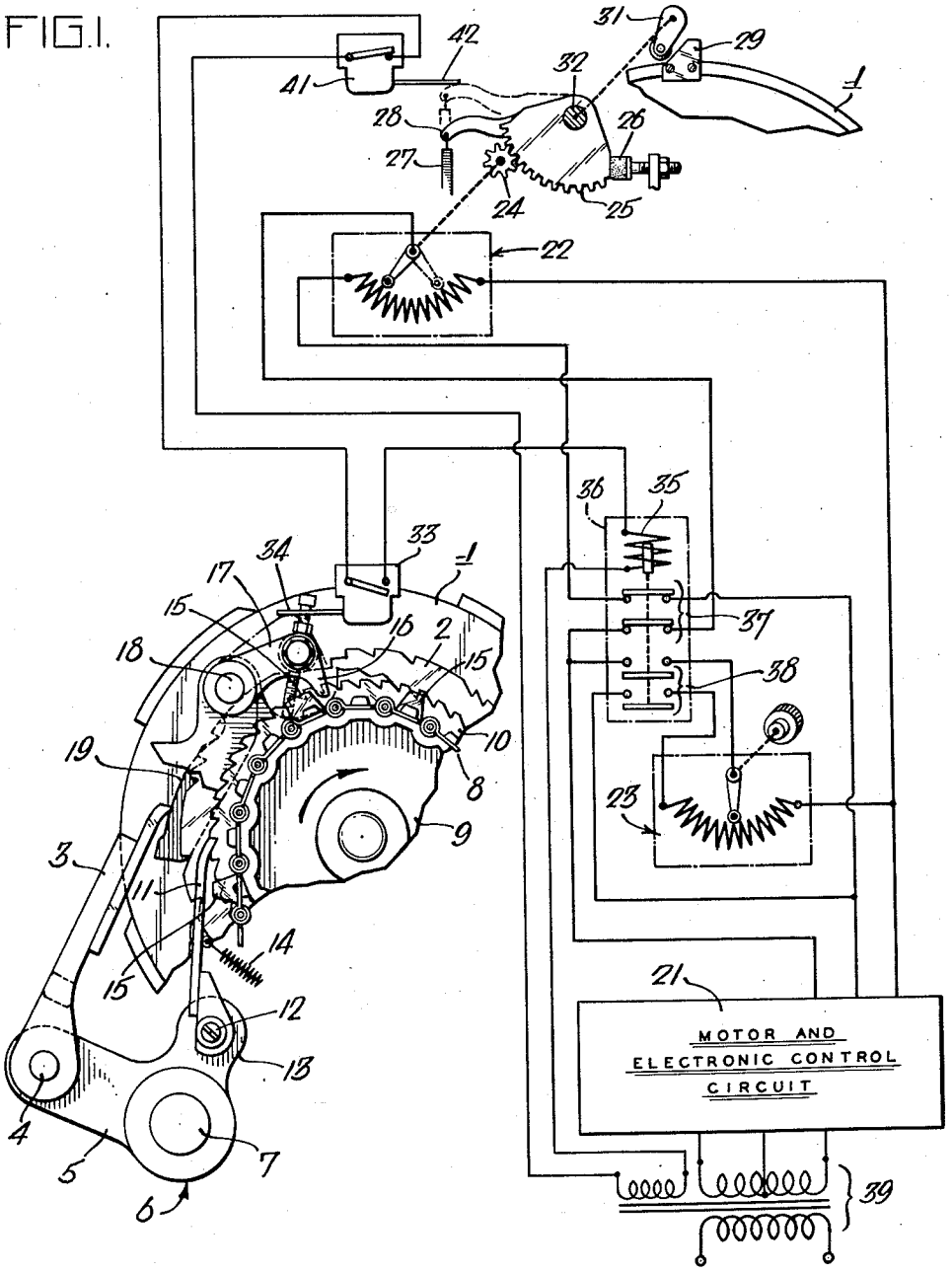
Jan. 3, 1961 J. T. McKIBBIN ET AL 2,966,783

ELECTRONIC CONTROL CIRCUITS FOR KNITTING MACHINES

Filed Dec. 2, 1958 3 Sheets-Sheet 1

FIG. 1.

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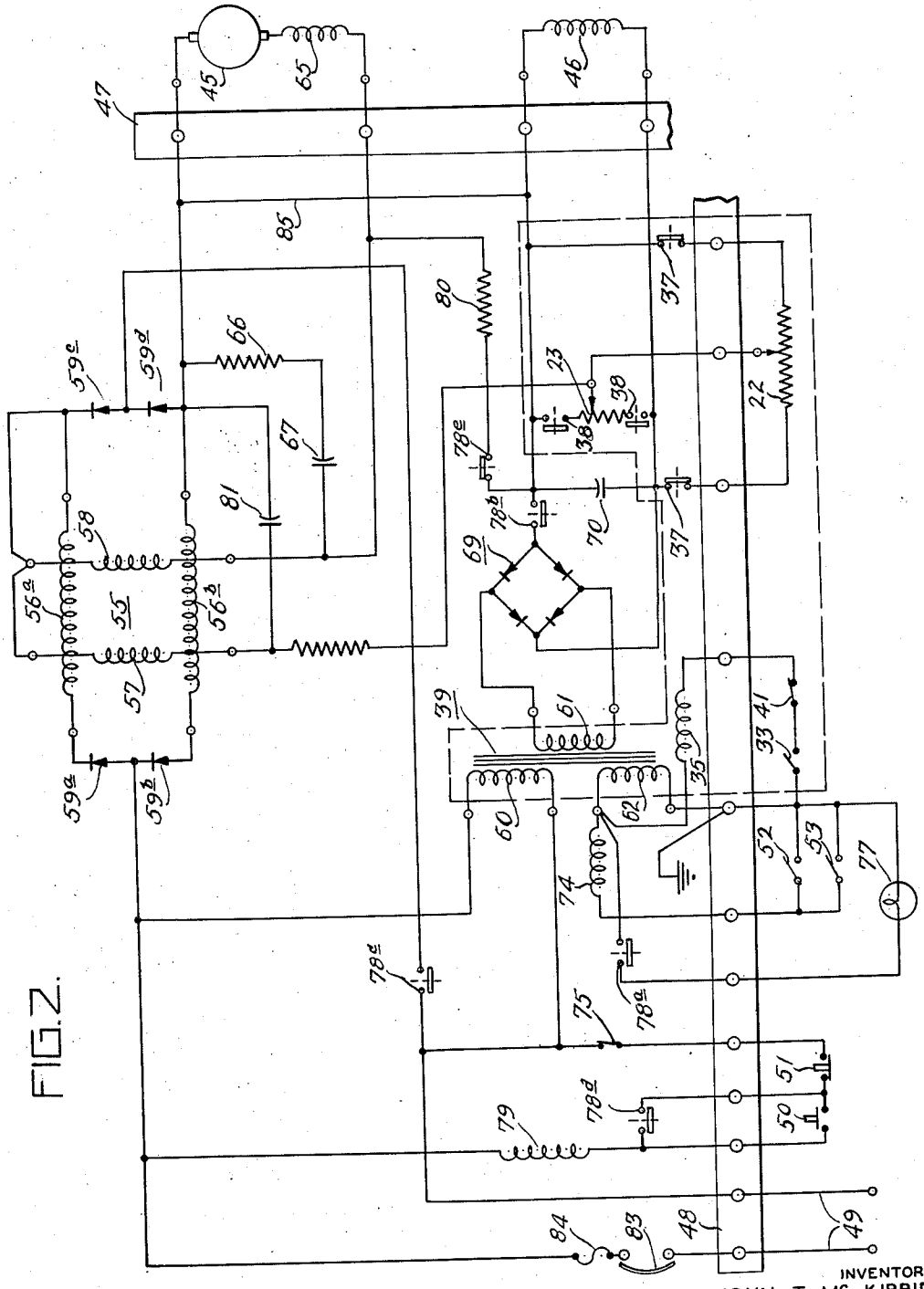


FIG. 2.

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Filed Dec. 2, 1958 3 Sheets-Sheet 3

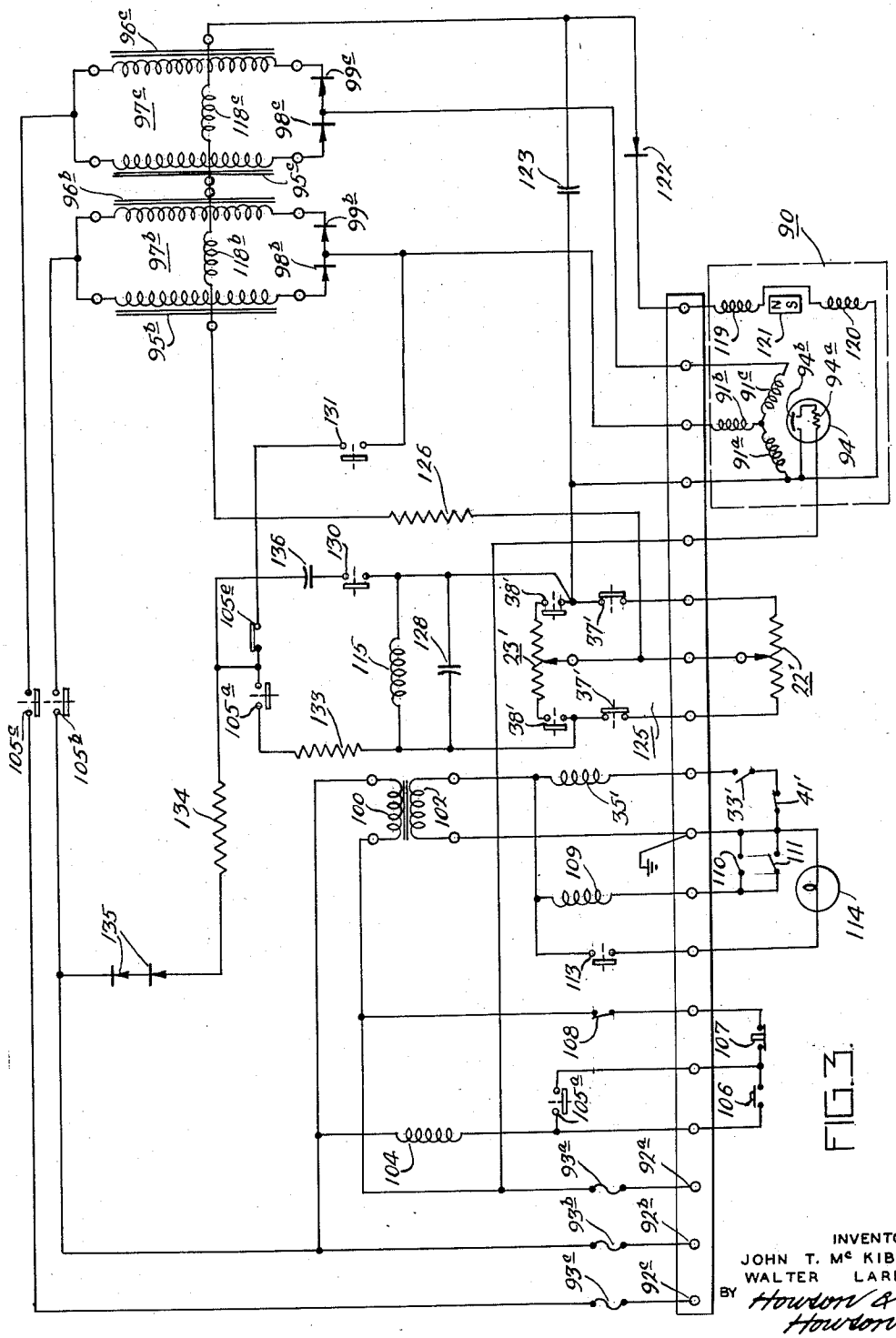

FIG. 3.

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2,966,783

# ELECTRONIC CONTROL CIRCUITS FOR KNITTING MACHINES

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3 Claims. (Cl. 66—56)

This invention relates to improvement in electrical speed controls disclosed in U.S. Patent 2,817,220 for circular knitting machines disclosed in U.S. Patent 2,422,568.

In the machine of Patent 2,422,568 means was provided for variably regulating the speed of the machine in accordance with the differing requirements of the several individual operations entailed in forming the end product. The speed variations were obtained through the medium of electronic control devices operatively associated with the electric motor constituting the prime mover of the machine, said devices including a potentiometer actuated directly from the pattern drum of the machine. By reason of technical advances, it has been found practicable to operate circular hosiery knitting machines of this class at relatively high rates of speed and to maintain the high speed constant throughout the forming of the entire stocking with exception only of one or more critical operations wherein it becomes necessary to greatly reduce the operating speed of the machine and, in shifting from one operation to another, where the mechanical moves entailed in the shift are such as to require a momentarily reduced speed. For example, the normal generally sustained operating speed may be of the order of 200 r.p.m., whereas in shifting from circular to oscillatory operation of the needle cylinder at the inception of the toe formation, it may be desirable or necessary to reduce the speed momentarily to as low as 40 r.p.m. or the equivalent.

Other operational shifts may require a speed reduction of considerably lesser but still substantial magnitudes. The prior speed control devices are not well adapted to changes of this magnitude. This is due in part to the fact that the shifts from one operation to another and the actuations of the speed control devices are under control of a common member, namely, the pattern drum so that the mechanical moves entailed in any operational change requiring a reduced knitting speed occurred simultaneously with the actuation of the speed regulating devices and at the initial relatively high speed.

U.S. Patent No. 2,817,220 discloses an improved speed control system wherein the reduction in speed is effected in advance of mechanical moves entailed in changing machine operation. This is particularly important in high speed machines. Moreover, it has enabled the speed change function to be divorced, at least in part, from the pattern drum in order to avoid a high degree of flexibility in the relative timing of the mechanical moves effecting a change of machine operation and the speed change required for said moves or for the new operation. An important aspect of that invention has been the relative simplicity of its form and the economy of its installation in preferred embodiments.

Unfortunately, rapid mechanical changes may be accompanied by heavy electrical surges and in practical embodiments of Patent No. 2,817,220 this has proved to be the case. For the most part, the systems could be designed to withstand the high current surges but it was found that the potentiometers, whose output was directly



used to supply the load, were subject to overloading causing breakdown or overheating, oftentimes sufficient to cause fire. Since the potentiometers may be subject to full line voltage, which in a 220 volt A.C. supply, subjects the potentiometer to a peak-to-peak voltage of approximately 600 volts, failure of the potentiometers may provide a substantial shock hazard to the machine operator. Furthermore, upon failure of the potentiometers and the associated circuit components, the knitting machine may continue to operate at maximum speed which, during the operations requiring a reduced speed, will severely damage the knitting machine, breaking needles, and frequently causing failure of the machine cams; and excessive damage may be occasioned before emergency measures may be taken to stop the machine.

The present invention insulates potentiometers from high current surges by placing them in the control circuits of saturable core reactors which absorb the high current pulses from the load and tend to smooth and round off peaked transient characteristics which would otherwise cause overheating and damage of the potentiometers before they can reach the potentiometers. More particularly, in accordance with the present invention, the potentiometers are arranged to control the current flow in the control winding of a saturable reactor, and by the resulting magnetic field produced in a common core with other windings to thereby regulate the current flow in those other windings which supply the current to the motor load and thereby determine the speed of the motor in a particular installation.

The present invention also contributes substantially to improved safety in the machine by enabling the potentiometers to be protected against full line voltage which may avoid dangerous shock hazards to the operators.

The present invention provides increased efficiency and less power expenditure which is lost to the knitting room in the form of additional heat by eliminating the necessity for electronic tubes which require heating of the filaments.

Another important object of the present invention is to provide a knitting machine control which is able to automatically reduce the motor speed in the event of failure of certain components, so that the machine, if it continues to operate, operates only at reduced speed at which the fragile components of the knitting machine are not damaged.

For a better understanding of the present invention, reference is made to the attached drawings which illustrate diagrammatically and schematically the nature of the present invention as follows:

Fig. 1 is a diagrammatic illustration of a control system in accordance with the invention of Mahler and McKibbin disclosed in Patent No. 2,817,220;

Fig. 2 is a circuit diagram showing a circuit controlling speed in a D.C. motor drive embodying a saturable reactor in accordance with the present invention; and

Fig. 3 is a schematic diagram of a circuit controlling speed in an A.C. motor drive embodying a saturable reactor in accordance with the present invention.

Referring to Fig. 1, the pattern drum which controls sequential operations of the machine is indicated by the reference numeral 1, and the numeral 2 indicates a ratchet wheel which is connected to the drum and constitutes an element of the drum indexing mechanism. A pawl 3, pivotally mounted at 4 on one arm 5 of a bell crank lever 6, constitutes the means for actuating the ratchet wheel 2 and for thereby indexing the drum, the lever being mounted on a rock shaft 7 which is oscillated continuously in timed relation with the rotary and oscillatory movements of the needle cylinder (not shown). A pattern chain 8, engaged with a sprocket 9, has attached thereto a ratchet wheel 10 which is actuated by

a pawl 11, this pawl being pivotally attached at 12 to the other arm 13 of the lever 6, and being resiliently held in operative position with respect to the wheel 10 by a spring 14. The ratchet wheel 10 and sprocket 9 are thus turned through a predetermined angle at each oscillation of the lever 6. It will be noted that during each working stroke of the pawl 11, the pawl 3 is being retracted, and vice versa.

The chain 8 carries longitudinally spaced lugs 15 which, as the chain is intermittently advanced as described, individually engage one end 16 of a lever 17 mounted at 18 on a fixed pivot, this lever 17 comprising at the opposite side of the pivot 18 an arm 19 positioned in proximity to one side of the ratchet wheel 2 for operative engagement with the pawl 3. When the lever end 16 is disengaged from the lugs 15 of the chain 8, as shown in the drawing, the said end 16 will be relatively depressed and the arm 19 relatively elevated so as to engage the end of the pawl 3 and to elevate the pawl in respect to the ratchet wheel 2 so that the pawl in its oscillatory movement will ride on the edge of the arm 19 in a path remote to the ratchet wheel and will be inoperative to actuate the latter. When the end 16 of the lever 17 is elevated by one of the lugs 15, the arm 19 will be retracted to release the pawl 3 to its normal operative position with respect to the ratchet wheel 2 so that in its working stroke the pawl will then be effective to actuate the wheel and through the wheel to index the pattern drum 1. This mechanism is essentially the same as that disclosed in U.S. Patent No. 2,422,568.

Also in accordance with the principle described in the aforesaid patent, the machine comprises an electronic control device for effecting variations in the speed of the driving motor (see Figs. 2 and 3) which constitutes the prime mover of the machine. This device comprises an electrical unit 21 of a character described in Patent No. 2,422,568 and in conjunction therewith a potentiometer 22. In the prior device this potentiometer is actuated by a cam ring on the pattern drum to vary the operating speed of the machine as required by any one or more of the operations under control of the pattern drum.

In accordance with Patent No. 2,817,220, the potentiometer 22 is also actuated by a cam element on the drum 1, but the speed control does not in this case lie solely with the potentiometer 22 but lies in part with a second manually adjustable potentiometer 23 which under circumstances described below assumes a part of the speed regulating function. The potentiometer 22 is set to a position which corresponds to the normal maximum operating speed of the machine, as shown in full lines in the drawing. This setting is obtained through the medium of a pinion 24 operatively connected to the potentiometer, a segmental gear 25 which meshes with the pinion 24, and a stop element 26 associated with the segmental gear 25 and serving to establish that gear in a position affording the said high speed setting of the potentiometer. A spring 27 exerts pressure through an arm 28 on the segmental gear 25 tending to hold that gear in engagement with the stop 26, as shown in full lines in the drawing. Thus under normal conditions, the potentiometer will be retained at the setting affording the normal high speed operation. The segmental gear 25 may be shifted from its position on the stop 26 by action of a cam 29 on the pattern drum 1, this cam moving with the drum in a path which will eventually bring it into operative engagement with the free end of an arm 31 operatively connected with the segmental gear 25. The arm 31 will normally occupy the full line position shown in the drawing. Displacement of the arm 31 by the cam 29 will displace the gear 25 angularly about the axis of its pivot 32 in clockwise direction as viewed in the drawing, and will thereby adjust the potentiometer 22 to a low speed position indicated in broken lines.

The lever 17 which is actuated by the lugs 15 of the pattern chain 8 as previously described, and which controls the position of the pawl 3 with respect to its ratchet wheel 2, is operatively associated with a microswitch 33 in a manner such that when the end 16 of the lever 17 is in the depressed position shown in full lines in the drawing, the switch 33 will be open as illustrated. When, however, the end 16 of the said lever is elevated by one of the lugs 15 of the chain, it will engage an actuating element 34 of the switch 33 and will close the latter. This closing of the switch 33 energizes solenoid 35 of a relay 36 and in so doing will cause the relay to open normally closed switch 37 and to close normally open switch 38. This manipulation of the switches 37 and 38 substitutes the potentiometer 23 for the potentiometer 22 in the motor control circuit containing the source of energy 39 so that the control of the speed of the said motor now becomes a function of the potentiometer 23. The potentiometer 23 is manually pre-set to a position of intermediate motor speed so that the substitution of this potentiometer in the motor control circuit will result in an immediate reduction of speed from the normal high to a selected intermediate speed. As previously set forth, the potentiometer 23 is manually adjustable and may be set to any required or desired intermediate speed.

This transfer of potentiometers occurs on the forward or working stroke of the pawl 11 as previously described and during this working stroke, the pawl 3 has been retracted so that the subsequent reverse oscillation of the lever 6 will cause it to advance in its working stroke. The pawl control element 19 has been retracted at this juncture by action of the lug 15 of the chain 8 on the lever 17 so that the pawl 3 in its working stroke will operate to advance the ratchet wheel 2 and with it, the pattern drum 1. The resulting movement of the drum will bring the cam 29 on the latter into engagement with the arm 31 and will thereby effect a movement of the segmental gear 25 away from the stop 26 and, through the pinion 24, will adjust the potentiometer 22 to a low speed position indicated in broken lines. This movement of the segmental gear 25 also results in the opening of a normally closed switch 41 in series relation with the switch 33, this actuation of the switch 41 being effected through an actuating element 42 located in the path of the arm 28 of the segmental gear. The opening of the switch 41 which occurs at the end of the angular movement of the segmental gear 25 and after the potentiometer 22 has been adjusted to low speed position, breaks the circuit of the solenoid 35 and results in again closing the switch 37 and opening the switch 38 so that the potentiometer 22 is now restored to the control circuit and the operation of the machine is reduced to the low speed to which the potentiometer 22 is now set. This low speed is below that at which the machine was operating under control of the potentiometer 23.

At the termination of this working stroke of the pawl 3 and the coinciding retractive movement of the pawl 11, the direction of movement of the lever 16 will be reversed with a resulting further indexing movement of the pattern chain 8. The lug 15 of the chain which now supports the end 16 of the lever 17 is of such extent that this indexing movement of the pattern chain fails to release the lever 17 from the lug so that the switch 33 remains closed and the arm 19 of the lever 17 remains in the retracted position permitting the pawl 3 to engage the ratchet wheel 2. The subsequent forward movement of the pawl 3, therefore, again indexes the pattern drum. In the present instance, this indexing movement performs two functions. The initial part of the movement effects the machine adjustment, the performance of which has required the reduction to low speed operation. Such adjustment might, for example, reside in the shifting of a clutch to change the full rotary movement of the needle cylinder to oscillatory movement, more particularly in initiating formation of the toe of the stocking. During that portion of the indexing movement

of the drum 1 wherein this machine adjustment is effected, the arm 31 is still held in the elevated position by the cam 29, but continued movement of the drum eventually releases the arm 31 from the cam and permits the segmental gear 25 under actuation by the spring 27 to return to the original position against the stop 26. This movement of the segmental gear first releases the actuating element 42 of the switch 41 and permits that switch to close; and subsequently readjusts the potentiometer 22 to the original high speed position. Since the end 16 of the lever 17 remains in the elevated position on the lug 15 and the switch 33 is therefore closed, the closing of switch 41 energizes the solenoid 35, again opening switch 37 and closing switch 38 and thereby transferring the control of machine speed to the potentiometer 23. The machine then assumes the intermediate speed to which the potentiometer 23 has been set manually. This intermediate speed of operation continues until the next forward movement of working stroke of pawl 11 which results in a further indexing movement of the chain 8 releasing the lever 17 from the lug 15 and permitting the lever to return to the original position shown in the drawing in which the arm 19 serves to elevate the pawl 3 from operative position with respect to the ratchet wheel 20. Release of the lever 17 also results in the re-opening of the switch 33 which breaks the circuit of solenoid 35, deenergizing the latter, closing switch 37 and opening switch 38, thereby restoring control of machine speed to the potentiometer 22 which now, as described above, occupies the original high speed position.

Referring next to Fig. 2, a schematic diagram of the control circuit, in accordance with the present invention is shown. This control system contemplates the use of a shunt D.C. motor having an armature 45 and a field 46. It is assumed that the elements already described in Fig. 1 are those which are shown in Fig. 2 and, accordingly, corresponding elements are designated by the same number designators. Terminal blocks 47 and 48 are meant schematically to represent the boundaries of the control box such that all components above and to the left of the strips 47 and 48 are within the control box, and those below and to the right of the strips are external to the control box. Thus the input power lines 49, and the start-button 50, the stop-button 51 and the safety interlock switches 52 and 53, the control switches 33 and 41, and the manually-adjustable potentiometer 22 are all external of the control box. A master switch 83 and fusing 84 is represented as being in one of the input power lines 49 inside the box, but it might well also be outside of the box.

Internal of the control box is the saturable reactor, generally designated 55, which has gate windings 56*a* and 56*b*, a control winding 57, and an output winding 58. The gate windings are connected directly across the power lines 49 through a rectifier arrangement employing rectifiers 59*a*, 59*b*, 59*c* and 59*d*. Also connected directly across the line is primary winding 60 of transformer 39 having secondaries 61 and 62. The armature 45 and a series field winding 65 in series with the armature 45 are energized through the gate windings 56*a* and 56*b* and the control winding 58. The resistance 66 and capacitance 67 provide an RC ripple-smoothing filter.

The field winding 46 is fed from secondary 61 through full wave rectifier 69 across which may be arranged a smoothing capacitor 70. Also across the field winding are the potentiometers 22 and 23. These potentiometers are placed in the circuit by the action of relay switches 37 and 38 which are actuated by energizing relay winding 35 across transformer secondary 62 which is in series with the switches 33 and 41. Switches 38 are normally open, and switches 37 are normally closed. Under these circumstances, manually-adjustable potentiometer 22, which may be used to adjust the normal relatively fast operating speed, is connected across the field winding 46. Upon energization of relay winding 35 due to the closing of



switch 33, switches 37 open and switches 38 close, placing potentiometer 23 across the field winding 46 to reduce the speed of operation to the intermediate speed, at which time the potentiometer 22 is actuated by the segmental gear 25 to the low-speed position. Deenergization of the relay winding 35 then further reduces the operating speed for such processes as the making of toes and heels. Potentiometer 23 is pre-set for slow speed and is actuatable by the segmental gear 25 to a setting for slow speed and potentiometer 22 is normally set for high speed. Potentiometer 23 is normally pre-set and is located internal of the machine so that readjustment cannot be as easily accomplished as with the externally arranged potentiometer control of potentiometer 22. The adjustable tap of both potentiometers are connected through resistor 73 to control coil 57. Coil 57 is arranged on the saturable core of reactors 55 so that the more current that flows through it the greater the D.C. magnetization of the core and the less the A.C. impedance of windings 56*a* and 56*b*, hence the larger the output current and the faster the motor speed. Whichever potentiometer is across or in parallel with the field winding 46, therefore, determines current output, depending upon its tap position, through the potentiometer tap, resistance 73, winding 57, rectifiers 59*c* and 59*d* and back through line 85. In the event of failure of the components in the control circuit such as to remove the voltage normally applied to the control winding 57, the impedance of the saturable reactor is increased to thereby reduce the motor speed to a rate at which the fragile components of the knitting machine are not damaged.

In addition to relay winding 35, there is in parallel with transformer secondary 62 another relay winding 74 adapted to act to open normally closed switch 75 in the power circuit in response to energization through switches 52 and 53 which may be safety switches, overload switches, and the like. Also in parallel across secondary 62 is pilot light 77 which indicates when the device is operating and when it is off. Its indication depends upon the condition of normally open switch 78*a*, one of the relay switches closed by energizing winding 79. The other switches of the relay are switch 78*b* in the line to the field which is normally open, switch 78*c* in the line to the saturable reactor which is normally open, switch 78*d* a self-held switch which is normally open but which is held closed once it is closed until the current through coil 79 is interrupted. Starting switch 50 stays closed only as long as it is pressed, but once closed sufficiently long for current to flow through winding 79 by-pass switch 78*d* is held closed until current through coil 79 is interrupted. Current through coil 79 may be interrupted either by pressing stop switch 51, to open that normally closed switch, or by opening normally closed switch 75 in response to energization of relay coil 74 upon the occurrence of closing of switches 52, 53, etc. Normally closed switch 78*e* is in series with braking resistor 80 connected between the field and the armature. It will be apparent that each of the switches 78*a*, 78*b*, 78*c*, 78*d* and 78*e* assumes its "normal" condition only when the machine is off and their operating conditions as opposed to "normal" are assumed when the "on" switch 50 is pressed energizing coil 79.

Capacitor 81 in parallel with control winding 57 and rectifiers 59*c* and 59*d* serves as a cushion to smooth out peaks.

In the operation of the device, the primary 60 of transformer 39 remains energized as long as switch 83 is closed. The machine is started by pressing start-button 50 which causes relay 79 to be energized and closes switches 78*a*, 78*b*, 78*c* and 78*d* whereby pilot light 77 is lit and energy is supplied to the field 46, the saturable reactor 55, and continues in relay winding 79. The field 46 receives a rectified D.C. output, due to rectifier 69 and its associated capacitor 70, and the armature receives a rectified output, due to the rectifiers 59*c* and 59*d* and

RC network 66—67. The high setting of the tap of the potentiometer 22 causes maximum current flow through winding 57 and thereby causes saturation of the magnetic core of saturable reactor 55, with the result as previously described that current output in coil 58 may be supplied through the reactor to the armature load. When the potentiometer 23 is switched in, in accordance with the action of switches previously described, in the usual case because of the relative resistance settings of the potentiometers lesser current flows through the control coil 57. The current output to the armature is therefore reduced, and hence the speed is reduced. When the potentiometer (now at its low-speed setting) is switched back into the circuit, the current flow through the coil 57 is further reduced and the motor speed is thus reduced to its lowest speed.

Referring now to Fig. 3, the A.C. circuit of the drive for the knitting machine is a three-phase A.C. induction motor together with some auxiliary equipment represented by dashed enclosure 90. The motor itself has phase windings 91*a*, 91*b* and 91*c* shown connected in Y. Power is supplied to these windings through power-supply lines 92*a*, 92*b* and 92*c* which include fuses 93*a*, 93*b* and 93*c*, respectively. Line 92*a* is connected to field winding 91*a* through a thermal overload device 94 wherein resistor 94*a* when overheated by overload heats and opens bimetal switch 94*b*. Field winding 91*b* is connected to line 92*b* through gate windings 95*b* and 96*b* of saturable reactor 97*b* and rectifiers 98*b* and 99*b*, and field winding 91*c* is connected to line 92*c* through gate windings 95*c* and 96*c* of saturable reactor 97*c* and rectifiers 98*c* and 99*c*. Also connected across lines 92*a* and 92*b* is primary 100 of transformer 101. Secondary 102 provides power for control circuit elements. Also across lines 92*a* and 92*b* is relay field coil 104 which operates normally open self-holding switch 105*a* and normally open switches 105*b* and 105*c* in the lines 92*b* and 92*c*, respectively, before the saturable reactors 97*b* and 97*c*. Relay 104 also operates normally open switch 105*d* and normally closed switch 105*e*. Starting switch 106 which remains closed only under continuous pressure, is pressed to energize relay 104 and thereby close switches 105*a*, 105*b*, 105*c* and 105*d* and open switch 105*e*.

Once closed switch 105*a* by-passes switch 106 so that current continues to flow through relay coil 104 until the circuit is opened by normally closed stop-switch 107. In the event of emergency, switch 108, which is also in series with coil 104, stops operation when opened by energization of relay coil 109 upon the closing of one of the normally open emergency or overload switches 110 or 111, etc., in parallel with one another to connect relay coil 109 across transformer secondary 102. Also across secondary 102 is normally closed switch 113 in series with light 114. Switch 113 is operated by relay 115 in the speed control circuit which will be described hereafter. Also across secondary 102 is relay coil 35′ which is in series with normally closed microswitch 41′ and normally open microswitch 33′ so that if switch 33′ is closed relay coil 35′ will be energized unless switch 41′ happens to be open.

The control circuit in this case contains control coils 118*b* and 118*c* on the saturable reactors 97*b* and 97*c*, respectively. The arrangement of the control winding in each case is such that current flow through them will produce magnetic flux which opposes the magnetic flux due to current in the gate windings 95*b* and 95*c* and 96*b* and 96*c* whereby current in the gate windings may be increased or decreased by decrease or increase of current through the control windings, thereby increasing or decreasing current to the motor windings and hence motor speed. Control windings 118*b* and 118*c* are in series with a rectifier 122 and the field windings 119 of tachometer 120 whose armature 121 is turned by the shaft of the induction motor 90. Across the tachometer and rectifier 122 is a smoothing capacitor 123. Also in series in the control circuit are a current limiting resistor 126 and a potentiometer and switching circuit generally designated 125 and containing potentiometers 22′ and 23′ and switching means 37′ and 38′. Potentiometer 22′ is normally positioned to have a relatively low resistance and is usually in the control circuit through normally closed switches 37. When switches 37 are opened by the energization of relay winding 35′ and normally open switches 38′ are closed, potentiometer 23′ normally preset at much higher resistance than potentiometer 22′ takes the place of adjustable potentiometer 22′ and the current flowing through the control windings is much lower. The adjusted setting of the potentiometer 22′ provides a higher resistance than the potentiometer 23′, and when placed in the circuit further reduces the current in the control windings. Across the full resistance of each of the potentiometers is connected capacitor 128 in parallel with relay winding 115. When current is flowing through winding 115, it closes normally open switches 130 and 131. Normally during operation resistor 133 connects one side of the potentiometers in circuit before reactor 97*b* to power line 92*b* through switch 105*d*, resistor 134 and rectifiers 135. Closing switch 131 through switches 105*d* and 105*c* connects the midpoint between resistors 133 and 134 to power line 92*b* on the output side of saturable resistor 97*b*. Switch 130 upon closing connects capacitor 136 across the other side of the potentiometer 22′ or 23′ to this same midpoint. The function of relay 131 is to provide a D.C. through the A.C. winding of the motor when it is deenergized to brake it to a stop.

In operation, a three-phase 240 volt 60 cycle current is applied to the field of the A.C. motor. The current fed to the motor may be limited by the saturable reactors 97*b* and 97*c* by the amount of current fed through control coils 118*b* and 118*c* and the amount of current depends upon the particular potentiometer 22′ or 23′ in circuit and the amount of resistance which it places in series with these windings. Current is generated by the tachometer and opposes the fields of the main windings thereby reducing total current fed to the motor as the current in coils 118*b* and 118*c* is increased with motor speed.

It will be observed that the system of Fig. 3 is somewhat simpler than that of Fig. 2. Therefore, from the standpoint of economy, Fig. 3 may be more desirable where a three-phase A.C. current is available. Where only one-phase A.C. or D.C. current is available, an arrangement of the type of Fig. 2 is definitely preferred. Furthermore, the arrangement of Fig. 2 is more adaptable to certain existing systems. However, both systems are within the scope of the present invention.

The two circuits illustrated are merely by way of example. It will be clear to those skilled in the art that many modifications could be made in these circuits. All such modifications within the scope of the claims are intended to be within the scope and spirit of the present invention. Furthermore, somewhat different circuits within the scope of the claims are intended to be within the scope and spirit of the present invention.

We claim:

1. A circular knitting machine comprising electric motor constituting the prime mover for the machine, a pattern drum for governing predetermined operations of the machine, a pattern chain for governing the operations of said drum, an electrical speed control circuit for and including said motor, and providing a saturable core device whereby high peaks of current may be eliminated, a variable control unit for said circuit adjustable to effect variations in the speed of said motor in accordance with the variations in the operation of the machine as prescribed by said pattern drum, means for relatively adjusting said unit including a cam follower and a cam carried by the pattern drum and engageable with said cam follower, a second and independent control unit for said

circuit, means for selectively and individually connecting said control units in said circuit, and means including separate switch means responsive to movements of said drum and chain for actuating said connecting means to selectively and individually connect said units of the circuit, said saturable core device having at least one winding connected in series with said variable control units to constitute a safety device to prevent peak overloads, and reduce the operating speed of the electric motor upon failure of components in the control circuit associated with said potentiometers.

2. The circular knitting machine of claim 1 in which the electric motor is a D.C. motor having armature and field windings and saturable reactor is used to limit current to at least one of the windings of the motor thereby affecting its speed.



3. The circular knitting machine of claim 1 in which the drive motor is an A.C. motor and the saturable reactor device is used to limit flow current to the field of A.C. motor.

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