

THREAD DELIVERY DEVICE HAVING AN ELECTRONIC THREAD TENSION
CONTROL SYSTEM

The invention relates to a thread delivery device having an electronic thread tension control system for thread processing textile machines, more particularly knitting or hosiery machines, having: a pivotably mounted thread delivery element which conveys the thread preferably in a substantially non-slipping manner and with which thread guide elements are associated and which is coupled to and driven by a frequency-controlled electric motor; thread tension feeling means which are disposed on the path of the thread downstream of the thread delivery element and which monitor the thread running off the thread delivery element and deliver an electric signal; and an electric control system which processes such signal and supplies a frequency signal to the motor in order to maintain the monitored thread tension constant at an adjusted required value.

In a thread delivery device of the kind specified disclosed in US Patent A 3858 416, the feeling means, having a linearly movable thread guide element which scans the thread running thereover, delivers an analog voltage signal which characterizes the thread tension and is compared with a fixed desired value voltage. The differential voltage corresponding to the control deviation is amplified and processed to generate an adjusting signal which is supplied as a frequency signal to the frequency controlled driving motor of the thread delivery element. Associated with the driving motor is a signal transmitter which delivers a signal characterizing the speed of the driving motor and therefore the

quantity of thread supplied per unit of time and which, in dependence on the position of a changeover switch, can be compared with a synchronization signal converted to an analog voltage and supplied by a second signal transmitter measuring the speed of the needle cylinder of the circular knitting machine equipped with the thread delivery device. The control deviation thus obtained and corresponding to the differential voltage is processed by the controller into a corresponding adjusting signal for the motor, so that the speed of the motor and therefore the thread delivery speed is synchronized with the speed of the needle cylinder of the circular knitting machine. By suitable manual operation of the changeover switch, therefore, it is possible to adjust optionally a constant thread tension or a quantity of thread delivered in a fixed dependence on the speed of the circular knitting machine.

The basic difficulty of a thread delivery device of that kind is that it cannot follow rapid changes in the thread tension or running speed. However, for example, in so-called striping operation changes in thread consumption take place extremely quickly in circular knitting machines, something which also applies to a lesser extent to Jacquard machines. Thus, for example, in a conventional circular knitting machine the thread consumption during striping at a knitting place is typically about 4 m/sec. When therefore according to programme the striper pays out the thread running at this speed and at the same time takes in a new, hitherto unprocessed and therefore stationary thread, the thread changeover takes place within fractions of milliseconds. This means that the old thread must be stopped

from its thread running speed of about 4 m/sec within this short interval of time, while the new thread must be accelerated to the full thread delivery speed of 4 m/sec within the same brief interval of time. Merely the inevitable inertia of the motor and the thread delivery element precludes such a fast acceleration, with the result that impermissible tension peaks occur in the thread. On the other hand, the slowing-down characteristic of the motor means that it cannot be stopped in the required short interval of time, the result being that loops become formed from the excess thread delivered before the thread delivery element stops, and thread tension collapses completely.

There is also the fact that with a frequency-controlled motor - i.e., a synchronous motor or a stepping motor, which is particularly advantageous since it can be precisely controlled - the frequency at starting and stopping cannot be raised at just any rate from the starting frequency to the frequency corresponding to steady-state operation, or lowered from the latter frequency to the stopping frequency, since otherwise the speed of the motor will no longer be capable of following this rapid change in frequency; the motor falls out of step and stops.

For these reasons the prior art thread delivery device is suitable only for thread processing textile machinery in which no particular rapid or abrupt changes in thread consumption occur. This is the case, for example, with circular knitting machines working unpatterned circular knitted fabrics, etc.

It is therefore an object of the invention to provide a thread delivery device having an electronic thread tension control system which is very simply and reliably constructed, does not require much power, and is suitable for use on, for example, circular knitting machines used for striping operation, in which the thread consumption changes very quickly and abruptly, although nevertheless the thread must be delivered positively with as constant a thread tension as possible.

To this end the thread delivery device of the kind specified is characterized according to the invention in that disposed on the path of the thread between the thread delivery element and the thread tension feeling means is a device which forms a thread reserve and whose size is adequate to cover the thread requirement during the starting of the motor; associated with such device are means to immediately fill up the thread reserve to an initial value at the latest after the motor has started; and the control system has a circuit arrangement which so limits the change in time of the frequency of the frequency signal, at least during the starting of the motor, that the loaded motor can follow the change in frequency.

If with this thread delivery device the thread requirement alters abruptly or when the striper takes in the hitherto stationary thread, the thread requirement at that moment is covered from the thread reserve, while at the same time the motor is accelerated. The motor is accelerated in accordance with its starting characteristic, without there being any risk of the motor falling out of step. On the other hand, during its removal from the

thread reserve the thread is not subjected to any excessive tensional stressings.

If the thread requirement is suddenly heavily reduced as occurs, for example, when the striper is paying out the thread, the slowing-down thread delivery element coupled to the motor may continue to deliver thread which is no longer accepted by the thread consumer and is therefore superfluous and leads to the formation of loops and the collapse of thread tension; to prevent this, advantageously by the circuit arrangement the change in the frequency of the frequency signal is so limited, also at least during the slowing down of the motor, that the loaded motor can follow the change in frequency, and associated with the device for forming the thread reserve are means for taking into the thread reserve the surplus quantity of thread supplied during the slowing-down of the motor, so that the thread tension always remains preserved. To limit the change in frequency of the frequency signal in dependence on the starting and slowing-down characteristics of the motor coupled to the thread delivery element, in a preferred embodiment of the invention the circuit arrangement can have an integrator for the electric signal delivered by the thread tension feeling means, the time constant of the integrator and therefore the duration of the starting and slowing-down phase of the motor being such that the motor can always follow the change in frequency without falling out of step. Since during the acceleration of the motor not only the mass inertia, but also the frictional torque counteract the driving torque, while in the deceleration of the motor the frictional torque has a braking effect, conveniently the

integrator associated with the starting of the motor has a higher time constant than the integrator associated with the slowing down of the motor. In a very simple and practical embodiment this can be achieved by the feature that the two integrators are formed by an RC section whose ohmic resistance can be switched over to two different values in dependence on the signal.

The device for forming the thread reserve has advantageously at least one thread guide element which is mounted to move over a predetermined path and with which at least one fixed thread guide element is associated and which cooperates with the movable thread guide element to form a lengthened thread path, and the movable thread guide element is acted upon by an adjustable desired value of force operating against the thread-pulling force operating on the movable thread guide element and is coupled to a signal transmitter of the feeling means which generates a signal depending on the position of the movable thread guide element.

Scanning the position of the movable thread guide element can be performed with a very simple apparatus. In a preferred embodiment the signal transmitter is an electro-optical signal transmitter scanning the movable thread guide element or a member connected thereto, such a signal transmitter being very suitable for this purpose since it exerts on the movable thread guide element no forces which might affect the accuracy of control.

According to another feature of the invention, the signal generated by the signal transmitter can stand in a given functional dependence on the particular position of the movable

thread guide element such that the signal increases subproportionally with increasing deflection of the thread guide element in the direction of increasing thread tension, so that the deflection path of the movable thread guide element does not increase excessively.

The signal delivered by the signal transmitter therefore characterizes not only a change in thread tension, but also indicates the position of the thread guide element and therefore the size of the thread reserve. From the signal in the control device that adjusting signal for the motor coupled to the thread delivery element is derived which so influences the speed of the motor and therefore the thread delivery speed that on the one hand thread tension is maintained at the particular desired value, while on the other hand the size of the thread reserve (by the position of the thread guide element) is always returned to an initial value depending on the thread running speed if the thread guide element is deflected.

The desired value of force operating on the movable thread guide element can be exerted, for example, by a desired value spring having a characteristic of variable steepness. However, it has been found to be convenient for the desired value of force to be substantially constant, independently of travel. To this end the movable thread guide element can be coupled to an electromagnetic desired value transmitter which generates the desired value of force and whose control current can be adjusted. Such an electromagnetic desired value transmitter is, for example, a permanently excited d.c. motor or an arrangement comparable with

the measuring means of a moving coil measuring instrument or the like. Particularly simple conditions are obtained for such a desired value transmitter generating a desired torque if the movable thread guide element is a pivotably mounted thread guide lever bearing a thread guide member, the thread guide lever being rigidly coupled to the spindle of the required value transmitter. An electromagnetic desired value transmitter has the advantage that the required value force can be adjusted electrically in a very simple manner.

Without incurring the need for any elaborate circuitry, the electromagnetic required value transmitter can be connected to the control system which, when a change takes place in the electric signal delivered by the signal transmitter, can temporarily superimpose on such signal a compensation signal which influences the desired value of force in order to counteract the change in thread tension. This ensures that if the thread consumption suddenly increases or decreases, the movable thread guide element is prevented from being excessively deflected or is very quickly returned to its required position, the result being very short control times. Conveniently the compensation signal is derived via a differentiating element from the signal delivered by the signal transmitter.

The electro-magnetic required value transmitter can also have an input for signals arriving from a central transmitter to adjust the desired value of force, so that the tension of the thread delivered by the thread delivery device can be adjusted by remote control. More particularly in the case of multi-system circular

knitting machines this therefore opens up the possibility of conveniently adjusting or altering to programme without further cost the thread tensions in individual knitting systems from a central point, even while the machine is operating.

Finally, advantageously the path of movement of the movable thread guide element is limited, and arranged in such path of movement adjacent the boundaries are feelers which cooperate with the thread guide element and each deliver a switch-off signal for the motor and/or the machine. This renders superfluous own slowing-down shut-off means, whose job is to stop the machine after a thread has broken. However, the motor and therefore the thread delivery element can also be stopped at one limit of the path of travel of the movable thread guide element; as a result, the thread delivery device is operated via the quantity of thread absorbed by the thread consumer. If the consumer accepts no more thread, the thread guide element moves to one limit of its path of movement; the associated feeler delivers a switch-off signal for the motor, thereby interrupting thread delivery. As already stated, the excess quantity of thread delivered until the motor stops is taken into the thread reserve without the thread tension collapsing.

In the normal operation of a knitting machine it is desirable for a precise given quantity of thread, depending on the speed of the machine, to be delivered to the individual knitting places. To this end according to a possible feature of the invention the control system can have an input for a synchronization signal arriving from an external synchronization source, and after a

speed corresponding to the adjusted required value of thread tension has been reached, the motor can be automatically synchronized with the synchronization signal by the control system.

The drive motor of the thread delivery element is frequency controlled; it can be a synchronous motor, but more particularly a stepping motor.

In the practical embodiment of the thread delivery device according to the invention, advantageously the signal transmitter coupled to the movable thread guide element delivers an analog signal and the control system has a voltage-to-frequency converter which is connected to the circuit arrangement processing the analog signal and which generates the frequency signal. At the same time, a threshold value circuit for the transmitted signal voltage can be disposed between the integrator and the voltage-to-frequency converter, such circuit preventing voltages below a lower threshold value from reaching the input of the voltage-to-frequency converter. The voltage-to-frequency converter also advantageously has on the output side an adjustable zero point suppression, such that the output frequency is adapted to the start-stop frequency of the motor. Lastly, to be able to influence the position of the thread guide element associated with a particular thread running speed and therefore the size of the thread reserve, the voltage-to-frequency converter conveniently has a device for changing its steepness.

When the motor is stopped, the thread tension is maintained by the control system at a predetermined value which is equal to or lower than the adjusted desired value. If the thread tension is adjusted to a higher value, the pulling force exerted by the thread in the inoperative condition has an adverse affect on the knitted fabric or leads to the release of the thread, for example, clamped in the thread clamp of a striper; to avoid this, conveniently the control system has means via which the required value of the thread tension can be reduced to a predetermined lower value, if the thread reserve decreases to a given extent in comparison with the initial value, and restored to its original value when the thread reserve diminishes again.

In one embodiment of the thread delivery device the thread delivery element is a thread wheel or a thread drum around which the thread is looped and by which the thread can be conveyed in a substantially non-slipping manner. However, the invention can also be similarly applied to thread delivery devices in which the thread delivery element is at least one cylindrical drive roller which can be coupled in frictional engagement to the periphery of a thread take-off bobbin or a thread winding member. Such thread delivery devices, in which a thread take-off bobbin is driven by the frictional engagement of its periphery with a drive roll on its periphery are more particularly required for highly resilient threads and yarns.

Other alternative embodiments of the thread delivery device according to the invention form the subject matter of subclaims.

In the drawings, which show embodiments of the subject matter of the invention:

Fig. 1 shows diagrammatically in perspective a thread delivery device according to the invention.

Fig. 2 is a side elevation of the thread delivery device shown in Fig. 1, sectioned along the line II-II in Fig. 1, the feed side thread brake being omitted.

Fig. 3 shows sectionally as in Fig. 2, and also in detail, a variant embodiment of the thread delivery device shown in Fig. 1.

Fig. 4 shows sectionally as in Fig. 2 and in detail another embodiment of the thread delivery device shown in Fig. 1.

Fig. 5 is a graph illustrating the starting characteristic of the motor and the thread wheel of the thread delivery device shown in Fig. 1.

Fig. 6 is a graph showing the slowing-down characteristic of the motor and the thread wheel of the thread delivery device shown in Fig. 1.

Fig. 7 is a block circuit diagram of the electronic devices of the thread delivery device shown in Fig. 1.

Fig. 8 is a simplified version of the circuit shown in the block circuit diagram in Fig. 7.

Fig. 9 is a graph showing the functional connection between the adjusting angle of the thread guide arm and the signal voltage delivered by the electro-optical signal transmitter in the thread delivery device shown in Fig. 1.

Fig. 10 is a block circuit diagram, similar to Fig. 7, of a thread delivery device shown in Fig. 1 which can be synchronized with an external synchronization source.

Fig. 11 is a circuit diagram of the thread tension reducing part of the circuit shown in Fig. 8.

Fig. 12 is a diagrammatic plan view of the thread guide arm of the thread delivery device shown in Fig. 1, showing the different zones within the path of movement of the thread guide arm.

Fig. 13 shows diagrammatically and in perspective another embodiment of a thread delivery device according to the invention, more particularly for the unwinding of highly elastic threads or yarns.

Fig. 14 is a diagrammatic view in perspective of a variant embodiment of the thread delivery device shown in Fig. 13.

Fig. 15 is a diagrammatic axially sectioned side elevation to a different scale of the thread delivery device shown in Fig. 13, and

Fig. 16 is a side elevation in axial section of the thread delivery device shown in Figs. 13 or 14, showing diagrammatically an embodiment of the drive of the drive rollers.

A thread delivery device shown diagrammatically in Fig. 1 has a casing 1 bearing a holder 2, which is adapted for attachment to the frame ring of a circular knitting machine (not shown) and in whose zone electric connection devices (not shown) are disposed for the electric and electronic structural elements, accommodated inside the casing 1. As can be seen from Fig. 2, disposed in the upper portion of the casing 1 is an electric stepping motor 3, which extends by its spindle 4 through a corresponding opening in the front wall of the casing and drives a thread wheel 5 non-rotatably placed on the spindle 4. The thread wheel 5 comprises a hub 6 placed on the spindle 4 and a number of substantially U-shaped bent wire members or brackets 7 which are connected to the hub 6 at the end face, each of which has a substantially axis-parallel thread bearing portion 8 and an adjoining feed end inclined portion 9. For satisfactory heat dissipation from the casing, the stepping motor 3 is attached by its bearing plate to a light metal plate-like cooling member 10 screwed to the outside of the front wall of the casing 1 and extending substantially behind the thread wheel 5. The cooling member 10 bears moulded-on cooling fins 11 which increase the surface giving off heat to

the surrounding air.

Associated with the thread wheel 5 forming the thread delivery element are thread guide elements which are disposed fixed on the casing 1 and consist of a feed end eyelet 13 provided on a holder 12 rigidly attached to the casing, a thread deflecting hook 14 disposed on the front wall of the casing adjacent the thread wheel 5, and two thread eyelets 15, 16 disposed on the casing on the thread paying-off side of the thread wheel 5.

A thread 17 arriving from a thread source, for example, a bobbin (not shown), runs through the feed end eyelet 13 via an adjustable thread disc brake 18 disposed on the holder 12 and the deflecting hook 14 on to the thread drum 5 in the zone of the feed end inclined portion 9 of the bent wire members 7, which push the forming thread windings on to the thread bearing portions 8 of the bent wire members 7, on which therefore a storage coil consisting of a number of thread windings 190 (Fig. 2) is formed which cooperates with the narrow bearing portions 8 to entrain the thread 17 in a substantially non-slipping manner along the periphery of the thread wheel 5.

From the storage coil 190 the thread 17 runs through the first stationary paying-out side thread eyelet 15, from there via a thread eyelet 19 at the end of a thread guide arm 21 forming a movable thread guide element and pivotably mounted at the other end on the casing 1 at a place 20, and from there back to the second stationary thread eyelet 16, which is disposed somewhat below, but laterally in the immediate vicinity of the first

thread eyelet 15.

From the second thread eyelet 16 the thread passes to a thread consumer (not shown), in the case of a knitting machine to the needles of a knitting place.

On the feed end side the thread 17 is monitored in the zone between the thread brake 18 and the deflecting hook 14 by a feed end thread feeler 22 which, if the thread breaks, switches over a switch which is disposed in the casing 1 and actuated by its feeler arm, and which then delivers an electric switch-off signal causing the stoppage of the machine.

On the paying-out side of the thread wheel 5 the pivotably mounted thread guide arm 21 forms with its thread eyelet 19 between the fixed third eyelets 15, 16 a substantially V-shaped elongated thread running path which represents a thread reserve whose size depends on the angular position of the thread guide arm 21.

As can be seen from Fig. 2, attached to a lower casing portion 24, divided off by a partition 23, is a small d.c. motor 25 which extends by its spindle 26 through a corresponding opening in the front wall of the casing and bears a non-rotatably attached, substantially L-shaped actuating lever 27 which bears at its end on one side against the thread guide arm 21 and thereby tends to pivot the latter anticlockwise with reference to Fig. 1.

The permanently excited d.c. motor 25, preferably taking the form of a so-called drag-cup motor, can, due to the limited range of angle of rotation of the thread guide arm 21 coupled thereto, also be replaced by an arrangement similar to the measuring unit of a moving coil measuring instrument, etc.; it forms an electromagnetic desired value transmitter which exerts via the actuating arm 27 a precise given adjustable desired value of force on the thread guide arm 21 and its eyelet 19. This desired value of force is oppositely directed to the pulling force exerted by the thread guided through the eyelet 19 and depending on the thread tension - i.e., the desired value of force points to the left as viewed in Fig. 1.

Coupled to the spindle 20 of the thread guide arm 21 is an electro-optical signal transmitter 28 which scans the angular position of the thread guide arm 21 and, as will be described in detail hereinafter, delivers a signal which characterizes the tension of the thread 17 running through the thread eyelet 19 of the thread guide arm 21 and at the same time also characterizes the angular position of the thread guide arm 21 and therefore the size of the aforementioned thread reserve.

The signal transmitter 28 consists of a luminous diode 29 and a phototransistor 30 disposed in the ray path of the luminous diode 29, these two elements being disposed on a holder 31 rigidly connected to the casing. Extending to a varying extent into the ray path of the luminous diode 29 by its edge is a baffle disc 32 which is wedged on the spindle 20 of the thread guide arm 21 and whose edge takes basically the shape shown in Fig. 9, which

substantially follows an e function.

In dependence on the pivoting of the thread guide arm 21, the phototransistor 30 is screened by the baffle disc 32 against the luminous diode 29, so that at the output of the phototransistor 30 an analog signal appears which stands in a fixed functional dependence on the angular position of the thread guide arm 21, given by the outline of the baffle disc 32.

The pivoting movement of the thread guide arm 21 is limited in both directions of rotation by two stop pins 33, 34 (Fig. 1). If no thread is taken off, the thread guide arm 21 remains in the vicinity of the left-hand stop pin 33; with increasing thread running speed - i.e., an increasing speed of the thread wheel 5 - the arm 21 moves to the right in the direction of the other stop pin 34, without being able to reach the latter in normal operation. The thread guide arm 21 bears against the stop pin 33 or the stop pin 34 only in case of malfunction:

If the thread breaks, or for some other reason the tension of the thread running off the thread wheel 5 collapses, the thread guide arm 21 is pivoted to the left-hand stop pin 33 and stopped thereby; if on the other hand, for example, due to a knot contained in the thread 17, which cannot pass through the thread eyelet 19, the thread guide arm 21 is suddenly pulled to the right, with reference to Fig. 1, its movement is limited by the right-hand stop pin 34.

Non-rotatably disposed on the spindle 20 of the thread guide arm 21 in the lower portion 24 of the casing is a switching eccentric 35 which so cooperates with a switch 36 accommodated in the casing 1 that via corresponding trip cams of the switching eccentric 35 the switch 36, thereby forming a position sensor, is actuated and delivers a switch-off signal to the machine before the thread guide arm 21 bears against the left-hand or right-hand stop pin 33; 34. A signal light 38 disposed in a coloured light member 37 on the underside of the casing 1 lights up if either the feed end thread feeler 22 responds, or the switch 36 is actuated and accordingly a switch-off signal has been delivered for the machine. In this way the faulty place on the circular knitting machine can be rapidly located.

Disposed in the casing 1 is a potentiometer 39 (Fig. 1), which can be actuated from outside and is disposed in a control circuit, still to be explained, of the d.c. motor 25 and enables the desired value of force exerted thereby on the thread guide arm 21, and therefore the thread tension, to be adjusted. Moreover, in the casing 1 above the potentiometer 39 a main switch 40 is provided which enables the total power supply to the thread delivery device to be so switched on and off that in the switched-off condition the whole apparatus is currentless, in which case no further machine-stopping signal is delivered by the switch 36 or the feed end feeler 22. With the main switch ⁴⁰20 engaged, an indicator light 41 indicates that the thread delivery device is ready for operation, while a manual feeler 42 provided in the same wall of the casing allows the manual coiling of the thread wheel 5 or an automatic winding-on of a precise number of

thread windings of the storage coil 190.

The embodiment illustrated in Fig. 3 differs from the one illustrated with relation to Figs. 1 and 2 merely by the feature that both the actuating arm 27 and the thread guide arm 21 are each coupled to a permanently excited d.c. motor 25; 25a or some other equivalent electro-magnetic desired value transmitter, so that the desired value of force counteracting the thread-pulling force operating at the thread eyelet 19 is exerted by the two d.c. motors 25 and 25a. For certain applications this has the advantage that merely two smaller motors can be used instead of a relatively large motor. The signal transmitter 28 is again disposed on the spindle 26 of the d.c. motor 25 coupled to the actuating arm 27; its construction was already explained with reference to Fig. 2; like members have like references. Instead of the switching eccentric 35 and the switch 36 shown in Fig. 2, in this case a contactless limit position feeler is associated with the thread guide arm 21 and consists of a suitably designed baffle disc 43 placed on the spindle 26a and a photoelectric cell 44 into whose ray path the baffle disc 43 enters to a varying extent, in dependence on the angular position of the thread guide arm 21. The phototransistor 45 of the photoelectric cell 44 delivers switch-off signals when the thread guide arm 21 reaches limit positions in the vicinity of the two stop pins 33, 34.

The embodiment illustrated in Fig. 4 also essentially corresponds to that illustrated in Figs. 1 and 2, but with the difference that instead of the switching eccentric 35 and the switch 36, the contactless electro-optical limit value sensor 43-45 of the

embodiment illustrated in Fig. 3 is provided, whose baffle disc 43 is directly connected to the spindle 26 of the d.c. motor 25 directly coupled to the thread guide arm 21. The actuating arm 27 is dispensed with.

The electric circuit for the stepping motor 3 driving the thread wheel 5 and the d.c. motor 25 acting as a desired value transmitter is illustrated in Figs. 7 and 8:

As can be gathered from the block circuit diagram (Fig. 7), the analog signal which is delivered by the phototransistor 30 of the signal transmitter 28 and which is characteristic of the angular position of the thread guide arm 21, and therefore of the size of the thread reserve, as well as of the tension of the thread 17 running through the thread reserve, is fed via a low-pass filter 50 and a voltage follower 51 to a control device 52 which processes the signal and generates on the output side a frequency signal of a particular pulse sequence frequency, which is indicated at a place 53 and is supplied to a control electronic system 54 which via a connected power output stage 55 delivers an adjusting signal in the shape of a corresponding sequence of stepping pulses to the stepping motor 3. The low-pass filter 50 filters interference signals of higher frequency out of the analog signal arriving from the signal transmitter 28, such signals originating, for example, from mechanical vibrations of the thread guide arm 21, etc. The voltage follower 51 delivers on the output side, with a relatively low output impedance, a signal voltage potential which depends on the particular angular position α of the thread guide arm 21. Fig. 9 shows the

functional dependence of the signal voltage potential U supplied to the input of the control device 52 on the angular position of the thread guide arm 21 which is caused by the special design of the baffle disc 32; as already pointed out, it substantially follows an e function; the characteristic line therefore takes a progressive shape, to ensure that the necessary adjusting angle range of the thread guide arm 21 does not increase excessively with an increasing quantity of thread supplied per unit of time.

The permanently excited d.c. motor 25 acting as a desired value transmitter is supplied with constant current from a constant current source 56 via a power output stage 57, so that the transmitter delivers a constant torque on its spindle 26, independently of the angular position of the actuating arm 27. The value of this torque and therefore the required value of the thread tension can be adjusted by the already mentioned potentiometer 39.

Moreover, the analog voltage signal delivered by the voltage follower 51 is supplied via a second potentiometer 58 coupled to the potentiometer 39 to a differentiating member 59, where it is differentiated. The output of the differentiating member 59 is connected via a full adder 60 and a voltage follower 61 to the potentiometer 39 - i.e., to the adjusting input of the constant voltage source 56. In this way a compensation signal is superimposed on the adjusting input of the constant current source 56, such signal becoming operative more particularly when the required value of thread tension is adjusted to a low value (smaller than about 3 p) and transiently influences the torque

exerted by the d.c. motor 25 on the actuating arm 27, to return the thread guide arm 21 to the desired angular position, if an abrupt control deviation takes place.

Lastly, via a separative element 62 and a full adder 60 and the voltage follower 61 an external adjusting signal can also be supplied from an external signal source, for example, a central control device for all or a particular number of thread delivery devices of a circular knitting machine, via the potentiometer 39 to the adjusting input of the constant voltage source 56, such adjusting signal enabling the torque of the d.c. motor 25 and therefore the required value of force exerted on the thread guide arm 21 to be remote controlled.

In steady-state operation the stepping motor 3 drives the thread wheel 5 at a speed determined by the frequency signal 53, so that the thread 17 is supplied at a corresponding speed to the consumer. The thread guide arm 21 stands in a predetermined angular position between the two stop pins 33, 34; the force exerted on the arm 21 by the running thread 17 via the thread eyelet 19 is in equilibrium with the desired value of force generated by the d.c. motor 25 and acting on the arm 21 via the actuating lever 27.

If a control deviation takes place, for example, the thread consumption declines, the thread guide arm 21 begins to move out of its desired angular position, so that the analog voltage signal $U + \Delta U$ supplied to the control device 52 undergoes a corresponding change. The control device 52 correspondingly

illustrate
adjusts the adjusting signal 53 for the stepping motor 3 and therefore the thread delivery speed, until a steady-state condition is again reached when the thread guide arm 21 occupies a fixed angular position, in which the thread pulling tension is in equilibrium with the desired value of force exerted by the actuating arm 27. Since the desired value of force is constant, independently of the angular position of the actuating arm 27 and the thread guide lever 21, the thread tension is constant within the control zone in the steady-state condition at any thread delivery speed and therefore also with any thread consumption per unit of time.

If a change in thread consumption occurs very abruptly as, for instance, takes place in a circular knitting machine working in striping operation, when the striper changes the thread, the stepping motor 3 with the coupled thread wheel 5 and the thread 17 running thereover is too inert to follow the rapid course of the control operation. Thus, for example, in striping operation when a fresh thread is introduced, the previously stationary thread must be accelerated to the normal thread delivery quantity of about 4 m/sec within fractions of a millisecond. However, the stepping motor 3 can follow a change (increase) in frequency of the adjusting signal 53 only within predetermined limits which are determined by the starting characteristic. Figs. 5 and 6 show the starting and slowing-down characteristics of the stepping motor 3 in a typical embodiment of the thread delivery device described. As can be gathered from Fig. 5, the stepping motor 3 requires at least about 50 milliseconds to reach a peripheral speed of 4 m/sec on the thread wheel 5. In any

attempt to accelerate it more quickly, it would fall out of step with the frequency signal 53 and stop.

Since of course a stepping motor has a predetermined start-stop frequency, the characterizing line in Fig. 5 does not pass through the zero point.

Basically the same thing also applies to conditions when thread delivery is stopped; this operation also can be performed only within the range lying below the slowing-down characteristic shown in Fig. 6, without the stepping motor 3 falling out of step with the frequency signal 53.

To prevent the thread tension on the running-off side of the thread wheel 5 from increasing impermissibly or the thread from even breaking, due to the aforescribed inertia of the unit comprising the stepping motor 3 and its control system, if the thread consumption increases very rapidly, for example, when a thread is fed into the striper, and also to prevent the thread wheel 5, relatively slowly running-down with the stepping motor 3, from delivering surplus thread if the thread take-off is suddenly interrupted, the result being the formation of loops and the collapse of the thread tension and therefore the actuation of the machine stopping switch 36, the following measures are taken:

A thread reserve is provided between the fixed thread eyelets 15, 16 and the movable thread eyelet 19, as already explained. The size of the thread reserve is such that it is adequate to cover thread requirement during the starting time of the stepping

motor 3 given by the starting characteristic (Fig. 5). This value can be very simply calculated on the basis of the known starting characteristic and the also known thread requirement during the starting phase; by a suitable selection of the length of the thread guide arm 21 and the value of its range of adjusting angle, the thread delivery device can be adjusted thereto.

The control device 52 also comprises a circuit arrangement which mainly comprises two integrators 63, 64 and which has a time constant adapted to the particular starting and slowing-down characteristics (Figs. 5, 6) of the stepping motor 3 and therefore so limits the change in time of the frequency of the frequency signal 53 during the starting or slowing-down of the stepping motor 3, that the stepping motor 3, loaded by the thread 17 and the thread wheel 5, etc., can follow the change in frequency. In practice this means that the starting and slowing-down curves of the stepping motor 3 controlled by the frequency signal 53 lie below the starting and slowing-down characteristics shown in Figs. 5 and 6.

This ensures that during the starting time of the stepping motor 3, the thread consumer can cover its thread requirement from the thread reserve, the thread tension being constantly maintained at its desired value by the desired value of torque, independent of the adjusting angle, of the d.c. motor 25. At the same time, during this period the stepping motor 3 can accelerate the thread wheel 5 to the speed corresponding to the required thread running speed within a time whose length is determined by the starting

characteristic and which ensures that the stepping motor 3 stays in step with the frequency signal 53.

Since the signal transmitter 28 scans the angular position of the thread guide arm 21, with an increase in speed of the stepping motor 3 and therefore an increasing quantity of thread delivered by the thread wheel 5 per unit of time, the thread guide arm 21 is also to an increasing extent transferred automatically by the actuating arm 27 into an angular position which corresponds to the steady-state condition, in which the quantity of thread delivered by the thread wheel 5 exactly corresponds to the thread consumption. When this steady-state condition is reached, the thread guide arm 21 is again in an intermediate position determined by the particular thread delivery speed between the stop pins 33, 34 - i.e., the thread reserve is again built up to an initial value.

Basically the same thing happens if the thread delivery is suddenly interrupted. In that case the thread consumption suddenly begins to diminish; the thread guide arm 21 is increasingly pivoted by the actuating arm 27, so that the quantity of thread no longer taken off is received into the thread reserve. At the same time the signal transmitter 28 delivers a signal characterizing this pivoting of the thread guide arm 21; the control device 52 alters the frequency of the frequency signal 53 in the direction of stopping the stepping motor 3, but the speed of the change in frequency is limited by the integrator 64 to a value lying below the slowing-down characteristic shown in Fig. 5, so that the stepping motor 3

exactly follows the change in frequency of the frequency signal 53 until stoppage.

Since during the slowing-down of the stepping motor 3 and the elements coupled thereto the frictional torque exerts an additional braking effect, something which is shown by the difference between the slowing-down characteristic and the starting characteristic, the time constant of the integrator 64 associated with the slowing down of the stepping motor 3 is smaller than that of the integrator 63 associated with the starting of the motor. As a rule the ratio between the two time constants is smaller than about 4 : 1.

Connected to the circuit arrangement formed by the integrators 63, 64 is a diode path 65 whose output is connected via a low-path filter 66 to a voltage-to-frequency transducer 67 which delivers the frequency signal 53. The diode path 65 forms the threshold value circuit preventing signal voltages lying below a lower threshold value from being delivered to the voltage-to-frequency transducer 67 which would result in a frequency signal of a frequency lower than permissible for the stepping motor 3 to be transiently delivered. A low-pass filter 66 prevents interferences with the voltage-to-frequency transducer 67.

For the reasons already stated, the voltage-to-frequency transducer 67 is constructed with a zero-point suppression on the output side. The steepness in its characteristic line can also

be altered, so as to enable the angular position of the thread guide arm 21 and therefore the size of the thread reserve to be suitably adjusted for a predetermined steady-state thread running speed.

The circuit corresponding to the block circuit diagram shown in Fig. 7 is illustrated in its details in Fig. 8, the description being limited to essential details:

Connected to the phototransistor 30 of the signal transmitter 28 via the low-pass filter 50 formed by a resistor 70 and a capacitor 71 is a transistor T_1 in an emitter follower sequence having an emitter resistor 90, which forms the voltage follower 51. Connected to the emitter of the transistor T_1 is a resistor 72 to which a second resistor 73 is connected which is included in the emitter circuit of a transistor T_2 , whose base is connected via a resistor 74 to ground and via a diode 75 to the emitter of the transistor T_1 . A capacitor 76 lies in parallel with the transistor T_2 .

The capacitor 76 essentially cooperates with the resistor 72 to form the integrator 63 associated with the starting of the motor, whose time constant is, for example, 100 m/sec.

If when the stepping motor 3 slows down, due to the corresponding deflection of the thread guide arm 21 the voltage signal delivered at the emitter of the transistor T_1 becomes negative in relation to the voltage potential applied to the capacitor 76, the transistor T_2 connected as an emitter follower connects the

resistor 73 parallel with the resistor 72 and the capacitor 76. The transistor T_2 therefore acts as a switch for switching on or off the resistor 73 in parallel with the resistor 72.

The capacitor 76 is adjoined by the diode path 65 formed by the two diodes 77, 78, which are bridged by a capacitor 79. The flat course of the discharge curve of the capacitor 76 in the lower portion of voltage is suppressed by the diodes 77, 78. To ensure an immediate response of the voltage-to-frequency transducer 67 during the running-up of the stepping motor 3, the two diodes 77, 78 are bridged by the capacitor 79 which due to its dimensioning is operative only with abrupt changes in voltage.

The slowing-down time constant of the integrator 64 formed by the resistors 72, 73 and the capacitor 76 is about $1/4$ of the time constant of the integrator 63, formed as already mentioned by the resistor 72 and the capacitor 76, associated with starting. Due to the diode path 65 only about 2-3 slowing-down time constants are required until the stepping motor 3 is completely switched off.

The diode path 65 is adjoined by a filter 66 consisting of a resistor 80 and a capacitor 81, to which the voltage-to-frequency transducer 67 is connected on the output side ($4151/IC_1$).

The voltage-to-frequency transducer 67 formed by an IC is negatively biased (about 50 mV) at its corresponding control input by a voltage divider 82, 83. This zero-point suppression ensures reliably that no pulses - i.e., no frequency signal 53 -

are delivered in the limit position of the thread guide arm 21. The voltage-to-frequency transducer 67 also generates a frequency signal 53 whose pulse sequence frequency is directly proportional to the voltage potential of the input signal. The steepness of the voltage-to-frequency transducer 67 can be altered by a potentiometer 84. In this way a particular steady-state or inoperative position of the thread guide arm 21 can be associated with a particular thread running speed in the zone between the stop pins 33, 34. The maximum pulse frequency of the frequency signal 53 is so adjusted by an external resistor 85, bridged by a capacitor 86, that a thread delivery quantity of about 10 m/sec is produced when the thread guide arm 21 is in the end position which it assumes with the maximum quantity of thread delivered per unit of time, and therefore with the maximum signal voltage at the input 87 of the voltage-to-frequency transducer 67.

The resistors 88, 89 and capacitors 92, 91 are merely required for the connection of the IC forming the voltage-to-frequency transducer 67 and therefore require no further explanation.

The d.c. motor 25 exerting the desired value of force on the thread guide lever 21 is permanently excited and supplied with constant current by the constant current source 56 which is also formed by an IC (IC_2 -PPL 3717) which at the same time contains the power output stage 57. The motor current and therefore the torque exerted by the d.c. motor 25 can be precisely adjusted to any required value via a voltage signal to an input 910 of this IC. The signal voltage required for this purpose is tapped at the slider of the adjusting potentiometer 39 and delivered to the

input 910 via an emitter follower formed by a transistor T_3 . The adjustment range is obtained at the top end by means of a potentiometer 93 and at the bottom end via an emitter follower which is formed by a transistor T_4 and an emitter resistor 94 and which cooperates with the full adder 60 (Fig. 7) to form the voltage follower 61. A remote adjustment signal can either be supplied to the base of the transistor T_4 via the separative element 62 comprising a resistor 95 and a connected diode 96, such signal altering the voltage value adjusted by the potentiometer 39, or at that place a compensation signal is superimposed which originates from the differentiating member 59. The differentiating member 59 mainly comprises a capacitor 97 and a resistor 99 bridged by a diode 98. The compensation signal is adjusted via the potentiometer 58, to which the analog signal is supplied which appears at the output of the voltage follower 51 formed by the transistor T_1 with the connected emitter resistor 90. The sliders of the two potentiometers 58, 93 are coupled to one another. Otherwise this compensation signal superimposition is so tuned to the physical properties of the whole thread guide arm mechanism, including the d.c. motor 25, that the superimposition preferably becomes operative only with relatively low thread tension adjustments (≤ 3 p). This is achieved more particularly by a suitable design of the potentiometer 58 and an associated resistor 100. Resistors 101 and 102 are used for the approximate linearization of the adjusting range. The diode 98 prevents the motor current value from being reduced by a negative voltage flank. The diode 96 of the separating member 62 ensures that the motor current value adjusted at the potentiometer 39 can only be increased, but not reduced.

The embodiment of the thread delivery device described hereinbefore is self-contained - i.e., without synchronization with an external signal source the apparatus always ensures that the tension of the thread paid off is always maintained at a given desired value, independently of the thread delivery speed - i.e. the thread consumption - every required quantity of thread being positively delivered within the operating range.

By a very simple addition to the electric circuit as shown in Fig. 10, the thread delivery device can also be so controlled by an external synchronization signal delivered, for example, by the central angular momentum transmitter of the circular knitting machine, that the quantity of thread delivered is synchronized with such synchronization signal. This mode of operation is important, for example, in high-speed stripers, sock knitting machines, etc., in which the knitting speed and the resulting thread delivery speed lies above a lower value which is given by the start-stop frequency of the particular stepping motor 3.

Since due to the aforescribed construction the thread delivery device is able to follow the extreme changes in the quantity of thread delivered when the thread is changed due to the transient emptying or filling of the thread store, the thread delivery device is per se outstandingly suitable for such machines. After the thread wheel 5 and the stepping motor 3 have been run up following a change of thread, a positive thread delivery takes place, to ensure an absolutely uniform turn-out of goods. The changeover of the thread delivery device from the aforescribed

self-contained operational mode during the starting operation to the positive operational mode in synchronization with an external synchronization signal takes place automatically, so that for this purpose no additional external means, for example, own control pulses or the like are required.

In Fig. 10 those elements of the block circuit diagram shown in Fig. 7 which are necessary for understanding are shown with the same references and will not be further described in detail.

Disposed between the output of the control device 52 and the operational electronic system 54 of the stepping motor 3 is an electronic switch 105 which enables the frequency signal 53 (self-contained operational mode) delivered by the control device 52, or a synchronization frequency signal 107 delivered via an input 106 from an external synchronization source to be supplied. For the operation of the electronic switch 105 use is made of a control circuit 108 comprising a voltage-to-frequency transducer 109, an adjusting potentiometer 110 and a comparator 111 having some hysteresis. The voltage-to-frequency transducer 109 converts the external synchronization frequency signal 107 to an analog voltage, which is applied via a resistor 112 to an adjusting potentiometer 110, which on the other side receives via a resistor 113 the analog signal at the output of the integrators 63, 64. The comparator 111 compares the two voltages and then delivers a changeover signal to the electronic switch 105. The adjusting potentiometer 110 enables the changeover level to be adjusted.

When the starting operation of the stepping motor 3 has been completed, the thread guide arm 21 takes up the position corresponding to the particular thread running speed in the steady-state condition, so that the analog signal tapped via resistor 113 at the output of the integrators 62, 63 also has a predetermined value. By comparing this value with the analog voltage corresponding to the external synchronization frequency signal 107, the comparator 111 automatically recognizes the completion of the starting operation of the stepping motor 3, whereafter it delivers the changeover signal from the self-contained operational mode to positive operation. This applies correspondingly to the switching back of the electronic switch 105, for example, when the thread is paid off by the striper.

If the take-off of the thread from the thread wheel 5 is interrupted, for example, when the thread is paid out by the striper, the thread guide arm 21 is first pivoted by the d.c. motor 25 via the actuating arm 27 in the direction of the left-hand stop position, with reference to Fig. 7. The position-dependent signal delivered by the signal transmitter 28 so influences the stepping motor 3 via the control device 52 in the manner already explained that the motor reduces its speed and thereby correspondingly and progressively reduces the quantity of thread delivered per unit of time. The stepping motor 3 is stopped as soon as the thread guide arm 21 enters a predetermined zone, the so-called shutting-off zone, in the direction of the left-hand stop pin 33 within its path of travel bounded by the two stop pins 33, 34. However, the thread guide arm 21 does not then stop instantaneously, but moves by the inertia of its own

system into the shutting-off zone until on the one hand the stepping motor 3 has actually stopped, and on the other the thread running through the eyelet 19 has again become tensioned by the thread guide arm 21 acted upon, as before, by the d.c. motor 25 with the desired value of force, thereby preventing further movement of the thread guide arm 21. On the other hand, the retaining force of the stepping motor 3 retains the thread firmly held by the thread clamp of the striper on the consumer side; the thread is retained by the thread guide arm 21 and the d.c. motor 25 at the required value of tension adjusted on the potentiometer 39. More particularly with higher required values of thread tension, there is a risk that the paid-out thread will be slowly pulled out of the thread clamp, so that operations will be interrupted on the next laying-in of the thread. Even when the circular knitting machine is shut off for fairly long periods, for example, over night, this maintained permanent thread tension may cause troubles by, for example, the stitch formation being unfavourably affected in the last row. These problems occur more particularly in the processing of rubber threads with a thread tension of more than 3p (30mN).

If necessary, these difficulties can be remedied by a slight modification of the control device 52 which is shown in Fig. 11:

Optionally, instead of the part of the circuit having the same reference and shown in chain lines in Fig. 8, the part 120 of the circuit shown in Fig. 11 can be incorporated in the circuit shown in Fig. 8. Corresponding connection points are denoted by the letters a to d.

In the part 120 of the circuit an adjusting potentiometer 121 is included in the collector circuit of the transistor T_1 . The analog signal arriving from the phototransistor 30 and characterizing the position of the thread guide arm 21 is turned through practically 180° in the collector circuit of the transistor T_1 and supplied via the slider of the adjusting potentiometer 121 to the base of a pnp transistor T_5 operating substantially as a switching amplifier. Incorporated in the emitter circuit of the transistor T_5 is an emitter resistor (about 560Ω), while the collector of the transistor is connected to the base via a negative feedback resistor 123. The potentiometer 93 (Fig. 8) and the switching elements connected thereto are also incorporated in the collector circuit of the transistor T_5 via the connection point b.

The negative feedback from the collector to the base of the transistor T_5 , produced by the negative feedback resistor 123, prevents any abrupt wobble in the collector potential when a predetermined voltage potential is reached at the base. The transition takes place without hysteresis and softly, on condition that the thread guide arm 21 moves smoothly. At the same time the resistor 123 (about $100 \text{ k}/\Omega$) adjusts the bottom value of thread tension which the thread experiences from the thread guide arm 21 when the stepping motor 3 is stationary.

If the thread guide arm 21 is pivoted so far to the left (Fig. 10), for example, when the striper pays off the thread, that the stepping motor 3 is stopped - i.e., if the thread guide arm 21 is in the shutting-off zone of its path of travel - the transistor T_5

is practically currentless. At the same time, however, the two potentiometers 93, 39 receive via the negative feedback resistor 123 only a small current which is enough to cause a drop in voltage at the base of the transistor T_3 such that it supplies at its emitter a substantially reduced voltage signal to the IC forming the constant current source 56 via its input 910. As a result the d.c. motor 25 is acted upon by a correspondingly reduced exciting current, so that the desired value of force exerted by the actuating arm 27 on the thread guide arm 21 is also reduced to an associated lower value corresponding, for example, to a thread tension of 0.5 p.

As a result the paid-off thread, retained on the end side by the thread clamp of the striper, is kept under this relatively low and therefore harmless tension when the thread wheel 5 is stationary.

When the thread is again introduced by the striper, the thread guide arm 21 begins to move quickly to the right (Fig. 10). The phototransistor 30 delivers to the transistor T_1 a corresponding, position-dependent analog signal. When a predetermined voltage threshold is reached, the transistor T_5 becomes completely conductive, so that its collector potential reaches approximately the value $+V$, the potentiometers 93, 39 therefore being also at $+V$, something which corresponds to the original condition (Fig. 8) and allows the complete and normal functioning of the adjusting potentiometers 39, 93.

The aforescribed function of the member 120 of the circuit produces the operation of the thread delivery device indicated diagrammatically in Fig. 12:

The path of movement, limited by the two stop pins 33, 34, of the thread guide arm 21 mounted to pivot around the horizontal axis 20 corresponds to a path of movement of the associated thread eyelet 19 lying on the arc of a circle. This total path of movement is subdivided into a number of zones:

If the thread guide arm 21 is within a first zone A, which adjoins the right-hand stop pin 34, the arm 21 is within the normal operating zone or sector, in which the required value of force adjusted at the potentiometer 39 is exerted on the thread guided through the eyelet 19, so that the thread is maintained at a corresponding constant thread tension. The thread reserve has its initial size; the particular position of the thread guide arm 21 within the operating zone A depends on the thread running speed and therefore the necessary speed of the stepping motor 3.

Adjoining the first or operating zone A and extending as far as the left-hand stop pin 33 is a second or shutting-off zone or sector B. As soon as the thread guide arm 21, for example, as a result of the paying-off of the thread by the striper, exceeds the limit between the two zones A and B and enters the shutting-off zone B, the stepping motor 3 is stopped. It comes to a stop in the time given by its slowing-down characteristic, as was explained in detail with regards to the control device 52.

Due to the aforescribed function of the part 120 of the circuit, the shutting-off zone B is further subdivided, namely into a third zone C, in which the thread tension is reduced, while in the remaining zone B-C the adjusted desired value of thread tension applicable with the operating zone A remains maintained.

If, therefore, the thread is abruptly paid off, for example, in striping at a relatively high thread speed, the thread guide arm 21 enters the shutting-off zone B by the inherent inertia of its system, until the stepping motor 3 has stopped and the thread is again tensioned, therefore preventing the further movement of the thread guide arm 21. The exact position or depth of entry of the thread guide arm into the shutting-off zone B depends inter alia on the rapidity with which the thread take-off was interrupted, and at what thread speed and thread tension it took place. If the thread guide arm remains in the zone B-C of the shutting-off zone B adjoining the operating zone A, when the stepping motor 3 is stopped the thread tension remains at the desired value which was adjusted by the potentiometer 39 and is also valid for the knitting operation.

If then the knitting machine should be unable to hold the thread at this thread tension because, for example, the thread clamp of the striper slightly yields, the desired value of force exerted via the actuating lever 27 by the d.c. motor 25 causes the thread guide lever 21 to move slowly in the direction of the left-hand stop pin 33. However, as soon as the arm 21 enters the zone C of

the shutting-off zone B, the member 120 of the circuit automatically reduces the excitation of the d.c. motor 25 and reduces the thread tension to a substantially lower value of, for example, 0.5 p. In any case this value is so low that the tensile force exerted by the thread is harmless. However, it is not zero and must moreover be reached, since otherwise the switch 36 would trigger the machine-stopping function. The fact that the thread guide arm 21 therefore remains held at a place within the shutting-off zone C of the thread when the stepping motor 3 is stopped, even though the arm 21 experiences a substantially reduced force, ensures that even with the stepping motor 3 stopped, the thread still remains in the thread guide, needle or thread clamp of the striper, etc., and can continue to be knitted in a proper manner in the further course of operations. However, if the thread guide arm 21 should have been pivoted to such an extent that it actuates the switch 36 in the vicinity of the left-hand stop pin 33, this means that the thread has been pulled out or torn off - i.e., that there is an operational fault in any case.

In the absence of any such operating fault, when thread consumption is resumed, the thread guide arm is returned at a varying speed from its aforescribed position in the shutting-off zone B to the right and into the operating zone A, the arm moving with only a slight "overshoot" towards the steady-state speed position applicable to the particular thread delivery speed present.

When the knitting machine is very quickly run up to high thread speeds, or the feed to the striper takes place at high thread speed, the switching-on point for the stepping motor 3 is displaced in the direction of the left-hand stop pin 33 - i.e., thread conveying by the thread wheel 5 starts earlier, in dependence on the thread speed at the start of the thread take-off. This is advantageous, since as a result there is less "overshooting" of the thread guide lever 21, more particularly at high thread speeds and low thread tensions, since practically full use can be made of the passive thread reserve produced by the thread guide arm 21 standing in the shutting-off zone B. This enables, for example, higher striping speeds to be reached. Moreover, with a correct selection of the switch-on point for the stepping motor 3 and a correctly selected changeover point of the thread tension from the reduced value of, for example, 0.5 p, to the desired operational value of, for example, 5 p, the first needles of the knitting machine still obtain a few centimeters of thread length with a lower thread tension, something which is advantageous for the start of knitting, since the risk that the thread will slip out is reduced. For the rest, the transition from the low thread tension value to the operating desired value of thread tension takes place softly (this also applies to the converse direction), so that bouncing is prevented.

The aforescribed thread delivery device, the design of which is shown more particularly in Figs. 1 to 4, has as the thread delivery element the thread wheel 5, around which thread is looped multiply to form the storage coil consisting of a number of thread windings 190, thereby ensuring that the thread is

entrained at its periphery in a substantially non-slipping manner, as explained in the second paragraph on page 11 (of this translation). Such a construction of the thread delivery device is more particularly suitable for supplying normal threads of endless or staple fibres which have no excess elasticity.

For highly resilient yarns, thread-covered or bare rubber threads, etc., thread delivery devices of a different construction are convenient, but the invention can be similarly applied thereto. Basically, such thread delivery devices are so constructed that the preferably cylindrical thread take-off bobbins or winding elements are driven by frictional connection at their periphery, as explained in detail, for example, in the Journal "Knitting International", June 1985, Pp. 47 et seq. In this case the thread delivery element according to the invention is a cylindrical driving roller which can be coupled by frictional connection to the periphery of a thread take-off bobbin or a thread winding element.

Embodiments of a thread delivery device of that kind are shown in Figs. 13 to 16, in which like elements to those of the thread delivery device embodiments already described have like references, so that repeated discussion is superfluous:

Washed Rotatably mounted on a casing 1, which bears a holder 2 and ^{receives} ~~bears~~ an electric stepping motor 3 in its upper portion (Fig. 15), are two axis-parallel cylindrical rollers 150, 151 which are aligned horizontally in the operational position of the apparatus. The two rollers 150, 151 form a paying-off place for at least one

thread take-off bobbin 152 whose sleeve has the reference 153 and which bears by its peripheral surface against the two rollers 150, 151. The distance of the two rollers 150, 151 is smaller than the diameter of the bobbin sleeve 153, so that when the take-off bobbin 152 is empty, the bobbin sleeve 153 does not drop between the two rollers 150, 151.

The two rollers 150, 151 can simply be disposed projecting on one side of the casing, in the manner shown in Fig. 13, but frequently to compensate the weight the arrangement shown in Fig. 14 is more convenient, in which the two rollers 150, 151 are so rotatably mounted projecting coaxially on both sides on the substantially rectangular upper portion of the casing 1, bounded with parallel flanks, that take-off places are produced on both sides of the casing. The length of the rollers 150, 151 is selected to match the height of the bobbin; embodiments are also conceivable in which a number of thread take-off bobbins ²150² can be applied disposed coaxially one beside the other on the pairs of rollers 150, 151.

The two rollers 150, 151 are rotatably mounted at the end side via anti-friction bearings 154 (Fig. 15) in an end plate 155 rigidly connected via struts 156 to the upper portion of the casing 1.

Disposed beneath the two rollers 150, 151 for each take-off place is a thread guide roller 158 which is freely rotatable around a horizontal spindle 157 and forms a fixed thread guide element and from which the thread 17 runs to the thread consumer.

Of the two rollers, the roller 150 constructed as a hollow spindle (Fig. 15) is slipped non-rotatably directly onto the spindle 4 of the stepping motor 3 and therefore forms a driving roller which is coupled with frictional connection to the periphery of the take-off bobbin 152 placed on the two rollers 150, 151. The other roller 151 is merely rotatably mounted on the upper portion of the casing 1.

In principle, however, both rollers 150, 151 can also act as driving rollers, as shown diagrammatically in Fig. 16. In that case the two rollers 150, 151 are drivably coupled with positive connection to a toothed belt pulley 160, wedged on to the spindle of the stepping motor 3, via an endless toothed belt 159 and toothed belt pulleys non-rotatably placed thereon. The toothed belt 159 is accommodated in the upper portion of the casing 1 and so ensures a constrained synchronization of the rotary movements of the two rollers 150, 151 with one another and with the rotary movement of the stepping motor 3 that the peripheral speed of both rollers 150, 151 always has the same value.

The thread 17, coming from a take-off bobbin 152 applied to a pair of rollers 150, 151 is deflected by the driving shaft 151 in the manner shown in Figs. 13 to 15. It passes through the eyelet 19 of the thread guide arm 21 and thence via a thread roller 158 to a thread consumer, so that between the driving roller 151 and the thread roller 158 the thread reserve is formed, which is scanned and controlled by the thread guide arm 21 in the manner already described. The thread guide arm 21 is acted upon with the desired value of adjusting force by the d.c. motor 25 via the

actuating arm 27, such force corresponding to the particular thread stress adjusted. In this case also the thread reserve is of such dimensions that it allows the starting and slowing-down of the stepping motor 3 without its falling out of step with the pulse signal with which it is supplied.

In the embodiment illustrated in Fig. 14, with two take-off places on both sides of the casing 1, as a rule its own driving stepping motor 3 is associated with each of the two pairs of rollers 150, 151 projecting on opposite sides of the casing, the motor 3 being controlled via its own thread guide arm 21 and a corresponding electronic system (Fig. 8). The two rollers of each pair 150, 151 can each be synchronized with its own toothed belt transmission (Fig. 16); alternatively, however, something which applies quite in general to all embodiments, an electric synchronization of the rollers 150, 151 is conceivable by each roller being coupled to its own stepping motor 3, in the manner shown in Fig. 15, and the two stepping motors in that case being electrically synchronized with one another.

Another alternative is that for certain applications a control system via the thread guide arm 21 is provided solely for the pair of rollers 150, 151 associated with one take-off place, while at the other take-off place the thread guide arm 21 actuates merely a normal switching-off device which responds if the thread breaks, etc. The associated pair of rollers 150, 151 is then driven at a constant speed.

Lastly, embodiments are also conceivable in which the threads of a number of take-off bobbins are passed over a common thread guide arm 21 having an associated control device and so acting on the roller drive via the associated control device that all the threads scanned remain within the adjusted range of desired values of thread tension.

CLAIMS

1. A thread delivery device having an electronic thread tension control system for thread processing textile machines, more particularly knitting or hosiery machines, having: a pivotably mounted thread delivery element which conveys the thread preferably in a substantially non-slipping manner and with which thread guide elements are associated and which is coupled to and driven by a frequency-controlled electric motor; thread tension feeling means which are disposed on the path of the thread downstream of the thread delivery element and which monitor the thread running off the thread delivery element and deliver an electric signal; and an electric control system which processes such signal and supplies a frequency signal to the motor in order to maintain the monitored thread tension constant at an adjusted required value, characterized in that disposed in the path of the thread downstream of the thread delivery element (5) is a device (15, 16, 19) which forms a thread reserve and whose size is adequate to cover the thread requirement during the starting of the motor (3); associated with such device (15, 16, 19) are means (28, 52) to immediately fill up the thread reserve to an initial value at the latest after the motor (3) has started; and the control system (52) has a circuit arrangement (63, 64) which so limits the change in time of the frequency of the frequency signal (53), at least during the starting of the motor (3), that the loaded motor (3) can follow the change in frequency.

2. A thread delivery device according to claim 1, characterized in that by the circuit arrangement (63, 64) the change in the frequency of the frequency signal (53) is so limited, also at



least during the slowing down of the motor (3), that the loaded motor (3) can follow the change in frequency, and associated with the device for forming the thread reserve are means (28, 52, 25) for taking into the thread reserve the surplus quantity of thread supplied during the slowing-down of the motor (3).

3. A thread delivery device according to claims 1 or 2, characterized in that the circuit arrangement has an integrator (63, 64) for the electric signal delivered by the thread tension feeling means.

4. A thread delivery device according to claim 3, characterized in that the integrator (63) associated with the starting of the motor (3) has a higher time constant than the integrator (64) associated with the slowing down of the motor (3).

5. A thread delivery device according to claim 4, characterized in that the two integrators (63, 64) are formed by an RC section (72, 73; 76) whose ohmic resistance can be switched over to two different values in dependence on the signal.

6. A thread delivery device according to any of the preceding claims, characterized in that the device for forming the thread reserve has at least one thread guide element (21) which is mounted to move over a predetermined path and with which at least one fixed thread guide element (15; 16; 158) is associated and which cooperates with the movable thread guide element (21) to form a lengthened thread path, and the movable thread guide element (21) is acted upon by an adjustable required value of



force operating against the thread-pulling force operating on the movable thread guide element and is coupled to a signal transmitter (28) of the feeling means which generates a signal depending on the position of the movable thread guide element (21).

7. A thread delivery device according to claim 6, characterized in that the signal transmitter (28) is an electro-optical signal transmitter scanning the movable thread guide element (21) or a member (32) connected thereto.

8. A thread delivery device according to claims 6 or 7, characterized in that the signal generated by the signal transmitter (28) stands in a given functional dependence on the particular position of the movable thread guide element (21), such that the signal increases subproportionally with increasing deflection of the thread guide element (21) in the direction of increasing thread tension.

9. A thread delivery device according to claim 6, characterized in that the required value of force operating on the movable thread guide element (21) is constant substantially independently of travel.

10. A thread delivery device according to claim 6, characterized in that the movable thread guide element is a pivotably mounted thread guide lever (21) bearing at least one thread guiding member (19).



11. A thread delivery device according to any of claims 6 to 10, characterized in that the movable thread guide element (21) is coupled to an electro-magnetic required value transmitter (25) which generates the required value of force and whose current is adjustable.

12. A thread delivery device according to claim 11, characterized in that the electro-magnetic required force transmitter is connected to the control system (52) which, when a change takes place in the electric signal delivered by the signal transmitter (28), temporarily superimposes on such signal a compensation signal which influences the required value of force in order to counteract the change in thread tension.

13. A thread delivery device according to claim 12, characterized in that the compensation signal is derived via a differential element (59) from the signal delivered by the signal transmitter (28).

14. A thread delivery device according to any of claims 11 to 13, characterized in that the electro-magnetic required value transmitter (25) has an input (at 62) for signals arriving from a central transmitter to adjust the required value of force.

15. A thread delivery device according to any of claims 6 to 14, characterized in that the path of movement of the movable thread guide element (21) is limited, and arranged in such path of movement adjacent the boundaries (33, 34) are feelers (35, 36; 43, 44) which cooperate with the thread guide element (21) and



each deliver a disconnection signal for the motor (3) and/or the machine.

16. A thread delivery device according to any of the preceding claims, characterized in that the control system (51) has an input (106) for a synchronization signal (107) arriving from an outer synchronization source, and after a speed corresponding to the adjusted required value of thread tension has been reached, the motor (3) can be automatically synchronized with the synchronization signal (107) by the control system (52).

17. A thread delivery device according to claim 16, characterized in that the control system (52) has an electronic switch (105) operated by a control circuit (108) comprising means (110, 111) for comparing the synchronization signal (107) supplied to such circuit with the signal delivered by the signal transmitter (28) and characterizing the thread tension, and for delivering a changeover signal to the electronic switch (105) in dependence on the result of the comparison.

18. A thread delivery device according to any of the preceding claims, characterized in that the motor is a stepping motor (3).

19. A thread delivery device according to one of claims 6 to 18, characterized in that the signal transmitter (28) delivers an analog signal and the control system (52) has a voltage-to-frequency converter (67) which is connected to the circuit arrangement (63, 64, 65, 66) processing the analog signal and which generates the frequency signal (53).



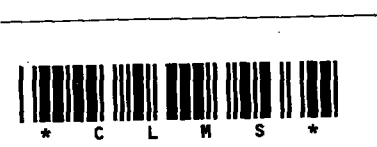
20. A thread delivery device according to claims 3 and 19, characterized in that a threshold value circuit (65) for the transmitted signal voltage is disposed between the integrator (63, 64) and the voltage-to-frequency converter (67).

21. A thread delivery device according to claim 19, characterized in that the voltage-to-frequency converter (67) has zero point suppression, such that the minimum value of the output frequency is adapted to the start-stop frequency of the motor (3).

22. A thread delivery device according to any of claims 18 to 21, characterized in that voltage-to-frequency converter (67) has a device (84) for changing its steepness.

23. A thread delivery device according to any of the preceding claims, characterized in that when the motor (3) is stopped, the thread tension is maintained by the control system (52) at a predetermined value which is equal to or lower than the adjusted required value.

24. A thread delivery device according to claim 23, characterized in that the control system (52) has means (120) via which the required value of the thread tension can be reduced to a predetermined lower value, if the thread reserve decreases to a given extent in comparison with the initial value, and restored to its original value when the thread reserve diminishes again.



25. A thread delivery device according to claims 9 and 24, characterized in that the path of movement of the movable thread guide element (21) has a first zone (A + B - C) within which such element is acted upon by the adjusted required value of force and which is adjoined in the direction of an increasing thread reserve by a second zone (C) in which the required value of force is reduced to a lower value, and the means (120) for changing the required value in this way are operated by the signal transmitter (28) delivering the position-dependent signal.

26. A thread delivery device according to any of claims 9 to 25, characterized in that the path of movement of the thread guide element (21) has a working zone (A), within which the thread guide element (21) in normal operation occupies a position given by the thread delivery speed, and the working zone (A) is followed by a disconnection zone (B), and when the thread guide element (21) stands in the disconnection zone (B), the control system (52) processes the signal delivered by the signal transmitter (28) to stop the motor (3).

27. A thread delivery device according to any of the preceding claims, characterized in that the thread delivery element is a thread wheel (5) or a thread drum around which the thread (17) is looped and by which the thread (17) can be conveyed in a substantially non-slipping manner.

28. A thread delivery device according to one of claims 1 to 26, characterized in that the thread delivery element is at least one cylindrical drive roller (150) which can be coupled in frictional



engagement to the periphery of a thread take-off bobbin (152) or a thread winding member.

29. A thread delivery device according to claim 28, characterized in that drive roller (150) is pivotably mounted, with a second cylindrical roller (151), disposed axis-parallel at a distance on common retaining means (1), with horizontal alignment and the formation of at least one unwinding place, at a distance which is smaller than the diameter of the bobbin sleeve (153) of the thread take-off bobbin.

30. A thread delivery device according to claim 29, characterized in that the second roller (151) is also coupled to a drive device (151, 160) which gives the second roller the same peripheral speed as the drive roller (150) and which is constrainedly synchronized with the drive (3) of the drive roller.

31. A thread delivery device according to claim 30, characterized in that the second roller (151) is driven by its own frequency-controlled electric motor (3), which is electrically synchronized with the drive motor (3) of the drive roller (150).

32. A thread delivery device according to claim 30, characterized in that the two rollers (150, 151) are synchronized with one another via a positively connected transmission (159, 160).



33. A thread delivery device according to any of claims 29 to 32, characterized in that the two rollers (150, 151) are rotatably mounted on the retaining means (1) projecting on opposite sides thereof, thereby forming at least two unwinding places (Fig. 14).

34. A thread delivery device according to one of claims 27 to 33, characterized in that a common electric control system (52) is associated with at least two unwinding places.

