

Nov. 11, 1969

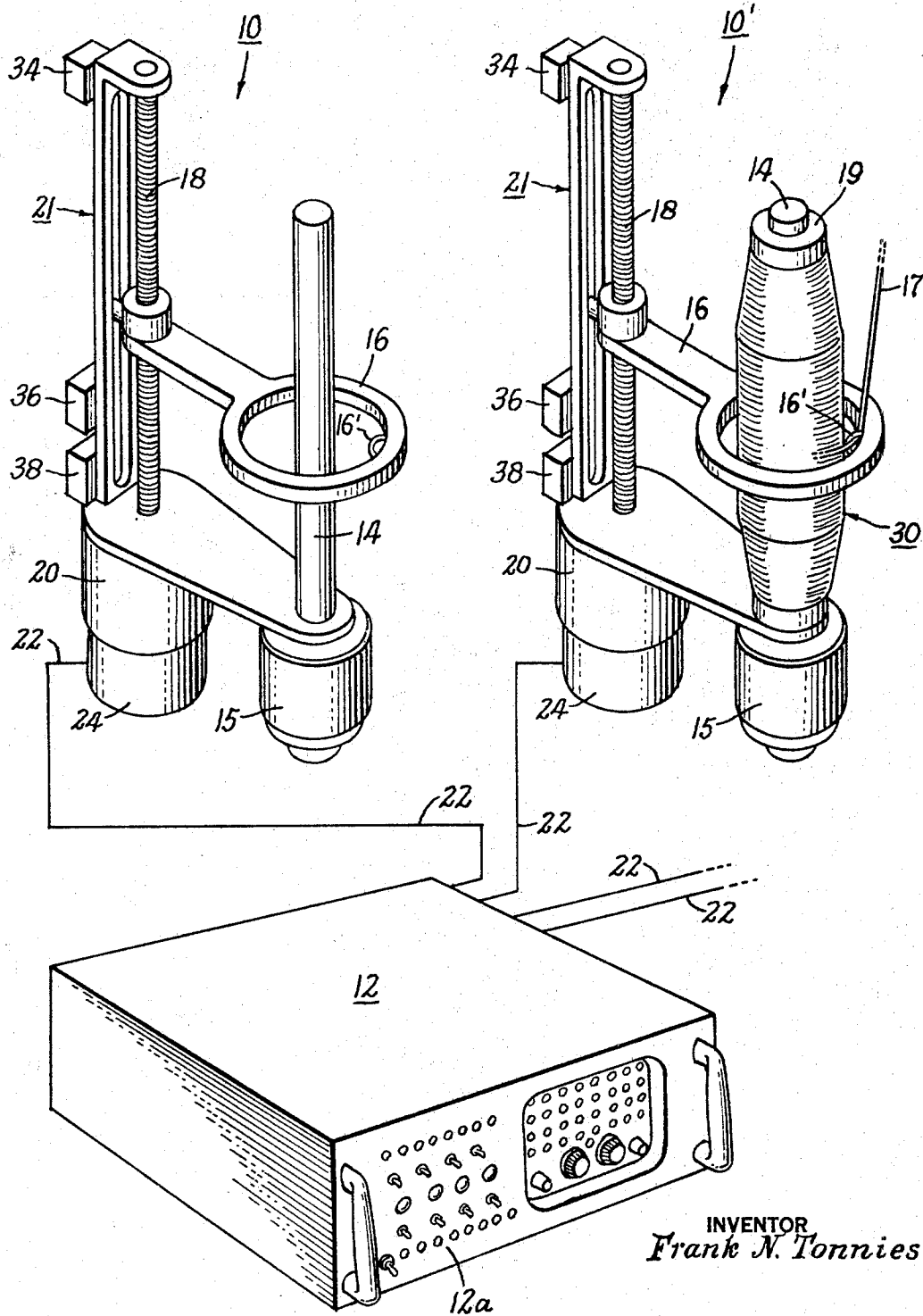
F. N. TONNIES
SELECTIVELY VARIABLE WINDING PATTERN CONTROL APPARATUS
FOR THREAD WINDERS

3,477,654

Filed Aug. 1, 1967

6 Sheets-Sheet 1

Fig 1



INVENTOR
Frank N. Tonnies

Nov. 11, 1969

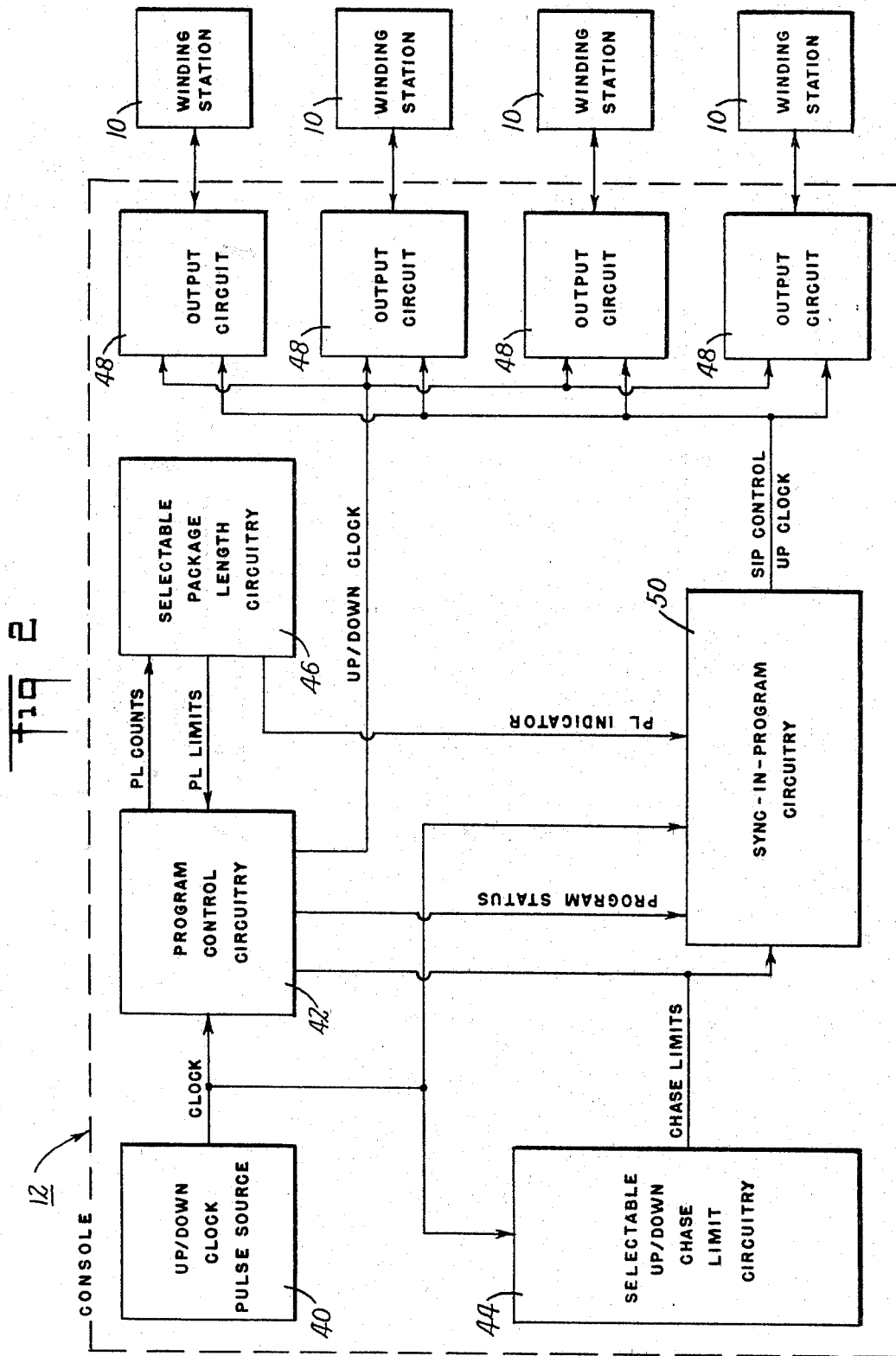
F. N. TONNIES

3,477,654

SELECTIVELY VARIABLE WINDING PATTERN CONTROL APPARATUS
FOR THREAD WINDERS

Filed Aug. 1, 1967

6 Sheets-Sheet 2



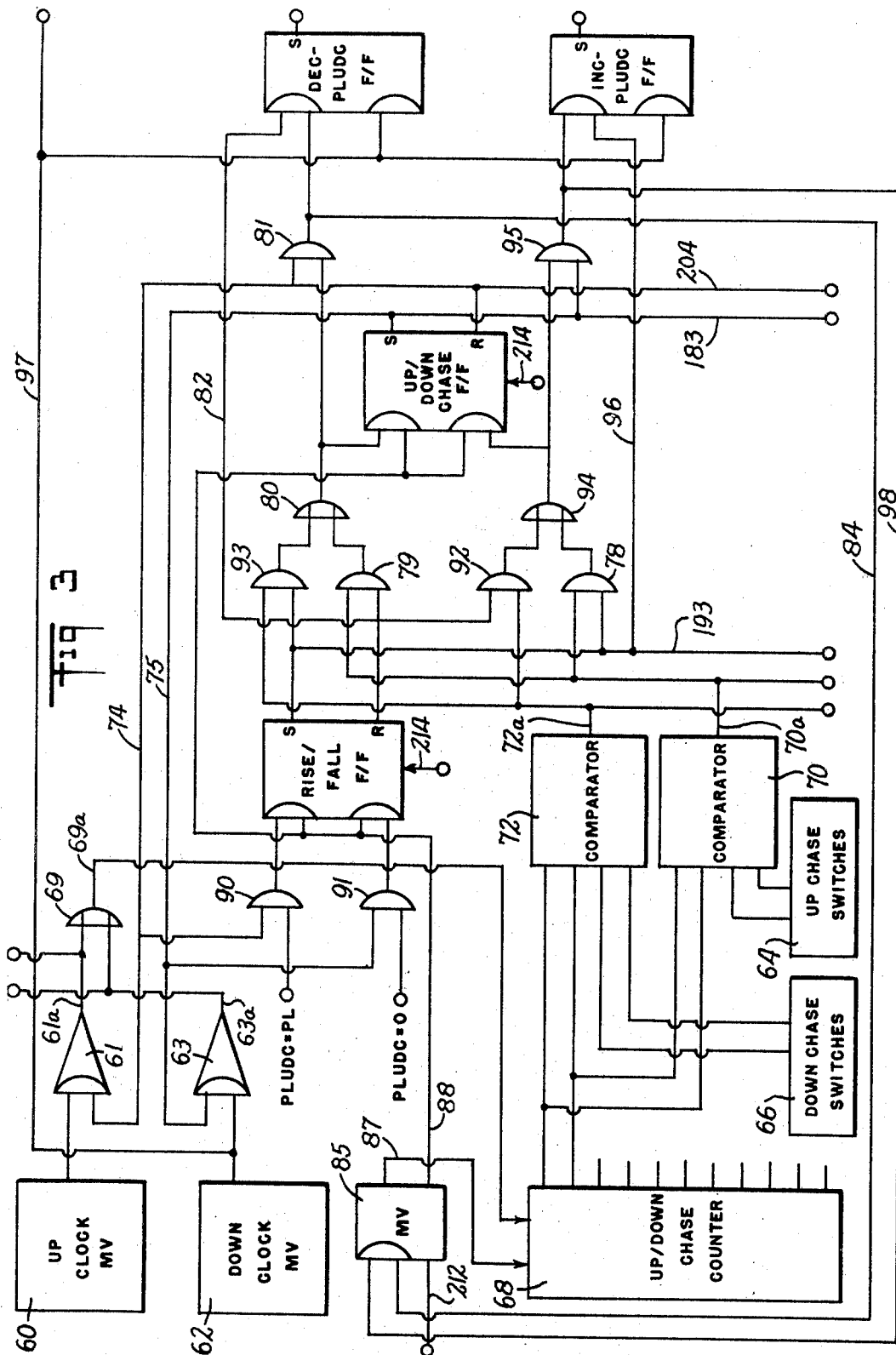
Nov. 11, 1969

F. N. TONNIES
SELECTIVELY VARIABLE WINDING PATTERN CONTROL APPARATUS
FOR THREAD WINDERS

3,477,654

Filed Aug. 1, 1967

6 Sheets-Sheet 3



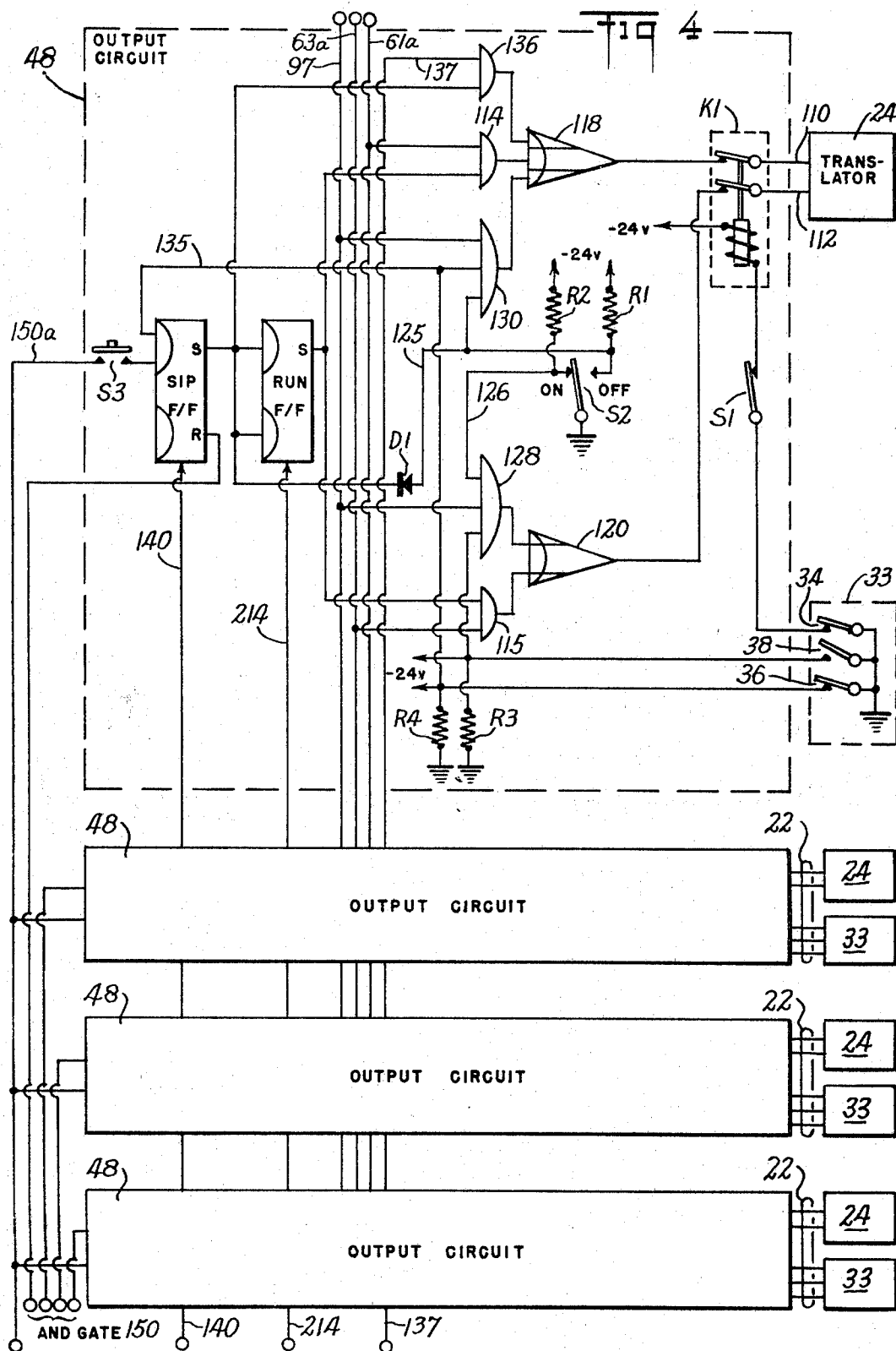
Nov. 11, 1969

F. N. TONNIES
SELECTIVELY VARIABLE WINDING PATTERN CONTROL APPARATUS
FOR THREAD WINDERS

3,477,654

Filed Aug. 1, 1967

6 Sheets-Sheet 4



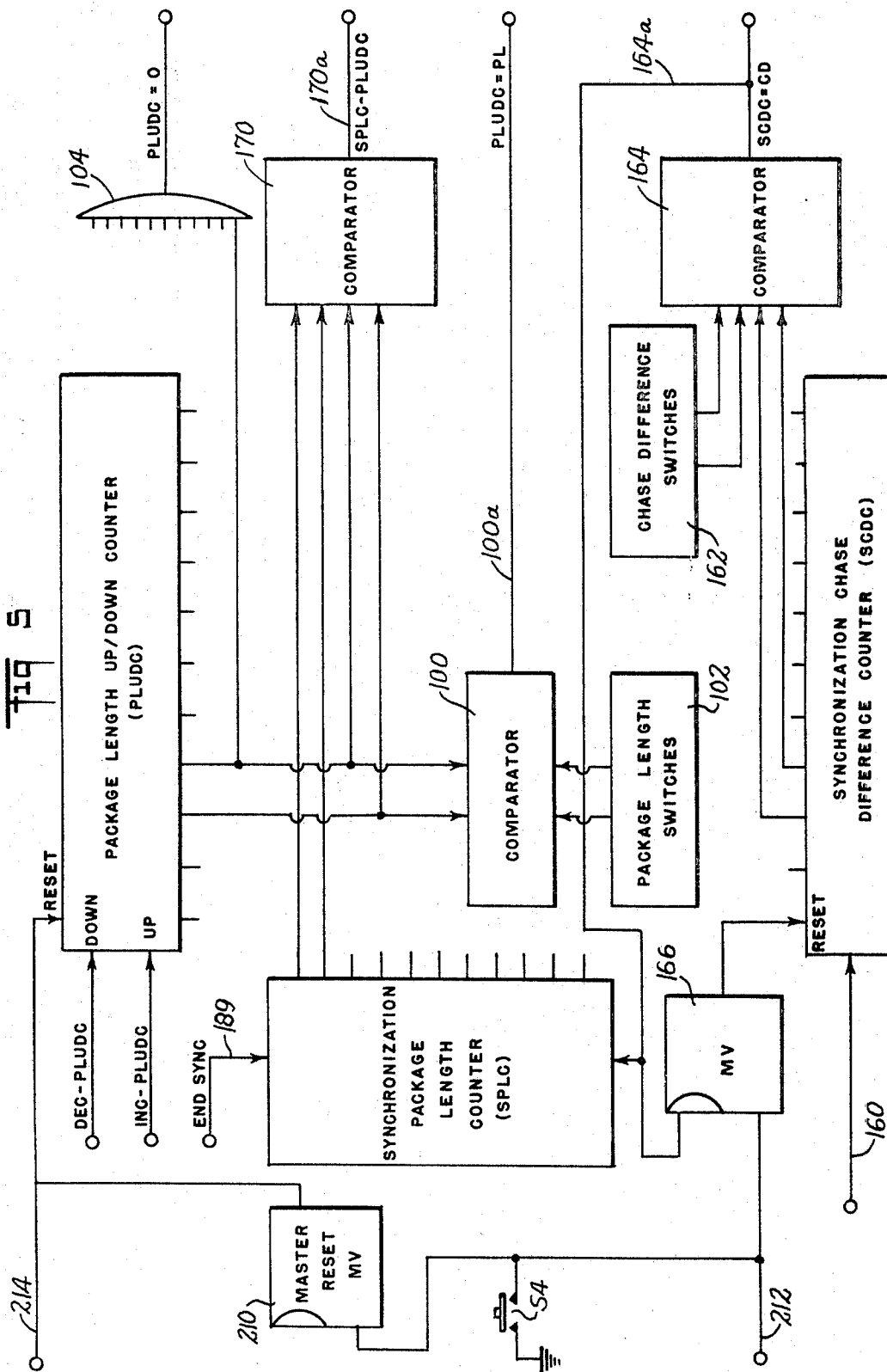
Nov. 11, 1969

F. N. TONNIES
SELECTIVELY VARIABLE WINDING PATTERN CONTROL APPARATUS
FOR THREAD WINDERS

3,477,654

Filed Aug. 1, 1967

6 Sheets-Sheet 5



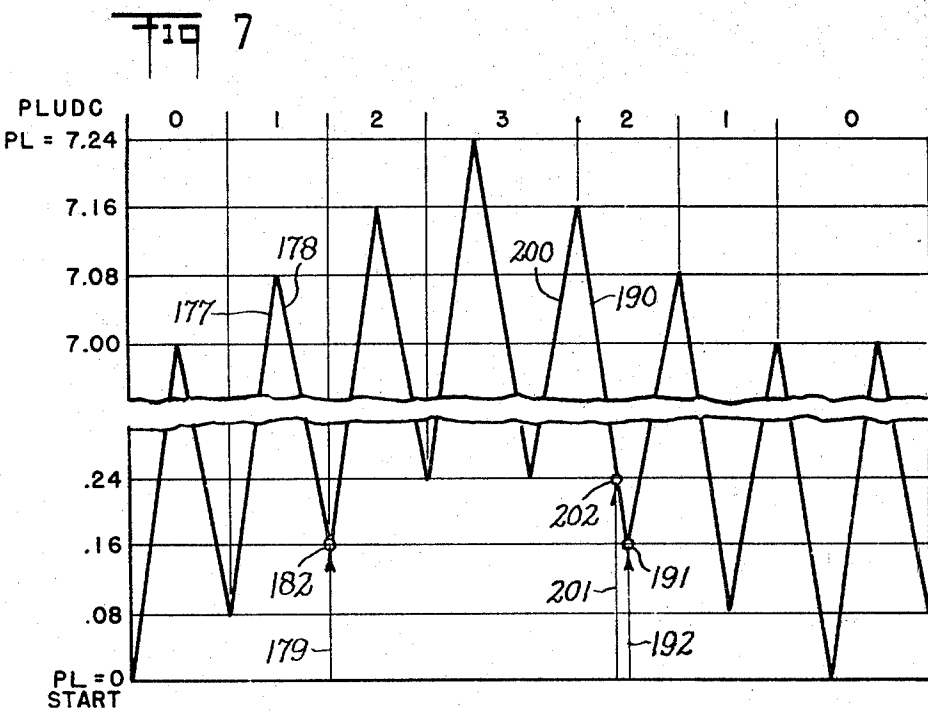
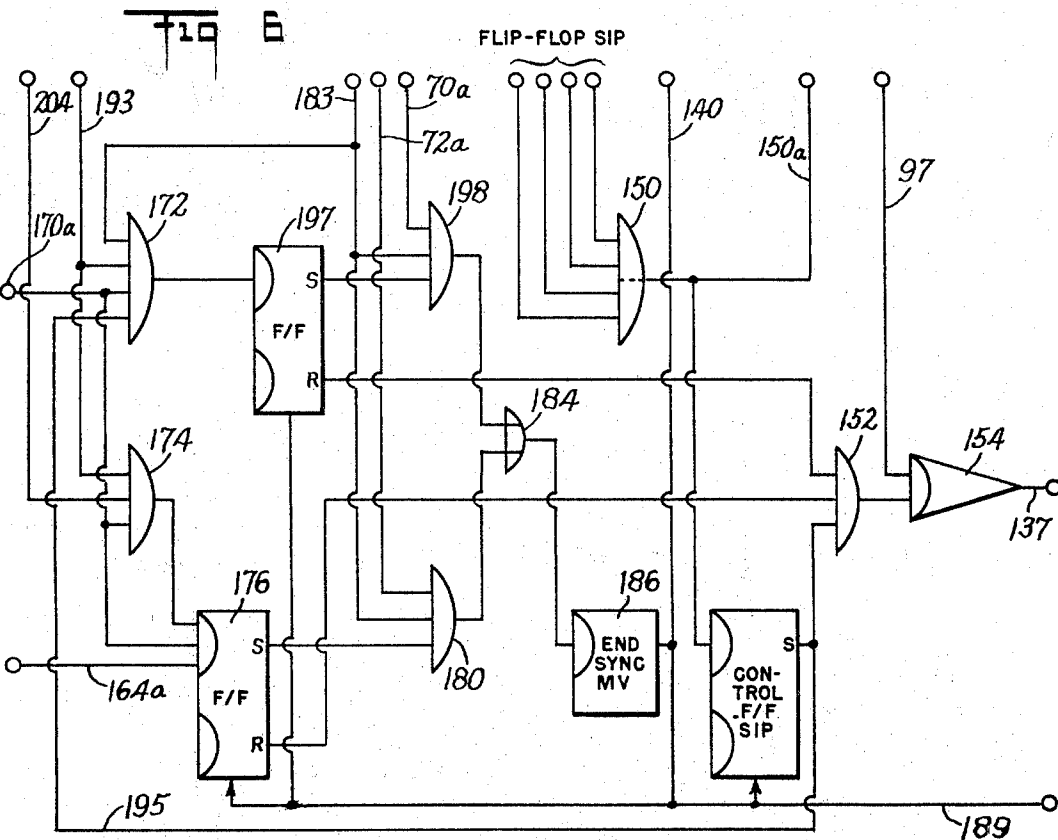
Nov. 11, 1969

F. N. TONNIES
SELECTIVELY VARIABLE WINDING PATTERN CONTROL APPARATUS
FOR THREAD WINDERS

3,477,654

Filed Aug. 1, 1967

6 Sheets-Sheet 6



1

2

3,477,654

SELECTIVELY VARIABLE WINDING PATTERN CONTROL APPARATUS FOR THREAD WINDERS

Frank Nicholas Tonnies, Bayside, N.Y., assignor to American Cyanamid Company, Stamford, Conn., a corporation of Maine

Filed Aug. 1, 1967, Ser. No. 657,570

Int. Cl. B65h 54/22

U.S. Cl. 242—26.1

16 Claims

ABSTRACT OF THE DISCLOSURE

The disclosed system for controlling thread winding apparatus to form selected thread packages includes program control circuitry feeding electrical pulses to separate thread guide mechanisms for producing traversing movements thereof relative to rotating thread bobbins; the extent of movement in each direction being established by chase limit circuitry according to a selected winding program. Package length circuitry reverses the winding program mode when the thread guide mechanisms reach positional limits corresponding to a selected thread package length. Sync-in-program circuitry operates to bring the thread guide mechanisms into a winding program in progress.

BACKGROUND OF THE INVENTION

Winding apparatus in various forms are widely employed in the textile industry to handle large quantities of thread. Thread is wound onto carriers such as cops, cones, pirns, spools, tubes and bobbins for convenient handling and shipment; ultimately to be unwound therefrom incident to the formation of cloth. The manner in which thread should be wound onto a carrier depends on the characteristics of the thread plus the manner by which it is to be unwound. The wound thread, termed thread package, must be stable, i.e., the winding pattern must be such that the individual coils of thread remain substantially fixed in relative positions during normal handling, shipment and use. Otherwise, the thread becomes entangled and cannot be readily unwound. Among the variables influencing the choice of a winding pattern needed to obtain a stable package are such thread characteristics as whether spun yarn or continuous filament yarn is involved, denier, modulus, surface friction characteristics, etc., and such use characteristics as tension under which package is wound, how package is to be unwound (whether from end or side and how rapidly), how package is to be handled prior to unwinding, etc. Each time any change is made, new winding patterns must be determined experimentally since, unfortunately, no method is known to calculate new winding patterns when variables are changed.

Typically, very few stable package forms for each size and type of thread are known. As new synthetic threads are developed, the size of known threads varied to new dimensions, where changes are made in the end uses of the thread package, a new stable package form must also be devised, requiring, in most cases, considerable experimentation.

Usually, thread winding apparatus relate the speeds of the spindle drive rotating the thread carrier and the traversing thread guide guiding the thread as it is wound onto the carrier by mechanisms which include gears, cams, shafts, etc., operating to achieve the desired winding pattern in terms of thread guide traversing movement relative to the rotating thread carrier. To change the winding pattern of a thread winder requires the substitution of gears and cams, a time consuming and therefore expensive procedure. Because of inherent physical limitation,

such as fixed shaft positions and the limited number of gear ratios available, only a small number of different package forms are possible, irrespective of stability. Thus existing thread winders are not universally applicable to wind all types and sizes of threads. Moreover, because of the difficulties in arriving at a stable package form for a particular thread which is also acceptable for latter processing, the optimum thread package form is not always achieved; it being understood that there are generally a number of acceptable package forms for each particular thread. Thus, once a suitably stable thread package is found, investigations into other possibly more stable package forms are not undertaken because of the time and expense involved.

Many existing thread winding apparatus have a plurality of winding stations, each with a spindle and a thread guide, operating off a common drive. In some apparatus of this type, a malfunction at one winding station requires shutting down the others due to the mutual drive dependency. This can amount to considerable lost time.

SUMMARY OF THE INVENTION

The present invention overcomes the various drawbacks of existing thread winding apparatus. The mechanical drive mechanism interconnecting the spindle and thread guide is eliminated and thus varying the package form, i.e., winding pattern, does not require the substitution of gears, cams, etc. Considerable time, labor and expense are saved. An inventory of replacement gears and cams is not required. Moreover, the usual maintenance required of such mechanical drive mechanisms is avoided.

According to the present invention, separate drives are employed for the spindles and the thread guides. The thread guide is driven off an electrical motor receiving energizing electrical signals. The characteristics of the energizing electrical signals are controlled and varied according to a preselected winding program, thus to establish a desired winding pattern or thread package. The pre-selected winding program is instituted by appropriate conditioning of electrical circuit elements which then act to control the motor energizing signal characteristics. A virtually unlimited number of different winding patterns and thread package forms are capable of achievement, and the change-over from one to another is achieved by the simple manipulation of electrical switches or the like. The search for one or more stable package forms for a particular thread is thus a relatively easy, simple task. An optimum stable thread package form can be achieved inexpensively whereas, heretofore, one had to be practical and settle for merely an acceptably stable package form.

The thread winding apparatus of the present invention is thus virtually universally applicable to all types and sizes of thread. The change over from one winding pattern to another may be accomplished conveniently with ease.

It is contemplated and in fact preferred that the energizing signals be supplied to more than one thread winding station with the plural thread guides traversing in synchronism with each other in executing the pre-selected winding program. The thread guide motor at each winding station is energized in parallel with the others and thus a malfunction at one station does not affect the operation of the others. Down time can therefore be held to a minimum.

The present invention also provides means for bringing a down winding station back into synchronism with those other winding stations which have been following a programmed winding pattern. Thus winding stations need not be even momentarily taken out of operation because of a malfunction at one or more other winding stations.

The console apparatus of the present invention is compact and may be located remotely relative to the winding stations being controlled. Its size increases only to a minor degree as the number of winding stations increases. Moreover, the individual winding stations may be positioned in closer proximity to each other than heretofore possible. The winding system consisting of both the control apparatus and the one or more winding stations takes up little space and therefore can be conveniently integrated into a continuous fiber manufacturing process. In addition, where plural winding stations are mounted on a single frame, some may be controlled from one console and others from a second console; each console developing a different winding program. The changeover of a winding station from one winding program to the other may then be accomplished by a substitution of electrical connectors or by a simple switching network.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings in which:

FIGURE 1 is a simplified diagrammatic illustration of the invention wherein plural thread winding stations are selectively controlled from a single console;

FIGURE 2 is a simplified electrical block diagram of the console and plural thread winding stations of FIGURE 1;

FIGURE 3 is a detailed electrical block diagram of the up/down clock pulse source, program control circuitry and selectable up/down chase limit circuitry seen generally in FIGURE 2;

FIGURE 4 is a detailed electrical block diagram of one of the console output circuits seen in FIGURE 2;

FIGURE 5 is a detailed electrical block diagram of the selectable package length circuitry and portions of the sync-in-program circuitry seen in FIGURE 2;

FIGURE 6 is a detailed electrical block diagram of the remaining portion of the sync-in-program circuitry seen generally in FIGURE 2.

FIGURE 7 is a graphical illustration of a simplified thread winding program.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Overall System

Referring now to the drawings and first to FIGURE 1, a plurality of winding stations, generally indicated at 10 and 10' are selectively controlled from a console, generally indicated at 12. While only two winding stations 10 are specifically shown in FIGURE 1, it will be appreciated that the console may be advantageously utilized to selectively control any number of such winding stations in fashioning desired thread packages. While the winding stations shown are ring twister stations, it will be appreciated that other types of winding stations, such as cap twisters, coning machines, quill winders, etc., may likewise be controlled by the principles of this invention.

The winding stations 10 each include a spindle 14 rotatably driven by a motor 15. Physically associated with the spindle 14 is a thread guide 16 which in the illustrated embodiment is in the form of a twisting ring having a wire loop 16' fitted thereon to travel about the inner circumference thereof. Thread 17 feeds from above through loop 16' to be twisted and wound on a thread carrier 19 as seen at winding station 10'. It will be appreciated that any of the various known forms of thread guides may be accommodated by the invention. The thread guide 16 threadably engages a lead-screw 18 rotatably driven by a motor 20. A supporting frame, generally indicated at 21, journals lead-screw 18 for rotation while maintaining its axial position fixed. Thus, rotation of the

lead-screw 18 by motor 20 in a first direction causes the thread guide to move upward relative to the spindle 14, while lead-screw rotation in the opposite direction causes the thread guide to move downward relative to the spindle.

In accordance with one embodiment of the invention, the lead-screw motor 20 takes the form of the stepper motor operating to rotate the lead-screw 18 in discrete increments in response to pulses received from the console 12. A SLO SYN electrical motor, model SS 400 1021, manufactured by the Superior Electric Co., has been found to be a suitable lead-screw motor 20.

In order to achieve stepping or indexing operation of the lead-screw motor 20, pulses are supplied from console 12 over cable 22 to a translator 24. The translator 24, such as a model ST 1800 manufactured by the Superior Electric Co., operates to translate each pulse received from the console into a suitable array of pulses energizing the plural windings of the lead-screw motor 20 to obtain the desired increment of lead-screw rotation in response to each received electrical pulse. The cables 22 connecting the various winding station translators 24 in parallel with the console 12 each include plural conductors, one carrying console pulses to the translator for producing lead-screw rotation in the first direction and the other carrying console pulses for producing lead-screw rotation in the opposite direction.

As will be seen, console pulses are supplied over one conductor of each cable 22 to cause the thread guides 16 to travel upwardly through a distance corresponding to the number of pulses received, and then console pulses are supplied over another conductor of each cable 22, causing the thread guides to travel downward through a distance again corresponding to the number of pulses received. In this manner, a thread package 30, shown at winding station 10', is formed.

Still referring to FIGURE 1, a plurality of microswitches 34, 36 and 38 are mounted on the frame 21 of each winding station. These microswitches are tripped by movement of the thread guide 16, thereby sending signals back to the console 12 over separate conductors of cables 22 indicating various reference positions of the thread guides 16. As will be described in connection with FIGURE 4, the uppermost microswitches 34 signal that the thread guides 16 have reached the uppermost limit of their travel. Microswitches 38, when tripped, signal the console 12 that the thread guides have reached their lower limit of travel and are thus in return positions. Microswitches 36 signal the console 12, when tripped, to indicate that the thread guides 16 are in start or ready positions from which to begin winding a thread package.

Turning now to FIGURE 2, the overall console operation is timed by an up/down clock pulse source 40. This source supplies clock pulses to program control circuitry 42 and also to selectable up/down chase limit circuitry 44. The program control circuitry 42 supplies package length (PL) counts to selectable package length circuitry 46, which, in effect, operates to keep track of the vertical positions of the thread guides 16 relative to their start positions. This circuitry is selectively conditioned to establish a desired thread package length and supplies to the program control circuitry 42 package length (PL) limit signals when the thread guides reach upper and lower limit positions corresponding to the desired package length.

The program control circuitry 42 operates, in effect, to pass up-clock pulses from source 40 to the separate console output circuits 48 associated with each winding station 10. The output circuits 48, in turn, transmit these up-clock pulses over the appropriate conductor of each cable 22 in order to produce upward travel or up chase movement of the thread guides 16. Simultaneously, the up/down chase limit circuitry 44 counts these up-clock pulses. This circuitry 44 is conditioned to count a selected number of up-clock pulses and then supply an up chase limit signal to the program circuitry 42.

In response thereto, the circuitry 42 operates, in effect, to terminate up chase movement and to pass down-clock pulses from clock pulse source 40 to the output circuits 48. These output circuits then supply these down-clock pulses over separate conductors of cables 22 to their respective winding stations 10 so as to produce downward travel or down chase movement of the thread guides 16. The selectable up/down chase limit circuitry 44 then counts these down-clock pulses and again signals the program control circuitry 42 when the count reaches a pre-set total. The program control circuitry reverts to an up chase mode wherein up clock pulses are again passed from the clock pulse source 40 to the output circuits 48. The thread guides then turns around from downward travel or down chase movement to upward travel or up chase movement.

In order for the thread guide 16 to traverse the selected thread package length established by the package length circuitry 46, the initial up chase length established by the chase limit circuitry 44 is greater than the down chase length. As a consequence, after the thread guides have completed a cycle including one up chase and one down chase, the next up chase begins at a point spaced above the beginning of the previous up chase by a distance equal to the difference between the established up and down chase lengths. Thus, it is seen that the thread guides 16 ultimately reach an upper positional limit corresponding to the selected package length set into the package length circuitry 46. This circuitry 46 having all the while received package length (PL) counts from the program control circuitry 42 thus to, in effect, track the positions of the thread guides 16, signals the program control circuitry when the thread guides reach positions corresponding to the package length desired. On this occasion, the program control circuitry 42 converts to a falling program mode wherein the up chase length set into chase limit circuitry 44 governs the extent of down chase movement of the thread guides and the down chase length governs the extent of up chase thread guide movement. As a consequence, the thread guides travel generally downward until ultimately reaching positions corresponding to the beginning of the package or the start position. The package length circuitry 46 then signals the program control circuitry 42 converting it to a rising program mode. The normal operation of the console is thus alternate rising and falling programs, each including a series of up and down chase movement of the thread guides 16. This would continue for typically many hours until the thread packages 30 (FIGURE 1) are built up to a desired diameter.

As will on occasion occur at some time during the overall winding program, a malfunction, such as a thread breakage, will occur at one of the winding stations 10. This winding station must be taken out of the program and the malfunction remedied. Then, the down winding station must be brought back into the winding program being followed by the other winding stations. The sync-in-program circuitry 50 serves this function. This circuitry receives clock pulses from the clock pulses source 40, program status signals from the program control circuitry 42, package length (PL) indicator signals from the package length circuitry 46 and chase limit signals from the chase limit circuitry 44. The program status signals indicate to the sync-in-program circuitry 50 that the program in progress is in either a rising or a falling program mode and in either an up or down chase. The package length indicator signals indicate to the circuitry 50 the approximate location of the program relative to the package start position. The chase limit signals indicate the thread guide turn around points, i.e., terminations of up and down chases.

Once the malfunction at the down winding station 10 has been remedied, its thread guide 16 is brought to the start position. From this position, the thread guide is moved upwardly with up-clock pulses passed by the cir-

cuitry 50 and then stopped at an appropriate position where it can wait for the winding program. At the precise instant when the program reaches the position of the waiting thread guide the sync-in-program circuitry 50 transfers control over it to the program control circuitry 42, whereupon it steps into the winding program. As will be seen, the sync-in-program circuitry 50 is also used at the very beginning of a winding operation to bring the winding stations successively into program.

10 Clock pulse source, program control, package length and chase limit circuitry.

Turning now to FIGURE 3, the up/down clock pulse source 40 (FIGURE 2) includes two separate pulse sources, one an up-clock multivibrator 60 generating the up-clock pulses and the other a down-clock multivibrator 62 generating the down-clock pulses. The up-clock pulses are gated in an AND driver 61 to provide gated up-clock pulses on output line 61a for application to the various output circuits 48 (FIGURES 2 and 4). Each gated up-clock pulse is effective to increment the thread guide motors 20 (FIGURE 1) producing a uniform increment of thread guide traverse in the up direction.

Similarly, down-clock pulses are gated in AND driver 63 to provide gated down-clock pulses on output line 63a for application to the various output circuits 48. Each gated down-clock pulse steps the thread guide motor in the opposite direction to produce a downward increment of traverse of the various thread guides 16.

The pulse repetition rates of multivibrators 60 and 62 may be varied by adjustment of resistance pots mounted on the front panel 12a of the console 12 (FIGURE 1), and, in practice, may be adjusted to different pulse rates for a winding program as, for example, 100 pulses per second for multivibrator 60 and 200 pulses per second for multivibrator 62.

To establish the length of the up and down chase movements of the various thread guides 16, an array of up chase switches 64 and a separate array of down chase switches 66 are included in the up/down chase limit circuitry 44 of FIGURE 2. These switch arrays are also mounted on the console front panel 12a. Each switch of the arrays 64 and 66 is preferably a simple two-position switch connected to serve as a digital switch. Thus the switches of each array represent different powers of the base two in the binary system and are pre-conditioned accordingly to set up the desired chase lengths in terms of the number of clock pulses necessary to achieve them. A binary up/down chase counter 68 counts combined gated up and gated down-clock pulses appearing on the output lead 69a of OR gate 69.

During an up chase, the counter 68 counts gated up-clock pulses and when it reaches the count set into the up chase switches 64, a comparison is sensed by a comparator 70. The comparator 70 may take the form of an AND gate whose inputs are taken from the contact arms of the individual switches of array 64. The contacts of each switch are connected to the set and reset outputs of the flip-flop stage of counter 68 corresponding to it in the binary number system. Thus, when the counter compares with the up chase switches 64, all inputs to the AND gate are logical ones and an output results. This output, the up chase limit signal, appears on output lead 70a of the comparator 70. Similarly, during a down chase the counter 68, having been reset to zero, counts gated down clock pulses on lead 69a until its count content compares with the down chase switches 66, whereupon a comparator 72 develops a down chase limit signal on output line 72a.

Still referring to FIGURE 3, the up chase and down chase limit signals are employed to control the state of an up/down chase flip-flop and a pair of flip-flops DECPUDC (decrement package length up/down counter) and INC-PLUDC (increment package length up/down counter). The counter PLUDC, as will be seen in connec-

tion with FIGURE 5, establishes and controls the length of the thread package by keeping track of the multiples of up and down chase difference.

Another flip-flop, the rise/fall flip-flop (FIGURE 3) operates to control what effect the up and down chase limit signals have on the up/down chase flip-flop, and flip-flops DEC-PLUDC and INC-PLUDC. Basically, the rise/fall flip-flop periodically effectuates a program reverse or a falling program mode wherein the up chase limit signal determines the down chase length and the down chase limit signal determines the up chase length.

Assuming a rising program mode as contrasted to a falling program mode, the rise/fall flip-flop, the up/down chase flip-flop and the flip-flops DEC-PLUDC and INC-PLUDC, all included in the control circuitry (FIGURE 2), are each in their reset state for an up chase. The reset output of the up/down chase flip-flop, being a logical ONE, is fed back on lead 74 to enable AND driver 61 to pass gated up/clock pulses. The logical ZERO at the set output of the up/down chase flip-flop disables AND driver 63 over lead 75 to block gated down/clock pulses. Thus as will be seen in FIGURE 4 only gated up-clock pulses are fed to the output circuits 48 and are counted by the up/down chase counter 68. The thread guides 16 travel upwardly and a count of their upward movement is accumulated in the counter 68.

Upon achieving the pre-set up chase length, the resulting up chase limit signal on line 70a is applied to one input of AND gates 78 and 79. Since the rise/fall flip-flop is reset, its logical ONE reset output enables AND gate 79 to pass the up chase limit signal through OR gate 80 to one input of AND gate 81. The logical ZERO set output of rise/fall flip-flop disables AND gate 78. Since the up/down chase flip-flop is also reset, AND gate 81 passes the up chase limit signal through to the gated set input of flip-flop DEC-PLUDC. However, this flip-flop is not set since its gated set input is disabled by the logical ONE reset output of the rise/fall flip-flop supplied thereto over lead 82.

The up chase limit signal passed by AND gate 81 is fed back over lead 84 to trigger a one-shot multivibrator 85. One of the resulting outputs on lead 87 from this multivibrator is used to reset the up/down chase counter to zero while its other concurrent output on lead 88 is applied to the gated set and reset inputs of the rise/fall flip-flop and the up/down chase flip-flop. The rise/fall flip-flop remains in its reset state since the outputs from AND gates 90 and 91 and logical ZEROES as will be brought out later. However, the up/down chase flip-flop is switched from its reset to its set state by the output of the multivibrator 85 since its gated set input is enabled by the up chase limit signal at the output of OR gate 80. As a matter of timing, the up/down chase flip-flop is set on the leading edge of the multivibrator output on line 88 and then the up/down chase counter is reset to zero by the trailing edge of the multivibrator output on line 87.

It is now seen that the up/down chase flip-flop, being in set condition, is effective to terminate the gated up-clock pulses by disabling AND driver 61 while enabling AND driver 63 to pass down-clock pulses. The thread guides 16 are thus moved downwardly in a down chase and a count of its downward movement is accumulated in the up/down chase counter 68. When the down chase length established by the down chase length switches 66 is achieved, the down chase limit comparator 72 develops the down chase limit signal on output 72a which is applied to one input of AND gate 92 and one input of AND gate 93 (FIGURE 3). Since the rise/fall flip-flop is still reset, the down chase limit signal passes through AND gate 92 and OR gate 94 to one input of AND gate 95. Since the up/down chase flip-flop is in the set condition, AND gate 95 passes the down chase limit output through to the gated set input of the INC-PLUDC flip-flop. The reset condition of the rise/fall flip-flop,

signalled over lead 96, enables the INC-PLUDC to be set by the down chase limit signal. This flip-flop is immediately reset by the next occurring ungated down-clock pulse supplied to its gated reset input over lead 97.

The set output of the INC-PLUDC flip-flop is fed to the increment or count-up input of a reversible binary counter PLUDC (package length up/down counter) seen in FIGURE 5. The transition of the INC-PLUDC flip-flop from its reset to its set and back to its reset state produces a pulse at its set output which is effective to increment the counter one count.

Returning to FIGURE 3, the down chase limit signal at the output of AND gate 95 is fed back over line 98 to trigger the one shot multivibrator 85. As in the case of the up chase limit signal, the multivibrator output on line 87 resets the up/down chase counter 68 to zero. The other multivibrator output on line 88 is ineffective to change the state of the rise/fall flip-flop because of the disabling effect of AND gates 90 and 91, but is effective to trigger the up/down chase flip-flop to its reset state due to the presence of the down chase limit signal at the output of OR gate 94. Thus, AND driver 63 is disabled while AND driver 61 is enabled to pass gated up-clock pulses pursuant to an up chase mode. From the description thus far it is seen that the system alternates up chase and down chase modes producing corresponding upward and downward traversing movement of the thread guides 16 (FIGURE 1). Each time the INC-PLUDC flip-flop is triggered, this occurring each time the thread guides 16 turn around from a down chase to an up chase, the counter PLUDC (FIGURE 5) is incremented. Since in a typical winding program the up chase length established by up chase switches 64 exceeds the down chase length established by down chase switches 66 by a selected chase difference, the point of turn around of the thread guides from a down chase to an up chase is spaced above the preceding corresponding turn around point by a distance equal to the chase difference. It is seen that since the counter PLUDC counts these turn around points, this counter is actually counting multiples of chase difference and in effect serves as a locator of the position of the thread guides at any time during a winding program.

It is further seen that by virtue of this chase difference, that the thread guides 16 will progress generally upward, thereby winding thread over substantially the entire length of the thread carriers.

Turning now to FIGURE 5, the count content of the counter PLUDC is compared in a comparator 100 with the setting of package length digital switches 102. The setting of the package length switches 102 establishes the package length in terms of the number of chase differences required to achieve it. This is done since the counter PLUDC is connected so as to count multiples of chase difference. When the chase difference count in the counter PLUDC compares with the chase difference setting in package length switches 102, the comparator 100 produces an output $PLUDC=PL$ on line 100a. This output is supplied to one input of AND gate 90 seen in FIGURE 3. The other input to AND gate 90 is derived from the reset output of the up/down chase flip-flop.

This circuit arrangement is provided because the thread guides will naturally reach the positional limit corresponding to the desired package length during an up chase mode. Thus, AND gate 90 enables the gated set input of the rise/fall flip-flop during the final up chase mode bringing the thread guides 16 up to the full package length. At the conclusion of the final up chase mode, the up chase limit signal from comparator 70 passes through AND gate 79, OR gate 80, and AND gate 81 and is fed back over lead 84 to trigger the one shot multivibrator 85. The resulting output on multivibrator line 88 is now effective to trigger the rise/fall flip-flop to its set state as well as to trigger the up/down chase flip-flop to its set state. The rise/fall flip-flop being in its set con-

condition institutes a falling program mode while the set condition of the up/down chase flip-flop institutes a down chase mode. Thus, the up/down chase flip-flop exerts the same control on the up and down chase modes as it did before the rise/fall flip-flop was set. However, the rise/fall flip-flop, now being set, operates to, in effect, reverse the controlling effect of the up and down chase limit signals issuing from comparators 70 and 72. In other words, in a falling program the up chase limit signal on lead 70a establishes the length of down chase movement while the down chase limit signal establishes the length of the up chase movement.

Accordingly, immediately after the rise/fall flip-flop is set, the first chase mode instituted is a down chase due to the fact that the up-down flip-flop is set. The set output of the rise/fall flip-flop enables AND gates 78 and 93 while its reset output disables AND gates 79 and 92. During this first down chase of the falling program, the down chase limit signal will appear on comparator output line 72a. This signal will pass through AND gate 93 and OR gate 80, but is blocked by AND gate 81 due to the set condition of the up/down chase flip-flop. Thus, the down chase limit signal is disregarded during each down chase of a falling program. It will be noted that the down chase limit signal, by virtue of the gated circuitry employed, is also disregarded during up chases of a rising program. Shortly after the occurrence of the down chase limit signal, the up chase limit signal will appear on comparator output line 70a. This signal is passed through AND gate 78, OR gate 94, and AND gate 95 to the gated set input of flip-flop INC-PLUDC. The gated set input of this flip-flop is permanently disabled during a falling program mode by the set output of the rise/fall flip-flop supplied over lead 96 just as the flip-flop DEC-PLUDC is permanently disabled during a rising program mode by the reset output of the rise/fall flip-flop supplied over lead 82. The up chase limit signal at the output of AND gate 95 is effective to trigger the multivibrator 85 over lead 98. The multivibrator output on line 87 resets the up/down chase counter 68 while its output on line 88 resets the up/down chase flip-flop. It is noted that the rise/fall flip-flop is not triggered since AND gates 90 and 91 are disabled. The up/down chase flip-flop, being reset, institutes an up chase mode.

During this first up chase in a falling program mode, the down chase limit signal will appear on comparator output lead 72a. This signal is passed through AND gate 93, OR gate 80 and AND gate 81 to the gated set input of flip-flop DEC-PLUDC. In a falling program mode, the gated set input of the flip-flop DEC-PLUDC is permanently enabled from the reset output of the rise/fall flip-flop supplied over lead 82. Thus, the flip-flop DEC-PLUDC is set and then reset again by the next occurring ungated down-clock pulse on line 97. The resulting pulse at the set output of the flip-flop DEC-PLUDC is supplied to the decrement or count down input of counter PLUDC (FIGURE 5). This counter thus counts down one count from the chase difference multiple total accumulated during the previous rising program mode.

From the foregoing description, it is seen that during a falling program, the thread guides 16 (FIGURE 1) progress generally downward and each time the thread guides 16 turn around from an up chase to a down chase, the counter PLUDC is decremented one count. Ultimately, the thread guides 16 will reach the package start position during the final down chase of a falling program mode. This final down chase is signified when the count content of counter PLUDC is zero. To signal this condition, the logical ZERO outputs of the plural binary stages of counter PLUDC are supplied to a multi-input AND gate 104 (FIGURE 5). When all the inputs to AND gate 104 are true, signifying a zero count in counter PLUDC, output PLUDC=0 issues therefrom. This output is used to enable AND gate 91 in FIGURE 3. Dur-

ing this final down chase of a falling program, the up/down chase flip-flop is set and its set output qualifies AND gate 91 to enable the gated reset input of the rise/fall flip-flop. At the end of this final down chase, the up chase limit signal on comparator output line 70a is transmitted through AND gate 70, OR gate 94, AND gate 95 and over lead 98 to trigger multivibrator 85. The resulting multivibrator output on line 88 triggers the rise/fall flip-flop to its reset state thereby conditioning a rising program mode which is carried out in the manner already described.

It is thus seen that the above-described program control circuitry 42 in conjunction with the selectable package circuitry 46 and the selectable up/down chase circuitry 44 (FIGURE 2) institutes alternate rising and falling winding programs, each including a series of up and down chases. The resulting movement of the thread guides 16 (FIGURE 1) is illustrated in FIGURE 7. In the abbreviated winding program shown in FIGURE 7, it is assumed that the initial up chase length set into up chase switches 64 (FIGURE 3) is 7 inches while the initial down chase length set into down chase switches 66 is 6.92 inches. Thus, during a rising program, the thread guides 16 travel upwardly 7 inches during an up chase and turn around to travel 6.92 inches downwardly during each down chase. Thus, as seen in FIGURE 7, the thread guides 16 gain 0.08 inch in height at the conclusion of each down chase during a rising program. Correspondingly during a falling program mode the thread guides lose 0.08 inch in height at the conclusion of each down chase inasmuch as the initial up chase length set into switches 64 (FIGURE 3) governs the down chase movement and vice versa.

Assuming that each up or down-clock pulse produces 0.01 inch of movement of the thread guides in the appropriate direction, the number 700 in binary form is set into up chase switches 64. The number 692 in binary form is set into down chase switches 66. Assuming that the desired package length is 7.24 inches, the number 3 in binary form is set into the package length switches 102 (FIGURE 5). As seen in FIGURE 7, in order to achieve a package length of 7.24 inches the thread guides must traverse upwardly through three chase difference multiples plus an additional up chase, i.e.

$$3(7.00 - 6.92) + 7.00 = 7.24 \text{ inches}$$

Accordingly, the appropriate multiple of the chase difference, in this case 3, is set into the package length switches 102 (FIGURE 5).

As previously noted in connection with FIGURES 3 and 5, the counter PLUDC is incremented one count in a rising program each time the thread guides turn around from a down chase to an up chase. This is shown in FIGURE 7. Thus, as the thread guides 16 proceed on the last up chase of a rising program mode, the counter PLUDC has accumulated a three count which compares with the number 3 set into the package length switches 102 in FIGURE 5. Thus, as previously described, AND gate 90 is qualified during this final rising program up chase to enable the gated set input of the rise/fall flip-flop, and it is set at the conclusion of the up chase to institute a falling program mode.

As also seen in FIGURE 7 and as described in conjunction with FIGURES 3 and 5, the counter PLUDC is decremented one count during the falling program each time the thread guides turn around from an up chase to a down chase. The progressive count content of this counter is indicated in FIGURE 7. As the thread guides turn around from the last up chase to the final down chase leading to the packaged start position, the counter PLUDC is decremented to a zero count. Thus, AND gate 91 is qualified during this last down chase to enable the gated reset input of the rise/fall flip-flop in FIGURE 3. At the conclusion of this last down chase, the down chase limit signal acting through multivibrator 85

is effective to trigger the rise/fall flip-flop to its reset state, thus instituting another rising program. Subsequent rising and falling program modes are carried out in the same manner in order to ultimately build up the thread packages the desired diameter.

It will be appreciated that the above-described winding program has been abbreviated for purposes of this description. In practice, the package length may be on the order of 13 inches and thus there are considerably more up and down chases included in each rising and falling program than are shown in FIGURE 7. In the situation where a 13 inch thread package is desired, it is seen that with initial up and down chase settings of 7.00 and 6.92 inches, respectively, that 75 chase difference multiples are required to achieve this selected package length. Thus, the number 75 in binary form is set into the package length switches 102 of FIGURE 5.

Output circuitry

Referring now to FIGURE 4 wherein one of the similarly constructed output circuits 48 is shown in detail, a switch S1 is closed to complete an energizing circuit for a relay K1 from a negative 24-volt supply through one of a plurality of microswitches 33 to ground. This one microswitch establishes an emergency stop upper limit position and corresponds to microswitch 34 (FIGURE 1). The two contacts of relay K1 close to connect conductors 110 and 112, included in cable 22 (FIGURE 1), respectively, to up and down chase input terminals of translator 24. Should the upward movement of the thread guides 16 exceed a predetermined maximum, microswitches 34 are tripped by the thread guides to break the energizing circuit for relays K1. The console 12 is thus disconnected from the winding stations 10 and traverse of the thread guides is stopped.

While the various thread guides 16 are following a winding program, a flip-flop RUN included in each output circuit 48 is in its set condition to enable AND gates 114 and 115. The other input to AND gate 114 is connected to lead 61a carrying gated up-clock pulses, and thus these pulses are passed through this AND gate and OR driver 118 to conductor 110 and the up chase input of translator 24. Similarly, the other input of AND gate 115 is connected to lead 63a carrying gated down-clock pulses which are passed through OR driver 120 and over conductor 112 to translator 24 pursuant to a down chase mode.

Should a malfunction, such as a thread breaking, occur at one of the winding stations 10, a switch S2, mounted on the console panel 12a is thrown to its off position. The off contact of switch S2 is connected through a resistor R1 to a negative 24-volt supply while its contact arm is grounded. Thus, switching to the off position produces a positive going signal transition on lead 125 which is passed through diode D1 to trigger the RUN flip-flop to its reset state. AND gates 114 and 115 are thus disabled, terminating chase movement of the associated thread guide 16.

The ON contact of switch S2 is similarly connected through a resistor R2 to a negative 24-volt supply. Since the ON contact is no longer grounded by the arm of switch S2, a negative signal level is supplied over lead 126 as an enabling input to AND gate 128. A second input to this AND gate is constituted by ungated down-clock pulses supplied over lead 97 (FIGURE 3). The third input to AND gate 128 is derived from the junction between resistor R3 and a negative 24-volt supply. This junction is also connected through return microswitch 38 (FIGURES 1 and 4) to ground. This return microswitch is normally open, and is closed only when the thread guide 16 reaches the return position preferably located at the point of lowest possible movement of the thread guide 16. Until microswitch 38 is closed by the thread guide reaching the return position, a negative signal level is supplied as the third input to AND gate 128. Thus, with switch S2 turned off AND gate 128 is fully enabled to pass ungated down-clock pulses through OR driver 120

and over conductor 112 to the down chase input or translator 24. The thread guide 16 is thus moved downwardly from whatever position it had achieved toward the return position when switch S2 is turned off. Upon reaching the return position, microswitch 38 closes to supply a disabling ground input to AND gate 128. The thread guide thus remains at the return position while the malfunction is remedied.

When the machine station is ready to go back into program, switch S2 is turned on. This serves to disable AND gate 128 while at the same time supplying an enabling negative signal input to AND gate 130. A second input to AND gate 130 is derived from the junction of resistor R4 and a negative 24-volt supply. This junction is connected through start microswitch 36 (FIGURES 1 and 3) to ground. The start microswitch is normally closed when the thread guide 16 is anywhere between the start position and emergency stop position but is open while the thread guide is at the return position or between this position and the start position. It is seen that while start microswitch 36 is open the junction at the upper terminal of resistor R4 is negative so as to further enable AND gate 130. The third input to AND gate 130 is ungated down-clock pulses supplied over lead 97 (FIGURE 1). Consequently, these ungated down-clock pulses are passed through OR driver 118 and over conductor 110 to the up chase input terminal of translator 24. The thread guide 16 is thus translated from the return position upwardly toward the start position. On reaching the start position microswitch 36 closes to apply a disabling ground input to AND gate 130. The thread guide is thus stopped at the return position, which preferably corresponds to the package start position preparatory to insertion into the winding program in progress.

It is to be noted that up and down-clock pulses can produce thread guide movement in either direction merely by routing them to the appropriate translator input terminal. In practice, it is preferable to use those clock pulses which are pre-set to the faster repetition rate for the purpose of translating the thread guides into position for insertion into a winding program.

As will be more clearly seen later, the sync-in-program circuitry 50 (FIGURES 2, 5 and 6) operates in conjunction with one of the output circuits 48 to move its associated thread guide 16 from its ready position upwardly into position for insertion into the winding program in progress. To initiate this function, a push button S3, located on the console front panel 12a, is depressed to set a flip-flop SIP. It is noted that closure of the ready microswitch 36 supplies an enabling signal level over lead 135 to qualify the gated set input of flip-flop SIP. Thus, flip-flop SIP can be set by push button S3 only when its associated thread guide 16 is in the ready position. The set output of the SIP flip-flop enables AND gate 136 to pass ungated down-clock pulses supplied over lead 137 from the sync-in-program circuitry 50 through to conductor 110 and the up chase input terminal of translator 24. The thread guide 16 is thus moved upwardly to an appropriate position from which it can step into the winding program in progress. When it is determined by the sync-in-program circuitry 50 that the winding program has progressed to the position of the waiting thread guide, the flip-flop SIP is reset by an end sync pulse supplied over lead 140. As this flip-flop resets, the RUN flip-flop is set to enable AND gates 114 and 115 whereby the thread guide 16 is launched properly into the winding program.

Sync-in-program circuitry

Referring to FIGURES 5 and 6, the sync-in-program circuitry 50 operates in conjunction with the counter PLUDC and the output circuits 48 (FIGURE 4) to bring a thread guide into the winding program in progress. It will be appreciated that it would be impractical to terminate the winding operation at all stations in the event of a thread breakage at any one. It is therefore an important feature of the present invention that only the

winding station where a thread breakage or other malfunction occurs is taken off program while the remaining winding stations are permitted to continue in the winding program. In addition, the sync-in-program circuitry 50 is used at the very beginning of a winding operation to successively bring the winding stations 10 into the selected winding program since generation of the winding program begins when the system is turned on. As will be seen, the winding stations can be synchronized into the program at any time, regardless of where the program is.

To bring a thread guide 16 from its ready position into the winding program, the push button S3 of the associated output circuit 48 (FIGURE 4) is depressed to set the flip-flop SIP. The reset outputs of the flip-flops SIP in each output circuit 48 are gated together in an AND gate 150 (FIGURE 6) whose output on lead 150a is commonly connected to one terminal of the various push buttons S3. When one of the flip-flops SIP is set, AND gate 150 serves to disable the push buttons S3 in the other output circuits so that only one winding station 10 can be brought into program at a time. The output of AND gate 150, when one of the flip-flops SIP sets, serves to set a control flip-flop SIP (FIGURE 6) whose set output then enables AND gate 152. The output of AND gate 152 thus enables AND driver 154 to pass ungated down-clock pulses on lead 97 (FIGURE 2) over lead 137 to one input of AND gate 136 in the output circuit 48 (FIGURE 4). This AND gate is enabled by the set condition of flip-flop SIP to pass ungated down-clock pulses over conductor 110 to the up terminal of translator 24. The associated thread guide 16 is thus stepped upwardly incident to being brought into the winding program.

The ungated down-clock pulses issuing from AND driver 154 on conductor 137 are also applied over lead 160 to increment asynchronization chase difference counter SCDC, seen in FIGURE 5. The count content of this counter is compared with chase difference switches 162 in a comparator 164. Switches 162 are set to express the difference between the settings of up chase switches 64 and down chase switches 66 (FIGURE 3). Each time the counter SCDC counts the number of ungated down-clock pulses equalling the chase difference set into chase difference switches 162, comparator 164 provides an output on line 164a which is used to increment a synchronization package length counter SPLC and to also trigger a multi-vibrator 166 which resets counter SCDC to zero. Thus, the counter SCDC repeatedly counts ungated down-clock pulses up to the chase difference, while counter SPLC counts multiples of chase difference as the one thread guide 16 moves upward into position for insertion into the program.

It is thus seen that the counter SPLC is counting in the same terms as the package length up/down counter PLUDC. When the counts of these two counters compare as sensed by a comparator 170, an output $SPLC=PLUDC$ on lead 170a is generated. Returning to FIGURE 6, the signal $SPLC=PLUDC$ on lead 170a is applied to AND gates 172 and 174 and to the gated set input of flip-flop 176.

Assume that the program illustrated in FIGURE 7 is either in the second up chase 177 or the second down chase 178 of a rising program mode. The count in the counter PLUDC is one. When the thread guide 16 being brought into program moves up 0.08 inch, the counter SCDC (FIGURE 5) contains a count of eight which compares with the setting of the chase difference switches 162. Accordingly, the comparator 164 generates the signal $SCDC=CD$ on line 164a which increments the counter SPLC from zero to a one count. As a result, the counters SPLC and PLUDC compare and the output $SPLC=PLUDC$ issues on comparator output line 170a. This output is applied to the gated set input of flip-flop 176 (FIGURE 6). At the same time, the counter SCDC is reset and begins counting to eight, the chase difference,

again while the thread guide moves up another 0.08 inch as indicated by the arrow 179 in FIGURE 7. When the counter SCDC again reaches a count of eight, the output $SCDC=CD$ on comparator output lead 164a, also applied to the gated set input of flip-flop 176 with signal $SPLC=PLUDC$ sets this flip-flop. The set output of flip-flop 176 enables AND gate 180 while its reset output, going to a logical zero, disables AND gate 152 which, in turn, disables AND driver 154. As a consequence, ungated down-clock pulses are no longer passed on lead 137 and the thread guide is stopped in a position, indicated at 182, to wait for the program at the bottom of the second down chase.

When the program reaches the bottom of the second down chase, AND gate 180 is fully enabled by the down chase limit signal on comparator output lead 72a (FIGURE 3) and the set output of the up/down chase flip-flop on lead 183 (FIGURE 3), and the resulting output is passed through an OR gate 184 to trigger an end sync multivibrator 186. The resulting output from this multivibrator on lead 140 resets flip-flop SIP in the output circuit 48 (FIGURE 4) associated with the winding station 10 being brought into program. This results in flip-flop RUN being set, and its set output enables AND gate 114 to pass gated up-clock pulses to the translator 24 as the program swings into the third up chase and the thread guide moves up in program. It is also noted that the output of end sync multivibrator 186 is also supplied over lead 189 to reset the common flip-flop SIP, flip-flop 176 and the counter SPLC (FIGURE 5).

It is seen from the foregoing description that depression of the push button S3 initiating a sync-in-program function must be timed with the program in order that the thread guide reaches position 182 before the program does. However, the thread guide should not wait at position too long as then, with the spindle 14 rotating, thread will build up excessively at that position. It has been found that an operator readily develops the requisite timing skills to properly carry out this operation. In practice, the operator starts the thread on a waste spool (not shown) beneath the carrier 19 with the thread guide in the return position and the spindle 14 rotating. Switch S2 is then turned on and the thread guide moves up to the start position. After a momentary pause to create a thread tail sometimes used in later processing, the push button S3 is depressed. Thus, in practice, the thread guide starts into a sync-in-program function from the return position and therefore switch S2 must be turned on at the proper time in order to get the thread guide to position 182 in time.

If the program is in a falling mode when a sync-in-program function is initiated, AND gates 172 and 174 come into play. First let it be assumed that the program is in the second down chase of a falling program mode, indicated at 190 in FIGURE 7, when a thread guide 16 is moved upward from the ready position. At this time, the counter in the counter PLUDC is two so the thread guide will move up two chase differences or 0.16 inch as indicated by arrow 192 to point 191 whereupon the signal $SPLC=PLUDC$ is generated from comparator 170 (FIGURE 5). As seen in FIGURE 6, this signal is applied to AND gate 172 together with the set output of the rise/fall flip-flop on lead 193 (FIGURE 3), the set output of the up/down flip-flop on lead 183 (FIGURE 3), and the set output of the common flip-flop SIP on lead 195. This latter input prevents this gate from opening during normal operation when counter PLUDC contains a zero count. It is seen that during the second down chase of a falling program mode AND gate 172 is fully enabled when the thread guide reaches position 191 (FIGURE 7), and an output is passed to set flip-flop 197. The set output of this flip-flop thus enables AND gate 198 while its reset output disables AND gate 152, thereby stopping the thread guide at position 181. The other inputs to AND gate 198 are the set output of the up/down chase flip-flop on lead 183 and the

15

up chase limit signal on lead 70a (FIGURE 3) which, during a falling program mode, serves as the down chase limit signal. When the program comes to the end of the second down chase where the one thread guide is waiting, AND gate 198 is fully enabled and its output is passed through OR gate 184 to trigger the end syn multivibrator 186. As before, this multivibrator resets flip-flops SIP of the output circuit 48 (FIGURE 4) associated with the winding station being brought into program, which, in turn, sets flip-flop RUN and enables AND gate 114. Gated up-clock pulses are thus passed to the translator and the associated thread guide 16 steps off into program.

AND gate 174 in FIGURE 6 handles the situation when the syn-in-program function is instituted while the program is in an up chase of a falling program mode. Assume for purposes of description that the program is in the first up chase after the start of a falling program mode as indicated at 200 in FIGURE 7. At this time, the counter PLUDC contains a three count and the one thread guide will move up three chase differences or 0.24 inch as indicated by arrow 201 to position 202 before the signal $SPLC=PLUDC$ appears. AND gate 174 is enabled by the set output of the rise/fall flip-flop on lead 193 (FIGURE 3) and the reset output of the up/down flip-flop on lead 204 (FIGURE 3) to pass the signal $SPLC=PLUDC$ through to set flip-flop 176. This flip-flop disables AND gate 152 and qualifies AND gate 180. The application of ungated down-clock pulses to the output circuit 48 (FIGURE 4) is terminated and the one thread guide stops at position 202 in FIGURE 7 to await the program.

When the program swings into down chase 190 leading to position 202, AND gate 18 is further enabled by the set output of the up/down chase flip-flop on lead 183 (FIGURE 3). On reaching position 202, the down chase limit signal appears on the comparator output lead 72a (FIGURE 3). This signal is passed through AND gate 180 to trigger the end sync multivibrator 186 terminating the sync-in-program function as previously described. Gated down-clock pulses are fed to the translator 24 (FIGURE 4) and the thread guide 16 moves in program downward to position 191 and then swings into the next up chase.

When at least one thread guide is following a program, the operator can ascertain where the program is by observing its traversing movement. However, at the beginning of a winding operation before any of the thread guides have been put into the winding program the operator has no way of telling where the program is. For this situation, means in the form of a system reset push button S4, shown in FIGURE 5, is provided. This push button, when depressed, generates a ground pulse which is effective to reset all flip-flops and counters, thus to start the program at its beginning. As is seen in FIGURE 5, depression of push button S4 triggers multivibrator 166 and a master reset multivibrator 210 whose resulting pulse outputs reset counters SCDC and PLUDC to zero. In addition, the push button generated ground pulse is supplied on lead 212 to trigger multivibrator 85 (FIGURE 3), thus resetting the up/down chase counter 68 to zero. Moreover, the pulse output from master reset multivibrator 210 is supplied over lead 214 to insure that all flip-flops RUN in the output circuits 48 (FIGURE 4) are in their reset states and that the rise/fall flip-flop and the up/down chase (FIGURE 3) are also reset. Thus it is seen that the winding program starts again at the package start position established by the positioning of the ready microswitch 36 on frame 21 (FIGURE 1). It is appreciated that the positions of the ready microswitch 36 may be readily adjusted to establish any desired start position relative to the bobbin or thread carriers 19 on spindle 14.

SUMMARY

From the foregoing detailed description, it is seen that the invention provides thread winding apparatus whose

16

operation can be readily and conveniently varied to form a wide variety of thread packages. It will be appreciated that the number of package forms obtainable from the disclosed apparatus may be increased considerably by incorporating additional apparatus to accomplish any or all of the following at selected times during a winding program—vary the rotational velocity of the spindles, vary the pulse rates of clock multivibrators 60 and 62, and vary the up and down chase lengths established by switches 64 and 66.

The various switch inputs establishing a winding program may be replaced with other forms of known data processing system input means such as punch or magnetically coded cards and tape, etc. While only a single thread guide 16 and spindle 14 is shown in FIGURE 1 in association with each lead-screw 18, it will be appreciated that plural laterally or vertically spaced thread guides may be driven off the same lead-screw. Alternatively, a motor 20 may drive plural lead-screws 18, each in turn driving one or more thread guides. Moreover, it will be appreciated that the present invention may be applicable to winding strand material other than thread as well as to controlling instrumentalities other than winding apparatus. Also, it will occur to those skilled in the art that the invention may be modified to provide analog rather than pulse output signals for controlling movement of the thread guides.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention, which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. Apparatus for controlling a thread winder having a spindle for rotating a carrier onto which thread is wound to form a thread package and a traverse mechanism operable to produce relative movement of a guide and the carrier, thus guiding the thread as it is being wound, said apparatus comprising, in combination

(A) a signal generator connected to supply alternately first and second output signals to the winder,

(1) said first output signal producing relative movement of the guide and carrier in a first direction, and

(2) said second output signal producing relative movement of the guide and carrier in a second direction;

(B) adjustably conditioned means alternately accumulating said first and second output signals, said means

(1) operating in response to said alternating first and second output signals to control the supply thereof by said generator to the winder; and

(C) adjustably conditioned means responsive to said accumulating means for controlling said signal generator such as to establish the overall limits of the relative movement of the guide and carrier,

(1) whereby to establish a desired thread package form.

2. The apparatus defined in claim 1 wherein

(1) said signal generator provides said first and second output signals in the form of separate pulse trains,

(a) each pulse thereof being effective to produce a discrete increment of relative movement of the guide and carrier.

3. The apparatus defined in claim 2 wherein said accumulating means includes

- (1) input means expressing the extent of desired bi-directional relative movement of the guide and carrier in terms of the numbers of output signal pulses required,
- (2) a counter counting said output signal pulses and
- (3) comparator means for comparing the count content of said counter to the numbers expressed by said input means and, upon comparison, generating an output to said generator effective to terminate one pulse train and initiate the other.
4. Apparatus for controlling at least one thread winding station having a spindle mounting a thread carrier for rotation, a thread guide driven by a traverse mechanism for up and down chase movements relative to the spindle so as to guide the thread being wound on the carrier pursuant to a selected winding program for forming a desired thread package, and a motor driving the traverse mechanism, said apparatus comprising, in combination:
 - (A) a clock pulse source generating first and second pulse trains;
 - (B) selectable up/down chase limit circuitry preconditioned to establish the desired extent of up and down chase movement;
 - (C) selectable package length circuitry preconditioned to establish a desired thread package length;
 - (D) program control circuitry including
 - (1) first circuit means responsive to said limit circuitry for alternately passing a predetermined number of pulses from said first clock pulse train to the motor in order to achieve up chase movement of the guide and pass a predetermined number of pulses from said second clock pulse train to the motor in order to produce down chase movement of the guide, and
 - (2) second circuit means responsive to said package length circuitry for establishing alternate rising and falling winding program modes,
 - (a) said second circuit means operating to alter the response of said first circuit means to said chase limit circuitry,
 - (b) whereby to alter the number of pulses from said first and second clock pulse trains passed to the motor for different program modes.
5. The apparatus defined in claim 4 wherein each pulse of said first and second pulse trains is effective to produce a predetermined increment of up or down chase movement of the guide relative to the spindle, said chase limit circuitry including
 - (1) a counter operating to count pulses from said first and second pulse trains up to a first predetermined total and thereupon generate an up chase limit signal, and count up to a second predetermined total and thereupon generate a down chase limit signal,
 - (a) said up and down chase limit signals being supplied to said first circuit means.
6. The apparatus defined in claim 5 wherein said first and second predetermined totals differ by a predetermined chase difference, and
 - (1) said second circuit means controls the response of said first circuit means to said up and down chase limit signals such that the cumulative movement of the thread guide is upward relative to the spindle during said rising winding program modes and downward relative to the spindle during said falling winding program modes.
7. The apparatus defined in claim 6 wherein said package length circuitry
 - (1) receives count inputs from said program control circuitry indicative of the upward movement of the guide during each said rising winding program mode and the downward movement of the guide during each said falling winding program mode,
 - (2) operates to convert said second circuit means from a rising winding program mode to a falling program

- mode when the thread guide reaches an upper limit position relative to the spindle, and
- (3) operates to convert said second circuit means from a falling winding program mode to a rising winding program mode when the thread guide reaches a lower limit position relative to the spindle,
 - (a) the distance between said upper and lower limit positions corresponding to a selected thread package length.
8. The apparatus defined in claim 7 wherein said package length circuitry includes
 - (1) a reversible binary counter connected to said first circuit means and operating to count multiples of said predetermined chase difference as the guide moves according to said rising and falling winding program modes,
 - (2) digital switches expressing the desired length of the thread package in terms of the number of chase difference multiples required,
 - (3) a comparator comparing the content of said reversible counter with the number set in said digital switches and upon comparison generating a first signal as the thread guide approaches said upper limit position,
 - (4) a coincidence circuit connected to said reversible counter and generating a second signal when its count content is zero to thereby signify the approach of the thread guide to said lower limit position.
9. The apparatus as defined in claim 8 wherein said program control circuitry further includes
 - (1) gating circuitry conditioned by said second circuit means operating in response to said first and second signals such that
 - (a) said up chase limit signal establishes the length of each up chase movement during each said rising winding program mode and the length of each down chase movement during each said falling program mode,
 - (b) said down chase limit signal establishes the length of each down chase movement during each said rising winding program mode and the length of each up chase movement during each said falling winding program mode.
10. Apparatus for controlling at least one thread winding station having a spindle mounting a thread carrier for rotation, a thread guide driven by a traverse mechanism to guide thread being wound on the carrier to form a desired thread package, and a motor driving the traverse mechanism, said apparatus comprising, in combination:
 - (A) a signal generator generating a preselected winding program of alternate rising and falling program modes, each mode including a plurality of alternate up and down chase modes,
 - (1) said generator generating said winding program in form of alternating first and second pulse trains each containing a predetermined number of pulses;
 - (B) an output circuit for each winding station operating to pass first and second pulse trains to the motor such as to produce alternate up and down chase movements of the guide in both said rising and falling program modes,
 - (1) each pulse of said first and second pulse trains being effective to produce a predetermined increment of up or down chase movement; and
 - (C) synchronization circuitry electrically connected to said signal generator and each said output circuit, said circuitry
 - (1) operating to pass pulses to one of said output circuits pursuant to bringing its associated thread guide from a reference position to an appropriate position for insertion into the wind-

ing program being generated by said signal generator.

11. The apparatus defined in claim 10 wherein
 - (1) said signal generator transmits an array of status signals to said synchronization circuitry designating the chase mode and the program mode of the winding program currently being generated.
12. The apparatus defined in claim 10 which further includes
 - (E) means located at each winding station operating to supply a signal to its associated output circuit inhibiting operation of said synchronization circuitry until the associated thread guide reaches said reference position.
13. The apparatus defined in claim 11 wherein the extent of up and down chase movements differ by a predetermined chase difference in both said rising and falling program modes, and said signal generator includes
 - (1) a clock pulse source generating first and second pulse trains,
 - (2) selectable up/down chase limit circuitry preconditioned to establish the desired extent of thread guide up and down chase movement, said circuitry including
 - (a) counting means counting pulses from said first and second pulse trains up to a first predetermined total and thereupon generating an up chase limit signal, and counting up to a second predetermined total and thereupon generating a down chase limit signal,
 - (3) program control circuitry including
 - (a) a first flip-flop conditioned by said chase limit signals to alternately pass said first and second predetermined pulse totals from said first and second pulse trains to each said output circuit,
 - (i) thereby to establish said alternate up and down chase modes, and
 - (b) a second flip-flop operating to modify the response of said first flip-flop to said chase limit signals,
 - (i) thereby to alternately condition said rising and falling program modes wherein cumulative movement of each thread guide is upward relative to its spindle during each said rising program mode and downward during each said falling program mode,

- (4) selectable package length circuitry preconditioned to establish a desired thread package length, said circuitry including
 - (a) reversible counting means counting the number of selected responses of said first flip-flop to said chase limit signals during a rising program mode to a predetermined total corresponding to the desired thread package length and thereupon conditioning said second flip-flop to establish a falling program mode, and thereafter counting selected responses of said first flip-flop to said chase limit signals until its content is zero and thereupon conditioning said second flip-flop to again establish a rising program mode.
14. The apparatus defined in claim 13 wherein
 - (1) said status signals received by said synchronization circuitry are derived from said up and down chase limit signals, the states of said first and second flip-flops and the count content of said reversible counting means.
15. The apparatus defined in claim 14 wherein said synchronization circuitry includes
 - (1) means operating to translate a thread guide from said reference position to an appropriate position to await said program, and responding to said status signals when said winding program reaches said appropriate position to condition the associated one of said output circuits to pass pulses from said first or second pulse trains to the associated motor according to the next normally occurring chase mode,
 - (a) whereby the thread guide begins chase movement according to said winding program.
16. The apparatus defined in claim 15 wherein
 - (1) said reversible counting means controls said synchronizing circuitry means according to its count content to bring the thread guide to said appropriate position.

References Cited

UNITED STATES PATENTS

2,529,559	11/1950	Kreamer.	
3,367,588	2/1968	Wolf	242—26.3
3,406,918	10/1968	Ramcke	242—26.3

STANLEY N. GILREATH, Primary Examiner

U.S. Cl. X.R.

57—99