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[54] **CIRCUIT FOR CONTROLLING THE THREAD VELOCITY IN WINDING EQUIPMENT WITH A TRAVERSING MECHANISM**

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[52] **U.S. Cl.**................ **242/45,** 242/75.51, 242/186, 318/6

[51] **Int. Cl.**.. **B65h 59/38**

[58] **Field of Search** 242/45, 75.5, 75.51, 186; 318/6

[56] **References Cited**

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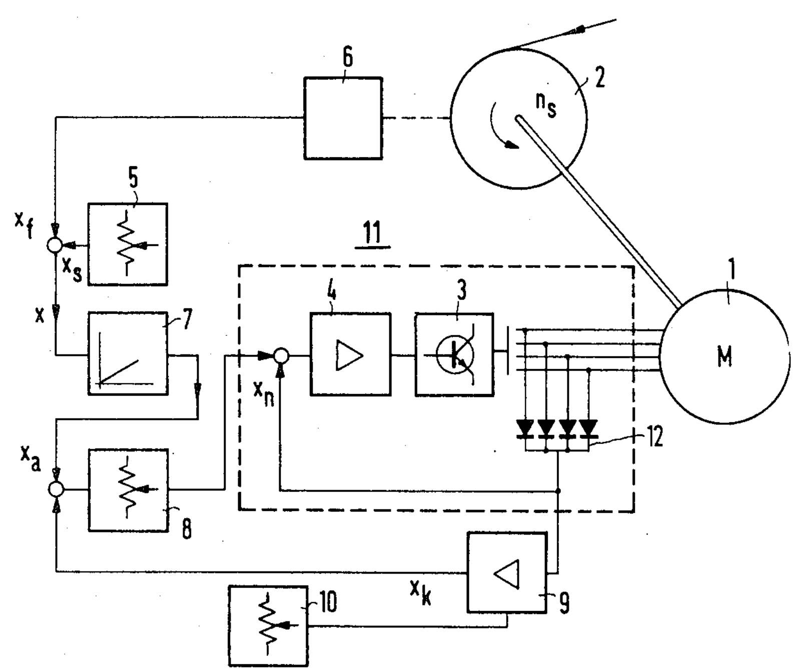
[57] **ABSTRACT**

A circuit for controlling the thread velocity in universal winding machines having a traversing mechanism is disclosed. The circuit develops a correction factor, derived from the diameter of the winding on the spindle or the speed of the motor driving the spindle. This correction factor is then used as an input to the thread velocity control circuit to maintain a constant velocity for the thread being fed to a spindle.

5 Claims, 4 Drawing Figures



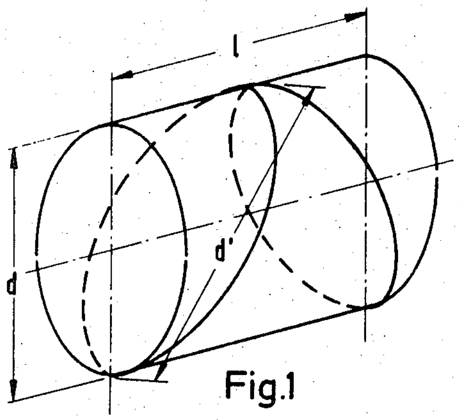


Fig.1

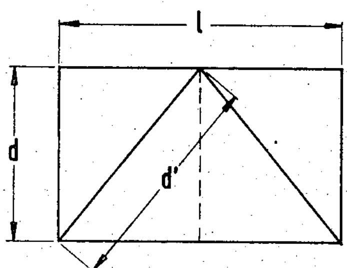


Fig.2

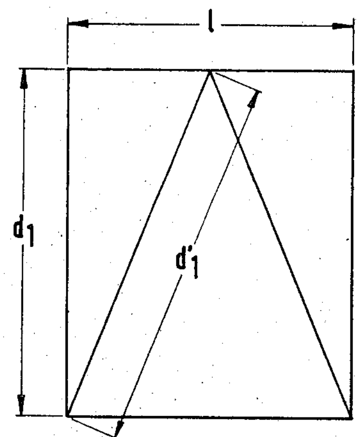


Fig.3

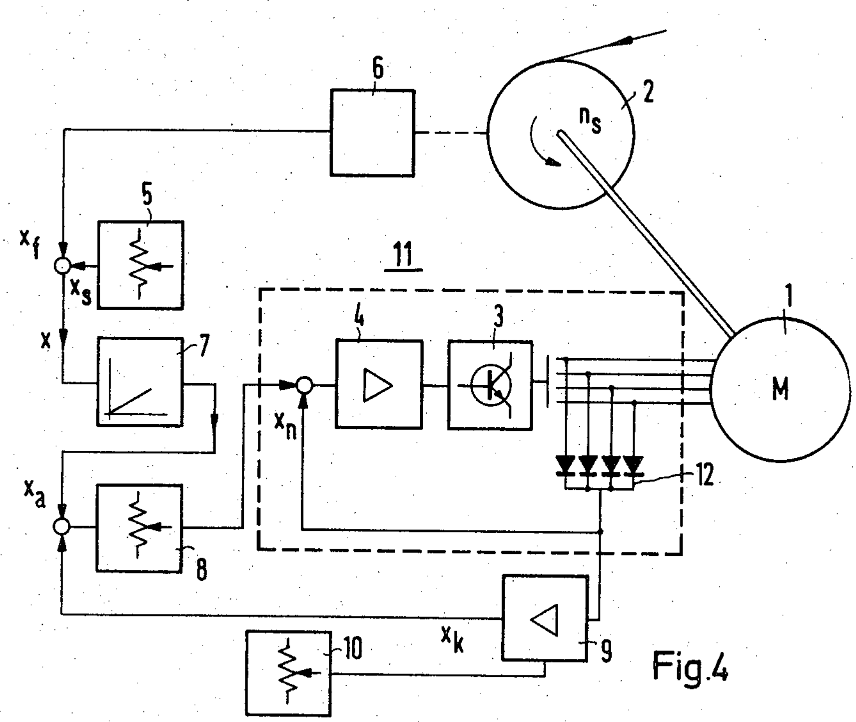


Fig.4

CIRCUIT FOR CONTROLLING THE THREAD VELOCITY IN WINDING EQUIPMENT WITH A TRAVERSING MECHANISM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is concerned with a circuit for controlling the thread velocity in a universal winding machine, in which a traversing mechanism is employed. More particularly, it is concerned with a means for measuring the velocity of the thread winding to thereby supply a reference value for a thread velocity control means in a spindle winder drive in which speed control is used.

In order to insure that the properties of thread-like materials such as yarns are not changed during winding operations, it is necessary to maintain the thread tension constant during the entire winding procedure. With extremely thin yarns the commonly used method of controlling the tension in heavier yarn thread by means of a feeler roll is not technically possible. Therefore, one must resort to some form of thread velocity measurement.

The direct measurement of the thread velocity for moving material, however, causes difficulties, and it is therefore advisable to measure the tangential velocity of the winding by means of a feeler roll. A system which operates in this manner is described in U.S. application Ser. No. 334,933, filed by M. Liska and H. Grünleitner on Feb. 22, 1973 and assigned to the same assignee as the present invention. However, sufficient accuracy is obtained by this method only if the thread velocity is proportional to the tangential velocity of the winding. Modern winding machines, however, are always equipped with a traversing mechanism which, by means of a thread guide, moves the thread along the axis of the reel once or several times during the revolution of the reel. The subsequent trouble free unwinding of spools can be accomplished only if the spools were originally wound in the same manner.

2. Summary of the Invention

It is therefore an object of this invention to use a relatively simple circuit to compensate for changes in thread velocity created during the winding process by the motion of the traversing mechanism.

According to the invention, the problem is solved by introducing into the thread velocity control circuit a correction factor derived from a quantity which is a function of the diameter of the winding such as from the speed of rotation of the spool winder. It is particularly advantageous if the correction fator is derived from the actual value of the speed of rotation of the spool winder drive, because it is usually very complicated to sense the diameter of the winding. The illustrated embodiment uses a d-c motor without a commutator as the spool winder drive with the e.m.f. induced in the stator winding by the permanent-magnet rotor utilized as a measure of the actual value of the speed of ratation. The e.m.f. is advantageously fed to an amplifier whose output signal is used as the correction factor for the reference value transmitter.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, as well as its objects and features will be better understood by reference to the following detailed description of the preferred embodiment of this invention taken in conjunction with the accompanying drawings in which:

FIG. **1** is a diagrammatic illustration of the apparent movement of the thread guide over the surface of the winding for a crossing ratio $k = 1$. The crossing ratio is defined as the number of double throws per revolution of the winding. As shown in FIG. **1**, the winding diameter d is apparently increased to d' during one traversing motion.

FIGS. **2** and **3** illustrate side views of the winding shown in FIG. **1**, with different diameters.

FIG. **4** is the block diagram of a thread velocity control circuit constructed according to the invention for a winding machine drive having subordinated speed control and a correction for the influence of the traversing motion.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** is a perspective view showing the manner in which the thread is wound on a spool. The actual diameter d' of a loop of thread will be greater than the diameter d of the total winding which is the diameter at which the tangential velocity is sensed. If the ratio of $d{:}d'$ remained constant, no problems would arise. However, as will be seen by comparing FIGS. **2** and **3**, the diameter ratio, $d{:}d'$, changes with increasing diameter as a result of the fixed spool length **1**. Thus, even with an exactly constant tangential velocity of the winding, as measured by a roller tangent to the diameter d, a thread velocity is obtained which decreases with the increasing diameter of the winding. The change in magnitude essentially depends on the change in the diameter of the winding and the crossing ratio. Practical investigations have shown that the velocity deviation can be 10 percent or more. Deviations of such an order of magnitude are no longer permissible in many cases, particularly in precision winding machines. With little thread on the spool, as shown on FIG. **2**, the difference between d and d' will be great. As more thread is wound on the spool, as shown on FIG. **3**, the difference becomes smaller. To maintain a constant tangential velocity the angular velocity of the motor will be higher when there is little thread on the spool and lower when more thread is on the spool. Thus, the velocity of the motor is directly related to the diameter error. The present invention makes use of this fact in providing the needed correction.

As shown in FIG. **4**, a commutatorless d-c motor **1** drives the shaft of a winding **2** on which thread-like material is to be wound. The winding equipment comprises a traversing mechanism, not shown in the drawing. The motor **1** has a permanent-magnetic rotor which interacts with four windings arranged in the stator. The stator windings are connected with each other at one end and the neutral point formed in this manner is connected with one terminal of a d-c source. The other ends of the windings are sequentially connected through an electronic commutator **3** and the other terminal of the d-c source in such a manner that a rotating field is produced in the stator. The electronic commutator **3** is controlled by a speed control means **4.** Similarly a conventional d-c motor such as that described in the above referenced application may be used.

The tangential velocity of the winding is converted into a pulse train x_f, by means of a non-contacting transducer means **6.** (Such means along with the other basic elements of the control circuit are described in detail in the above referenced U.S. application Ser. No.

334,933, and will only be briefly described herein). The voltage-time area of the pulse train x_f representing the tangential velocity is compared with an average d-c voltage value x_s representing a desired velocity, produced by a reference value transmitter **5.** The deviation, x, the error between the actual and desired velocities, between x_f and x_s is fed to an integrator **7,** which may be a differentiating-feedback amplifier i.e., it has a capacitor in its feedback path. As long as the deviation x remains at zero the output of the integrator will remain fixed. An error in either direction will cause a charging or discharging of the feed back capacitor to adjust the integrator output until the proper velocity is reached. The output quantity x_a of integrator **7** is picked off by a potentiometer **8** used to provide coarse control of motor speed. This is the speed control value fed to the speed control means **4.**

The actual value x_n of the speed of rotation of the motor **1** is determined in a known manner from the e.m.f. of the motor by means of the plurality of diodes **12.** Voltages corresponding to the e.m.f. of the motor are induced in the windings of the stator by the revolving permanent-magnet rotor. A tachometer may also be used to develop this signal as described in the above referenced application. The entire circuit for the speed control circuit **11** is indicated by the dashed lines in FIG. **4.** Here in well known fashion the output of potentiometer **8** is summed with the value x_n to provide outputs to maintain the required motor speed. The portion of the circuit thus far described is conventional and as noted may be constructed in the manner described in application Ser. No. 334,933. However, it will exhibit the inaccuracies described above.

To correct for these inaccuracies, the present invention uses the e.m.f. of the motor which is proportional to the angular velocity to derive a correction factor for the thread velocity control circuit **11.** This is accomplished by feeding the coupled output of diodes **12** to an amplifier **9,** whose output signal x_k is summed with the input x_a at the input to potentiometer **8** to provide a correction factor. Although shown as a potentiometer, block **8** may also contain a summing amplifier to sum these signals. The resulting output is then fed to the thread velocity control circuit **11.** In order to obtain compensation for different crossing ratios and different reel sizes amplifier **9** has a variable feedback means **10** which, to provide better compensation, can be made non-linear. In this manner, the correction quantity is no longer directly proportional to the angular speed of rotation of the spool and by proper selection of feedback elements the deviation of the thread velocity from the ideal value can be made approximately zero. As illustrated schematically by the block **10,** the variable feedback means can comprise a variable resistor in a feedback path which resistor may be setup at the beginning of a winding operation to give the desired gain. Similarly, the resistor may be replaced by non-linear networks comprising for example, diodes resistors, variable resistors, etc., which also will be initially set up prior to a winding operation.

The invention thus permits the application of thread velocity control to precision winding machines. In addition it permits adding improved accuacy to a normal thread velocity control with no additional mechanical components and only a minimum amount of additional circuitry. In addition, one obtains the ability to adapt and use the correction factor produced by the circuit to different designs of spools such as those having different crossing ratios and different ratios of length to diameter. A further advantage consists, moreover, in the fact that the dynamic behavior of the thread velocity does not influence the control circuit because the correction factor only influences the reference value. By introducing non-linear feedback in the correction factor amplifier the deviation of the thread velocity from the ideal value can thereby be reduced to almost zero.

In the foregoing, the invention has been described in reference to specific exemplary embodiments. It will be evident, however, that variations and modifications, as well as the substitution of equivalent constructions and arrangements for those shown for illustration, may be made without deparing from the broader scope and spirit of the invention as set forth in the appended claims. The specification and drawings are accordingly to be regarded in an illustrative rather than in a restrictive sense.

What is claimed is:

1. A circuit for controlling the thread velocity in a universal winding machine having a traversing mechanism, said machine including a spool drive operated by a speed control, said circuit providing compensation for inaccuracies resulting from said traversing mechanism comprising:

a. means to measure the tangential velocity of the spool and to provide a first output signal proportional thereto;
b. means to provide a second signal representing a desired tangential velocity;
c. means having said first and second signals as inputs to develop a speed control signal;
d. means to develop a third signal proportional to the actual spool drive speed;
e. means to couple said speed control signal and said third signal to said speed control;
f. means to develop from said actual spool drive speed a correction factor signal proportional to the diameter of the winding on the spool; and
g. means to add said correction factor signal to said speed control signal.

2. A circuit for controlling the thread velocity in a winding machine as in claim **1** in which the spool winder drive is a d-c motor without a commutator and having a permanent magnet rotor and in which the e.m.f. inducted in the stator windings by the permanent-magnet rotor is used to represent the actual value of the speed of rotation of the spindle winder.

3. A circuit for controlling the thread velocity in a winding machine as in claim **2** wherein said means to develop a correction factor signal comprises an amplifier having as an input said e.m.f. induced in the stator windings.

4. A circuit for controlling the thread velocity in a winding machine as in claim **3,** in which the amplifier has adjustable feedback.

5. A circuit for controlling the thread velocity in a winding machine as in claim **4,** in which the adjustable feedback is made non-linear.

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