32.5 mm
32.5 mm
56
22
58
Brand
60
61
62
63
64
65
66
67
57
cut
B.)
130 mm
130 mm
294
295
296
297
7 mm
12.75 mm
25 mm
C.)
65 mm
7 mm
12.75 mm
25 mm
D.)
36 mm
300
302
298
E.)
5 mm
306
308
60 mm
46 mm
304
F.)
18 mm
65 mm
83 mm
295A
296A
G.)

Figure 7A

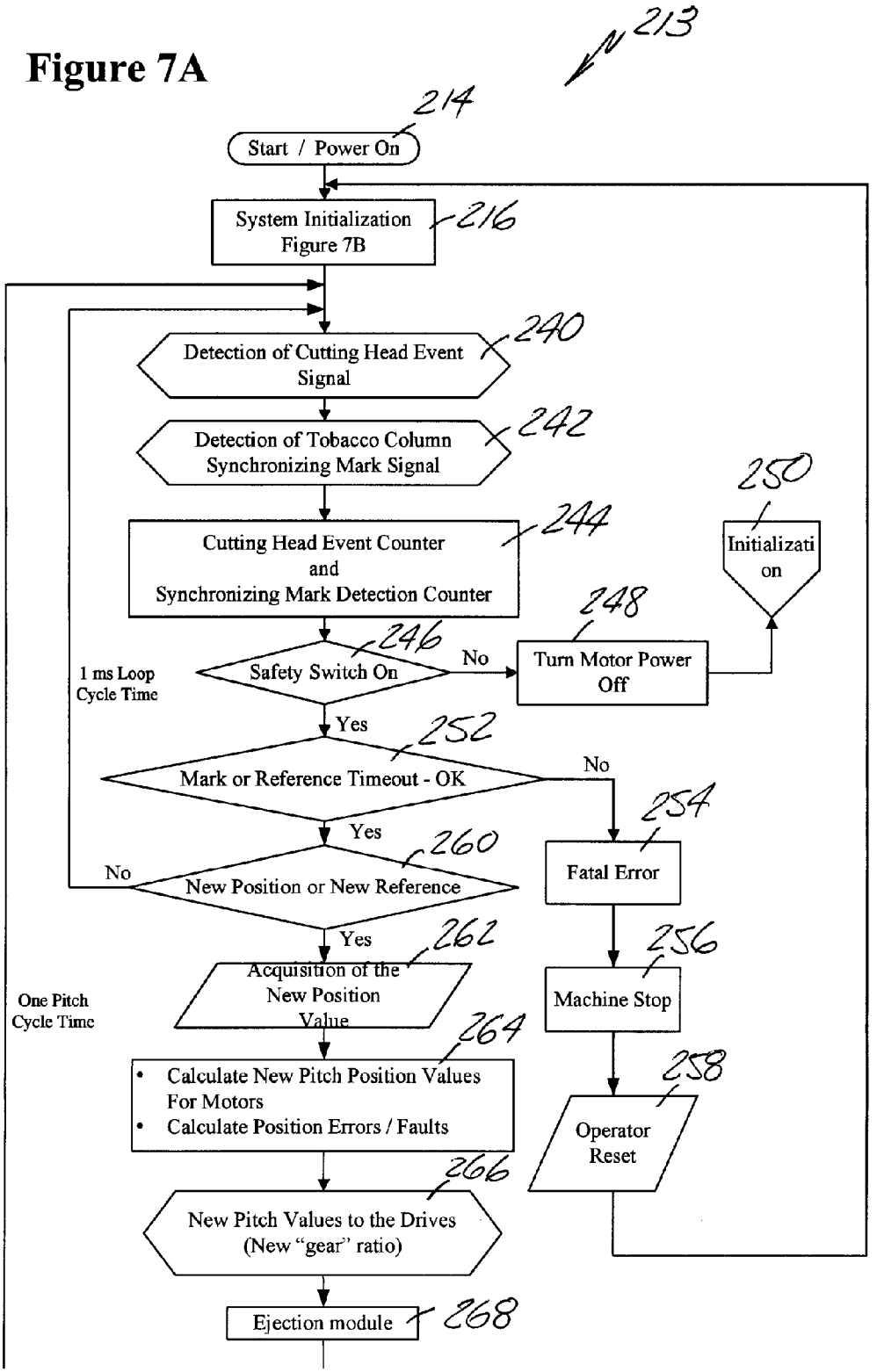

213
214
Start / Power On
System Initialization
Figure 7B
216
240
Detection of Cutting Head Event Signal
242
Detection of Tobacco Column Synchronizing Mark Signal
244
Cutting Head Event Counter and Synchronizing Mark Detection Counter
250
Initializati on
248
246
Safety Switch On
No
Turn Motor Power Off
1 ms Loop Cycle Time
Yes
252
Mark or Reference Timeout - OK
No
254
Yes
260
New Position or New Reference
No
Fatal Error
Yes
262
Acquisition of the New Position Value
256
Machine Stop
One Pitch Cycle Time
264
• Calculate New Pitch Position Values For Motors
• Calculate Position Errors / Faults
258
Operator Reset
266
New Pitch Values to the Drives (New "gear" ratio)
Ejection module
268

Figure 7B

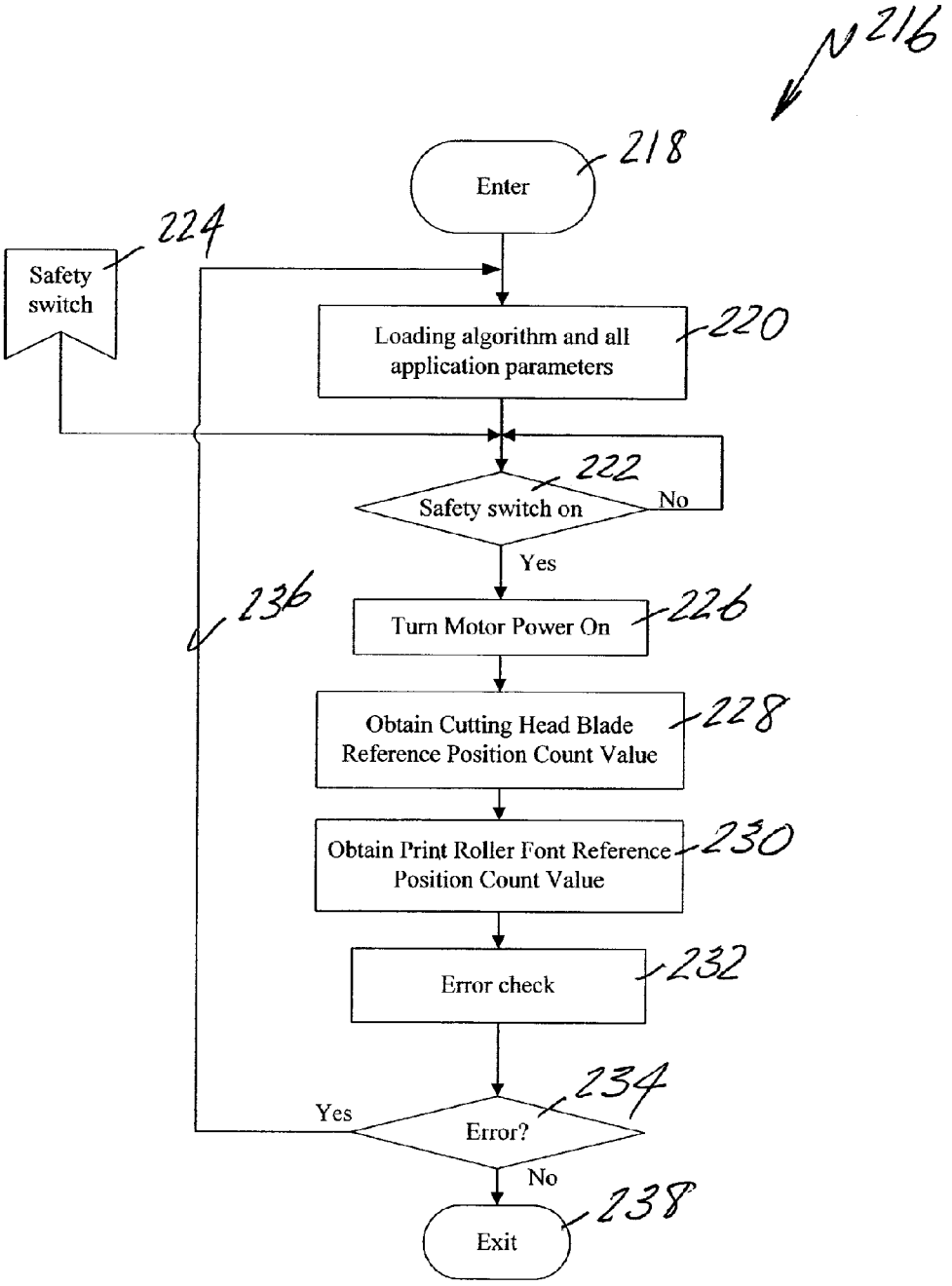
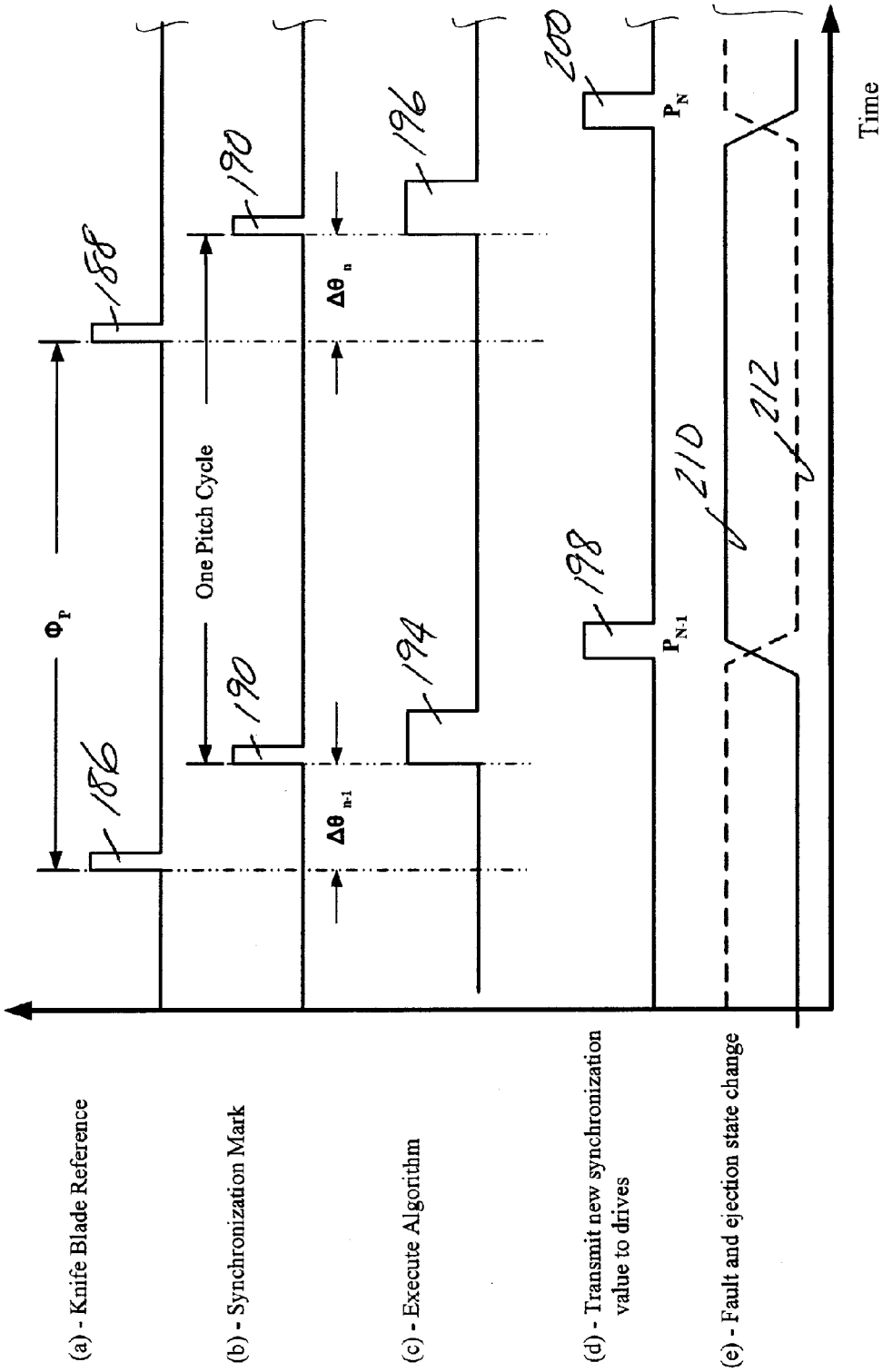

216
Enter
218
Safety switch
224
Loading algorithm and all application parameters
220
222
Safety switch on
No
Yes
236
Turn Motor Power On
226
Obtain Cutting Head Blade Reference Position Count Value
228
Obtain Print Roller Font Reference Position Count Value
230
Error check
232
234
Yes
Error?
No
238
Exit

Figure 8


(a) - Knife Blade Reference
(b) - Synchronization Mark
(c) - Execute Algorithm
(d) - Transmit new synchronization value to drives
(e) - Fault and ejection state change
Time
One Pitch Cycle
Φ_P
$\Delta\theta_{n-1}$
$\Delta\theta_n$
P_{N-1}
P_N
186
188
190
190
194
196
198
200
210
212

LOW IGNITION PROPENSITY (LIP) PAPER SMOKING ARTICLES

TECHNICAL FIELD

[0001] This invention relates to the manufacture of smoking articles, and more particularly to the manufacture of low ignition propensity smoking articles which are designed to self extinguish if left unattended.

BACKGROUND ART

[0002] With smoking articles, such as cigarettes, the paper wrapper is important to the overall quality of the cigarette. The paper affects the taste and ash appearance of the cigarette, and the paper porosity (i.e. the oxygen permeability) determines the rate and direction of airflow through the cigarette. Higher porosity papers produce lower tar and nicotine yields to the user by increasing the heat and burn rate of the cigarette without altering the flavor. This has led to the use of higher porosity papers by cigarette manufacturers. Today's conventional cigarette papers have porosity levels on the order of 40 to 50 Coresta units (cu), which are expressed as: cu=cc/minute/cm^2 at 100 mb pressure (1000 mm water).

[0003] While these high porosity papers introduce air into the smoke stream to lower the concentration of gases and particulate matter in the smoke, an unintended result of their high oxygen permeability is that, when lighted, they can burn their entire length without the user having to draw smoke or the cigarette having to be placed in a free burn environment. As a result, if left unattended, they can ignite flammable objects they come in contact with. As public concern has grown about the fire risks of cigarettes, manufacturers have developed low ignition propensity ("LIP") designed products using reduced fire risk LIP papers.

[0004] The object of all LIP product designs is to produce smoking products, that will self extinguish if left unattended by the user for a period of time. This is achieved by wrapping the article's tobacco filler in one of several known types of LIP papers. LIP papers are conventional tobacco paper with added low porosity (LP) bands that are placed in localized areas. The LP bands reduce the tobacco burn rate and oxygen diffusion within their area so as to retard combustion and cause the article to self-extinguish unless the user actively draws smoke while the tobacco burns through the LP band region.

[0005] There are several known methods of manufacturing LIP paper. U.S. Pat. No. 5,534,114 discloses the creation of LP bands in conventional tobacco paper by applying a material slurry of cellulosic pulp or fiber to localized regions of the paper to increase the paper density, and reduce the porosity of these areas. U.S. Pat. No. 5,360,516 discloses application of the slurry in rectangular bands, which alternate with untreated, high porosity areas along the smoking length of the paper. The bands are shown to be equally spaced and substantially parallel to one another on the paper web. U.S. Patent Application Publication 2002/0129824 discloses the creation of LP bands by applying thermoplastic polymer aqueous suspensions to the base paper. The bands are applied in parallel, in widths of 4 to 12 mm and separated by 20 to 25 mm wide areas of untreated paper. The band porosity is less then 15 cu while the untreated paper may have porosities of 20 to 120 cu.

[0006] While all of these LP bands are effective in providing LIP papers with self extinguishing characteristics, questions arise as to how to apply the LIP papers in the manufacture of LIP smoking articles. In the manufacture of conventional smoking articles, such as cigarettes, a 25 mm wide strip of cigarette paper is fed from a bobbin through feed rolls to the top stretch of a tape drive, where it receives the tobacco filler and is formed into a tobacco column. The column is then cut into single "rods" (or into double rods which are cut into singles downstream). The rod lengths range from 60 mm-67 mm for King Size and 70 mm-75 mm for the 100's models, and filters are added to create the finished product.

[0007] The cut rod length is determined by the relative speeds of the tape drive (which controls the column transport speed) and the rotational speed of the cutting head. This is controlled by powering the tape drive and cutting head from a common drive shaft so that, subject to individual gearing tolerances, any shaft speed errors are common to both and are cancelled. If brand markings are to be applied, the paper is threaded through a print head before reaching the top stretch. There the paper is pinched through a print roller and a backer roller combination which ink prints the characters. This is essentially a dry process which does not wet and weaken the paper, and no perceptible stretching of the paper occurs. The print roller is also connected to the common drive shaft, so that print wheel to cutting head speed differences are similarly cancelled, thereby allowing for accurate and repeatable placement of the print marking on the cigarette rod.

[0008] In addition to the considerations involved in the manufacture of conventional smoking articles, the manufacture of LIP smoking articles further requires the controlled placement of the LP bands on the rods to ensure LIP effectiveness. This must be done accurately since LIP effectiveness more or less limits location of the bands to the middle half of the rod. Also, since the wet slurry processes of forming the LP bands cannot be performed during the manufacture of the smoking article due to the likelihood of the wet paper breaking when placed under tension, the LIP smoking article is preferably manufactured using pre-manufactured LIP wrapping paper. This requires the further synchronization of the forming and cutting machinery to the repeating LP band pattern to ensure the LP bands are placed at the proper location along the length of the smoking article tobacco column.

[0009] Since conventional smoking articles do not have this constraint, conventional smoking article manufacturing equipment is not capable of performing the required synchronization. There are also no prior art methods for achieving this pattern length to tobacco column length registration. It is apparent, therefore, that there is a need for a method and apparatus capable of providing accurate and repeatable placement of the LP bands within the tobacco column, and that conventional article manufacturing methods and apparatus are not capable of providing this.

DISCLOSURE OF INVENTION

[0010] A first aspect of the present invention is to provide an improved LIP paper tobacco wrapper for LIP smoking articles which is capable of having its LP band pattern synchronized with the smoking article manufacturing appa-

ratus to provide controlled placement of its LP bands in their assigned locations within the article tobacco column. A second aspect of the present invention is to provide both process and apparatus for manufacturing LIP smoking articles using this improved LIP paper. A third aspect of the present invention is to provide an improved LIP smoking article.

[0011] According to the first aspect, improved LIP paper tobacco wrapper has LP bands disposed thereon the width of the paper, the being bands arranged in interleaved fashion with untreated areas in a longitudinally extending array of consecutive panels, each panel extending horizontally a panel length which substantially equals the desired length of the tobacco column of the smoking article formed by the LP paper, the LIP paper further including synchronizing marks disposed longitudinally thereon, in the direction of the panels, and at mark interval spacing which is proportional to the panel length, each synchronizing mark thereby located on the LIP paper in known axial relation to the panel boundaries, the synchronizing marks being capable of detection by the LIP smoking article manufacturing apparatus to permit the apparatus to synchronize cutting of the continuous LIP wrapped tobacco column at locations proximate to the panel boundaries, thereby to provide registration of each panel to the cut length of article tobacco column.

[0012] In further accord with this first aspect, the LIP pattern panels and the synchronizing marks may be disposed, alternatively, on the same side or on opposite sides of the LIP paper, as desired. In still further accord with this first aspect, the LP bands may themselves further function as the synchronizing marks. In yet still further accord with this first aspect, the mark interval spacing is substantially equal to a pitch interval comprising two consecutive panel lengths. In yet still further accord with this first aspect, the synchronizing marks are disposed on the LIP paper in a density and color resolution which provides detectable contrast with the LIP paper pattern. In yet still further accord with this first aspect the synchronizing marks are disposed on the LIP paper in a density and color resolution which permits optical detection. In yet still further accord with this first aspect, the synchronizing marks are disposed on the LIP paper in a density and color resolution which permits detection by a laser detector.

[0013] According to the second aspect of the invention, improved LIP smoking article manufacturing apparatus includes maker apparatus for forming, from LIP paper of the type disclosed by the present invention, IP smoking articles having a LIP wrapped tobacco column with an LP band panel pattern registered thereon, the maker apparatus having a rotating cutting head, and having a conveyor belt for linearly transporting a continuous LIP paper wrapped tobacco column to the cutting head, the cutting head forming single article or, alternatively, double article cut tobacco column lengths, the maker apparatus further having individual electric drive motors and associated motor controls for the conveyor belt and for the cutting head, the maker apparatus detecting the arrival of each of the synchronizing marks of the LIP paper wrapped tobacco column at a location upstream of the cutting head and adjusting the speed and, alternately, the position of the conveyor belt motor in response to such detection to synchronize the cutting head cut location on the continuous column in relation to the synchronizing marks, whereby the continuous tobacco column is cut at the boundaries of the LIP pattern panels.

[0014] In further accord with this second aspect, the maker apparatus further includes a rotating print wheel for applying print markings to the LIP paper strip prior to formation of the continuous tobacco column, the print wheel having an independent electric drive motor and associated motor control, the maker apparatus detecting the arrival of each of the synchronizing marks of the LIP paper strip at a location upstream of the of the print wheel and adjusting the speed and, alternately, the position of the print wheel motor in response to such detection to synchronize the print wheel print marking location on the LIP paper strip in relation to the synchronizing marks, whereby the print marking of the LIP paper strip are at a desired location on the LIP paper strip.

[0015] In still further accord with this second aspect, the conveyor belt, cutting head, and print wheel motors each include motor shaft sensors for providing instant motor shaft position information, and the maker apparatus further includes mark sensors for providing individual synchronizing mark detection signals for the LIP paper wrapped tobacco column and for the LIP paper strip, the maker apparatus having a master controller responsive to the instant motor position information from each motor sensor and to the synchronization mark detection signals from each mark sensor, for adjusting the conveyor belt motor shaft speed and/or shaft position in dependence on the cutting head motor shaft speed and/or shaft position to synchronize the instant position of the LIP paper wrapped tobacco column on the conveyor belt to the instant cutting head rotational position, whereby the cutting locations on the continuous column occur at the boundaries of the LIP panel patterns, and for adjusting the print wheel motor shaft speed and/or position in dependence on the belt conveyor motor speed and/or position to achieve synchronization of the LIP paper strip linear position to the print wheel rotational position, whereby the print markings are applied at a desired location within each LIP pattern panel.

[0016] According to the third aspect of the invention, a LIP smoking article includes a first aspect LIP paper wrapped tobacco column with registered LIP pattern panel. In further accord with this third aspect, the registered LIP paper pattern provides the LIP smoking article with the required number and location of LP bands. In still further accord with is third aspect, the LIP smoking article includes a filter section attached to the synchronizing mark cut end thereof, the filter section being attached with tipping paper that extends onto the body of the tobacco column to secure the filter to the column, thereby covering from sight the LIP paper synchronizing mark.

[0017] The present invention provides for controlled placement of the LP bands of the LIP paper along the cigarette's rod length, so as to provide repeatable registration of the LP bands and a consistent appearance to the finished cigarette product. The invention provides this with no visible indications remaining on the LIP paper, other than that resulting from the caps LP bands themselves.

[0018] These and other objects, features, and advantages of the present invention will become more apparent in light of the following detailed description of a best mode embodiment thereof, as illustrated in the accompanying Drawing.

BRIEF DESCRIPTION OF DRAWING

[0019] **FIG. 1** is a schematic diagram of an exemplary embodiment of LIP smoking article manufacturing apparatus according to the present invention;

[0020] **FIG. 2** is a system block diagram of apparatus used to control operation of the apparatus embodiment of **FIG. 1**;

[0021] **FIG. 3** is an illustration of different LIP paper patterns as may be used in the apparatus embodiment of **FIG. 1**;

[0022] **FIG. 4** is an illustration showing the sequence of steps performed by the embodiment of **FIG. 1** in manufacturing cigarettes having one type of LIP designed paper;

[0023] **FIG. 5** is an illustration showing the sequence of steps performed by the embodiment of **FIG. 1** in manufacturing cigarettes having another type of LIP designed paper;

[0024] **FIG. 6** is an illustration showing the sequence of steps performed by the embodiment of **FIG. 1** in manufacturing cigarettes having yet another type of LIP designed paper;

[0025] **FIGS. 7A, 7B** are flow chart diagrams illustrating the steps performed in the present invention in the manufacture of LIP paper cigarettes in the embodiment of **FIG. 1**; and

[0026] **FIG. 8** is a timing diagram used in the explanation of the performance of the invention in the embodiment of **FIG. 1**.

BEST MODE FOR CARRYING OUT THE INVENTION

[0027] As described above, the present invention has several interrelated aspects; all of which relate to the manufacture of LIP paper smoking articles which use a LIP tobacco wrapper having one or more LP bands which encircle the article's tobacco column and extinguish the burning tobacco if the article is left unattended. The point at which the bands are located on the column determines the LIP effectiveness, and the present invention provides positional placement of the LP bands within tolerances specified by the smoking article manufacturer. This ensures LIP effectiveness and consistent product appearance. It does this with the combination of improved LIP paper and improved manufacturing apparatus, to provide a novel LIP smoking article.

[0028] The LIP paper of the present invention embodies and/or incorporates such of those prior art manufacturing methods deemed suitable by those skilled in the art for providing the LP bands on cigarette paper, including the use of a gravure process for printing a cellulosic formulation on the paper to form the LP bands, and the wet processes of applying a cellulosic pulp or fiber slurry to the LP band regions to increase the paper density and reduce its porosity in the regions. However, the LIP paper of the present invention has added features and function which improve its utility for the manufacture of LIP smoking articles.

[0029] **FIG. 3**, illustrations (a) through (c) show representative samples, not to scale, of three LIP paper strips **20-22** that are configured according to the present invention. The sample papers **20-22** shown are intended for use as tobacco wrappers for King Size length LIP cigarettes, which may have a tobacco column, or rod length ranging from 60 millimeters (mm) to 67 mm. In the description of the best mode embodiment of the papers which follows the finished rod length is specified as 65 mm. The papers **20-22** are shown lying flat, in strip form, as they appear prior to rolling the tobacco column. The strip width (W) is nominally 25 mm for cigarette wrappers, but varies for other type LIP smoking products, as known to those skilled in the art.

[0030] Each of the illustration (a)-(c) samples show LP bands disposed in different repeating patterns in the axial direction (X) of the papers, which corresponds to the axis of the manufactured cigarette rod. The illustrated paper samples have different LP band patterns which produce a different number and/or placement of the LP bands within each 65 mm length rod. The LIP paper of the present invention achieves the necessary placement precision by adding synchronizing marks to the surface of the paper at spaced intervals which are proportional to the specified rod length. The position of the LP bands on the papers **20-22** is then fixed with respect to these synchronizing marks at a distance which corresponds to their desired location on the rods.

[0031] In illustration (a), the LIP paper sample **20** has synchronizing marks **24-26** at spaced intervals of 130 mm; twice the desired 65 mm rod length. The LP band pattern of the paper sample **20** includes LP bands **28-31** that are spaced on center at substantially equal 65 mm intervals. The band width is nominally 7 mm and each band is substantially within 29 mm of a closest one of the synchronizing marks **24-26**. A series of intended "cut line icons"**32-36** which identify potential rod segments, are also shown in illustration (a) (and **FIG. 3** generally). These cut line icons are intended here for purposes of description only and do not otherwise appear on the LIP papers. As shown by the potential rod segment **38** (between cut line icons **33, 34**) the LP band **29** is nominally 29 mm from each cut lines **33, 34** to place the band substantially in the middle of the 65 mm rod.

[0032] The sample paper **21** of illustration (b) includes synchronizing marks **40-42** similarly spaced at substantially 130 mm intervals, and the paper's band pattern includes bands **44-47**. In this pattern the bands are asymmetrically spaced on center at repeating 93 mm and 37 mm intervals. Each band is again nominally 7 mm wide and positioned within a nominal 15 mm of a closest one of the synchronizing marks **40-42**. Cut line icons **48-52** again identify potential rod segments and segment **54** (between cut lines **48, 49**) show the band **44** asymmetrically spaced at 15 mm from the synchronizing mark **40** and **43** mm from cut line **49**. As known and as explained in detail hereinafter with respect to **FIGS. 4-6**, the conventional method of manufacturing filtered cigarettes is to do it in pairs of rods, where a double length filter is inserted between the trailing end of a first cut rod and the leading end of a next following cut rod. The double filter is then cut in half and the trailing rod (the second of each pair) is inverted 180° to orient all the finished filtered cigarettes in the same direction. The filer end of the rod is indicated by the Brandprint mark shown in each of the samples **20-22** of **FIG. 3**, and the LP band pattern of paper sample **21** provides a single LP band per rod, with the band asymmetrically spaced closest to the filter end of the rod.

[0033] Sample **22** of illustration (c) also has synchronizing marks **56-58** spaced at substantially equal 130 mm intervals,

and LP bands **60-67**. Here, the LP bands are spaced at substantially equal center-to-center spacing of 32.5 mm to again provide a symmetrical alternating pattern. With the cut lines **70-74** identifying the potential 65 mm rod segments, this pattern provides two LP bands per rod. The bands are symmetrically spaced approximately 12.75 mm from each rod end, as shown by bands **62**, **63** of rod segment **76**. They are also separated by an approximate 25.5 mm length untreated (i.e. higher porosity) area **78**.

[**0034**] The LIP paper patterns of **FIG. 3** differ in the number and/or placement of the LP bands within a rod length. Each rod length band pattern is here referred to as a panel of the overall LIP paper pattern, which is a succession of reoccurring pattern panels that repeat at a pattern interval equal to the rod length. For the LIP King Size cigarette example discussed here that pattern interval is 65 mm. The synchronizing marks are positioned at the junction between succeeding pairs of panels, or at a mark interval spacing which is substantially twice that of the pattern interval. This is referred to as "double rod" spacing, and corresponds to the cigarette manufacturing protocol which performs the post cut rod processing, e.g. adding filters, in double rod combinations. This double rod spacing is referred to as the "pitch" of the LIP paper pattern. The pitch, therefore, identifies the paper's synchronizing mark spacing as well as twice the LP band pattern interval length. In the King Size cigarette example the pitch is 130 mm.

[**0035**] The synchronizing marks may be disposed on either of the two major surfaces of the LIP paper, i.e., either the same surface as the LP bands or the opposite side surface, as desired or found necessary by article manufacturers who wish to conceal or make the LP bands less visible. The methods used in disposing the marks on the LIP paper may be any of such prior art process that may be deemed suitable by those skilled in the art. This includes ink printing. The synchronizing mark material must have a color density and tone which contrasts the mark from the LIP paper surface sufficiently to provide a resolution accuracy of +/−0.2 mm in the mark position on the LIP paper, at a repeating mark rate of 100 marks/second. This is associated with a cigarette rod production rate of 12,000 King Size (65 mm) rods/minute, with a mark pitch of 130 mm and a belt speed of 750 meters/minute. Suitable contrast colors for the marks include the black, dark gray and blue color spectrums.

[**0036**] In the description which follows of the best mode embodiment of the invention's smoking article manufacturing apparatus, the synchronizing marks are detected using optical sensors; most preferably using red wavelength laser light (approximately 650 nanometer wavelength). Therefore the LIP paper synchronizing mark material should provide at least 30% higher reflectivity than the untreated surface area of the LIP paper on which they are disposed. It should be understood, however, that the invention is not limited to use of optical detection of the synchronizing marks, and such alternative detection methods as may be known to those skilled in the art may be used.

[**0037**] In **FIG. 3**, the synchronizing marks are shown to be substantially 2 mm wide and to extend in length to the width (W) of the paper samples; nominally 25 mm. These are preferred dimensions for the marks. The width may be increased if considered necessary. The only limiting factor, other than cost, is that in a best mode embodiment of the manufacturing apparatus it is preferred to hide the synchronizing marks from view in the finished product. This is done first by locating the synchronizing marks on the LIP paper samples **20-22** at the filter ends of the potential rod segments, as shown by their placement at the brand marked end of each potential rod segment. Some portion of the mark is cut away when cutting the rod, and when the cut rods are moved from the cigarette maker to the filter assembly equipment, any mark residue is covered by the tipping paper applied by the filter assembly to secure the filter to the rod. In general, the tipping paper extend onto the body of the rod by as much as 5 mm; more than enough to hide the marks.

[**0038**] Similarly, the length of the mark may be reduced if necessary. The advantage of the full width length mark is that it may be detected by the manufacturing apparatus at any incident angle to the exposed surface of the continuous tobacco column. If the length must be shortened it should not be reduced by more than would allow for a sensed angle of detection of from 30° to 90° to the vertical.

[**0039**] The LIP paper of the present invention is not limited to the illustrated LP band patterns of **FIG. 3**, which are representative and were selected only for teaching purposes. Any band pattern which is deemed necessary or satisfactory by those skilled in the art may be used. The novel feature of the present LIP paper are the detectable synchronizing marks which occur at periodic intervals and which have a defined relationship to the positions of the LP bands on the paper. These synchronizing marks provide the manufacturing apparatus with detectable indicia that allows for synchronization of the continuous tobacco column to the apparatus cutting head, so as to control the column cuts to those column locations which result in registration of the selected LIP LP band pattern to the article tobacco column length.

[**0040**] Although in a best mode embodiment the synchronizing marks comprise discrete indicia, separate from other LIP paper markings, the invention is to provide a LIP paper with detectable markers which occur at periodic intervals in the paper so as to be capable of calibration to the position of the LP bands. Therefore, it is possible that such other paper markings, such as decorative and/or cosmetic imprints, or a manufacturer's logo, that have the necessary color density, background contrast, and resolute edging may be used as synchronizing marks, if found desirable. Similarly, although in the best mode embodiment the synchronizing marks are distinct from the LP bands, the LP bands themselves may be used as synchronizing marks if they can be made sufficiently distinct in appearance from the untreated areas to provide a physically detectable edge. These alternative forms of synchronizing marks may simplify the manufacturing of the LIP paper, but require that the manufacturing apparatus to then be calibrated to the position and cyclic appearance pattern of these alternative forms.

[**0041**] These alternative embodiments are not limited to those applications in which the LP bands are exposed on the outside of the LIP paper wrapped tobacco column, but may be used even if the manufacturer elects to place the LP bands inside the column wrapper to hide them for cosmetic purposes. Similarly, the synchronizing marks may be located on either the inside or outside surfaces of the LIP paper wrapped tobacco column. In the best mode embodiment the synchronizing marks are disposed on the outside surface.

[0042] Referring now to **FIG. 1**, which is a simplified schematic of a best mode embodiment of cigarette maker apparatus **80**, according to the present invention. The apparatus **80** includes a LIP paper bobbin **82** which provides a strip of LIP paper **84** through guide rollers **86**, **87**, print roller **88**, backing roller **89**, and guide rollers **90-92**, to the top stretch **94** of a conveyor belt **96**. In the embodiment of **FIG. 1** the LIP paper is fed onto the top stretch **94** with the treated surface face up so that the paper's LP bands will be inside of the finished tobacco rod. This is preferred due to the possibility that the material slurry deposits which form the LP bands may be visible if left outside. This, however, is design choice and if desired the paper may be fed to the top stretch with the treated surface face down. At this point the paper wrapper is lying flat on the top stretch, and the exposed belt surface may have a surface treatment to enhance its frictional grip of the LIP paper.

[0043] Conveyor belt drum **98** and guide rollers **100**, **102** drive the belt **96** in the travel direction of arrow **104** to pull the paper strip **84** past the terminal end roller **106** of a vacuum conveyor assembly **108**. The conveyor assembly **108** collects and conveys tobacco filler **110** from bin **112** to the terminal end roller **106**, where it is released in a continuing stream onto the surface of the passing LIP paper strip. The top stretch **94** and tobacco filled LIP strip next pass through a garniture assembly **114** which, as known to those skilled in the art, is a channel and fold device having a tapered groove that brings the belt's top stretch and accompanying paper strip into a substantially U shaped formation around the deposited tobacco filler. A gluing device **116** next applies adhesive along the inside face of one of the two longitudinal edges of the U folded strip, and the paper edges are closed in a loop and dried in dryer assembly **118** so as to wrap the tobacco filler in a tubular paper sheath to provide a continuous column **120** of wrapped tobacco.

[0044] Following exit from the dryer **118** the conveyor belt **96** lineally transports the tobacco column **120** to a cutting location **122** where knife blades **124**, **126** mounted on a rotating cutting head **128** dissect the column into single cigarette rod lengths **130**, **131**. In certain high speed maker apparatus the cutting head **128** may only provide double length lengths to meet operating speed requirements, with a separate cut of the double rods to single rods occurring downstream. As known to those skilled in the art, the transport speed of the belt **96** and the rotational speed of the cutting head **128** determine the rod length, and variations in speed of either device can result in improper length rods. As known, the conveyor belt and cutting head speeds in maker apparatus for conventional, i.e. non-LIP, smoking articles, is controlled by driving both through individualized gearing, from a common drive shaft. In that way the effects of speed variations on rod length are cancelled, subject to the mechanical tolerances of the individual gear and connecting assemblies.

[0045] This common drive shaft arrangement, however, is not suitable to the manufacture of LIP smoking articles. Here the LP band pattern of pre-manufactured LIP paper must be synchronized with the cutting blades **124**, **126** to cut the continuous column **120** at the proper interval points (e.g. the cut lines of **FIG. 3**) to register the LP bands at their desired locations on the cut rod. To do this the translational speed of the continuous LIP paper wrapped tobacco column must be adjusted to synchronize the column's LIP pattern to the cutting head blade position when the two intersect at the cutting location **122**.

[0046] This requires replacing the common drive shaft and drive shaft motor of the prior art apparatus with individual drive motors for the conveyor belt, the cutting head, and, if present, the print roller **88**. This allows the speed and rotational position of each to be adjusted independently, as necessary to achieve the necessary synchronization. In a best mode embodiment the cutting head drive motor also powers the apparatus ancillary functions formerly driven from the common drive shaft. Added sensors are also required to detect the instant position of the LIP paper pattern wrapped tobacco column **120** relative to the cutting location **122** and, for systems with a printer, the instant position of the LIP paper pattern strip **84** relative to the instant position of the print roller **89**. Preferably, the cutting head (and ancillary machine functions), belt drum, and print roller motors are brushless, permanent magnet, three phase synchronous AC servomotors **132-134**. These are direct drive, synchronous motors, with high acceleration and deceleration performance characteristics. The motors are of a type known in the art, such as the model HD142C6 servomotor by SEM Ltd., Kent, England, or such equivalents as may be deemed suitable for the application by those skilled in the art. The motors **132-134** each have shaft sensors **136-138** which provide shaft rotational information from which shaft speed and position may be determined.

[0047] The motor shaft sensors **136-138** provide shaft speed and position information on lines **140-142**. The sensors may be either a shaft mounted resolver or encoder. As known, resolvers and absolute encoders each provide absolute shaft position information, while incremental encoders provide relative information in the form of incremental rotational movement. In the best mode embodiment the sensors **140-142** are incremental encoders, such as the Model BHK16.05A 1024-12-5 optical incremental encoder from Baumer Electric AG, Switzerland, or such equivalents as may be deemed suitable for the application by those skilled in the art. The sensors provide Channel A and Channel B output signals that are phase shifted 90° with respect to each other (i.e. a "quadrature encoder"). Each channel provides some number of pulses for each 360° of rotation, as well as an index pulse which marks each full revolution. Depending on the sensor model the pulse count may be 1024, 2048, or more pulses per revolution.

[0048] As described hereinafter, the sensor model selected is determined by the required sensed accuracy required for each of the motor driven functions (cutting head, belt drum, or print roller) and the gear ratio between the motor and the particular device. The sensed resolution of each channel is determined by the number of pulses per revolution of its signal, such that a 2048 pulse signal provides a 0.176° per pulse resolution. However, with quadrature, the rising and falling edges of both channel signals may be counted to provide a 4×increased sensitivity of 8192 pulses per revolution and a 0.044° per pulse scale resolution.

[0049] Referring to **FIG. 2**, the sensed signal data from sensors **136-138** is presented on lines **140-142** to motor servo amplifier and driver stages **144-146**. The servo amplifier and driver stages ("servo amplifier/drivers") **144-146** provide inner loop, set point control of the motors **132-134**,

and in a best mode embodiment comprise digital servo amplifiers with integral power stage of a type used in motion control applications, such as the SAM model family of smart digital drives available from the Inmotion Technologies Corporation, Switzerland. Typically the SAMs are used in multi-axis motion control applications, where each SAM performs single axis control under the supervisory control of a programmable axes manager ("PAM"), in a master-slave arrangement. The PAM, which is also a known type programmable controller available from Inmotion Technologies Corporation, executes the overall motion control algorithm and commands the execution of the individual SAM proportionate control functions in a coordinated manner to achieve the algorithm commanded motion.

[0050] The control structure of the present invention is similar to that of motion control in its requirement to provide a weighted command of individual motor performance to achieve a joint result. In the maker apparatus **80** of **FIG. 1**, the conveyor belt motor must be controlled to satisfy concurrent, and possibly competing, objectives of synchronizing the tobacco column LIP paper pattern to the cutting head, and the LIP paper strip pattern to the printer roller. This is done by having a supervisory controller **152** which functions as a PAM and commands the servo amplifier/drivers **144-146** to provide the necessary set point speed and/or position commands to the motors **132-134** in response, jointly, to the commands from controller **152** and the data from sensors **136-138**.

[0051] The supervisory controller **152** is connected to the servo amplifier/drivers through a fiber optic network **154**. A fiber optic network **154** is preferred for its noise immunity, high data rates, and the capability for wide spacing and long cable runs between the system components. Alternatively, an electronic signal network may be used if deemed suitable for a given application installation by those skilled in the art. Human operator access to the controller **152** is provided through a graphic user interface ("GUI") **156** and known type industrial serial communication interface.

[0052] Referring again to **FIG. 1**, the synchronizing marks placed on the LIP paper (**FIG. 3**) are detected by mark sensors **158** and **160**. The mark sensor **158** detects the synchronizing marks appearing on the LIP paper wrapped continuous tobacco column **120**, and mark sensor **160** detects the synchronizing marks on the LIP paper strip **84**. The type of sensors used is selected based on the circumstances of a given application, including the type of LIP paper, the material composition of the synchronizing marks, the environment that the apparatus is installed in, and such other variables which may affect the detection resolution accuracy. Therefore, the type sensor used in a given application is that deemed suitable by those skilled in the art.

[0053] In the best mode embodiment optical sensors are used; preferably red laser wavelength sensors (approximately 650 nanometer), such as the model OZDM 16P1001/S14 laser sensor from Baumer Electric AG, Switzerland, or such equivalent as may be deemed suitable by those skilled in the art. The sensors **158**, **160** are located at a reference distance upstream of the location at which the LIP paper processing event occurs, i.e. the cut location **122** where the continuous tobacco column is cut to rod lengths or the point at which the print roller font contacts the strip LIP paper **84**. The reference distance is selectable, but preferably no greater than two pitch interval lengths. As described above the pitch interval is the distance between consecutive synchronizing marks, and is equal in length to two panel lengths; i.e. two rod length patterns.

[0054] In the present embodiment the reference distance is one pitch interval, and for the 65 mm King Size cigarette the sensors **158**, **160** are positioned a travel distance of 130 mm upstream from the cutting location **122** and print roller **88**. At those locations the sensors are located in suitable proximity of the LIP paper surface to enable detection of the synchronizing marks under prevailing ambient conditions, such as a dust and vibration environment. The sensor **158** is positioned between 30° and 90° of the vertical of the tobacco column **122**. With consideration of the possibility that seam deformation of the LIP paper along the top surface of tobacco column **122** may compromise detection accuracy, and also the possibility that ambient dust conditions may affect detection accuracy at the lower positions, the preferred angular position of sensor **158** is 50° to 70° of the vertical. The sensor **160** will be positioned more or less orthogonal to the strip LIP paper **84**; nominally +/−20° of orthogonal.

[0055] The sensors **158**, **160** provide a pulsed output signal on lines **162**, **164** to the cutting head servo amplifier/driver **144** and to the print roller servo amplifier/driver **146** (**FIG. 2**), one pulse for each detected synchronizing mark. The detected synchronizing mark signal frequency is dependent on the travel speed of the conveyor belt **96**. At a production rate of 12,000 King Size cigarettes per minute, or 200 rods per second, the conveyor belt speed is 200 rods/sec×65 mm/rod=1300 mm per second, and the mark signal pulse repetition frequency is 100 pulses per second.

[0056] In terms of precision, the maker **80** must provide both proper rod length and proper registration of the LIP paper pattern within the cut rod. The standard rod length tolerance for King Size cigarettes is +/−0.5 mm. As described earlier with respect to **FIG. 3**, the LIP paper synchronizing marks have sufficient resolution to provide a detection accuracy of +/−0.2 mm, which is well within the rod length tolerance. In order to hold the overall pattern registration tolerance, i.e. the tolerance of placing the LP bands in position on the rod, as closely as possible to +/−0.2 mm tolerance, it is desirable to limit the sensed resolution of the cutting head, belt drum, and print roller positions to one order of magnitude less, or +/−0.02 mm.

TABLE 1

System Parameter*	Value
R - (sensed motor shaft position resolution)	+/−0.02 mm
N_C - (number of cigarettes per cut)	1
N_K - (number of cutting head knives)	2
R_L - (rod column length)	65 mm
CH_R (cutting head motor (132) to cutting head (128) ratio)	2:1
C_{PR} - (cigarettes per revolution of print roller (88))	4
PR_R - (print roller motor (134) to print roller (88) ratio)	2:1
BD_D - (belt drum (98) diameter)	300 mm
BD_R - (drum motor (133) to belt drum (98) ratio)	6:1

*Reference numerals are with respect to FIG. 1

[0057] Based upon the assumed system parameters listed in Table 1, we determine the minimum counts per 360° of shaft revolution necessary to achieve this resolution accuracy.

$$\text{Minimum Cutting Head Motor Pulses/Rev} = \frac{(R_L)(N_C)(N_K)}{(CH_R)(R)} = 3250$$

$$\text{Minimum Belt Drum Motor Pulses/Rev.} = \frac{(BD_D)(\pi)}{(BD_D)(R)} = 7854$$

$$\text{Minimum Print Roller Motor Pulses/Rev.} = \frac{(R_L)(C_{PR})}{(PR_R)(R)} = 6500$$

[0058] With the defined Table 1 gear ratios, and using a 1024 pulse encoder for the cutting head motor sensor **136**, and 2048 pulse encoders for the belt drum and print roller motor sensors **137**, **138**, the sensed position incremental resolutions (with sensor quadrature) are 0.016 mm for the cutting head, 0.019 mm for the belt drum, and 0.016 mm for the print roller.

[0059] In addition to sensed position, it is also necessary to provide individual "event" signals which separately identify the occurrence of a reference position of the cutting head blades and that of the print roller fonts. In the best mode embodiment these event signals have a periodicity equal to that of the mark detection signal, or once per pitch. So, although the cutting head has two blades and cuts two rods per pitch, and the print roller has two dual font heads and prints two brand pairs per pitch, each have only one sensed event signal per pitch cycle.

[0060] These event signals are provided by a blade position sensor **166** on line **168** for the cutting head **128**, and by a font position sensor **170** on line **172** for the print roller **88**. The sensors are of a known type, and are selectable based upon the circumstances of the given system embodiment. Subject to sensed accuracy requirements the sensors may be magnetic proximity sensors, but in the best mode embodiment optical sensors similar to the mark sensors **158**, **160** are preferred. Once again, these are a known type red laser sensors, such as the model OZDM 16P1001/S14 laser sensor from Baumer Electric AG, Switzerland, or such equivalent as may be deemed suitable by those skilled in the art.

[0061] Referring again to **FIG. 2**, the cutting head servo amplifier/driver **144** receives the cutting head event signal on line **168**, together with the sensed motor shaft position signal from sensor **136** on line **140**, and the synchronizing mark signal from the tobacco column mark sensor **158** on line **162**. Similarly, the print roller servo/driver **146** receives the print roller event signal on line **172**, the print roller motor shaft position signal from sensor **138** on line **142**, and the synchronizing mark signal from the strip LIP paper mark sensor **160** on line **164**. The belt drum servo/driver **145** only receives the drum motor sensed position signal from sensor **137** on line **141**, but it includes the communication interfaces with the host machine as well as the host machine ejection actuator.

[0062] The synchronizing mark signals, sensed motor position signals, and cutting head and print roller event signals are each time stamped by the receiving servo amplifier /driver and forwarded to the supervisory controller **152** through the network **154**. The servo/drivers connect to the network through converters, similar to the optical-to-digital converter **174** and digital-to-optical converter **176** of controller **152**. The controller **152** includes a microprocessor **178**, a program memory **180**, and a data memory **182** which interconnect through signal bus **184** to the converters **174**, **176** and GUI **156**.

[0063] The time stamped data is received by the controller and stored in data memory **182**. The controller uses the algorithms described below to measure and extrapolate the angular position values of the individual motor shafts. With time stamps on all of the sensed data, the motor shaft positions may be accurately determined with respect to the synchronizing mark signals and event signals. Within each pitch interval the controller determines the difference position values between: (i) the cutting head event reference to tobacco column synchronizing mark, and (ii) the print roller event to strip LIP paper synchronizing mark. Each of the motor positions are then calculated as:

[0064] Difference Position=$(\Delta\theta * P_N)/(\phi_P * K/D)$

[0065] Where:

[0066] $\Delta\theta$ is the difference angle between an event reference signal (either cutting head or print roller) and its related synchronizing mark signal (either LIP wrapped tobacco column or the LIP paper strip)

[0067] P_N is the nominal Pitch value for the particular smoking article product;

[0068] ϕ_P is the angular value the motor has to turn to achieve exactly one nominal pitch cycle

[0069] K is a conversion constant to establish a convenient scale; and

[0070] D is a factor that identifies the particular maker as performing one or two cuts per pitch (D=1 for one cut and D=2 for two cuts).

[0071] The controller calculates the difference position values in each of at least ten data cycles performed within each pitch cycle interval between consecutive synchronizing marks. At a maximum synchronizing mark signal frequency of 100 Hertz for a system throughput of 12,000 cigarettes per minute, the pulse repetition period is 10×10^{-3} seconds. The system's maximum internal cycle time is therefore 1×10^{-3} seconds.

[0072] **FIG. 8** illustrates the control signal sequence for synchronization of the cutting head **128** and the sensor **158** detected synchronization marks from the tobacco column **120**. Illustrations (a), (b) show the cutting head event signals **186**, **188** and synchronizing mark signal pulses **190**, **192** from sensor **158** (**FIG. 1**). The difference angle between the cutting head event signal **186** and the mark signal **190** is $\Delta\theta_{n-1}$, and that between the signals **188** and **192** is $\Delta\theta_n$. The interval between mark signal pulses **190**, **192** is one pitch cycle, and the cutting head motor is shown to have rotated through one nominal pitch cycle angular value ϕ_P.

[0073] The $\Delta\theta_{n-1}$ and $\Delta\theta_n$. difference angular values translate to a linear travel distance of the tobacco column **120** or the strip LIP paper **84** which, based upon the known placement of the synchronizing marks on the LIP paper pattern, identify the location on the LIP paper at which the event will occur, i.e. either the rod cutting location or the brand print mark. The optimum linear distance between the cutting head

and print roller events and their respective mark signals is known to the system operator and to the controller **152**, which stores the optimum distances as equivalent reference difference angular values ($\Delta\theta_R$).

[0074] The controller executes the correction algorithm **194**, **196** in response to the $\Delta\theta_{n-1}$ and $\Delta\theta_n$. values to calculate the commanded speed and/or position values for each of the motors **132-134** as necessary to restore and/or maintain the $\Delta\theta_R$ value, and transmits new synchronization command values **198**, **200** to the motors in each pitch cycle. If the $\Delta\theta_{n-1}$ and $\Delta\theta_n$. pulse count values are less than the $\Delta\theta_R$ reference, the knife blade event is late with respect to the synchronizing mark, i.e. the belt speed, and the speed of the belt drum motor **133** is decreased. If the pulse counts are greater than the reference the knife blade is too fast or to early (relative to the belt) and the belt drum motor speed is increased.

[0075] When synchronization is established between the cutting head blades and the tobacco column synchronizing marks from sensor **158**, the speed and position of the cutting head motor **132** is maintained constant, and linear variations in operating conditions due to system tolerances (e.g. paper pattern, sensor, signal noise) are controlled by linear speed adjustment of the belt motor **133**. Under transient operating conditions, such as system start-up or LIP paper bobbin change-over, it may be necessary to change both the motor speed and shaft position of all motors, including the cutting head, to again achieve steady state.

[0076] The supervisory control recognizes these transient conditions based upon defined control condition limits. These limits define the threshold between satisfactory and unsatisfactory rod lengths and/or non-registered rod LIP patterns. In this manner the fixed gear ratios of the physical drive shaft used in conventional smoking article manufacturing equipment is replaced with a "virtual gear box" which calculates independent position profiles for each motor, that are constantly renewed to handle start, acceleration, level, deceleration and stop situations. In this way the invention provides the capability to modify the gear ratio to match the paper instantaneous pitch.

[0077] There are two corrections, the Averaging Correction and the Derivative Correction, which are shown by the algorithm below. The Averaging Correction is an integral and proportional closed loop control, and the Derivative Correction is the derivative component of the loop. There are also boundary conditions that are applied to the algorithm's results to limit the system response to accepted limits of the particular cigarette manufacture equipment, such as the minimum and maximum tobacco column length limits which will not stop the machine.

TABLE 2

Factor	Definition
$\in_0, \in_1, \ldots \in_n$,	the recent n number of errors from the set point S_P
N_A	the number for the Averaging Correction
N_D	the number for the Derivative Correction;
Lim^+, Lim^-	upper and lower limits for total correction;
P_P	("PreviousPitch") the last Pitch value sent to the servo amplifier/drivers;
N_P	("NewPitch") the next Pitch value to be sent to the servo amplifier/drivers

TABLE 2-continued

Factor	Definition
Lim Δ^+, Lim Δ^-	the +/− correction limits between P_P and N_P;
NP	("Nominal Pitch") is the nominal length of a double article tobacco column (e.g. double rod);
GA	the gain applied to the Averaging Correction;
GD	the gain applied to Derivative Correction.

[0078] The algorithm factors are defined in Table 2.

[0079] The algorithm may then be written as:

$$N_P = \left(P_P + GA * \left(\sum \epsilon_n \{\text{for } n = 0 \text{ to } n = N_A\}/N_A\right) + GD * \left(\sum \epsilon_n \{\text{for } n = 0 \text{ to } n = N_D/2\}/N_D/2\right) + \left(\sum \epsilon_n \{\text{for } n = N_D/2 \text{ to } n = N_D\}N_D/2\right)\right)/N_D/2$$

[0080] With the conditions:

If $N_P<(NP-Lim^-)$; then $N_P=(NP-Lim^-)$;	Condition 1
If $N_P>(NP+Lim^+)$; then $N_P=(NP+Lim^+)$;	Condition 2
If $(N_P-P_P)<Lim\Delta^-$; then $N_P=P_P-Lim\Delta^-$;	Condition 3
If $(N_P-P_P)>Lim\Delta^+$; then $N_P=P_P+Lim\Delta^+$.	Condition 4

[0081] Conditions 1 and 2 limit the total length variation to avoid difficulty with downstream processing, including filter and/or packaging. Conditions 3 and 4 limit the pitch to pitch variation to prevent LIP paper break. The Averaging number correction and the Derivative number correction are complementary and apply their corrections together. The Averaging correction corrects long term drift and discontinuities in the LIP paper patter as occurs at splices. The Derivative correction corrects short term and cyclic variations.

[0082] Included among the several categories of errors to be corrected are the following.

[0083] Long Term Evolution ("LTE")—of the pitch is the variation in pitch length over a full bobbin due to paper tension variation with the reduction in bobbin diameter as the paper depletes, and the paper tension variation caused by the cigarette maker itself.

[0084] Splice Error ("SE")—is a sudden offset in position of successive pattern panels due to a splice within a bobbin or between two bobbins in an automated bobbin change. This offset can have a random value of +/−one pitch.

[0085] Sudden Pitch Error ("SPE")—is the sudden pitch variation that occurs in conjunction with a SE. In a bobbin change the new bobbin pitch never exactly match the finishing bobbin pitch.

[0086] Bad Mark ("BM")—are both missing synchronizing marks due either to paper error or failure to detector, as well as added false marks due interference (e.g. dirt) detected as a normal mark.

[0087] Noise Error ("NE")—is error due to various forms of ambient noise.

[0088] In synchronizing the cutting head blades to the LIP paper pattern of the tobacco column, the invention corrects errors in synchronization by first changing the speed and/or position of the belt drum motor **133**, as necessary to restore synchronization. Under extreme synchronization error conditions it may also be necessary or desirable to simultaneously change the speed and/or position of the cutting head motor **132** to quickly reduce the error. In either case, the belt drum motor is changed first and to that extent it is subordinate to the cutting head motor in the invention control hierarchy. Similarly, in controlling the synchronization of the print roller to the LIP pattern of the paper strip **84** (**FIG. 1**), synchronization errors are corrected by changing the speed and/or position of the print roller motor **134** which, in the control hierarchy is subordinate to the belt drum motor.

[0089] **FIG. 7A** is a flow chart diagram of the control processes **213** performed by the controller **152** for cutting head-to-tobacco column synchronization. Since the process for controlling the print roller-to-strip LIP pattern synchronization is identical to that of process **213** with the exchange of print roller event for cutting head event and strip LIP paper synchronizing mark for tobacco column synchronizing mark, the print roller synchronization is not separately described. Referring to **FIG. 7A**, following system Power On at **214**, a system initialization process **216** is performed, as shown in **FIG. 7B**.

[0090] Referring to **FIG. 7B**, the controller enters the initialization routine at **218** and process **220** loads the application program and operating parameters for the type of smoking article to be manufactured. Decision **222** determines if safety switch **224** is on, if the answer is NO, the process will display a message to the operator on the GUI **156** (**FIG. 2**) and loop back to decision **222** until all safety guards and emergency switches are set. If the answer to decision **222** is YES, process **226** next turns on power to the motors **132-134** (**FIG. 1**). Process **228** next obtains the reference position count value for the cutting head **128** (**FIG. 1**) as the pulse count of shaft sensor **136** at the time of occurrence of a cutting head event signal from blade position sensor **166**.

[0091] Process **230** similarly obtains the reference position count value for the print roller **88** as the pulse count of shaft sensor **138** at the time of the print roller event signal from the font position sensor **170**. Subroutine **232** next performs an error check on all system initialization parameters, and decision **234** determines if errors were found. If the answer is YES, the controller re-executes the initialization process **236**. If the answer is NO the controller exits routine **216** at **238**.

[0092] Referring back to **FIG. 7A**, following successful completion of the initialization process **216**, the controller **152** (**FIG. 2**) begins processing the system performance data. As described earlier, the controller monitors the appearance of the cutting head event signal which marks the cutting blade position, and the appearance of a synchronizing mark signal pulse from sensor **158** (**FIG. 1**) reporting a detected tobacco column synchronizing mark by performing at least ten successive data cycles within each pitch interval.

[0093] Each data cycle begins with process **240** which looks for the presence of a cutting head event signal, and process **242** which looks for the presence of a synchronizing mark signal. If either signal is detected, its time stamp value is recorded. Process **244** counts the cutting head motor pulses from shaft sensor **136** (**FIG. 1**) since (i) the last detected cutting head event signal, and (ii) since the last detected synchronizing mark signal. Decision **246** next determines if the system safety switch **224** (**FIG. 7B**) is ON, as part of a system safety audit. If the answer is NO, process **248** turns off power to all motors **132-134**, and prompts the operator **250** to manually set the safety switch on and again perform the initialization routine **216**.

[0094] The safety switch audit of decision **246** is a system overhead function and is described here for completeness, but is not otherwise necessary to the performance of the invention. If the answer to decision **246** is YES, decision **252** determines if a time out has occurred without the appearance of either one or both of the cutting head event signal or the synchronizing mark signal. The timeout threshold is the number of pitch cycles that have occurred since the last appearance of the missing signal, or signals.

[0095] In each pitch cycle there are normally two cutting head event signals (with a dual blade cutting head) and one synchronizing mark signal. The cause of a missing signal can be equipment failure or a transient signal interruption. The most likely cause for loss of the cutting head event signal is equipment failure, e.g. failure of sensor **166** (**FIG. 1**). Alternatively, the more likely cause of a loss of a synchronizing mark signal is a transient effect, e.g. a bad mark or splice occurring on the paper. There may, therefore, be different timeout threshold values for the two signals.

[0096] Also, the occurrence of signal loss following a period of active control in which the cutting head event signal and the synchronizing mark signals are in registration to provide cutting head to tobacco column synchronization, would not result in an out of tolerance condition for several pitch cycles. A nominal timeout value then may be three pitch cycles for either signal. A more conservative option may be to set different timeout thresholds for different signals based upon the likely cause of their loss. In that case the cutting head event signal loss timeout may be limited to 2 pitch cycles and that for the synchronizing mark signal limited to three.

[0097] If timeout is exceeded the answer to decision **252** is NO, and process **254** responds by setting a flag identifying a Fatal Error State. Process **256** then turns off power to the system motors. Module **258** reports the time out conditions to the operator through the GUI **156** (**FIG. 2**), and the operator must restart the **213** process.

[0098] If the timeout is within the set limit, the answer to decision **252** is YES, and decision **260** determines if the data shows a change of the relative position of the LIP paper wrapped tobacco column pattern to the cutting head position. If the answer to decision **260** is NO, signifying a steady state condition, the data loop is complete and the controller branches back to decision **240** for the next data cycle. If the answer is YES, signifying a change in the position of either and/or a change in signal registration, instructions **262** acquire the most recent position data, and process **264** calculates a new pitch ratio of cutting head motor-to-belt drum motor set points, as necessary to restore signal registration.

[0099] The process **264** also sets a flag in response to $\Delta\theta$ error magnitudes that are greater than that which can be

corrected in a single pitch interval, i.e. out of tolerance conditions. This error limit value depends on the system gain but $\Delta\theta$ errors that are less than two millimeters can generally be corrected within one pitch cycle. Larger $\Delta\theta$ errors, such as those due to a bobbin change, can be offset by as much as a full pitch interval. These sized errors require several pitch cycles to correct, resulting in several rods that must be rejected for poor quality.

[0100] Process **264** retains the set flag for as many pitch cycles as are required to reduce the error to less than +/−2 mm, or such other limit as the manufacturer may set. When process **264** is complete, process **266** transmits the next pitch cycle position values to the belt drum motor and/or the cutting head motor. Process **268** is the ejection module, and it issues an EJECT command through the belt drum servo amplifier/driver **145** (**FIG. 2**) on line **206** to the ejection actuator whenever the process **264** sets the flag. The process **268** maintains the EJECT command for each succeeding pitch cycle in which the flag is set, and removes the command when the flag is cleared in response to a remaining error of less than +/−2 mm. In response to the command, the ejection actuator ejects the defective rods before they are delivered to the downstream processes.

[0101] **FIGS. 4 through 6** illustrate the processing steps performed by the invention in manufacturing King Size LIP cigarettes having the LIP paper LP band patterns shown in **FIG. 3**, illustrations (a) through (c). In these examples the operating parameters assumed for the maker apparatus **80** of **FIG. 1** are those identified in Table 1 above. A nominal manufacturing rate of 8000 rods per minute is assumed, although it could be as high as 12,000 rods per minute. At the 8000 rod rate the cutting head **128**, with twin blades **124**, **126** has a nominal rotational speed of 4000 revolutions per minute (RPM), or 66.67 revolutions per second (RPS), and with a 2:1 gear ratio the cutting head motor **132** rotation is a nominal 8000 RPM. With two blades spaced substantially at 180° intervals along the circumference, the nominal head cutting speed is 133.33 cuts per second.

[0102] The transport speed of the belt **96** is nominally 500 meters per minute, or 128 rods per second. The belt drum with a 300 mm diameter rotates at an approximate 500 RPM and at the 6:1 gear ratio the belt drum motor **133** rotates at a nominal 3000 RPM. The print roller **88** rotates at 4000 RPM, and includes two font heads, each having two brand print marks, for applying brand indicia on each rod at a rate of two pitch (4 rod) per revolution. At a gear ratio of 2:1 the print roller motor **134** rotates at a nominal 8000 RPM.

[0103] **FIG. 4**, illustration (a) is the LIP paper sample **20** of **FIG. 3**, illustration (a), with synchronizing marks **24-26** and LP bands **28-31**. As described earlier above the cutting head **128** slices the LIP paper wrapped tobacco column **120** into pitch lengths, which is twice the unit length of the tobacco column of the finished smoking article, i.e. a "double rod". Therefore the slicing performed by the cutting wheel **128** is the first of two cuts to be made in processing the finished product and in the present invention, the slices performed by the wheel **128** occur at the synchronizing mark locations. In the **FIG. 3**, illustration (a) tobacco column **120** the cutting wheel **128** slices the column at the marks **24-26**.

[0104] The slicing of the double rods into unit lengths occurs in the processing steps performed downstream of the maker **80** (**FIG. 1**). These downstream processing steps include (i) slicing the double rod into unit lengths, (ii) adding a double length filter between the sliced unit lengths, (iii) connecting the filter body to the cut unit length tobacco columns with tipping paper which also conceals any residue of the synchronizing marks and completes the finished product, (iv) shuffling the finished product into a uniform orientation (e.g. all article filters lying in the same direction), and (v) delivering the oriented smoking articles to conveying apparatus which transports the finished articles to the manufacturer's packing machinery. All of these steps (i) through (v) are well known in the prior art, as shown and described in U.S. Pat. No. 5,135,008 to Oesterling et al., entitled: METHOD OF AND APPARATUS FOR MAKING FILTER CIGARETTES, the entire disclosure of which is fully incorporated by reference herein.

[0105] Similarly, the conveying apparatus which transports the finished articles to the manufacturer's packing machinery is well known as shown and described in U.S. Pat. No. 4,339,026 to Tolasch et. al., entitled APPARATUS FOR DELIVERING CIGARETTES OR THE LIKE FROM A MAKER TO A CONSUMING MACHINE, and U.S. Pat. No. 4,365,702 to Tolasch et al., entitled APPARATUS FOR TRANSPORT AND TEMPORARY STORAGE OF CIGARETTES OR THE LIKE BETWEEN PRODUCING AND PROCESSIGN MACHINE. Each of these references disclose the steps performed in shuffling the finished smoking articles to the point of delivery to the apparatus which groups the articles for packaging, and the entire disclosure of each is fully incorporated by reference herein.

[0106] Finally, the apparatus for grouping and for packaging the finished smoking articles is also known, as shown and described in the following references to U.S. Pat. No. 5,548,941 to Portaro et al., entitled METHOD OF FEEDING GROUPS OF TOBACCO ITEMS, IN PARTICULAR CIGARETTES, TO A CONTINUOUS PACKING MACHINE, which discloses method and machinery for grouping the articles for packaging, and U.S. Pat. Nos.; 4,979,349 to Heinz Focke, entitled PAKCING MACHINE FOR FLIP TOP BOXES; 6,732,497 to Spatafora et al., entitled: CIGARETTE PACKING MACHINE; 6,782,674 to Mario Spatafora, entitled CIGARETTE PACKING MACHINE; and 6,789,370 to Mario Spatafora, entitled CIGARETTE PACKING MACHINE, each of which disclose apparatus for packaging the finished smoking articles. The entire disclosure of each of these references is also fully incorporated by reference herein.

[0107] **FIG. 4**, illustration (b) shows the cut rods **270-273**, each of which are 65 mm long. Illustrations (c) through (g) depict the post cut processing of consecutive rods **271**, **272**, each of which have a LIP paper pattern panel with a 7 mm LP band placed symmetrically in the center of each rod, 29 mm from either end. In illustration (d), the paired rods **271**, **272** are subjected to a filter process which inserts a 36 mm double filter **274** between the trailing end **275** of the first rod **271** and the leading end **276** of the trailing rod **272**. In illustration (e) the double filter is covered with tipping paper **278** that extends **279**, **280** a nominal 5 mm onto the body of each rod. In illustration (f) the double filter is cut to separate the rods into finished LIP smoking articles **271**A and **272**A. In the final illustration (g), during the downstream packaging process, the trailing article **272**A is rotated 180° to orient it with article **271**A for packaging.

[0108] **FIG. 5**, illustration (a) is the LIP paper sample **21** of **FIG. 3**, illustration (b), with synchronizing marks **40-42** and LP bands **44-47**. **FIG. 5**, illustration (b) shows the cut rods **282-285**, each of which are 65 mm long. Illustrations (c) through (g) depict the post cut processing of consecutive rods **283**, **284**, each of which have a LIP paper pattern panel with a single 7 mm LP band placed asymmetrically, 43 mm from the front (lighted end) and 15 mm from the rear (filter end). In illustration (d), the paired rods **283**, **284** are subjected to a filter process which inserts a 36 mm double filter **286** between the trailing end **287** of the first rod **283** and the leading end **288** of the trailing rod **284**. In illustration (e) the double filter is covered with tipping paper **290** that extends **291**, **292** a nominal 5 mm onto the body of each rod. In illustration (f) the double filter is cut to separate the rods into finished LIP smoking articles **283**A and **284**A. In the final illustration (g), during the downstream packaging process, the trailing article **284**A is rotated 180° to orient it with article **283**A for packaging.

[0109] Finally, **FIG. 6**, illustration (a) is the LIP paper sample **22** of **FIG. 3**, illustration (c), with synchronizing marks **56-58** and LP bands **60-67**. **FIG. 5**, illustration (b) shows the cut rods **294-297**, each of which are 65 mm long. Illustrations (c) through (g) depict the post cut processing of consecutive rods **295**, **296**, each of which have a LIP paper pattern panel with two 7 mm LP band, each located a nominal 12.75 mm from an associated one of the front and rear ends, with an intermediate spacing of 25 mm. In illustration (d), the paired rods **295**, **296** are subjected to a filter process which inserts a 36 mm double filter **298** between the trailing end **300** of the first rod **295** and the leading end **302** of the trailing rod **296**. In illustration (e) the double filter is covered with tipping paper **304** that extends **306**, **308** a nominal 5 mm onto the body of each rod. In illustration (f) the double filter is cut to separate the rods into finished LIP smoking articles **295**A and **296**A. In the final illustration (g), during the downstream packaging process, the trailing article **296**A is rotated 180° to orient it with article **295**A for packaging.

[0110] Although the invention has been shown and described with respect to a best mode embodiment thereof, it should be understood by those skilled in the art that various changes, omissions, and additions may be made to the form and detail of the disclosed embodiment without departing from the spirit and scope of the invention, as recited in the following claims.

What is claimed is:

1. A method of manufacturing low ignition propensity (LIP) smoking articles having a tobacco column of desired length with a low porosity (LP) band pattern disposed thereon, comprising:

providing a continuous strip of LIP material wrapper having LP bands disposed on a major surface thereof, in interleaved fashion with untreated material areas, to provide a longitudinally extending array of LP band pattern panels, each said LP band pattern panel having one or more LP bands disposed along its panel length, said panel length extending longitudinally, between panel boundaries, at a distance substantially equal to the desired length of the LIP smoking article tobacco column, the LIP material wrapper further having synchronizing marks disposed longitudinally there along, in known axial relation to said panel boundaries and at substantially equal pitch intervals, said synchronizing marks being physically detectable from the LIP material wrapper surface;

wrapping tobacco filler within the LIP material wrapper along a top stretch of a moving conveyor belt to form a continuous LIP material wrapped tobacco column having synchronizing marks appearing there along, and transporting said continuous LIP material wrapped tobacco column, at a tobacco column transport speed proportional to the conveyor belt speed, to a cutting location;

cutting the continuous LIP material wrapped tobacco column at the cutting location, at a selected cutting speed, into the desired cut length tobacco columns;

as characterized by:

monitoring the values of said cutting speed and said conveyor belt speed;

detecting passage of succeeding ones of said synchronization marks on said LIP wrapped tobacco column past a reference point located along the tobacco column travel path, at a reference distance upstream from the cutting location, and providing a synchronizing mark signal pulse in response to each such detection, said synchronizing mark signal pulses individually providing a sensed representation of the position of the LP band panels with respect to the cutting location and collectively providing a sensed synchronization mark signal having a pulse repetition frequency proportional to the instant tobacco column transport speed past the reference location; and

adjusting the conveyor belt speed as necessary to synchronize the sensed location of the LP band panel, as represented by said synchronizing mark signal pulse, and the tobacco column transport speed, as represented by said synchronizing signal pulse repetition frequency, to the monitored cutting speed to provide cutting of the continuous tobacco column at axial cutting positions outside of said LP band pattern panel boundaries, thereby providing LIP smoking articles having a tobacco column with a registered LP band pattern.

2. The method of claim 1, where one or more of said LP bands are located in a defined arrangement within each said LP band pattern panel.

3. The method of claim 1, where said pitch interval spacing of said synchronizing marks is proportional to the desired length of the smoking article tobacco column.

4. The method of claim 3, where said pitch interval value is a whole number multiple of the desired length of the smoking article tobacco column.

5. The method of claim 4, where said pitch interval is twice the desired length of the smoking article.

6. The method of claim 3, where said synchronizing marks are in the form of stripes which extend a proportionate part of the width of said continuous strip of LIP material wrapper.

7. The method of claim 6, where said synchronizing marks extend a proportionate part of the width of said continuous strip of LIP material wrapper, sufficient to permit physical detection of said synchronizing marks from the LIP

material wrapper surface along an appreciable length arc of said LIP material wrapped tobacco column circumference.

8. The method of claim 6, where said synchronizing marks extend the width of continuous strip of LIP material wrapper.

9. The method of claim 7, where said synchronizing marks extend from an edge of said continuous strip of LIP material wrapper at a length no less than one fifth the width of said strip.

10. The method of claim 5, where said synchronizing marks are disposed at alternating ones of said axial cutting positions, each such alternating axial cutting position occurring at the end of cut length tobacco columns at which the a smoking article filter is to be attached with tipping paper to provide a filtered LIP smoking article, whereby any post cutting residue of the synchronizing mark is covered by the tipping paper.

11. The method of claim 1, where said synchronizing marks are disposed at said LP band pattern panel boundaries.

12. The method of claim 10, where said LP band pattern panels and said synchronizing marks are disposed on a common major surface of said continuous strip of LIP material wrapper.

13. The method of claim 10, where said LP band pattern panels and said synchronizing marks are disposed on opposite major surfaces of the LIP material strip.

14. The method of claim 1, wherein the synchronizing marks have sufficient contrast to the LIP material wrapped tobacco column surface to be detected by physical means.

15. The method of claim 14, where the synchronizing marks may be detected at a resolution accuracy no greater than plus or minus 0.2 millimeters of their actual position on the continuous LIP material tobacco column, at a mark signal frequency of substantially 100 pulses per second.

16. The method of claim 14, where said synchronizing marks have at least thirty percent higher light reflectivity than the LIP material surface.

17. The method of claim 16, where said synchronizing marks are optically detected.

18. The method of claim 17, where the synchronizing marks are detected using red wavelength laser light.

19. The method of claim 1, where the synchronizing marks are in the form of stripes disposed transverse to the length of the strip, and having a stripe length which extends a proportionate part of the width of the strip.

20. The method of claim 19, where said synchronizing mark stripes extend a proportionate part of the width of the strip sufficient to permit their physical detection along an arc which is no less than one fifth the circumference of said continuous LIP wrapped tobacco column.

21. The method of claim 19, where said synchronizing mark stripes have a width no greater than two millimeters.

22. The method of claim 1, further comprising:

inserting a double length filter section between succeeding smoking article cut length tobacco columns and attaching the distal ends of said filter section with tipping paper to the cut end of the smoking article cut length tobacco column immediately adjacent thereto, said tipping paper overlapping an end surface portion of each such joined tobacco column; and

cutting the joined tobacco columns substantially at the center of the filter section to produce a finished product LIP smoking article.

23. The method of claim 22, where said synchronizing mark stripes are located at the end of the cut length tobacco column which receives said filter section, whereby said synchronizing marks are covered by said tipping paper in the finished product LIP smoking article.

24. The method of claim 1, where said reference distance is no greater than twice said mark interval spacing.

25. The method of claim 24, where said reference distance is substantially equal to said mark interval spacing.

26. The method of claim 1, further comprising:

specifying the length tolerance limits for an acceptable LIP smoking article tobacco column length, and quantifying the specified length tolerance in terms of a synchronization tolerance indicative of the acceptable degree of non-synchronization between the sensed synchronization signal and the monitored cutting speed;

determining the maximum synchronization correction that a change in belt speed can provide within the cutting time interval between successive cut length tobacco columns;

monitoring the value of synchronization correction provided within the cutting time interval for each cut length of tobacco column, and identifying as defective product, those cut length tobacco columns provided in a cutting time interval in which the non-synchronization magnitude exceeded the maximum synchronization correction value; and

discarding the defective product prior to the step of inserting the double length filter section.

27. Apparatus for manufacturing LIP smoking articles having a desired length tobacco column with a registered LP band pattern, comprising:

bobbin means, for providing a continuous strip of LIP material wrapper of the type having LP bands disposed on a major surface thereof, in interleaved fashion with untreated material areas, to provide a longitudinally extending array of LP band pattern panels, each said LP band pattern panel having one or more LP bands arranged in said interleaved fashion along its panel length, said panel length extending longitudinally, between panel boundaries, at a distance substantially equal to the desired length of the LIP smoking article tobacco column, the LIP material wrapper further having synchronizing marks disposed longitudinally there along, in known axial relation to said panel boundaries and at substantially equal pitch intervals, said synchronizing marks being physically detectable from the LIP material surface;

conveyor means, having a conveyor belt moving at belt speed for receiving the continuous strip LIP material at a top stretch area thereof where tobacco filler is rolled in the continuous strip LIP material wrapper to form a continuous LIP material wrapped tobacco column having synchronizing marks appearing therealong, the conveyor belt transporting the continuous LIP material wrapped tobacco column to a cutting location at a column transport speed proportional to said belt speed; and

cutting head means, having one or more cutting blades which cycle at a cutting head speed through the cutting

location to cut the continuous LIP material wrapped tobacco column into the desired length tobacco columns;

as characterized by:

conveyor belt motive means, including a belt motor with rotating shaft for moving the conveyor belt at said belt speed, a belt motor shaft sensor for providing a sensed belt feedback signal representative of the instant rotational speed of said belt motor shaft, and belt motor control means for controlling the conveyor belt speed in response to said sensed belt feedback signal and to belt motor command signals presented thereto;

cutting head motive means, having a cutting head motor with rotating shaft for cycling said cutting head blades at said cutting head speed through said cutting location, a cutting head motor shaft sensor for providing a sensed cutting head feedback signal representative of the instant rotational speed of said cutting motor rotating shaft, and cutting head motor control means for controlling the cutting head speed in response to said sensed cutting head feedback signal and to said cutting head motor command signals presented thereto;

tobacco column sensor means, for detecting the passage of succeeding ones of said synchronization marks on said LIP wrapped tobacco column past a reference point located along the tobacco column travel path, at a reference distance upstream from the cutting location, and providing a synchronizing mark signal pulse in response to each such detection, said synchronizing mark signal pulses individually providing a sensed representation of the position of the LP band panels with respect to said cutting location and collectively providing a sensed synchronization mark signal having a pulse repetition frequency proportional to the instant tobacco column transport speed past said reference location; and

supervisory control means, having memory means for storing signal information, including the occurrence of said sensed synchronizing mark signal pulse representation of the position of the LP band panels with respect to said cutting location and said sensed synchronization mark signal pulse repetition frequency, said supervisory control means being responsive to said sensed synchronizing mark signal pulses, said sensed synchronization mark signal pulse repetition frequency, said sensed belt feedback signal, and said sensed cutting head feedback signal, to provide, in response thereto, belt motor command signals to the conveyor belt motor means to adjust said conveyor belt speed as necessary to synchronize the sensed location of the LP band panel, as represented by said synchronizing mark signal pulse, and the tobacco column transport speed, as represented by said synchronizing signal pulse repetition frequency, to the monitored cutting speed to provide cutting of the continuous tobacco column at axial cutting positions outside of said LP band pattern panel boundaries, thereby providing LIP smoking articles having a tobacco column with a registered LP band pattern.

28. The apparatus of claim 27, where the synchronizing marks are disposed at the LIP material panel boundaries.

29. The apparatus of claim 28, further comprising:

filter assembly means, for receiving the cut length tobacco columns and inserting, between each succeeding two cut length tobacco columns, a double length filter section, the filter assembly means attaching the distal ends of the filter section with tipping paper to the ends of the cut length tobacco columns immediately adjacent thereto, the tipping paper overlapping an end surface portion of each such joined tobacco column; and

filter cutting means, for cutting the joined columns at substantially the center of the filter section to produce a finished product LIP smoking article.

30. The apparatus of claim 29, where the mark interval spacing is substantially equal to two panel lengths.

31. The apparatus of claim 27, where the synchronizing marks have sufficient contrast to the LIP material wrapped tobacco column surface to be detected by physical means.

32. The apparatus of claim 31, where the synchronizing marks may be detected at a resolution accuracy no greater than plus or minus 0.2 millimeters of their actual position on the continuous LIP material tobacco column, at a mark signal frequency of substantially 100 pulses per second.

33. The apparatus of claim 31, where the synchronizing marks have at least thirty percent higher light reflectivity than the LIP material surface.

34. The apparatus of claim 33, where the synchronizing marks are optically detected.

35. The apparatus of claim 34, where the synchronizing marks are detected using red wavelength laser light.

36. The apparatus of claim 33, where the synchronizing marks are in the form of stripes disposed transverse to the length of the strip, and having a stripe length which extends a proportionate part of the width of the strip.

37. The apparatus of claim 27, where the synchronizing mark stripes extend a proportionate part of the width of the strip sufficient to permit their physical detection along an arc which is no less than one fifth the circumference of the continuous LIP wrapped tobacco column.

38. The apparatus of claim 37, where the synchronizing mark stripes have a width no greater than two millimeters.

39. The apparatus of claim 29, where the synchronizing mark stripes are located at the end of the cut length tobacco column which receives the filter section, whereby the synchronizing marks are covered by the tipping paper in the finished product LIP smoking article.

40. The apparatus of claim 27, where said reference distance is no greater than twice the mark interval spacing.

41. The apparatus of claim 27, where said reference distance is substantially equal to the mark interval spacing.

42. The apparatus of claim 27, further comprising:

user interface means, responsive to operator control, for receiving operator entered specification signals which defines the maximum synchronization correction that a change in belt speed may provide within a cutting time interval, and a maximum non-synchronization error magnitude, beyond which the apparatus produces unacceptable cut length tobacco columns, the supervisory control means monitoring the non-synchronizing error magnitude in each cutting time interval and identifying, as defective products to be ejected by the apparatus prior to the filter assembly means, those cut length tobacco columns produced in cutting time intervals in

which the non-synchronization magnitude exceeds the maximum non-synchronization error magnitude.

43. The apparatus of claim 27, where said LP band pattern panels and said synchronizing marks are disposed on a common major surface of said continuous strip of LIP material wrapper.

44. The apparatus of claim 27, where said LP band pattern panels and said synchronizing marks are disposed on opposite major surfaces of the LIP material strip.

45. LIP strip material tobacco wrapper for use in apparatus for manufacturing LIP smoking articles having a desired length tobacco column, comprising:

strip material, having opposing major surfaces and a material porosity there between suitable for use as conventional smoking article tobacco wrapper;

LP bands disposed on one of the strip material major surfaces in interleaved fashion with untreated material areas, to provide a longitudinally extending array of LP band pattern panels, the LP bands extending substantially the width of the strip material, transverse to its length, and interleaved along the length of the strip with untreated material areas, in a repeating, longitudinally extended array of LP band pattern panels, each pattern panel having one or more LP bands interleaved with untreated sheet material areas within a panel length thereof, the panel length extending longitudinally between panel boundaries at a distance substantially equal to the desired length of the LIP smoking article tobacco column; and

synchronizing marks disposed on one of the strip material major surfaces, the synchronizing marks being disposed in spaced apart fashion along the length of strip, at mark interval spacing proportional to panel length to locate the synchronizing marks along the strip length in known axial relationship to the pattern panels, the synchronizing marks having sufficient contrast to the sheet material surface on which they are disposed to be physically detected by physical means.

46. The LIP strip material tobacco wrapper of claim 45, where the synchronizing marks are disposed at the LIP material panel boundaries.

47. The LIP strip material tobacco wrapper of claim 45, where the mark interval spacing is substantially equal to two panel lengths.

48. The LIP strip material tobacco wrapper of claim 45, where the synchronizing marks have sufficient contrast to the LIP material wrapped tobacco column surface to be detected by physical means.

49. The LIP strip material tobacco wrapper of claim 48, where the synchronizing marks may be detected within a sensed resolution of plus or minus 0.2 millimeters when the LIP strip material synchronizing mark array is scanned by physical means at a relative scanning rate of 100 synchronizing marks per second.

50. The LIP strip material tobacco wrapper of claim 48, where the synchronizing marks have at least thirty percent higher light reflectivity than the LIP material surface.

51. The LIP strip material tobacco wrapper of claim 48, where the synchronizing marks are optically detected.

52. The LIP strip material tobacco wrapper of claim 51 where the synchronizing marks are detectable with a red wavelength laser light.

53. The LIP strip material tobacco wrapper of claim 45, where the synchronizing marks are in the form of stripes disposed transverse to the length of the strip, and having a stripe length which extends a proportionate part of the width of the strip.

54. The LIP strip material tobacco wrapper of claim 53, where the synchronizing mark stripe length extends at least one fifth the width of the LIP strip material.

55. The LIP strip material tobacco wrapper of claim 54, where the synchronizing mark stripes have a width no greater than two millimeters.

56. The LIP strip material tobacco wrapper of claim 45, where the LIP strip material comprises paper tobacco wrapper.

57. The LIP strip material tobacco wrapper of claim 45, where the LP bands and the synchronizing marks are disposed on the opposite side major surfaces of the LIP strip material.

58. A low ignition propensity (LIP) smoking article, comprising:

a tobacco column,

one or more low porosity (LIP) bands disposed on said tobacco column at a location thereon which is dependent on its relative position there along to one or more synchronizing marks similarly disposed on said tobacco column in known axial relation to said LP bands.

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