

Nov. 9, 1943.

R. BASSIST

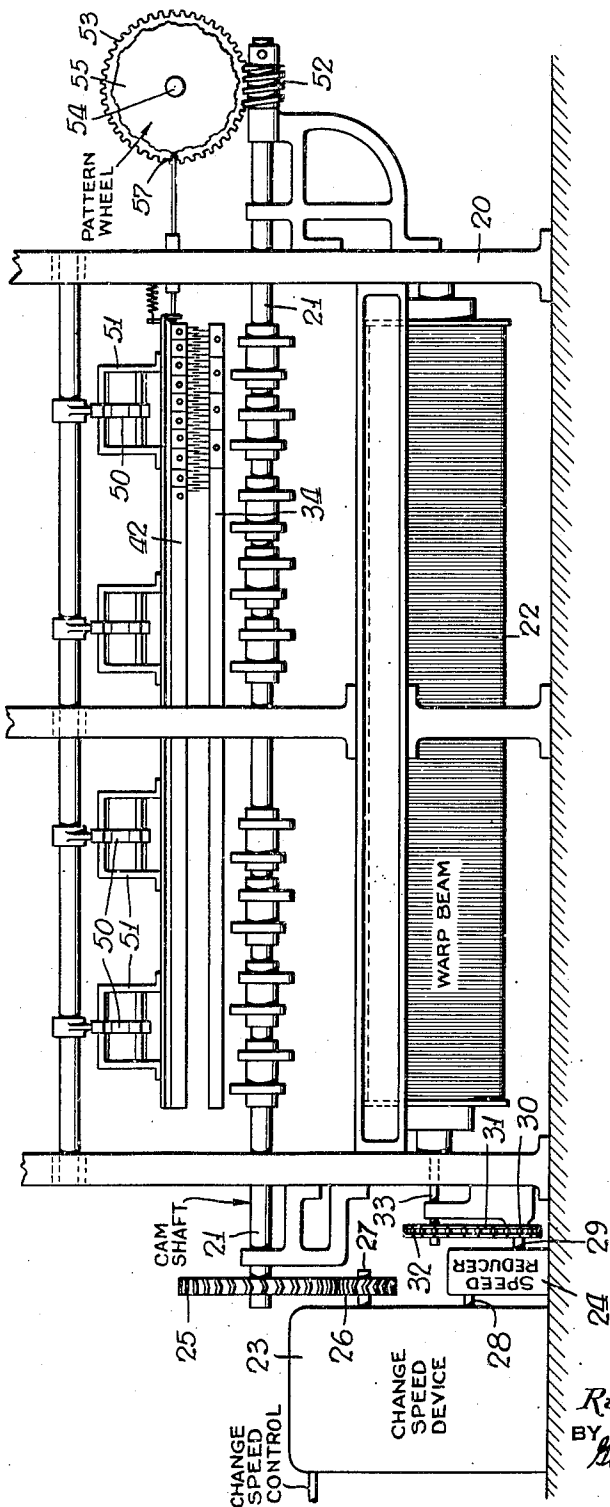
2,334,058

WARP KNITTING MACHINE

Filed Nov. 28, 1942

3 Sheets-Sheet 1

FIG. 1.



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a2-175

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3 Sheets-Sheet 2

FIG. 2.

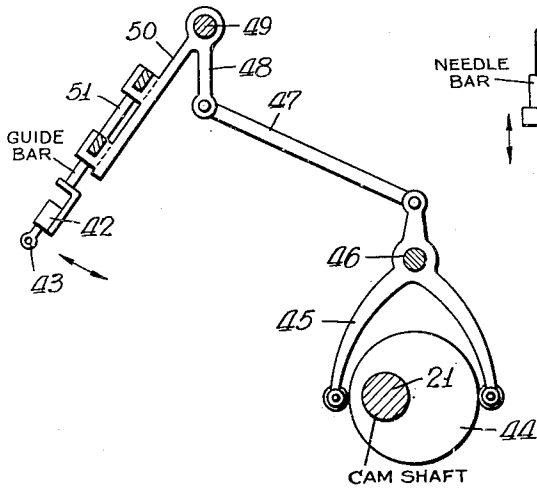


FIG. 3.

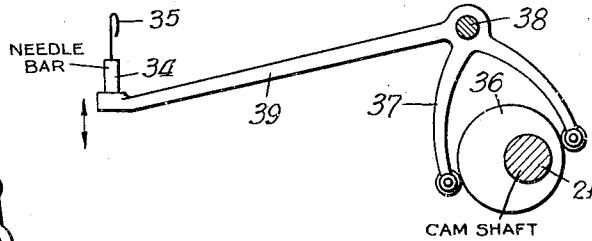


FIG. 4.

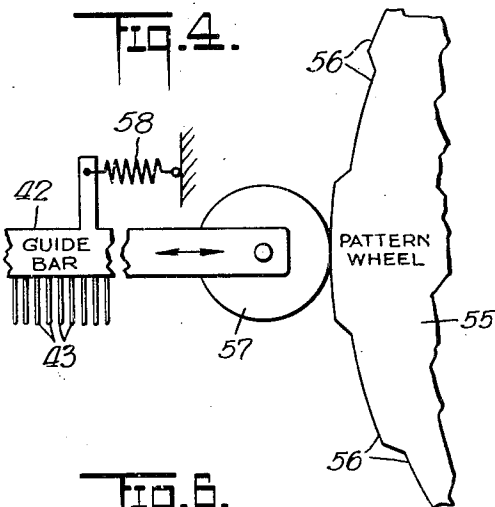


FIG. 5.

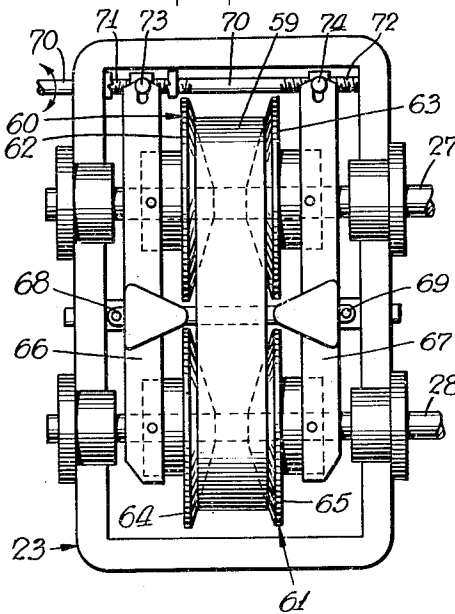
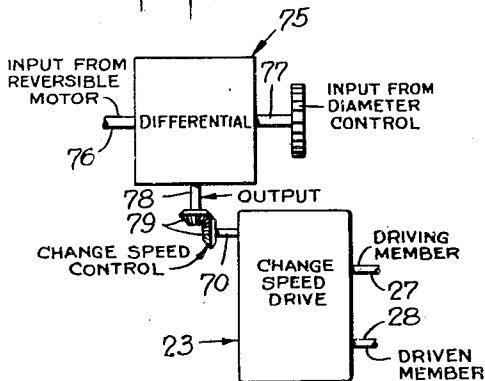


FIG. 6.



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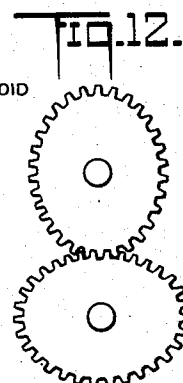
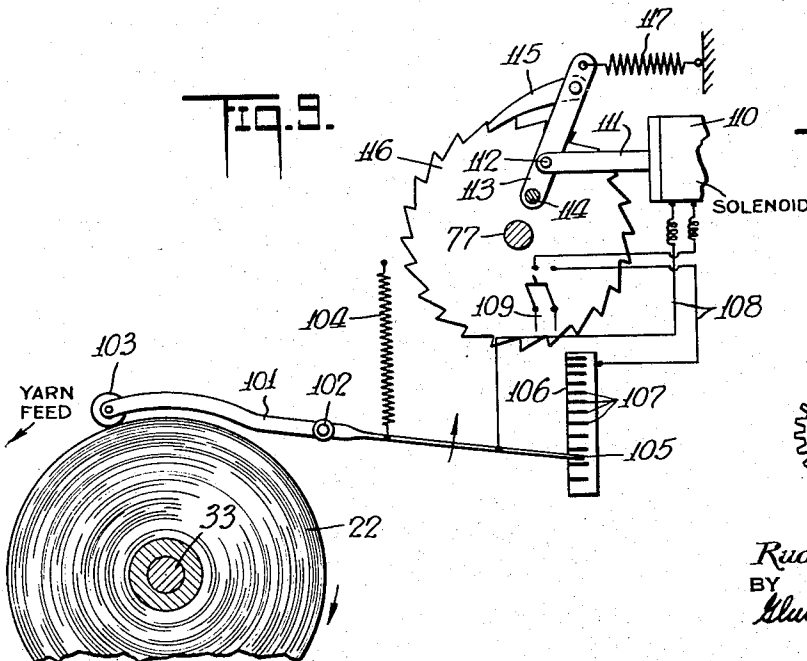
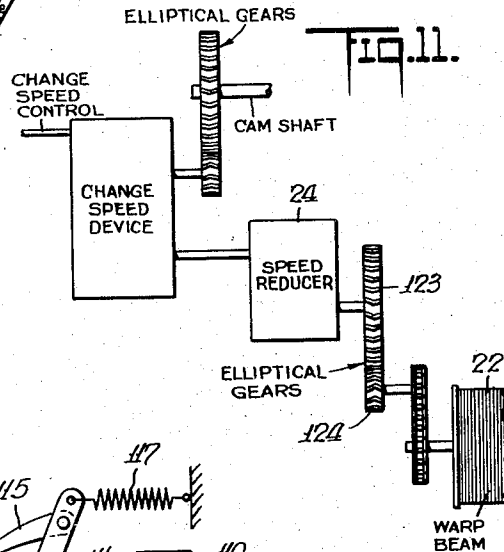
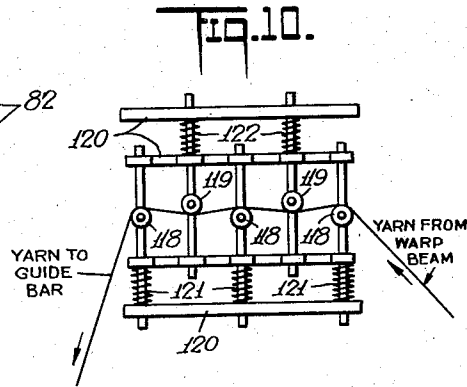
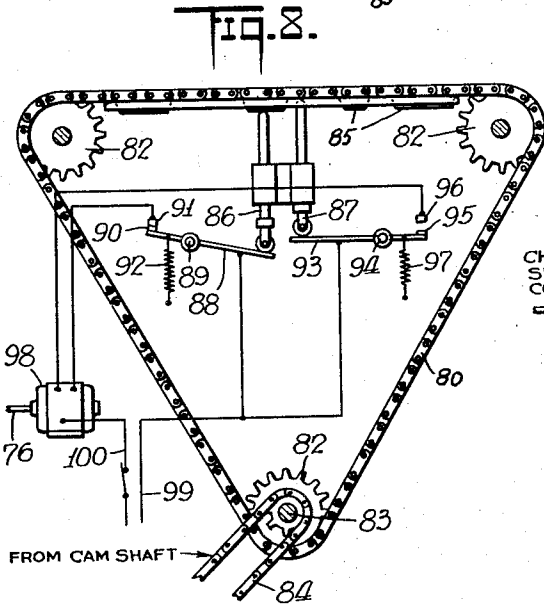
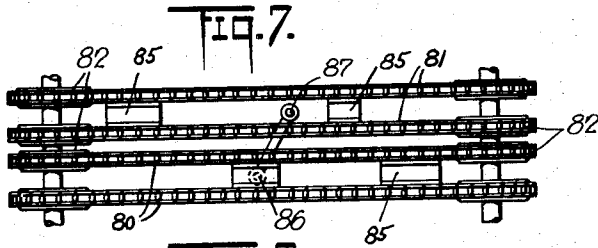
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WARP KNITTING MACHINE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,334,058

WARP KNITTING MACHINE

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 forty-five per cent to Rudolph Bassist, Long
 Island City, N. Y., ten per cent to Harold H.
 Stern, twenty-two and one-half per cent to
 Edith Abrams, and twenty-two and one-half
 per cent to Edith April, all of New York, N. Y.

Application November 28, 1942, Serial No. 467,188

18 Claims. (Cl. 66—86)

My present invention relates generally to knitting machines and has particular reference to so-called warp knitting machines.

While certain phases of my invention are not necessarily restricted in their applicability to any particular kind of warp knitting machine, the general object of the invention is to provide certain improvements in high-speed knitting machines of the so-called "Tricot" type. These machines are of relatively high gauge, employing approximately 28 to 34 needles per inch, and operating at rates of speed up to about 600 courses or stitches per minute.

In a warp knitting machine, the yarn is initially wound on one or more warp beams and is directed in parallel rows to a bank of needles which operate in a predetermined intermittent manner to interengage the threads to produce a knitted fabric of the "jersey" type. The yarn is directed to the needles by one or more guide bars through which the individual strands are threaded and by means of which the threads are looped around the needles or otherwise subjected to their operation, in a predetermined manner and sequence depending upon the particular pattern or style of knitted fabric which is to be produced.

In order that my invention may be better understood, I will preface this description by outlining, in a general way, the mode of operation and cooperation of the main parts of a warp knitting machine.

A main driving shaft (hereinafter referred to as a cam shaft) is associated with means for intermittently moving the needles through the knitting cycle. Generally speaking, this movement is an up-and-down movement. Thread is suitably looped around the needles while they are in their upward positions, and when the needles move downwardly they perform a knitting operation, with the aid of a "presser bar," a "sinker," and other suitable auxiliary parts which are well known per se. Each guide bar is provided with a corresponding number of needles through which the strands coming from the warp beam are threaded. Actuated by the cam shaft is a means for imparting a predetermined intermittent movement to the guide-bar, one component of movement being in a substantially forward-and-back direction, the other component of movement being longitudinal. These movements of the guide-bar are so timed and controlled, relative to the needle operation, that the strands are suitably looped around or otherwise

subjected to the action of the needles in accordance with a predetermined pattern.

For example, assuming that only one warp beam is employed, the guide-bar may be moved so as to loop a strand around one needle during one course, around an adjacent needle during the next course, then around the first-mentioned needle again during the third course, and so on. Or, depending upon the fabric desired, the guide-bar may loop a strand around one needle for one course, then shift longitudinally and loop the strand around a needle at a distance from the first for the second course, then shift again either in the same or reverse direction to loop the strand around a third selected needle for the third course, and so on. A large number of different optional cycles are possible, depending upon the results desired in the finished product.

The machine may employ either one, two or three warp beams, possibly more. The simplest type of fabric is produced by the employment of only a single warp beam. A different type of fabric would result from the employment of two warp beams, it being understood that there is usually a separate guide-bar for each warp beam. Where a "filler" thread, or more accurately, an unknitted warp thread, is to be associated with the fabric for the purpose of forming loops or other ornamental effects, it is customary to employ one or two warp beams to produce the so-called "ground fabric," and to employ a separate warp beam for the additional warp thread. In such case, the guide-bar through which the latter strands are threaded will have its movements so controlled that these strands are brought into proper relationship to the needles, and to the strands of the ground fabric, in a predetermined manner.

For the sake of simplicity, the features of the present invention will be described in connection with a single warp beam and a single guide-bar, although it will be understood, as hereinbefore pointed out, that more than one warp beam may be employed if necessary or desirable.

In the conventional type of warp knitting machine, one of the shortcomings has arisen from the fact that the threads are drawn from the warp beam by a pulling action initiated by the needles themselves and by the guide-bar which controls the disposition of the yarn with respect to the needles. The warp beam is generally provided with some sort of brake or equivalent clutch mechanism operated by the pull of the yarn, whereby the warp beam is released for rotation whenever the knitting cycle calls for

thread, and whereby it is secured against rotation in the interim periods. This arrangement has numerous disadvantages and imposes severe limitations upon the knitting operations. For example, the interdependence between yarn feed and warp beam rotation restricts the types of fabric that may be produced. Also, any stopping or starting of the machine as a whole produces an irregularity in the knitting operation whereby an undesirable line or streak known as a "stop-mark" is produced in the fabric. The latter disadvantage often causes material impairment of the commercial value of the fabric, and it manifests itself most frequently in the high-speed machines to which my invention has primary reference, and in cases where the yarn is of the relatively slippery character of rayon or the like.

In my co-pending patent application Ser. No. 405,631 (now Patent No. 2,303,903), I disclosed a means whereby these disadvantages, and others, are successfully overcome, one of the characterizing features of the improved machine residing in the fact that the warp beam is continuously rotated in yarn-feeding direction in a predetermined timed relationship with respect to the knitting cycle, but independent of any pulling action upon or by the yarn itself.

My present invention is directed toward a further improvement and refinement of this general type of structure and mode of operation. A warp knitting machine incorporating the structural innovations of the present invention is capable of operating smoothly and efficiently, and at high speeds, for long periods of time without any of the disadvantages or limitations hereinbefore referred to, and is capable of producing a wide variety of different knitted fabrics, many of which have not heretofore been capable of manufacture at all by means of a warp knitting machine.

My present invention is predicated upon a thorough understanding of the basic reasons for the difficulties heretofore encountered and upon a fuller appreciation of the inherent potentialities of warp knitting machines, even those of the high-speed type, provided that the supply of yarn to the guide-bars and the needles is properly and adequately synchronized with the knitting cycle, and is capable of practical and sufficiently varied adjustment to meet the varied requirements imposed upon the knitting procedure by different patterns and types of fabrics.

Generally speaking, my invention contemplates the production of a high-speed warp knitting machine in which guide-bar movements of widely varying character may be provided for in accordance with predetermined selected patterns, and in which a continuously rotating warp beam may have such additional components of movement imposed upon it that the thread feed is always accurately synchronized with, and adequately capable of meeting the moment-to-moment requirements of, the needles and the guide-bars.

The basic elements of a knitting machine constructed in accordance with the present invention consist, therefore, of a cam shaft, needles, a warp beam, a movable guide-bar controlling the disposition with respect to the needles of yarn directed to it from the warp beam, a means driven by the cam shaft for intermittently moving the needles through the knitting cycle, an alterable means also driven by the cam shaft for intermittently moving the guide bar in accordance with

a predetermined selected pattern, and a transmission from the cam shaft to the warp beam for continuously rotating the latter in yarn-feeding direction independently of any pull by either needles or guide-bar upon the yarn itself.

One of the features of my present invention lies in the provision of a means for imposing upon the continuously rotating warp beam an additional fluctuating component of movement which corresponds to the fluctuating demands for yarn of the guide-bar and thus sets the tempo, as it were, of the yarn feed. This result is preferably accomplished by the employment, in the warp beam transmission, of a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member. Such a mechanism is exemplified by a pair of meshing non-circular gears.

The warp beam transmission includes a speed reducer. In accordance with my invention the mechanism referred to in the preceding paragraph is operatively interposed between the cam shaft and the speed reducer. I contemplate, however, that a similar mechanism may be additionally interposed between the speed reducer and the warp beam, if desired, to further enhance the possible variations in the warp beam control.

My invention further provides for the operative interposition, in the warp beam transmission, of an adjustable change-speed device of the character described and illustrated in my aforementioned pending patent application, this device being of the character which comprises rotating driving and driven members and which is adjustable during continuous operation thereof so as to vary the relative speeds of rotation of said members. While this adjustment may obviously be performed by manual operation, if desired, the present invention provides for a preferred automatic adjustment of said device in accordance with a predetermined selected pattern, this automatic adjustment being under the control of an alterable means driven by or in timed relation to the cam shaft.

The present invention also provides a means which is responsive to the diminishing diameter of the warp beam as yarn is fed therefrom for automatically adjusting the change-speed device, independently of any other adjustments thereof, to compensate for such diminishing diameter. A means for accomplishing this general objective was disclosed in my aforementioned pending patent application, but the present invention provides an improved means for achieving this result.

I attain the foregoing general objects and advantages, and I provide for the embodiment of the foregoing features, and others, in a practical machine, in the manner illustratively exemplified in the accompanying drawings in which:

Figure 1 is a diagrammatic front elevational view of a warp knitting machine employing certain of the features of the present invention;

Figure 2 is a fragmentary transverse view showing one manner of controlling certain movements of the guide-bar;

Figure 3 is a view similar to Figure 2 showing one manner of controlling the movements of the needle-bar;

Figure 4 is a fragmentary enlarged view of the pattern wheel shown at the right end of Figure 1, illustrating the manner in which it controls certain other movements of the guide-bar;

Figure 5 is a view showing an illustrative change-speed device of the character indicated at the left end of Figure 1;

Figure 6 is a diagrammatic view showing the manner in which the change-speed device may be automatically adjusted;

Figure 7 is a plan view of one form of pattern chain that may be employed for automatically adjusting the change-speed device;

Figure 8 is an elevational view of Figure 7, showing diagrammatically the electric circuits controlling the automatic adjustment;

Figure 9 is a fragmentary enlarged view of the automatic diameter control, showing diagrammatically the electric circuit involved and the means controlled by the electric circuit;

Figure 10 is a fragmentary view of a slack take-up;

Figure 11 is a diagrammatic view similar to the left portion of Figure 1, illustrating a modification; and

Figure 12 is an end view of a pair of non-circular gears.

Mounted within the confines of a suitable framework 20 is a main driving shaft or cam shaft 21. This shaft extends in a longitudinal direction with respect to the machine as a whole, and it is driven by a motor or by any other suitable motive power (not shown) in well-known fashion. It carries such cams and other driving elements as may be required to transmit predetermined driving impetus to the various elements of the machine. At 22 I have indicated a warp beam which may be mounted in any suitable manner for rotation about an axis longitudinally arranged with respect to the machine. In the conventional machine, this warp beam (together with one or more additional warp beams) is mounted upon the framework 20, usually in the upper region of the machine. In accordance with my present invention however, it is possible to mount this warp beam in an independent support or framework (not shown) at the rear of the machine. This is of great importance since much larger warp beams may be employed, and since the tremendous weight of the beams is thus removed from any possibility of impairing the smooth high-speed operation of the knitting machine with a minimum of vibration.

In accordance with my invention, this warp beam is continuously rotated by means of a transmission actuated by the cam shaft 21 and indicated at the left of Figure 1. This transmission includes a change-speed device 23, and a speed reducer, 24. Between the cam shaft 21 and the change-speed device 23 there is operatively interposed a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member. I have illustratively shown such a mechanism in the form of a pair of meshing non-circular gears 25 and 26.

The motive power of the cam shaft is thus transmitted through the gears 25-26 to the driving shaft 27 of the change-speed device. The driven shaft 28 of this device, rotating at the same or at a predetermined different speed with respect to the shaft 27, transmits its rotation to the gears or other mechanism within the speed reducer 24, and the driven shaft 29 leading from the speed-reducer is connected by any suitable transmission to the warp beam 22. I have illustratively indicated a sprocket 30

mounted on the shaft 29 and a chain 31 leading from this sprocket to a sprocket 32 on the shaft 33 of the warp beam 22. A transmission consisting of a pair of meshing gears might also be used for this purpose, if desired.

Mounted in the machine in well-known manner is a needle bar 34. Projecting upwardly from it are the needles 35 by means of which the knitting operation is performed. This needle bar is intermittently operated by the cam shaft 21 to move the needles through the desired knitting cycle which is well-known per se. Any suitable mechanism may be employed for accomplishing this purpose, and in Figure 3 I have illustratively shown a transmission which consists of the cam 36, the rocker 37 (pivoted at 38), and the link 39, which is suitably connected to the needle bar 34. The mechanism is of such a character that the continuous rotation of the cam shaft 21 imparts predetermined up-and-down movements to the needle bar 34.

Mounted in proximity to the needles is a guide-bar 42 which carries a plurality of downwardly-projecting teeth or equivalent elements 43 which are adapted to move in a forward-and-back direction, within the spaces between the needles 35. This component of movement of the guide-bar is under the control of the cam shaft 21 by means of any suitable well-known mechanism such as that which is indicated in Figure 2. In this figure I have illustratively shown a cam 44, a rocker 45 (pivoted at 46), and a link 47 which transmits a rocking movement to a link 48 mounted on the rock-shaft 49. The link 48 is suitably connected to the hanger elements 50, and the guide-bar 42 is provided with brackets 51 which are suitably supported within the hanger elements 50 so that the rocking movements of the latter will transmit corresponding forward-and-back movements to the guide-bar proper.

The articulation between the brackets 51 and the hangers 50 is of such a character (well-known per se) that the guide-bar 42 can also be subjected to longitudinal shifting movements. These movements are also under the control of the cam shaft 21, through the intermediary of suitable drive mechanism such as a worm 52 (see Figure 1) and the worm wheel 53. Mounted on the shaft 54 of the worm wheel 53 is a pattern wheel 55 which is thus slowly and continuously rotated. The periphery of the pattern wheel 55 is provided with a predetermined series of raised and depressed portions 56 (see Figure 4) and the end of the guide-bar is provided with a follower 57 which is constantly pressed against the periphery of the pattern wheel in a yieldable manner, by means of the spring 58 or the like. Accordingly, certain longitudinal movements are imparted to the guide-bar in a predetermined sequence and of predetermined magnitudes as the follower 57 is pushed to the left or right under the actions of the pattern wheel 55 and the spring 58.

The projections and depressions 56 may be integral portions of the pattern wheel 55 or, as is preferable, they may be provided for by means of suitable elements separably mounted on the pattern wheel in predetermined spaced relationships. A pattern wheel of this general character is well-known per se, although the present invention makes it possible to provide a far greater number of variations in the peripheral contour controlling the longitudinal movements of the guide-bar.

It will also be understood that the pattern wheel 55 is merely illustrative of a general type of pattern-controlling mechanism and that a continuously moving chain, or equivalent instrumentality may be driven by the cam shaft in a similar manner, and may control the longitudinal movements of the guide-bar by means of equivalent projections, depressions, or other suitably contoured elements.

The yarn from the warp beam is directed in suitable fashion to the guide-bar, each strand being threaded through one of the teeth of the guide-bar. The movements of the guide-bar, both forward-and-back and longitudinal, control the disposition of this yarn with respect to the needles, looping it successively around predetermined needles, or otherwise bringing it into the range of operation of the needles, or into association with strands emanating from other warp beams, all in accordance with a predetermined plan or pattern which manifests itself in the operative contour of the pattern wheel 55. Simultaneously, the needles, operating in timed relationship with the guide-bar, perform the actual knitting operation, a knitted fabric being thus produced, course by course, and being wound up on a suitable roller (not shown) at the forward portion of the machine.

It is obvious that this mode of operation imposes varying requirements upon the thread feed. Thus, whenever the guide-bar is moving to loop the strands around the needles, or otherwise to bring the strands into the range of the knitting operation, yarn must be made available; and during those interim periods during which the needles are knitting or otherwise incorporating the yarn into the fabric, the demand for thread feed is momentarily diminished. Similarly, whenever the guide-bar is moving longitudinally through relatively large distances (skipping for example, from one needle to another selected needle some distance away), the demand for yarn is correspondingly greater than during other longitudinal movements of the guide-bar which are of lesser magnitude. In accordance with my present invention, it is possible to conform the yarn feed with considerable accuracy to these varying requirements, notwithstanding the fact that the warp beam is continuously rotated quite independently of any clutch or brake mechanism depending for its operation upon any pulling effect of the yarn itself.

One of the improvements contributing to this desirable result is the mechanism exemplified by the meshing non-circular gears 25 and 26 (see Figure 12). By properly designing and selecting these gears, a predetermined rotation of the cam shaft 21 at uniform angular velocity can be caused to impose upon the driven member 26 an angular velocity of predetermined fluctuating character. These fluctuations are synchronized with the needle and guide-bar operations, and thus "set the tempo," as it were, of the yarn feed. A component of movement is thus imposed upon the warp beam which is in conformity with the fluctuating demands of the needles and the guide-bar.

Another controllable and important factor in this transmission is the change-speed device 23. This device may be of any well-known character, and I have illustratively shown a typical "Reeve's drive" device in Figure 5.

As shown in Figure 5, a belt 59 is in driving relationship between two conical pulleys 60 and 61, the pulley 60 being mounted on the driving shaft 75

27, the pulley 61 being mounted on the driven shaft 28, and the effective diameter of these pulleys being relatively adjustable. It will be observed that the pulley 60 consists of two sections 62 and 63 splined to the shaft 27, while the pulley 61 consists of similar sections 64 and 65 splined to the shaft 28. By separating the sections 62 and 63 and by bringing about a corresponding mutual approach of the sections 64 and 65, the speed of the driven shaft 28 can be correspondingly reduced; and by bringing the sections 62 and 63 together and causing a corresponding separation of the sections 64 and 65, the speed of the driven shaft 28 can be correspondingly increased. This adjustment is effected by means of levers 66 and 67 pivoted respectively at their centers 68 and 69, the opposite ends of the lever 66 being pivotally connected to the pulley sections 62 and 64, while the opposite ends of the lever 67 are pivotally connected to the pulley sections 63 and 65. A control shaft 70 provided with oppositely-directed worm portions 71 and 72 causes relative separation or approach of elements 73 and 74 which engage the ends of levers 66 and 67 respectively. Thus, any rotation of the worm shaft 70 in one direction or the other will bring about a corresponding relative adjustment of the pulleys 60 and 61 thereby altering the speed relationship between the shafts 27 and 28 in any contemplated manner.

Obviously, if desired, the control shaft 70 may be manipulated by hand during a continuous operation of the machine. My present invention provides an improved means, however, whereby the change-speed control may be automatically regulated in accordance with a predetermined plan. My invention also provides a simultaneous means whereby the change-speed control is automatically adjusted to compensate for the diminishing diameter of the warp beam as thread is withdrawn therefrom. These automatic controls are illustrated in Figures 6-8.

In Figure 6, the reference numeral 75 is applied to a diagrammatic representation of any suitable differential mechanism such as that which is commonly employed, for example, in association with the rear axle of an automobile. Since the internal parts of the motive portion of such a differential mechanism are well-known, I have deemed it sufficient merely to indicate two input driving shafts 76 and 77 and a single output shaft 78. Using the automobile analogy, the shafts 76 and 77 correspond to those which commonly extend respectively to the rear wheels of the automobile, while the shaft 78 corresponds to the transmission shaft extending to the engine. However, whereas the automobile differential imposes the input power upon the shaft 78 and derives the output in equal or varying degrees at the shafts 76 and 77, the present differential mechanism is employed in a reverse fashion. I have illustratively shown a pair of beveled gears 79 connecting the output shaft 78 to the control shaft 70 of the change-speed device 23. Applied to the input shaft 76 is the motive power of a reversible electric motor, and applied to the input shaft 77 is the motive power of a special mechanism presently to be described.

Referring now to Figures 7 and 8, I have illustrated two pairs of chains 80 and 81 mounted on suitable sprockets 82 and continuously moved in one direction by a rotative force applied to the shaft 83 by means of any suitable driving mechanism 84 leading from the cam shaft 21. The driving mechanism 84 is intended to be merely dia-

grammatically represented, and may consist of a chain or a train of meshing gears, or the like, a suitable reduction in speed being provided for in any desired manner. The chains of each pair 80, 81, are so designed that they may have connecting plates 85 removably applied to them at selected spaced intervals. One such set of plates controls the up-and-down movements of a pusher rod 86. The other set of plates, associated with the other pair of chains, controls the up-and-down movements of a pusher rod 87. Whenever the rod 86 is pushed downwardly, it acts upon a lever 88 pivoted at 89 and carrying an electric contact 90 which is thus brought into operative engagement with a fixed contact 91. When the rod 86 is no longer pressed downwardly by one of the plates 85, a spring 92 may serve to withdraw the contact 90 from the contact 91 and restore the pusher rod 86 to its normal position. Similarly, whenever the rod 87 is pushed downwardly by one of the plates 85 on the other pair of chains, it moves a lever 93, pivoted at 94, so as to bring an electric contact 95 into operative engagement with the fixed contact 96. When the rod 87 slips off the plate 85, a spring 97 may serve to separate the contacts 95 and 96 and restore the rod 87 to its normal position.

The fixed contacts 91 and 96 are connected to suitable windings of the reversible motor 98 whose shaft is connected with the shaft 76 of the differential 75 hereinbefore referred to. The movable contacts 90 and 95 are connected to one side 99 of a suitable supply of current, the other side 100 of this supply being electrically connected to the motor 98.

The plates 85 on the chain pairs 80 and 81 are so positioned, prior to the commencement of operation of the knitting machine, that at predetermined times the rod 86 will be pushed and thereby cause rotation of the motor 98 in one direction, while at other times, the rod 87 will be pushed and will cause rotation of the motor 98 in the opposite direction. During certain periods of time neither of the rods 86 or 87 will be pushed, and during those periods the circuit to the motor 98 will be broken and no rotation at all will be imposed upon the shaft 76. Whenever the motor 98 rotates in one direction or the other, it transmits a corresponding rotation to the control shaft 70 of the change-speed device 23, thereby automatically changing the speed relationships of the shafts 27 and 28. Accordingly, the positioning of the plates 85 between the pair of chains 80 and between the pair of chains 81 may be caused to control, automatically, a predetermined series of adjustments of the change-speed device. These adjustments are caused to be effected in accordance with the predetermined pattern which the knitting operation is to follow.

It will be understood that the chains of Figures 7 and 8 are merely illustrative of a general type of pattern-controlling mechanism and that a pattern wheel, similar to the wheel 55, or any other equivalent alterable device, may be employed to accomplish the same purpose. It will also be understood that, whereas I prefer to employ an electrical means of the character shown in Figures 7 and 8, any mechanical or other instrumentality may be used to bring about the desired adjustments of the change-speed device at predetermined times and in a predetermined sequence, depending upon the pattern which the knitting machine is to follow.

The other automatic control of the change-speed device is shown most clearly in Figure 9. A lever 101 is pivoted at 102 and is provided at one end with a feeler 103 which rests against the peripheral surface of the yarn on the warp beam 22, a constant contact being retained by means of a spring 104. The other end of the lever 101 is provided with an electric contact 105 which moves over a specially-designed fixed contact member 106. This member is provided with a series of suitably spaced insulating or non-conductive portions 107 so that as the contact 105 moves along, it alternately establishes and breaks an electric contact between the lever 101 and the contact 106. The lever 101 and the contact member 106 are arranged in an electric circuit 108 which includes a suitably responsive instrumentality such as the solenoid 110.

Whenever the solenoid 110 is energized it moves a rod 111 (to the left, as viewed in Figure 9). This rod is articulated at 112 to a lever 113 which is pivoted at 114 and which carries a pawl 115 at its opposite end. This pawl is in engagement with the teeth of a ratchet wheel 116 mounted on the shaft 77 of the differential mechanism, or mounted in some other fashion so that rotation of the ratchet wheel 116 will bring about corresponding rotative movements of the shaft 77. A spring 117 normally retains the pawl 115 in a retracted position.

As the yarn is fed from the warp beam 22, the diameter of the warp beam gradually diminishes. Accordingly, in the absence of a diameter control device, the amount of thread fed from the warp beam during each rotation of the latter would gradually diminish. To compensate for this, the change-speed device 23 is automatically adjusted in a step-by-step manner to speed up the rotation of the warp beam by a suitable amount as the diameter of the warp beam diminishes. Thus, as the lever 101 moves gradually in a counter-clockwise direction (as viewed in Figure 9), the contact 105 moves upwardly along the element 106. Whenever the contact 105 encounters a conductive portion of the element 106, the circuit through the solenoid 110 is completed and the pawl 115 is actuated to impart a slight rotative movement to the ratchet wheel 116, hence to the shaft 77, and thus to the control shaft 70 of the change-speed device 23. At intermittent times, the contact 105 encounters a non-conductive portion, and the circuit of the solenoid 110 is thus broken, allowing the spring 117 to retract the pawl 115 and to hold it in readiness for the next operative movement.

It is preferable that the widths of the conductive portions of the element 106 be of gradually diminishing size, since the compensatory movements of the ratchet wheel 116 must be slightly accelerated as the diameter of the warp beam diminishes. This is due to the fact that the deficiency in thread feed is not directly proportional to the diminishing radius of the warp beam.

There is thus imposed upon the control shaft 70 of the change-speed device 23 a series of automatic adjustments, certain of which are brought about by the instrumentalities of Figures 7 and 8, acting upon the input shaft 76 of the differential 75, others of which are brought about by the instrumentalities shown in Figure 9, acting upon the other input shaft 77 of the differential 75.

These adjustments of the change-speed device, coupled with the "tempo" set by the non-cir-

cular gears (or equivalent mechanism) cause a continuous movement of the warp beam 22 in yarn-feeding direction which is a composite or resultant of various component movements, and the ultimate result is that the yarn is continuously directed toward the guide-bar in successive increments which are synchronized with the requirements of a predetermined pattern.

Any suitable series of rollers or shafts may be employed for supporting or guiding the yarn during its travel from the warp beam to the guide bar. Preferably, but not necessarily, during this course of travel of the yarn, it is directed through a sensitive slack take-up of the character shown in Figure 10. A series of rollers 118 and 119 are mounted in staggered relationships within suitable framework members 120. Springs 121 constantly urge the rollers 118 in one direction, while springs 122 impose a similar force upon the rollers 119. These springs are relatively delicate and the movements of the rollers 118 and 119 are of relatively small magnitude. This take-up is provided merely for the purpose of "ironing out" minute irregularities in thread feed, and is not to be confused with any of the devices heretofore employed by means of which the pull of the needles or guide-bar upon the yarn is translated into a control of warp beam rotation. The slack take-up of Figure 10 has no effect on the movements of the warp beam.

Where a looped fabric is being produced, i. e., where one of the guide-bars is feeding yarn in certain excess quantities to the action of the needles or of the strands entering into a ground fabric, a spring-controlled slack take-up of the character shown in Figure 10 cannot be used.

In Figure 11 I have diagrammatically illustrated a possible modification of the transmission shown at the left end of Figure 1, whereby a second set of non-circular gears 123 and 124 (or equivalent mechanism) is interposed in the transmission between the speed reducer 24 and the warp beam 22. Whatever the movements of the driving gear 123 may be, a movement is transmitted to the driven gear 124 which is of relatively fluctuating character. These fluctuations, however, are relatively gradual and do not affect the moment-to-moment movements of the warp beam. The mechanism 123-124 imposes an additional fluctuating component of movement upon the warp beam, which, by proper design and selection of the gears 123 and 124, may be caused to bring about corresponding additional variations in the nature of the fabric that is being knitted.

In general, it will be understood that the details herein described and illustrated may be modified by those skilled in the art without departing from the spirit and scope of the invention as expressed in the appended claims. It is therefore intended that these details be interpreted as illustrative and not in a limiting sense.

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

1. In a warp knitting machine, a cam shaft, needles, a movable guide-bar arranged in proximity to the needles, a warp beam, means for directing yarn from said warp beam to said guide-bar, said guide-bar controlling the disposition of said yarn with respect to the needles, means driven by the cam shaft for intermittently moving said needles through the knitting cycle, alterable means driven by the cam shaft

for intermittently moving said guide-bar in timed relation to the needle movements and in accordance with a predetermined selected pattern, and a transmission from the cam shaft to the warp beam for continuously rotating said warp beam in yarn-feeding direction and for imposing upon it a fluctuating component of movement which corresponds to the fluctuating demands for yarn of said intermittently-moving guide-bar.

2. In a warp knitting machine, the combination set forth in claim 1, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member.

3. In a warp knitting machine, the combination set forth in claim 1, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, said mechanism comprising a pair of meshing non-circular gears.

4. In a warp knitting machine, the combination set forth in claim 1, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, said transmission also including a speed-reducer, said mechanism being arranged in said transmission between the cam shaft and said speed-reducer and having its cycle of operation synchronized with the needle movements.

5. In a warp knitting machine, the combination set forth in claim 1, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, said transmission also including an adjustable change-speed device comprising rotating driving and driven members, and means for adjusting said device during continuous operation thereof so as to vary the relative speeds of rotation of said members.

6. In a warp knitting machine, the combination set forth in claim 1, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, said transmission also including an adjustable change-speed device comprising rotating driving and driven members and alterable means driven by the cam shaft in accordance with said predetermined selected pattern for automatically adjusting said device during continuous operation thereof so as to vary the relative speeds of rotation of said members.

7. In a warp knitting machine, the combination set forth in claim 1, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, said transmission also including an adjustable change-speed device comprising rotating driving and driven members, means for adjusting said device during continuous operation thereof so as to vary the relative speeds of rotation of said members, and

means responsive to the diminishing diameter of said warp beam as yarn is fed therefrom for automatically adjusting said device, independently of any other adjustments thereof, to compensate for said diminishing diameter.

8. In a warp knitting machine, the combination set forth in claim 1, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, said transmission also including a speed-reducer and an adjustable change-speed device, and means for adjusting said device during continuous operation thereof, said mechanism being arranged in said transmission between the cam shaft and said change-speed device, said speed-reducer being arranged in said transmission between the change-speed device and the warp beam.

9. In a warp knitting machine, a cam shaft, needles, a movable guide-bar arranged in proximity to the needles, a warp beam, means for directing yarn from said warp beam to said guide-bar, said guide-bar controlling the disposition of said yarn with respect to the needles, means driven by the cam shaft for intermittently moving said needles through the knitting cycle, means driven by the cam shaft for intermittently moving said guide-bar in timed relation to the needle movements, and a transmission actuated by said cam shaft for continuously rotating said warp beam in yarn-feeding direction, said transmission including a mechanism of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, whereby a corresponding fluctuating component of movement is imposed upon the continuous rotation of said warp beam.

10. In a warp knitting machine, the combination set forth in claim 9, said mechanism comprising a pair of meshing non-circular gears.

11. In a warp knitting machine, the combination set forth in claim 9, said transmission also including a speed-reducer, said mechanism being arranged in said transmission between said speed-reducer and the warp beam whereby the fluctuating component of movement of the warp beam is a gradual one relative to the needle movements.

12. In a warp knitting machine, a cam shaft, needles, a movable guide-bar arranged in proximity to the needles, a warp beam, means for directing yarn from said warp beam to said guide-bar, said guide-bar controlling the disposition of said yarn with respect to the needles, means driven by the cam shaft for intermittently moving said needles through the knitting cycle, alterable means driven by the cam shaft for intermittently moving said guide-bar in timed relation to the needle movements and in accordance with a predetermined selected pattern, and a transmission from the cam shaft to the warp beam for continuously rotating said warp beam in yarn-feeding direction, said transmission including a speed-reducer and also two mechanisms each of which is of the character which comprises rotating driving and driven members wherein a fluctuating angular velocity is imparted to the driven member relative to that of the driving member, one of said mechanisms being arranged in said transmission between the cam shaft and said speed-reducer and having its cycle of operation syn-

chronized with the needle movements, thereby imposing upon the warp beam a relatively rapid fluctuating component of movement which corresponds to the fluctuating demands for yarn of said intermittently-moving guide-bar, the other of said mechanisms being arranged in said transmission between said speed-reducer and the warp beam, thereby imposing upon the latter an additional relatively gradual fluctuating component of movement.

13. In a warp knitting machine, the combination set forth in claim 12, at least one of said mechanisms comprising a pair of meshing non-circular gears.

14. In a warp knitting machine, the combination set forth in claim 12, said transmission including also an adjustable change-speed device comprising rotating driving and driven members, and means for adjusting said device during continuous operation thereof so as to vary the relative speeds of rotation of said members.

15. In a warp knitting machine, a cam shaft, needles, a movable guide-bar arranged in proximity to the needles, a warp beam, means for directing yarn from said warp beam to said guide-bar, said guide-bar controlling the disposition of said yarn with respect to the needles, means driven by the cam shaft for intermittently moving said needles through the knitting cycle, means driven by the cam shaft for intermittently moving said guide-bar in timed relation to the needle movements, a transmission actuated by said cam shaft for continuously rotating said warp beam in yarn-feeding direction, said transmission including an adjustable change-speed device, and an alterable means driven by the cam shaft for automatically adjusting said device, during continuous operation thereof, in accordance with a predetermined selected pattern.

16. In a warp knitting machine, a cam shaft, needles, a movable guide-bar arranged in proximity to the needles, a warp beam, means for directing yarn from said warp beam to said guide-bar, said guide-bar controlling the disposition of said yarn with respect to the needles, means driven by the cam shaft for intermittently moving said needles through the knitting cycle, means driven by the cam shaft for intermittently moving said guide-bar in timed relation to the needle movements, a transmission actuated by said cam shaft for continuously rotating said warp beam in yarn-feeding direction, said transmission including an adjustable change-speed device, an alterable means driven by the cam shaft for automatically adjusting said device, during continuous operation thereof, in accordance with a predetermined selected pattern, and means responsive to the diminishing diameter of the warp beam as yarn is fed therefrom for automatically adjusting said device, independently of any other adjustments thereof, to compensate for said diminishing diameter.

17. In a warp knitting machine, the combination set forth in claim 15, said change-speed device being of the character wherein the relative speeds of rotation of a driving and a driven member are governed by the rotation of an adjusting member, a reversible motor operatively connected with said adjusting member, and electric means actuated by said alterable means for controlling the direction and magnitude of rotation of said motor.

18. In a warp knitting machine, the combination set forth in claim 16, said change-speed device being of the character wherein the relative

speeds of rotation of a driving and a driven member are governed by the rotation of an adjusting member, a differential whose output is operatively connected with said adjusting member, a mechanism operatively connected with one input of the differential and actuated by the means which is responsive to diminishing warp-beam diameter,

a reversible motor operatively connected with another input of the differential, and electric means actuated by said alterable means for controlling the direction and magnitude of rotation of said motor.

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