June 10, 1952 J. L. M. MORRISON ET AL 2,600,256

THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

Filed Feb. 6, 1947

22 Sheets-Sheet 1

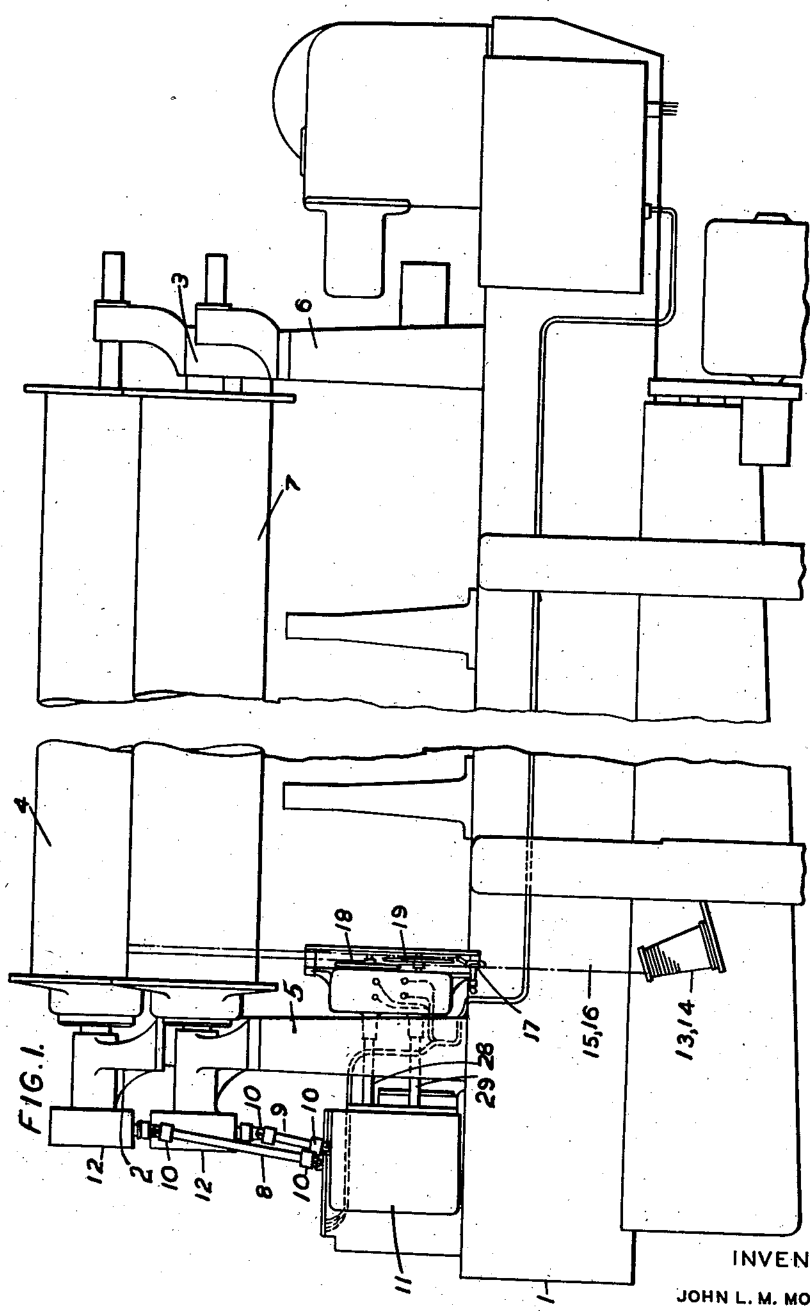

FIG. 1.

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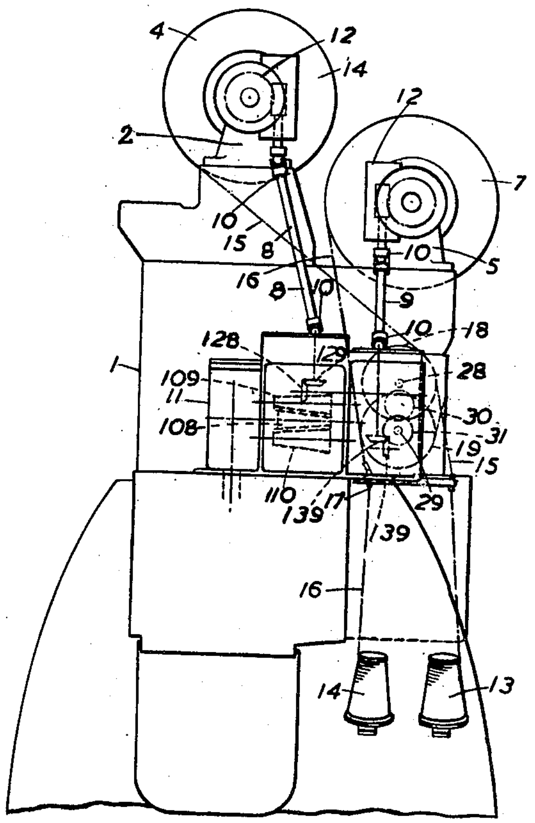
FIG.2.



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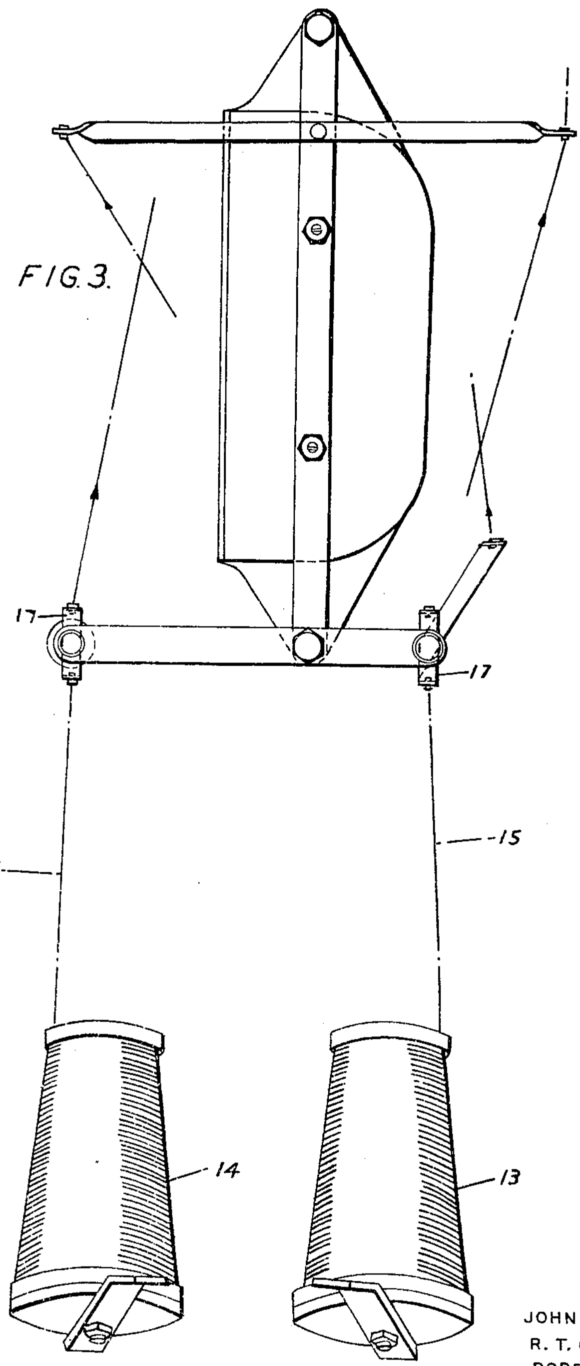

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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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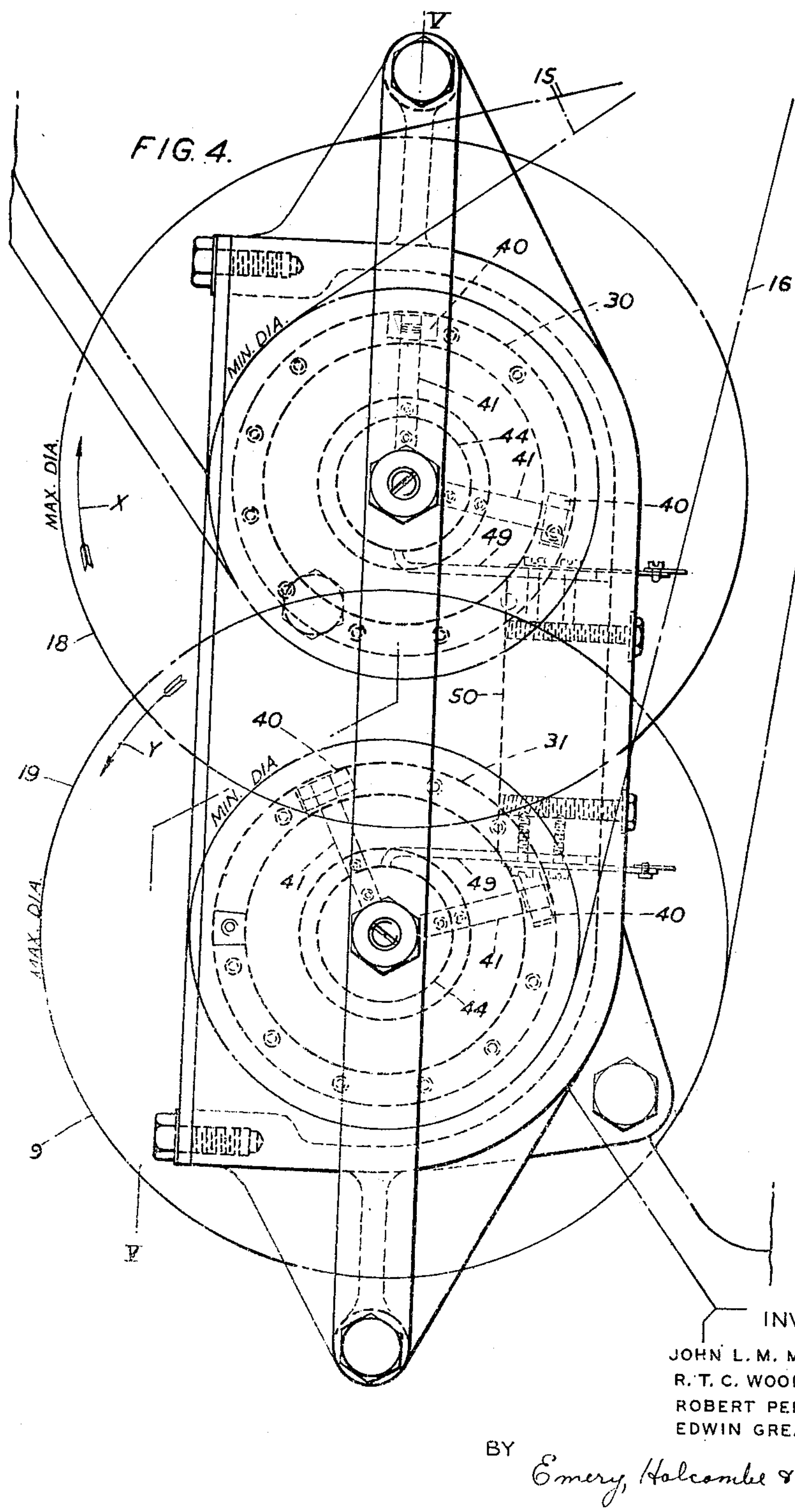
FIG. 4.



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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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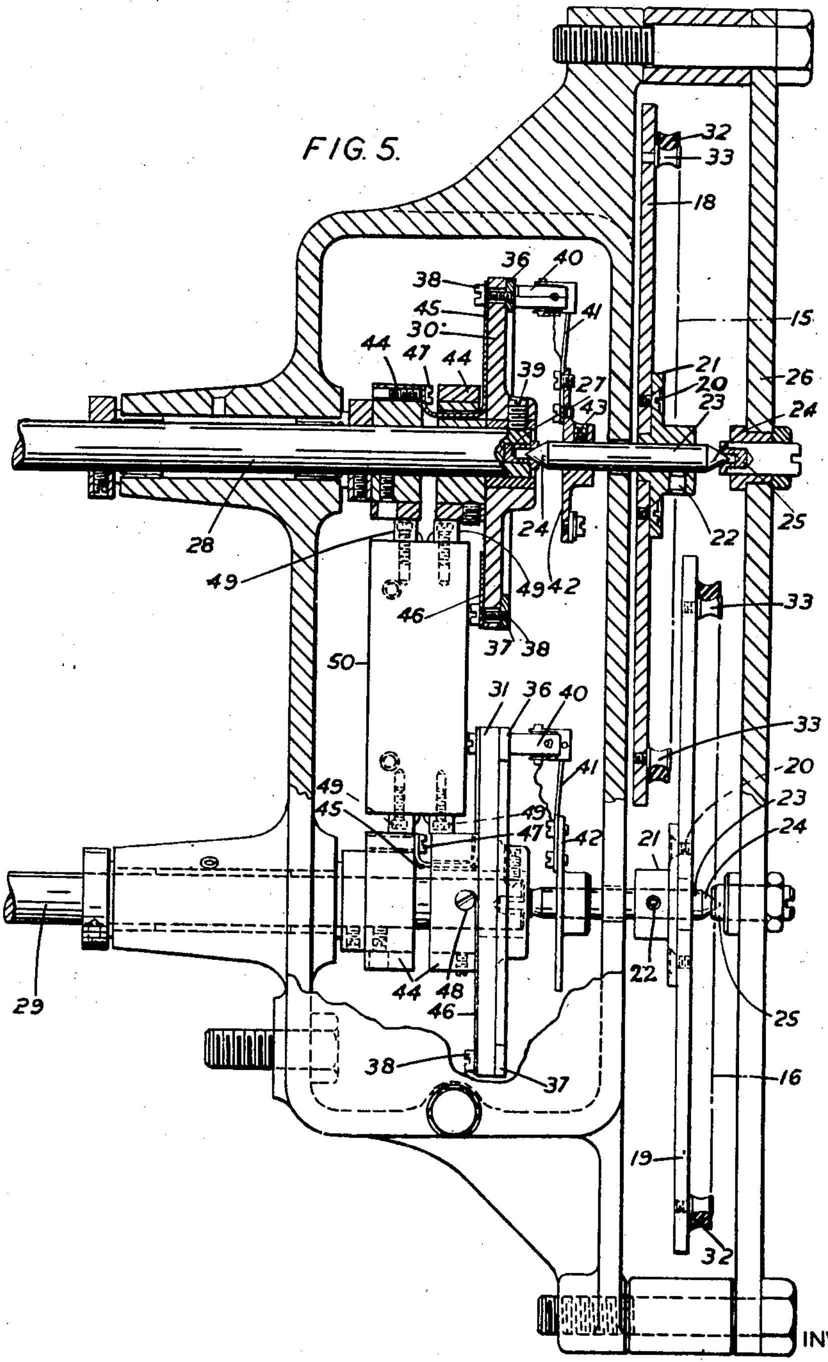
FIG. 5.



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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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FIG. 6.

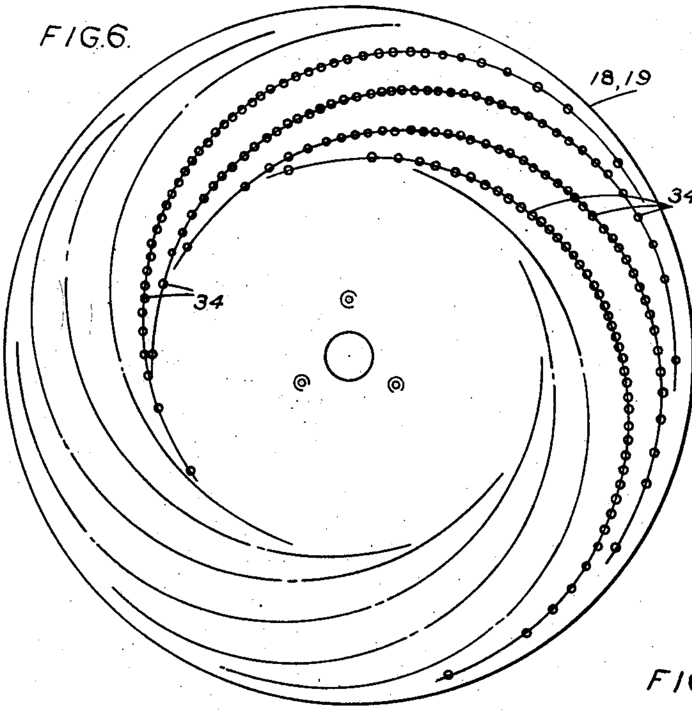


FIG. 23

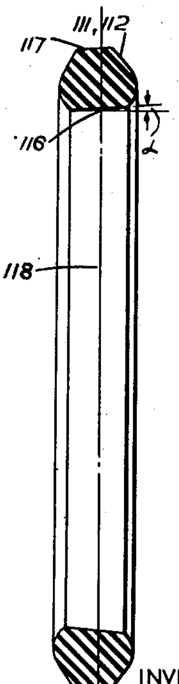


FIG. 7.

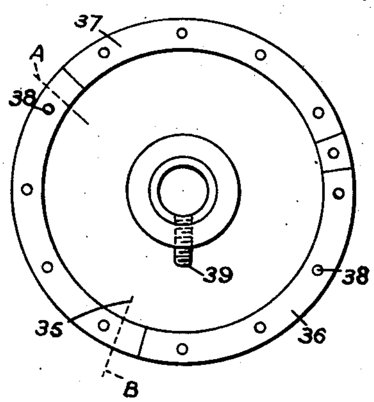
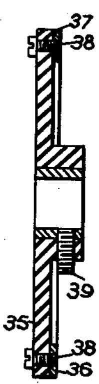


FIG. 8.



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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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FIG. 9.

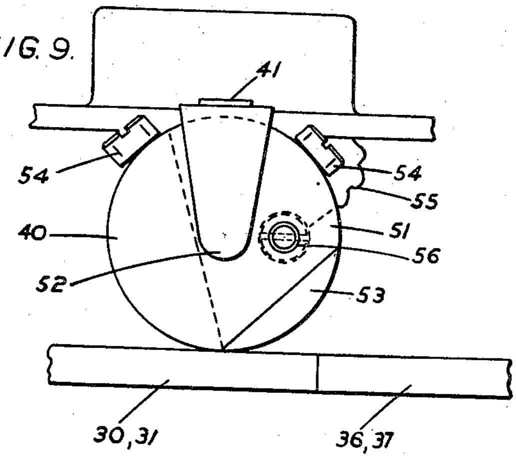

FIG. 10.

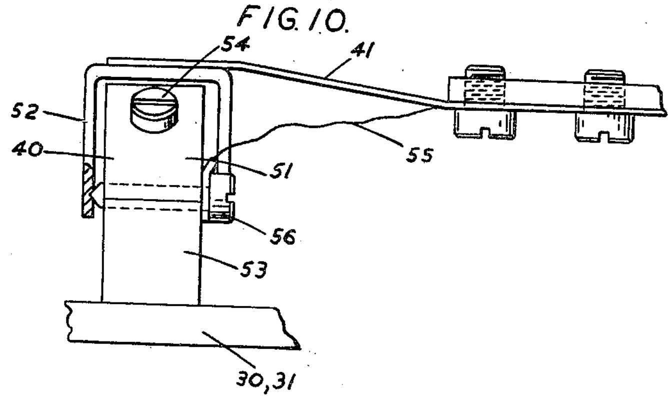

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FIG. 11.

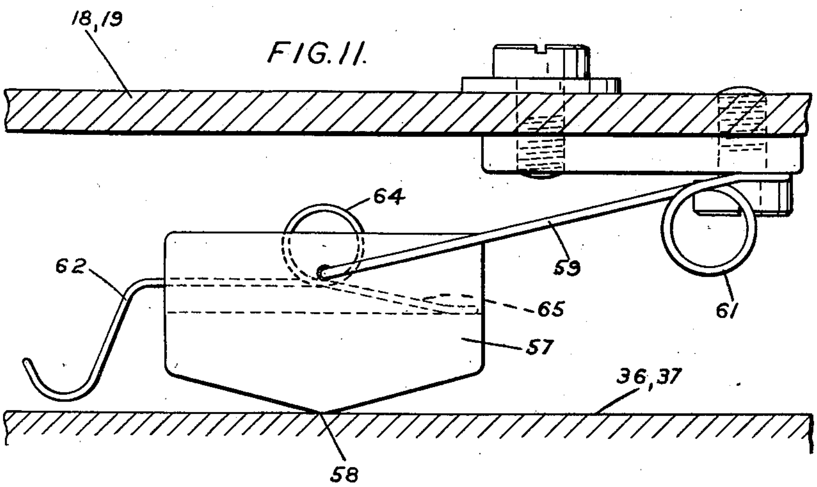
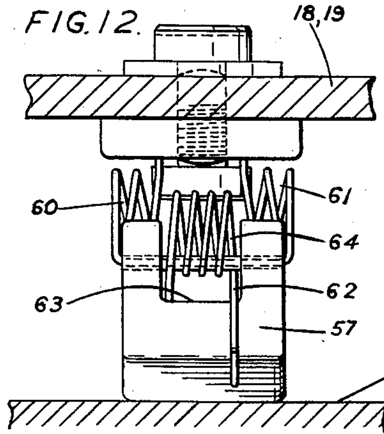


FIG. 12.



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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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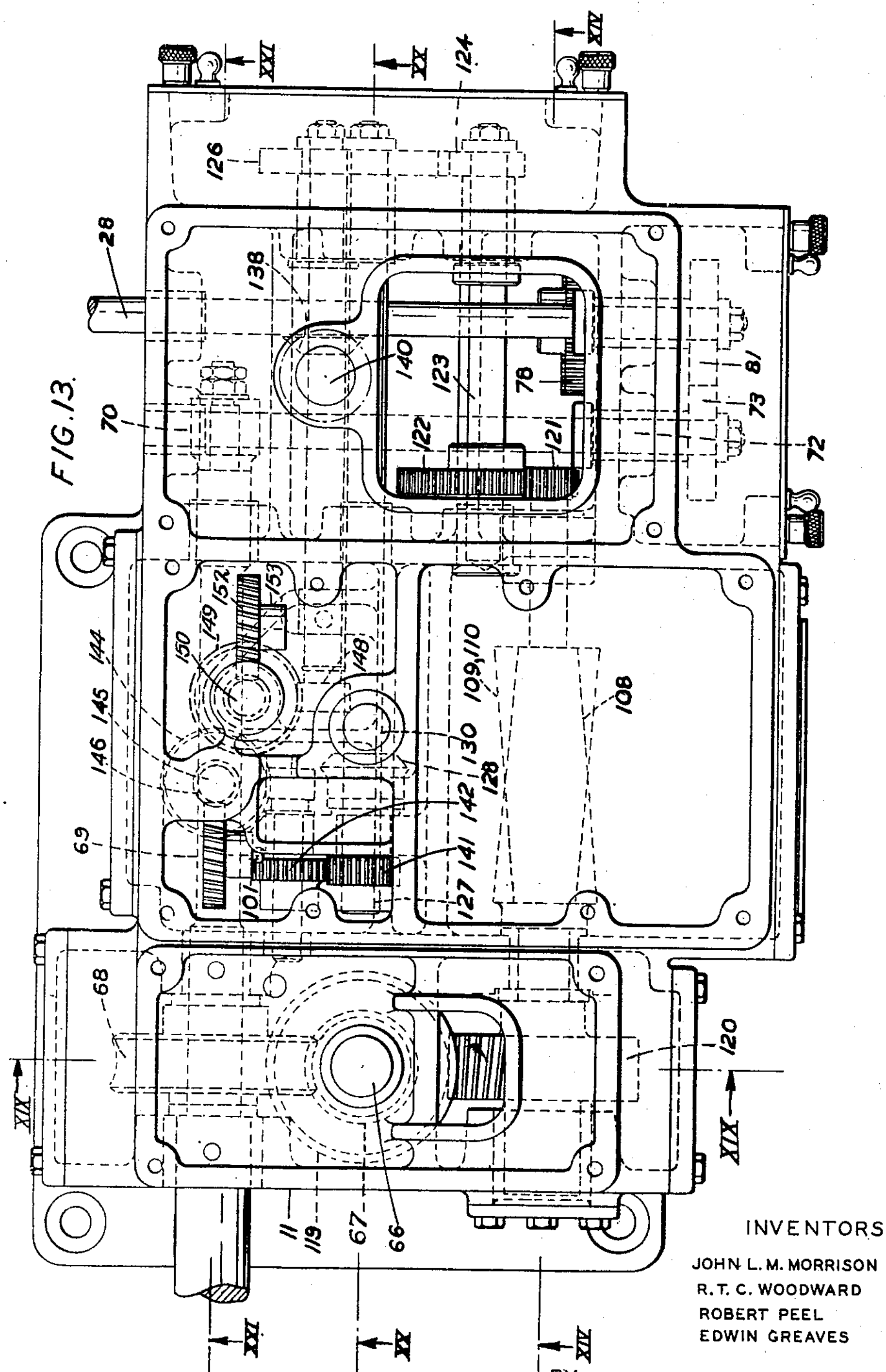

FIG. 13.

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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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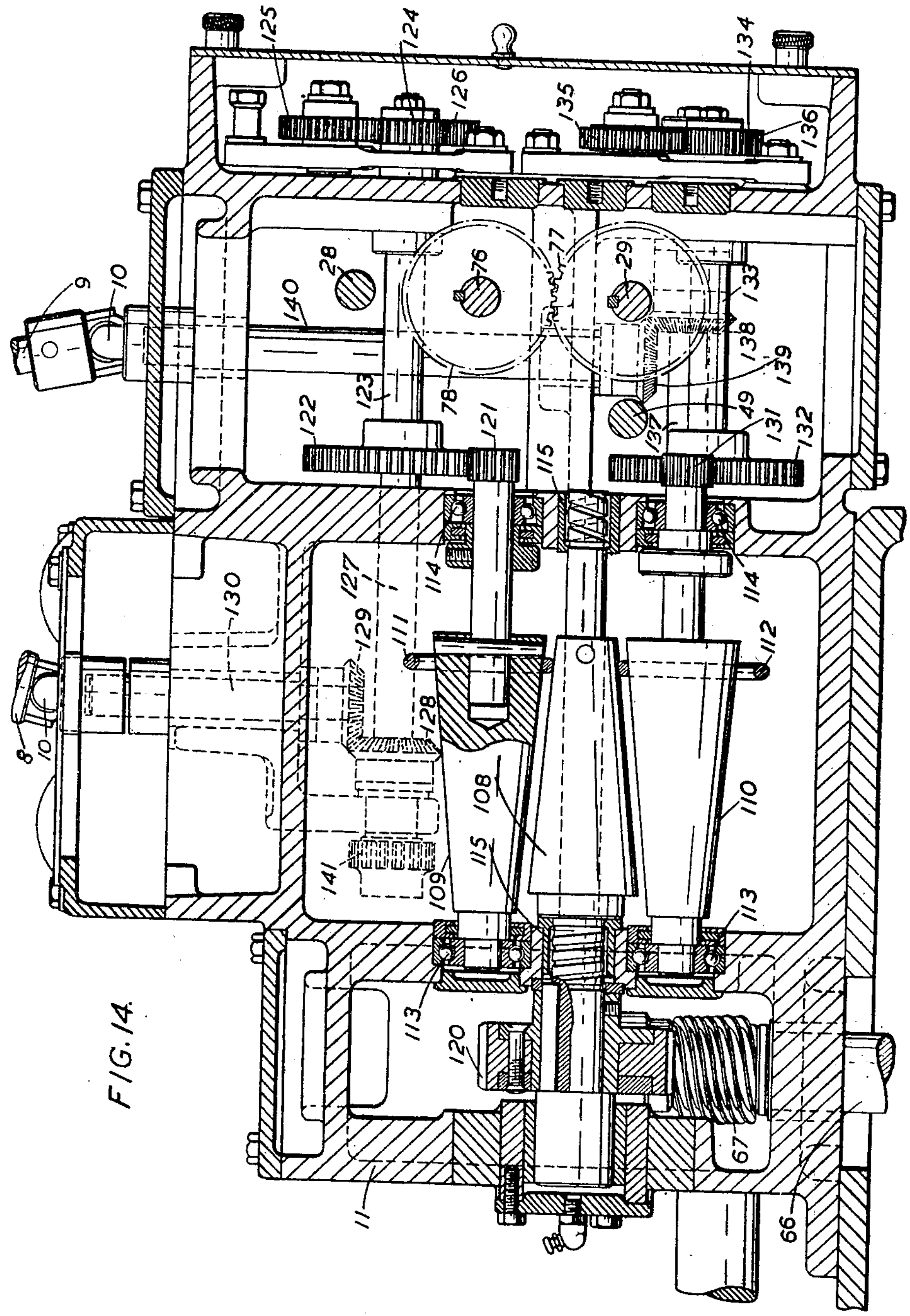

FIG. 14.

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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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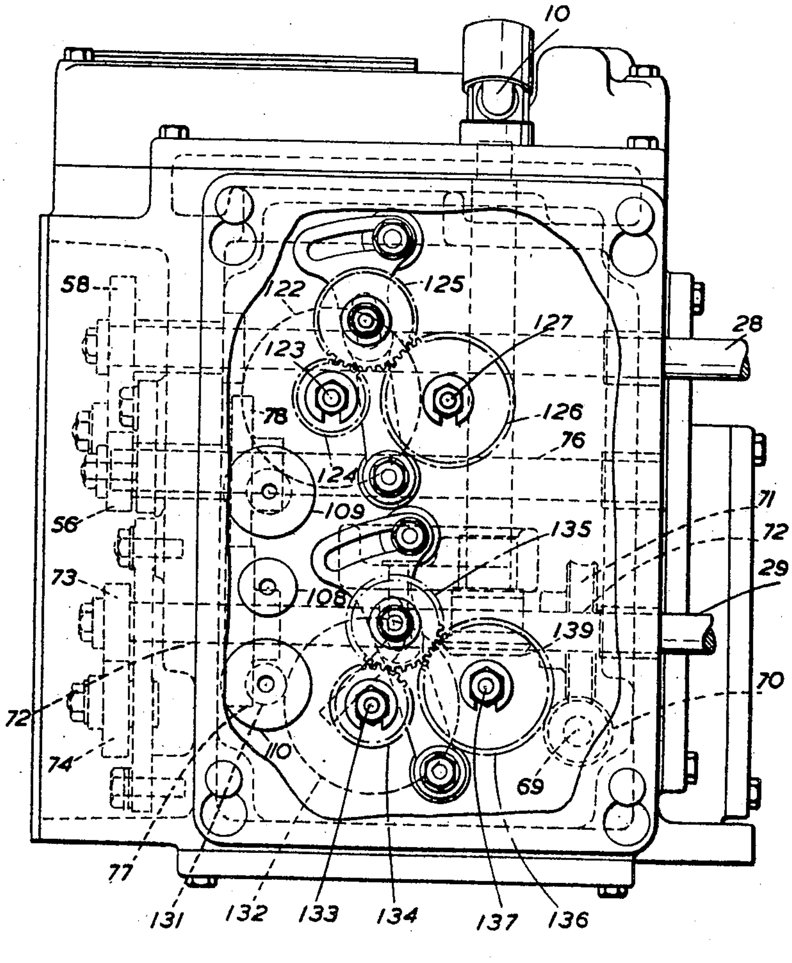
FIG. 15.



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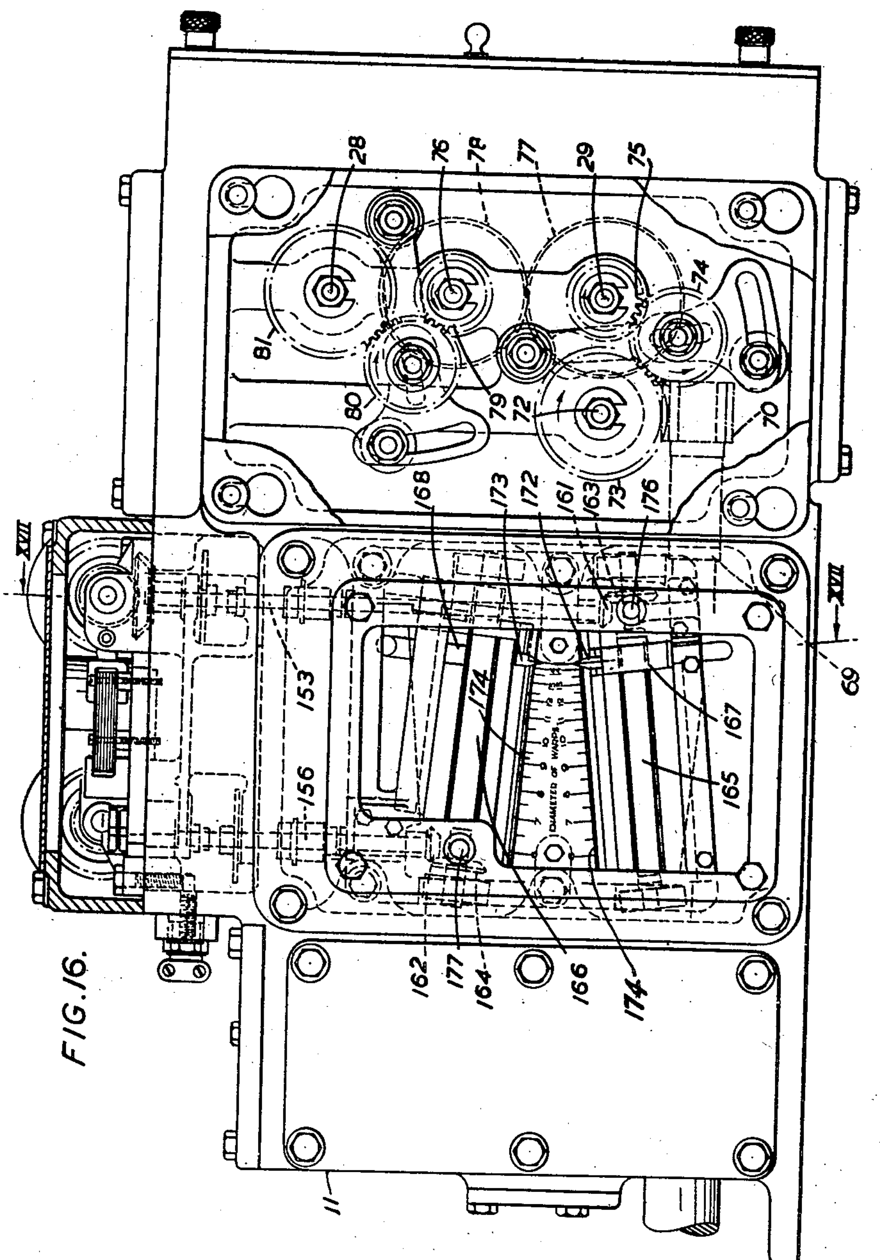

FIG. 16.

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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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FIG. 17.

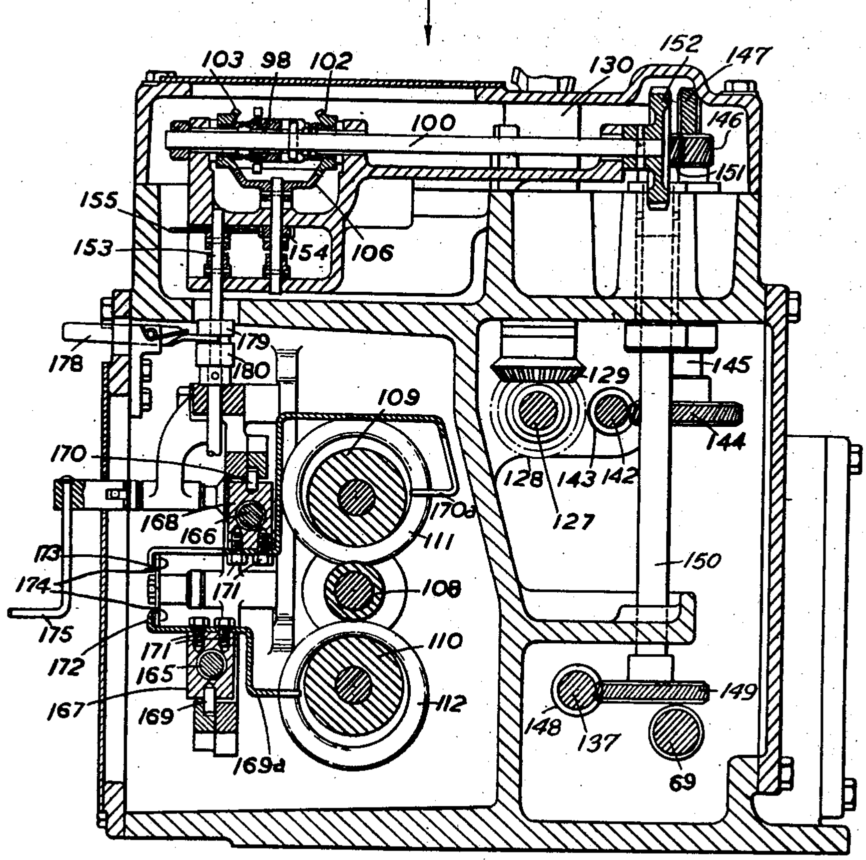

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FIG. 18.

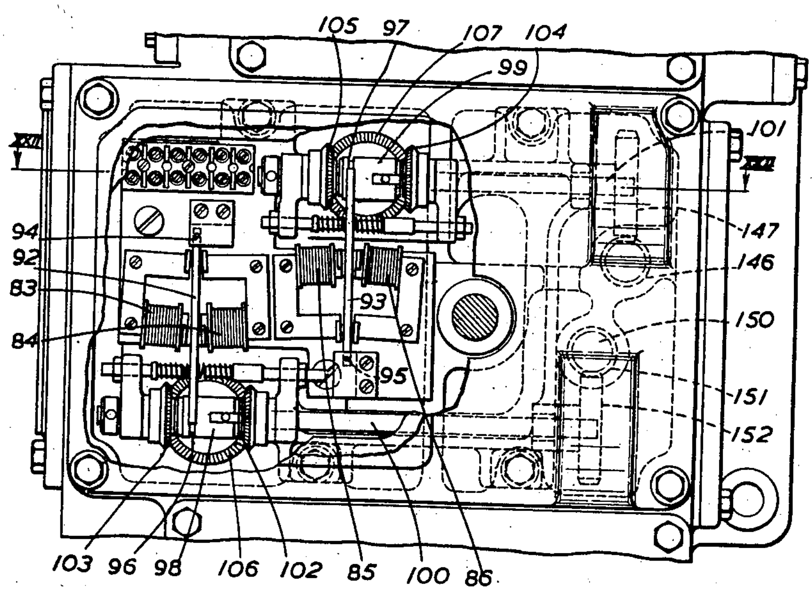
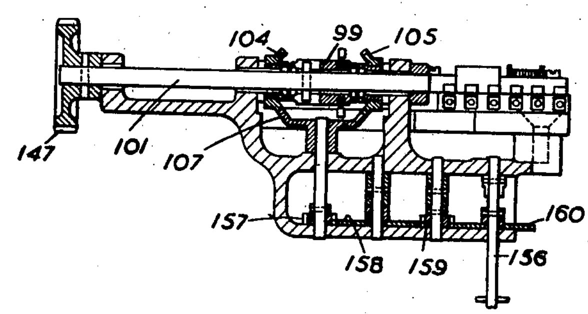


FIG. 22.



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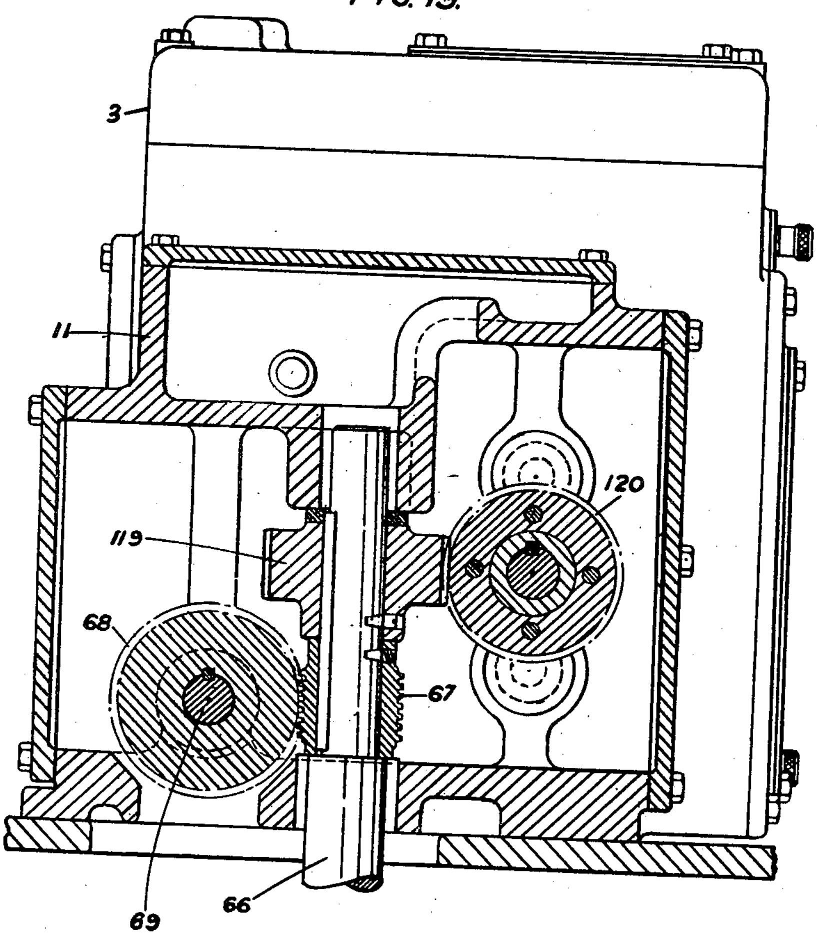
THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

FIG. 19.



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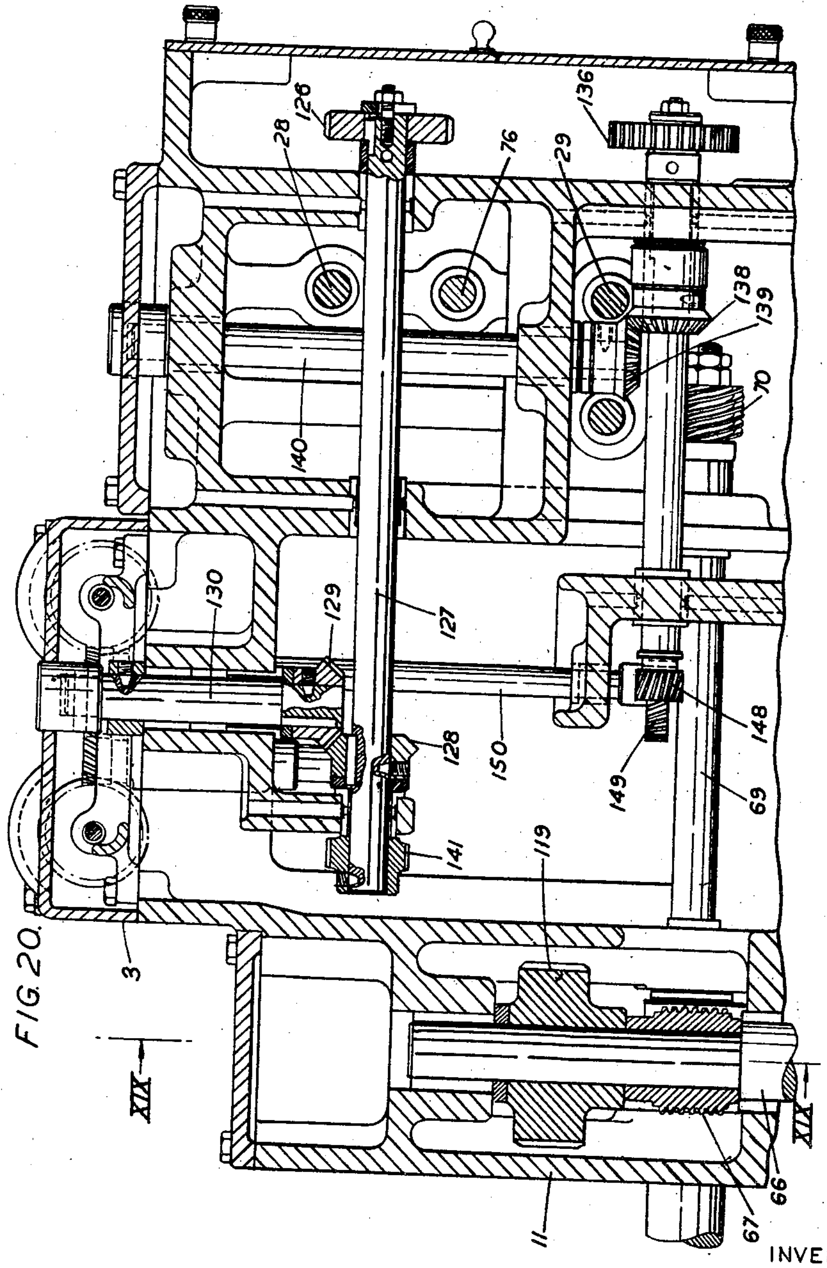

FIG. 20.

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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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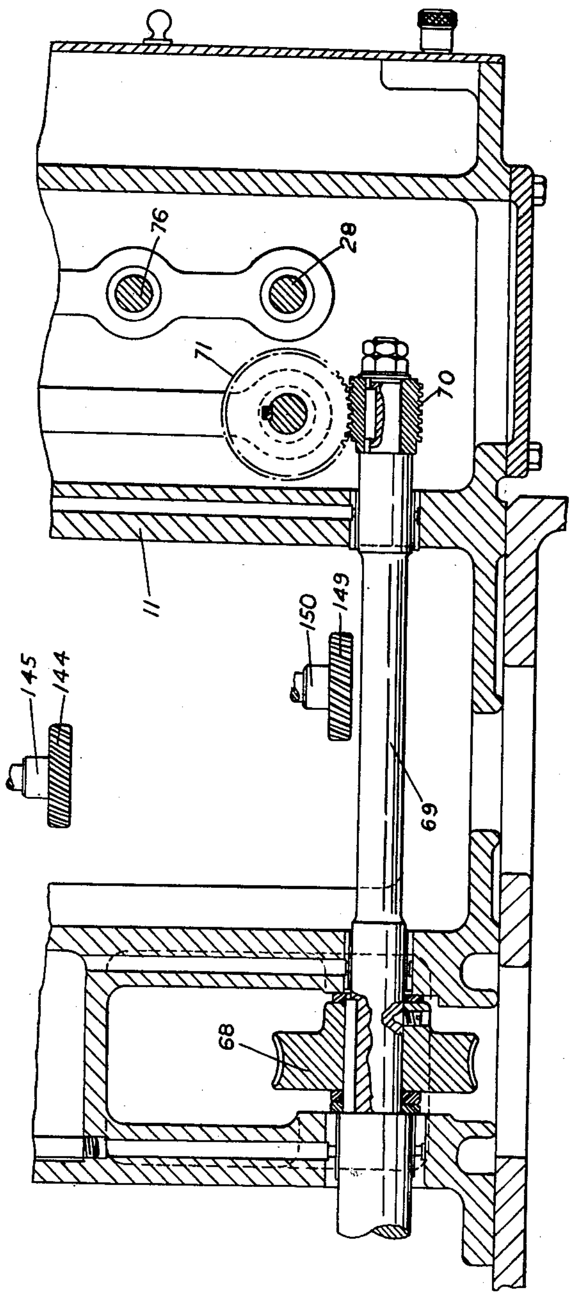

FIG. 21.

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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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FIG. 24.

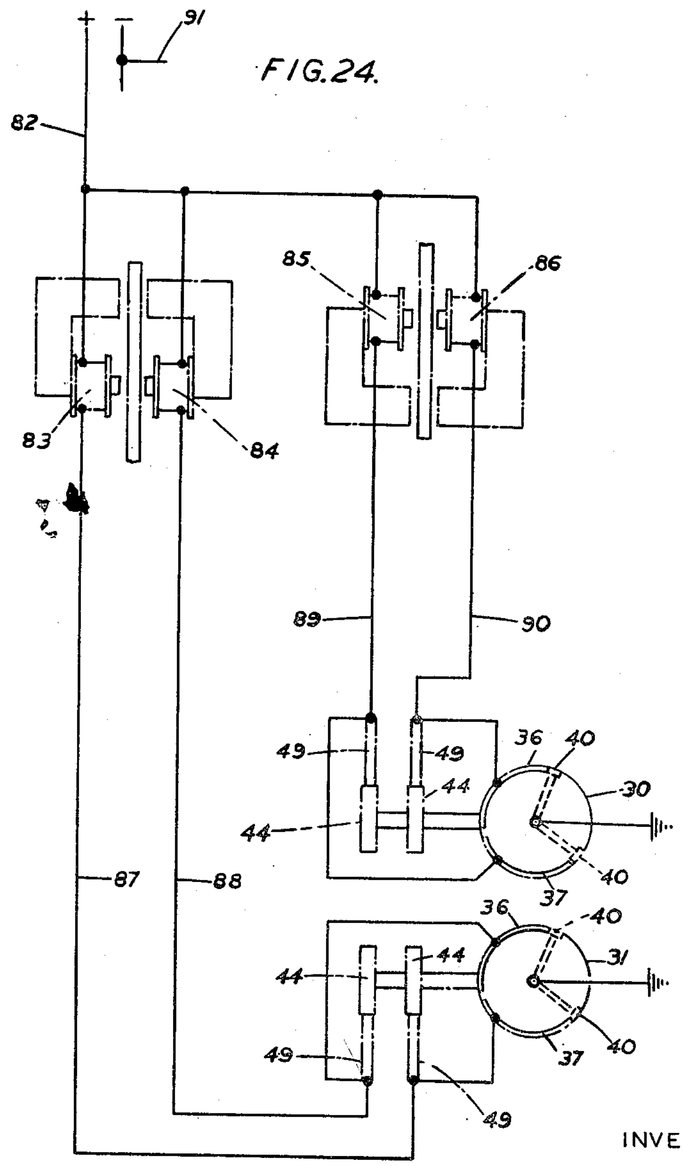

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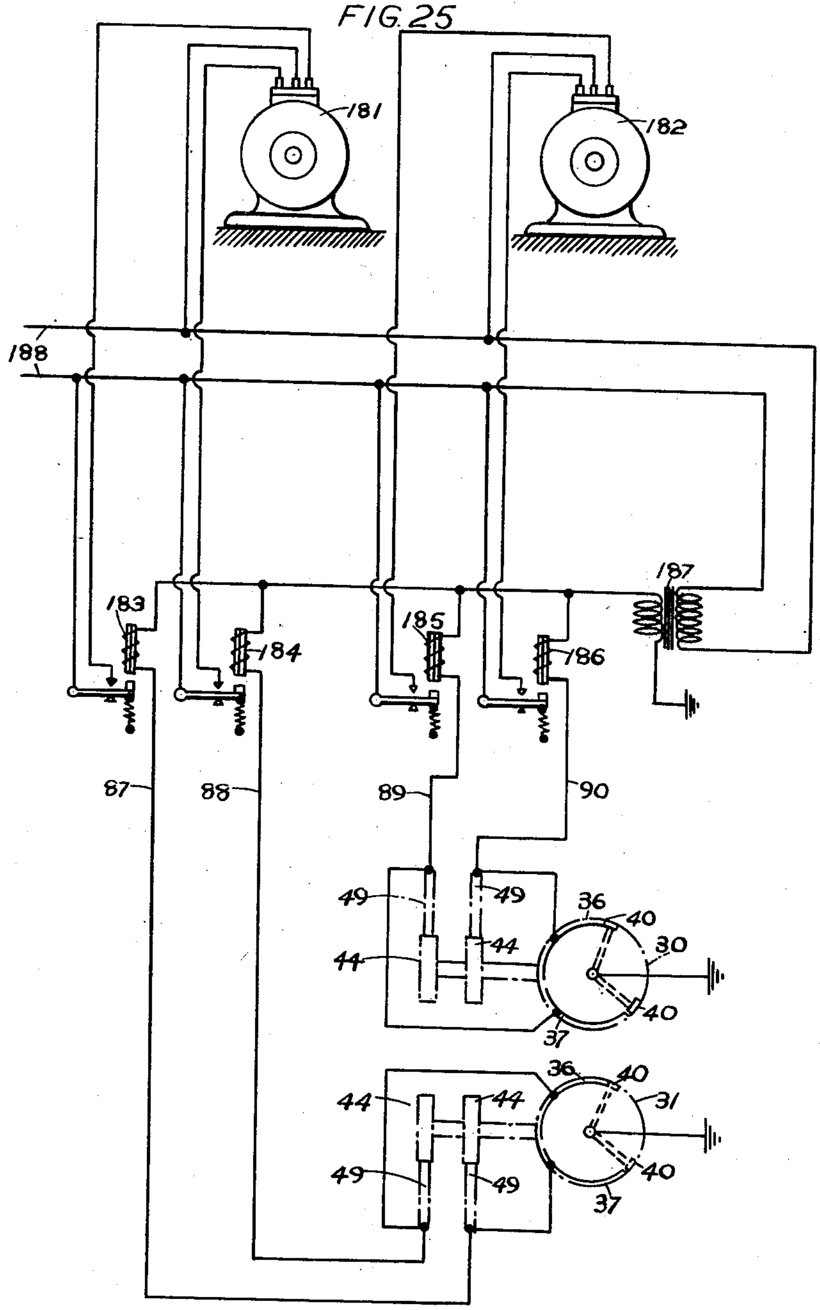
FIG. 25



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THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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FIG. 26.

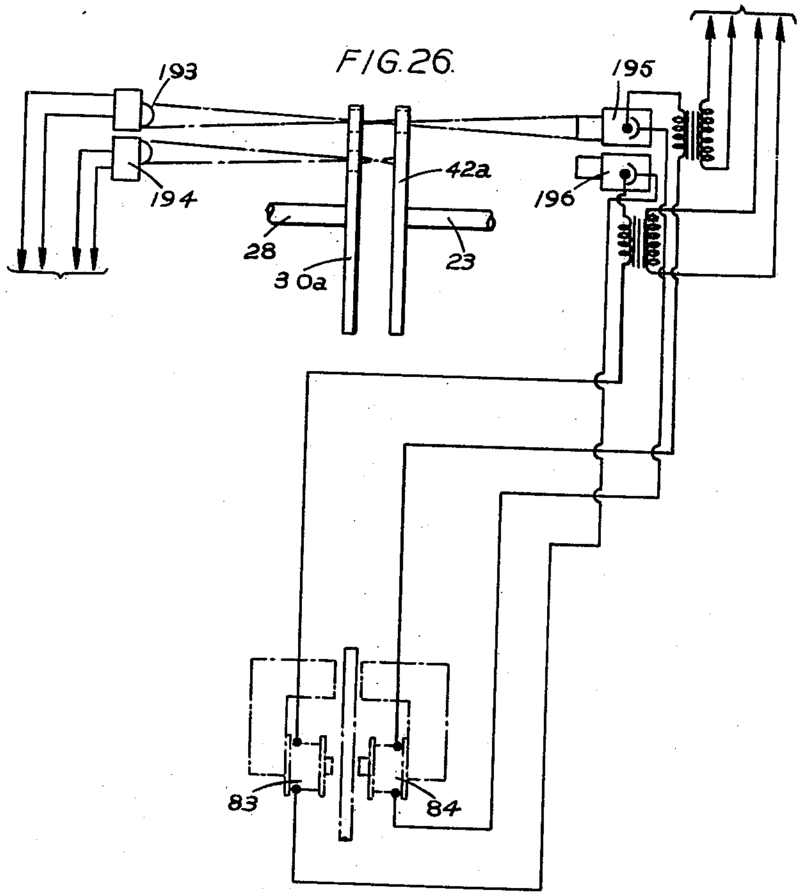

FIG. 27.

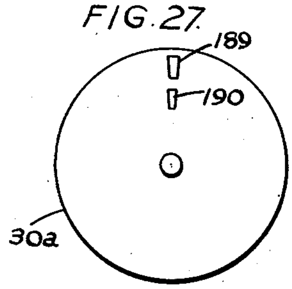

FIG. 28.

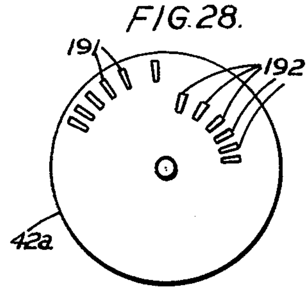

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FIG. 29.

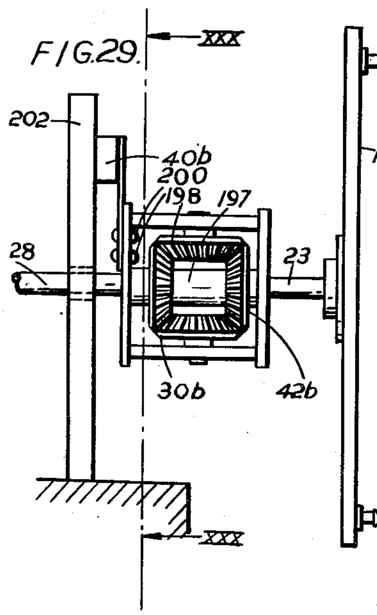

FIG. 30.

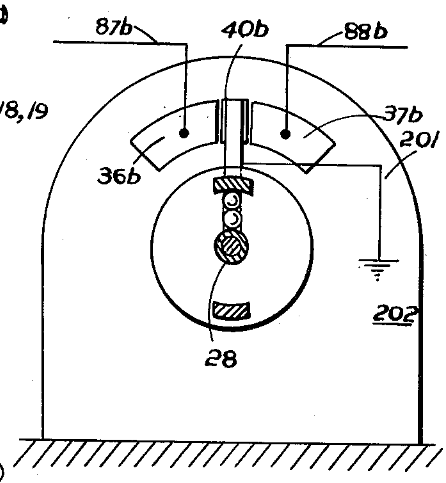

FIG. 31.

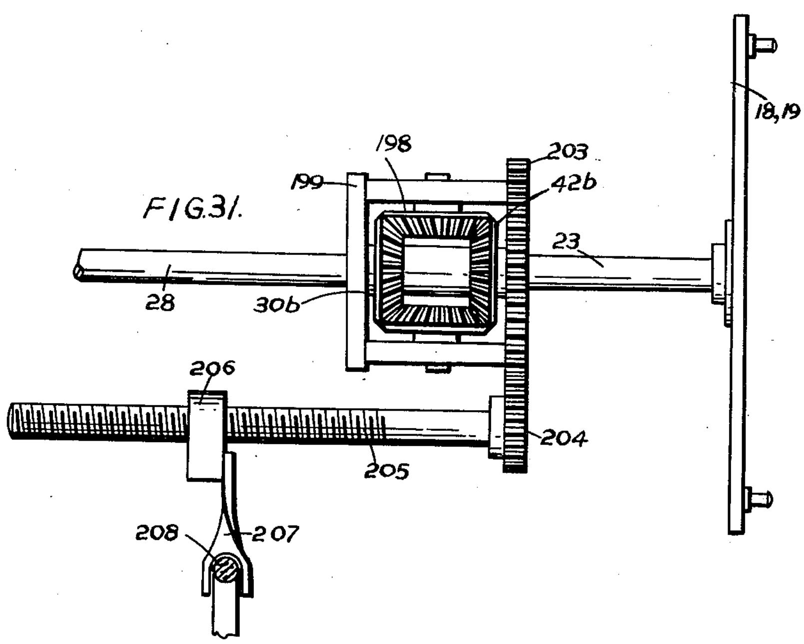

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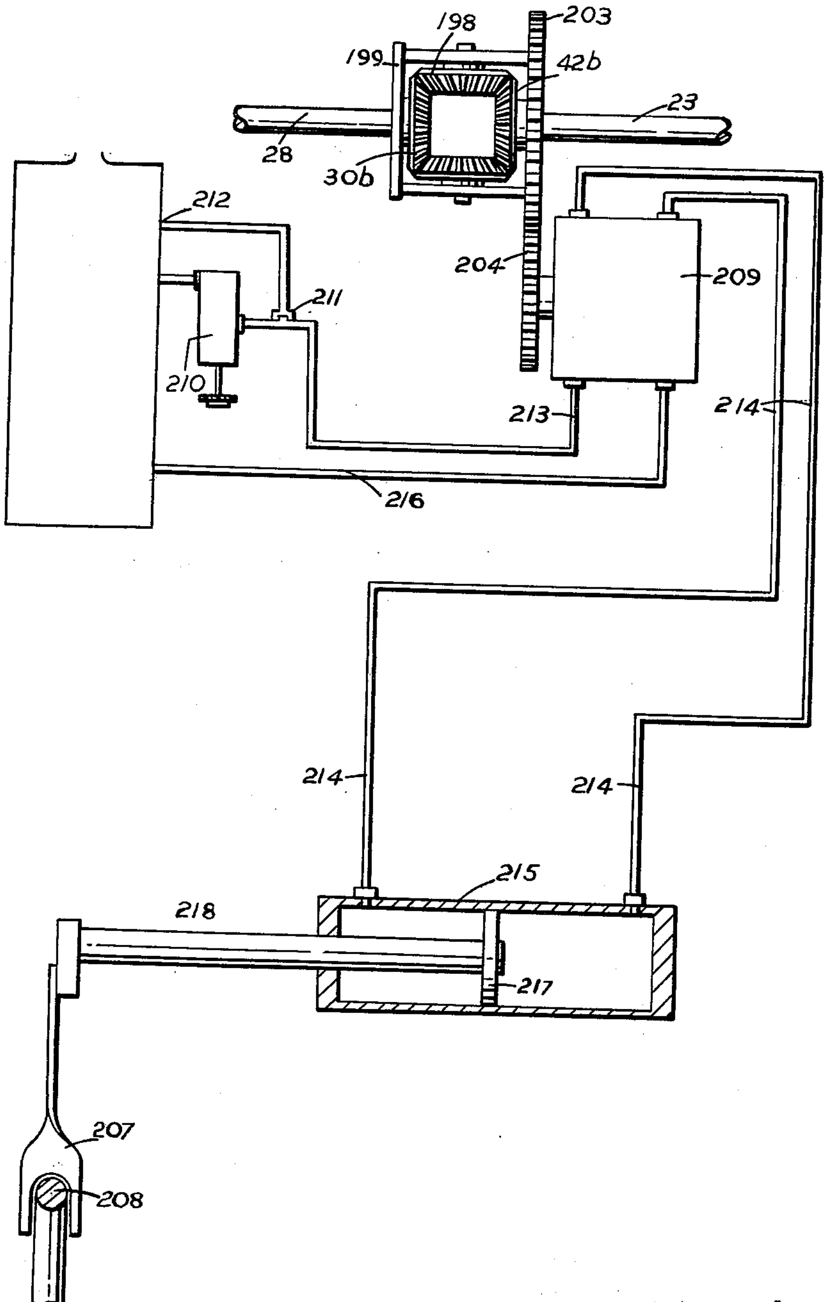
FIG. 32.



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Patented June 10, 1952

2,600,256

UNITED STATES PATENT OFFICE

2,600,256

THREAD CONTROLLING APPARATUS IN TEXTILE MACHINES

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Application February 6, 1947, Serial No. 726,930
In Great Britain February 12, 1946

23 Claims. (Cl. 66—86)

1

This invention relates to apparatus for controlling the feeding of thread, yarn strip or other material in flexible form in machinery where the material is fed from, or towards, a positively controlled beam, bobbin, roller or other rotary member on which the accumulation of material varies in diameter. The invention may be applied to the feeding of a single thread or strip, or only a few threads or strips, but it is particularly concerned with the warp threads in weaving machines, lace machines, warping machines and, specially, warp knitting machines.

One important aim of the invention is to provide a robust but extremely sensitive warp let-off motion which can withstand prolonged wear and which may be used effectively in a knitting machine running a high speed, for example 1000 revolutions per minute, that is to say, to knit 1000 courses per minute.

According to the invention, a device is arranged to respond to changes in the linear speed of a thread or other flexible material, and an infinitely variable gearing is controlled by the said device to adjust the circumferential speed of the material on the beam, bobbin or other member associated with the thread. The said device may include a freely mounted revoluble disc or wheel round which the material is wound so that, as the material is fed forward, the wheel rotates at a speed which is a direct measure of the speed of the thread.

In a warp knitting machine, for example, there are two methods by which such a wheel may be associated with a warp beam. In the first method, one of the warp threads, instead of passing straight to the tension bar or the like, is caused to take one or more turns round a circumferential groove in the wheel and then passes over the tension bar or the like to the knitting centre so that it is consumed at the same speed as the other threads on the beam and rotates the wheel at that speed. In the second of the said methods which presents certain advantages, one of the warp threads is not derived from the warp beam at all but is a slave thread which travels from a stationary bobbin or the like and passes round the wheel and then round the warp beam. After passing round the beam, the thread continues to the knitting centre where it is knitted just as if it was one of the threads having its source in the warp beam. Owing to the fact that this unique thread is wound round the warp-beam, it is let-off by the warp beam at the same rate as the other threads; the rate, of course, depending on the diameter of the mass of threads remaining on the beam and the speed of rotation of the beam. When this unique thread is used it may have tension applied in any known manner before it passes on to the wheel so as to ensure that no slip occurs.

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The wheel may be of the order of three to eight inches in diameter and it may be formed with several peripheral grooves to enable it to be rotated by a number of threads acting in parallel, such an expedient being necessary when there is a danger of the operation being affected by the stretching of a single thread.

To enable a variation in the speed of the wheel to be detected, it may be mounted coaxially with a rotor which is positively driven at the angular velocity at which the wheel carrying the thread is driven when the thread is being fed at the required speed. Therefore, so long as the thread feed is in equilibrium there is no relative movement between the rotor and wheel. As soon, however, as the linear speed of the thread starts to increase or diminish, the wheel begins to gain or lose with respect to the rotor, and this may be made use of to operate contacts which control means for operating the aforesaid infinitely variable gear to modify the speed of rotation of the warp beam or the like and thereby restore the speed of the thread to the required value. In place of contacts, the rotor and wheel may be arranged to open and close an aperture to operate a photoelectric cell. This has the advantage that friction, which the yarn has to overcome due to the contacts is eliminated.

Where contacts are employed, they may comprise a pair of brushes mounted at diametrically opposed points on the face of the wheel and arranged to move over the adjacent face of the rotor, the latter embodying two conducting segments. This arrangement is such that, in the equilibrium condition, neither brush is in contact with a segment but that, as soon as the wheel gains on the rotor, one of the brushes engages one of the segments while the other brush moves further from the second segment. Conversely, of course, when the wheel loses, the last mentioned brush makes contact with the second segment while the distance between the first brush and its associated segment increases. The two segments may be connected through slip rings to opposite poles of a source of current earthed at its centre, while the two brushes are earthed through the member on which the wheel is journaled. The two circuits may comprise electro-magnetic relays controlling a reversible electric motor or an electrically operated clutch.

Various forms of infinitely variable friction gearing may be used in the drive of the warp beam or beams. The known type having pulleys with adjustable and separable side flanges on parallel shafts and in driving connection through a steel ring may well be used. However, good results have been obtained by the use of the form of gearing comprising driving and driven cones on parallel shafts with the narrow end of one adjacent to the larger end of the other with a flexible driving ring located in the narrow gap between the cones to provide the driving connection between them. In that case, the gearing ratio is progressively varied by shifting the driving ring longitudinally along the cones.

In order that the invention may be clearly understood and readily carried into effect, an example of a warp let-off motion for a knitting machine having two warp beams as is fairly common, will now be fully described with reference to the accompanying drawings; in which:

Figure 1 is a diagrammatic rear elevation of the whole warp knitting machine;

Figure 2 is an elevation seen from the left of Figure 1;

Figure 3 is an elevation from the rear showing the arrangement of the two bobbins holding the two slave threads;

Figure 4 is a detailed end elevation showing the mounting of the pair of thread-driven disc-wheels and contact rotors;

Figure 5 is a vertical section of same taken on the line V—V in Figure 4;

Figure 6 is a detailed front elevation of one of the disc-wheels;

Figure 7 is a front elevation; and

Figure 8 is a diametral transverse section of one of the contact rotors;

Figures 9 and 10 are detailed elevations of one of the contact brushes and its supporting arm as seen respectively along the axis of the contact-rotor and at right angles to that axis;

Figures 11 and 12 are similar views of an alternative form of contact mechanism;

Figure 13 is a plan of the gearing and control box of the let-off unit;

Figure 14 is a vertical section of same taken on the line XIV—XIV in Figure 13;

Figure 15 is an end elevation of the box as seen from the right of Figure 13 and with the casing broken away to show the gear wheels in full;

Figure 16 is an elevation of the box as seen from below in Figure 13;

Figure 17 is a transverse vertical section on the line XVII—XVII in Figure 16;

Figure 18 is a plan of the box seen from the top of Figure 17 and with the casing broken away to show interior parts;

Figure 19 is a vertical section taken on the line XIX—XIX in Figure 13; or Figure 20;

Figure 20 is a vertical section taken on the line XX—XX in Figure 13;

Figure 21 is a vertical section taken on the line XXI—XXI in Figure 13;

Figure 22 is a vertical section taken on the line XXII—XXII in Figure 18;

Figure 23 is a detail diametral section of one of the friction driving rings of the cone gearings;

Figure 24 is a diagram of the electrical connections of the contact rotors and clutch magnets.

Figure 25 is a circuit diagram of an embodiment in which reversible electric motors are provided instead of the clutch magnets;

Figure 26 is a diagram of an alternative form in which photoelectric cells and shutter discs are employed;

Figures 27 and 28 are side elevations of the constant speed disc and thread-driven disc respectively;

Figure 29 is a diagrammatic elevation seen from the back of the machine of an alternative form in which a contact brush is actuated by a differential or balance gearing;

Figure 30 is a sectional elevation taken on the line XXX—XXX in Figure 29;

Figure 31 is a view similar to Figure 29 of a modification wherein the differential gearing is mechanically connected to the variable speed gearing of the warp knitting machine; and

Figure 32 is a similar view of another modification wherein the differential gearing controls the variable speed gearing hydraulically.

The general conventional features of the warp knitting machine to which the invention is applied are shown in Figures 1 and 2. The bed casting 1 bears bearing standards 2, 3 for the top warp beam 4 and standards 5, 6 for the lower warp beam 7. The beams 4, 7 are driven through shafts 8, 9 respectively furnished with universal couplings 10 at either end and receiving their drives from the gearing and control box 11 which is mounted at the left-hand end of the base 1 as seen from the rear in Figure 1. The details of the drives to the shafts 8, 9 will be described below. The shafts 8, 9 each drives the respective warp-beams 4, 7 through a worm and worm wheel mounted in gear casings 12. The yarn stored on the warp-beams 4, 7 passes forwardly to the left in Figure 2 over a tension plate which is not shown in the drawings and then to the knitting centre through the warp guides in the ordinary way.

In order to maintain the linear speed of the yarn constant, the speed of the warp-beams 4, 7 has to increase as the yarn is taken off and the effective diameter of the warp-beams becomes less. This is effected automatically in a simple manner by means of the present invention. To that end, two bobbins 13, 14 of thread are mounted on the back of the machine framework and from each of them a single "slave" thread 15, 16 is taken over one of the warp-beams 4, 7 and is then knitted in exactly in the same way as the threads on the warp-beams 4, 7. On the way, each of the threads 15, 16 is taken between a pair of spring tension washers 17 and around one of the disc-wheels 18, 19 and then around the yarn on the warp-beam 4, 7 as seen in Figure 2.

Each of the disc-wheels 18, 19 is, in effect, a light pulley driven by its slave thread and the construction is shown in detail in Figures 4 to 6. Each wheel is a disc fixed by screws 20 to a hub 21. The latter is secured by a set screw 22 to the wheel spindle 23 which has a conical centre 24 at each end running in a bearing pivot. At one end this pivot 25 is supported in a fixed frame member 26 and at the other end, the pivot 27 is carried on the end of the shaft 28, 29 of the contact rotor 30, 31. Each disc wheel 18, 19 is furnished with an adjustable rim formed by an interchangeable rubber ring 32. This ring is stretched over a set of ten pegs 33. In order to permit of adjustment, the disc 18, 19 is drilled with ten sets of holes 34 (Figure 6) to receive the pegs 33. Each set of holes lies along a spiral so that if the ten pegs 33 are inserted in corresponding holes in each set, the pegs lie on a circle and the rubber ring 32 presents a circular rim for the engagement of the slave thread 15, 16. The spacing of the holes 34 may be such that if the pegs 33 are each moved into the adjacent hole in a clockwise direction as seen in Figure 6, the effective diameter of the pulley rim is increased by $\frac{1}{16}$ of an inch and, if each is moved one step in the opposite direction, the diameter of the pulley rim is decreased by the same amount. By this means the speed of the disc wheels 18, 19 may be varied relatively to that of the thread and the speed may be different for the two warp beams 4, 7 as is necessary in knitting some patterns.

The construction of the contact rotors 30, 31 is most clearly shown in Figures 7 and 8. Each rotor consists of a disc 35 of moulded insulating material with two annular metal segments 36, 37 let in flush and secured by screws 38 from the back. The rotors are fixed to their shafts 28, 29 by set screws 39 passing through their hubs so that the rotors are driven at the speeds at which the disc wheels 18, 19 run when the two slave threads 15, 16 are travelling at the desired speeds.

A pair of brushes 40 bears on the face of each of the rotors 30, 31 and each brush is carried by a flat spring brush arm 41 which presses the brush against that face. The arms 41 are supported by brackets 42 also fixed to the wheel shafts 23 by set screws 43 so that all four brushes 40 are earthed to the frame of the machine. When the disc wheel 18, 19 is driven at the correct speed which is the same as that of the respective contact rotor 30, 31, the brushes 40 rest on the insulating portions of the rotors near the ends of the metal segments 36, 37, the centre lines of the brushes being at A, B as seen in Figure 7. If, however, one of the disc wheels 18, 19 is running temporarily too fast, for example, the upper wheel 18, which is turning clockwise (see arrows X, Y in Figure 4), then it carries one of the brushes 40 from the centre line A (Figure 7) on to the adjacent metal segment 37 which is thus earthed by the brush. The other brush 40 is moved from the centre line B further from the adjacent metal segment 36. If, however, the disc 18 is running temporarily too slowly, the brush 40 at centre line A is moved backwards from the segment 37 and the brush 40 at centre line B is shifted on to segment 36 so that now, the latter segment is earthed. It will be explained in detail later how these relative movements of the brushes 40 over the contact rotor 30, 31 result in the driving gear ratio to the warp beam 4 or 7 being decreased or increased respectively.

The metal segments 36, 37 of each rotor 30, 31 are connected to insulated slip rings 44 also fixed to the shafts 28, 29. The connections are made by conductors 45, 46 both gripped under one of the screws 38 and fixed to the slip rings 44 by screws 47, 48. The slip rings 44 are engaged by contact brushes 49 fixed by screws to opposite faces of an insulating block 50.

The brushes 40 carried by the wheels 18, 19 are shown in detail in Figures 9 and 10. Each brush consists of a roller 51 of insulating material mounted to turn in a bracket 52 fixed to the spring arm 41. The roller 51 has a metal segment 53 inserted and subtending an angle of rather less than 90 degrees. The angular movement of the roller 51 is limited by stop-pins 54 screwed into it and engaging opposite sides of the bracket 52. Electrical connection to earth the brush 40 effectively is made by a pigtail 55 secured to a stud 56. The brush is shown in Figure 9 in its mid position with the stop pins 54 at equal distances on opposite sides of the bracket 52. If the roller 51 moves to the right, it turns through a small angle and the metal segment 53 of the roller touches the metal segment 36, 37 of the contact rotor; immediately, however, there is reverse movement, the roller 51 turns back and the insulating portion comes into contact with the metal segment 36 or 37 so that the connection is interrupted before the speed correction which is made as will be described below, is fully effected. As a result of the action, hunting of the brush contact is prevented.

An alternative construction of contact brush to produce a similar result is shown in Figures 11 and 12. In this case, the brush takes the form of a rocker block 57 of insulating material shaped with an edge 58 subtending an obtuse angle and extending radially of the contact rotor 30, 31 across the middle of the block 57. The block 57 is carried from the disc wheel 18 or 19 by a wire arm 59 coiled at 60 and 61 so that the arm 59 lies tangentially of the disc wheel. The contact member proper is constituted by another wire 62 which extends into a groove or recess 63 in the top of the block 57; the wire 62 is coiled around the end of the wire arm 59 at 64 and has a tail 65 which rests on the block 57 in the groove 63. In this case, when the block 57, moves towards the metal segment 36, 37 of the rotor 30, 31, the wire 62 turns down and makes contact while, upon a reverse movement, the block 57 immediately rocks clockwise, as seen in Figure 11, and the wire 62 quickly leaves the metal segment 36 or 37.

The shafts 28, 29 which carry the contact rotors 30, 31 and are driven at constant speeds extend from the right hand side of the control gear box 11 as seen in Figure 1. The drive to these shafts is taken as follows: The main machine shaft (not shown) drives a vertical shaft 66 (Figures 19 and 20) which enters the control box 11 from the bottom. The shaft 66 carries a worm 67 meshing with a worm wheel 68 on a longitudinal horizontal shaft 69 (Figures 15, 17, 19 and 20). This shaft 69 bears a worm 70 gearing with a worm wheel 71 on a transverse shaft 72. The shaft 72 is geared by change wheels 73, 74, 75 to the lower constant speed shaft 29 (Figures 15 and 16). The shaft 29 is connected to an intermediate shaft 76 by a 1:1 gearing 77, 78. Finally, the shaft 76 is connected by change wheels 79, 80, 81 to the upper constant speed shaft 28. The change wheels 73, 74, 75 permit the speed of the shaft 29 to be adjusted to any desired constant value and the wheels 79, 80, 81 allow the speed of the shaft 28 to be set to any desired value with respect to that of the shaft 29.

It is now convenient to consider in detail how the connections made by the contact brushes 40 are utilised. For that purpose, reference will now be made to the connections shown diagrammatically in Figure 24. The brushes 40 which are earthed to the frame of the machine as already stated are shown in their normal positions on the contact rotors 30, 31 which they assume when the correct speeds are obtained. A conductor 82 from the positive side of the source of supply is connected to the windings 83, 84, 85, 86 of a pair of electromagnetic clutches (also seen in Figures 17, 18 and 22). From each of the windings 83, 84, 85, 86, a conductor 87, 88, 89, 90 leads to each of the brushes 49 on the slip rings 44. The windings 83, 84 are the "increase" and "decrease" windings of the clutch which controls the increase and decrease of speed of the top warp-beam 4 and therefore of the upper disc wheel 18 while the windings 85, 86 are those of the clutch which controls the speed of the lower warp-beam 7 and therefore of the lower disc wheel 19. It will be observed that if the speed of either of the wheels 18 or 19 becomes high or low compared with that of the associated rotor 30 or 31, the corresponding segment 36 or 37 will be earthed by one of the brushes 40 and as the negative side of the source of supply is earthed by connection to the machine frame at 91, the corresponding magnet winding 83, 84, 85 or 86 is energised and the corresponding clutch is operated in the manner to be described later to correct the speed of the warp-beam 4 or 7 in question.

Referring now to Figures 17, 18 and 22, each clutch has an armature lever 92, 93 pivoted at 94, 95 and has a fork engaging a groove 96, 97 in a clutch sleeve 98, 99 which is slidably mounted on a shaft 100, 101 but is driven by the shaft. In its extreme positions, the sleeve 98, 99 engages dog-teeth on either of two bevel wheels 102, 103, 104, 105 and so clutches the bevel wheel in question to the shaft 100 or 101. The bevel wheels 102, 103 engage a larger bevel wheel 106 so that the operation of the clutch in one direction or the other reverses the drive of the wheel 106. In a similar way, the bevel wheels 104, 105 engage a wheel 107 which is reversed by the other clutch. The bevel wheels 106, 107 adjust the ratios of two infinitely variable cone friction gearings as will be described fully later.

In the meantime, it may be explained that the said cone gearings for varying the speeds of the driving shafts 8, 9 of the warp-beams 4, 7 comprise a middle driving cone 108 (Figures 14 and 17) and upper and lower cones 109, 110 whose speeds can be varied independently by shifting driving rings 111, 112 which transmit the drive from the middle cone 108 to the two driven cones. These cones 109, 110 are furnished with journal ball bearings 113 and thrust ball bearings 114 while the cone 108 has simple oil retaining bearings 115. The form of the driving rings 111, 112 is important and is shown in detail in Figure 23. The ring should be of hard rubber having the following contents:

In order to prevent the ring jumping from the belt forks and to cause it to move freely along the cones when shifted by the fork it is found necessary to have the inner and outer cone-engaging surfaces 116, 117 not at right angles to the central transverse plane 118 of the ring. In a gearing in which the angle of the cone is 5 degrees with the axis of the shaft, the angle between either engaging surface 116, 117 and the normal to the plane 118 is also made 5 degrees.

The middle cone 108 is driven from the vertical shaft 66 through gearing 119, 120. The drive from the cones 109, 110 to the warp-beam 4, 7 is as follows: The cone 109 is connected by spur gearing 121, 122 to a shaft 123 which drives through external change wheels 124, 125, 126 a parallel shaft 127 (Figures 14 and 15). The latter bears a bevel wheel 128 gearing with a bevel wheel 129 fixed to the lower end of a vertical shaft 130 which is coupled to the shaft 8 by one of the universal joints 10 and so drives the top warp-beam 4.

The lower cone 110 is connected by spur gearing 131, 132 to a parallel shaft 133 connected in turn by external change wheels 134, 135, 136 to a shaft 137 to which a bevel wheel 138 is fixed. The latter engages a bevel wheel 139 fixed to the lower end of a vertical shaft 140 which is coupled by one of the universal joints to the shaft 9 which drives the lower warp-beam 7.

The cones 109, 110 also drive the sliding clutch sleeves 98, 99 through the following mechanism: The shaft 127 which, as just described, is driven from the top cone 109 is coupled by 1:1 gearing 141 to a parallel shaft 142 (Figures 14, 17 and 20) which carries a worm 143 engaging with a worm wheel 144 on a vertical shaft 145. This shaft has a worm 146 at its upper end in engagement with a worm wheel 147 on the shaft 101 of the clutch sleeve 99 (Figures 17 and 18). Hence the clutch sleeve 99 is driven at a speed proportional to that of the top cone 109. The shaft 137 driven from the lower cone 110 as already described, bears a worm 148 engaging a worm wheel 149 on another vertical shaft 150. This shaft has a worm 151 at its upper end engaging a worm wheel 152 on the shaft 100 of the other clutch sleeve 98.

The bevel wheel 106 is connected to a vertical shaft 153 by spur gearing 154, 155 while the bevel wheel 107 is connected to another vertical shaft 156 by spur gearing 157, 158, 159, 160. The connections of the shafts 153, 156 to the gear changing mechanism are best shown in Figures 16 and 17. These shafts carry bevel wheels 161, 162 on their lower ends gearing with bevel wheels 163, 164. Each of the latter wheels is fixed on a spindle cut as a lead screw 165, 166. The lead screws 165, 166 are engaged by rectangular nuts 167, 168 each prevented from turning by a guide pin 169, 170. Therefore, when either clutch sleeve 98, 99 is caused to engage at either end of its sliding movement, the corresponding spindle 165, 166 is turned and the nut 167 or 168 is moved along the cones to increase or decrease the gearing ratio to the top or lower warp-beam 4, 7. This is effected by a shifting fork 169*a*, 170*a* fixed by screws 171 to the nut 167, 168. Each fork is formed with a pointer 172, 173 moving over one of a pair of scales 174 to indicate the respective ratio of any particular setting of either driving ring 111, 112.

Either of these rings may be set approximately by hand by turning the respective lead-screw 165, 166 by a hand-key 175 inserted into one of two sockets 176, 177 to turn a bevel wheel 178, also engaging with the bevel wheel 163 or 164. It is not desirable when setting by hand to rotate all the gearing back to the bevel wheels 106, 107, so a pair of pivoted spring pressed finger pieces 178 are provided arranged, when depressed, to lift a coupling sleeve 179 and thus to free a driving dog on a collar 180 pinned to the lower part of the vertical shaft 153, 156 so that when the gear ratio is being set, the upper part of the respective vertical shaft is not driven.

It is preferred to form the spindles 165, 166 with plain unthreaded portions at both ends. The object is to provide a dead effect in case either cone gearing is adjusted to the limit in either direction.

The form of the invention already described may be modified in various respects. Thus in Figure 25, a form of control is shown in which, as already mentioned, reversible electric motors 181, 182 are employed instead of the clutch windings 83, 84 and 85, 86. The rotors 30, 31 with the brushes 40, contact segments 36, 37 and slip rings 44 with brushes 49 are precisely as in Figure 24 but the conductors 87, 88 and 89, 90 instead of leading to the clutch windings 83, 84 and 85, 86 now lead to the windings of four electromagnetic switches 183, 184 and 185, 186 fed from the secondary of a low voltage transformer 187, the primary of which is supplied from alternating current lines 188. The contacts of the switches 183, 184 and 185, 186 are connected to control the reversible motors 181, 182 so that when the switches 183, 185 are energized, the motors 181, 182 rotate in one direction and if the switches 184, 186 are excited, the motors are reversed. The motors are geared to the shafts 153, 156 (Figure 16) respectively and thus can increase or decrease the ratio of the cone gearing and thus change the driving speeds of the warp beams 4, 7 as already described.

In Figures 26 to 28, the rotor discs 30, 31 of Figure 5 are replaced by apertured shutter discs such as the disc 30*a* shown affixed to the constant speed shaft 28 and the brush carrying brackets 42 of Figure 5 are replaced by apertured shutter discs such as the disc 42*a* secured to the shaft 23 carrying the thread-driven wheel 18 or 19. It will be seen that the constant speed disc 30*a* has two radially aligned slots 189, 190 and that the thread-driven disc 42*a* has two sets of slots, one set 191 co-operating with the slot 189 and the other set 192 co-operating with the slot 190. When the thread is moving at normal speed, the slots 191, 192 lie on either side of the slots 189, 190 and are not in register so that no light can pass from the two arc projectors 193, 194. If, however, the warp beam 4 or 7 is running too fast and the disc 42*a* moves forwardly, for example, clockwise relatively to the disc 30*a*, the slot 189 registers with the slots 191 in succession and the photo-electric cell 195 is illuminated and the clutch winding 84 is energized with the result that the upper warp beam 4 is driven more slowly as described with reference to Figure 24. If, on the other hand, the warp beam 4 is running too slowly, the disc 42*a* lags, for example, counter-clockwise relatively to the disc 30*a* and then the slot 190 registers with the slots 192 in succession and the second photo-electric cell 196 is illuminated resulting in the clutch magnet 83 being energized and the speed of the upper warp beam increased. The two sets of slots 191, 192 are provided so that if the speed correction is not sufficient or does not take place quickly enough, the slots 189, 190 can move over the slots 191 or 192 in succession until the correction is effective. The provision of a series of slots 191 or 192 also provides an antihunting effect.

Of course, the machine may have more than two warp beams 4, 7 in which case, a disc wheel 18, 19 and a rotor 30, 31 with corresponding variable gearings would be provided in conjunction with each beam.

Furthermore, as illustrated in Figures 29 to 32, the shutter discs 30*a*, 42*a* of Figures 26 to 28 may be replaced by two members 30*b*, 42*b* of a differential or balance gearing 197, the member 30*b* being affixed to the constant speed shaft 28 and the member 42*b* being secured to the shaft 23 of the thread-driven wheel 18, 19. In each of these embodiments, the shafts 23 and 28 are rotated in opposite directions so that as long as they run at the same speeds, the planet wheel 198 does not turn about the axis of the shafts 23, 28. If, however, the wheel 18, 19 is driven too fast or too slowly by the thread the wheel 198 and its carrier 199 turn either clockwise or counter-clockwise on the shafts 23, 28.

In Figures 29 and 30, a brush 40*b* is riveted to the planet carrier 199 at 200 and is grounded at 201 as in Figure 30. The brush 40*b* co-operates with two contact segments 36*b*, 37*b* mounted on a fixed insulating plate 202 and makes contact with one or the other depending upon whether the thread wheel 18, 19 is running fast or slow. The segments 36*b*, 37*b* are connected by conductors 87*b*, 88*b* to the windings of clutch magnets as in Figure 24 and otherwise, the control is effected in the same way as in that embodiment.

In Figure 31, the planet carrier 199 is integral with a spur wheel 203 which meshes with a pinion 204 affixed to a lead-screw 205 engaged by a nut 206 corresponding to the nut 167, 168 in Figure 17 and formed with a fork 207 to shift the driving ring 208 of the variable speed cone gearing.

Finally in Figure 32, the differential gearing has a spur wheel 203 as in Figure 31 but the driven wheel 204 now actuates a hydraulic control valve 209 which is connected to control the flow of liquid from a pump 210 furnished with the usual relief valve 211 and by-pass pipe 212. The valve controls the flow of pressure liquid from the delivery pipe 213 to one or other of two pipes 214 leading to opposite ends of a hydraulic cylinder 215, the low pressure liquid being exhausted to the pump 210 through a return pipe 216. Thus the ram or piston 217 in the cylinder 215 is moved one way or the other depending on whether the thread-driven shaft 23 is running too fast or too slowly. The piston rod 218 bears a shifting fork 207 which operates the driving ring 208 as in Figure 31.

We claim:

1. An apparatus for controlling the movement of thread in a textile machine comprising a thread beam and driving means therefor, said driving means including a power shaft and means for driving said shaft continuously, variable speed gearing operatively connected between said driving means and said thread beam and controlled by means responsive to the linear speed of the thread with relation to the constant desired speed thereof to vary the speed of rotation of the beam inversely to the effective outer diameter of the thread on the beam so as to maintain substantially constant the rate of passage of the thread with respect to the beam.

2. An apparatus according to claim 1, in which the means which responds to the changes in the linear speed of the thread is driven by a thread moved at the same speed as that carried upon the thread beam and the variable speed gearing is controlled in accordance with the difference in the speeds of the said means and of a second means comprising a rotary member maintained at substantially constant speed corresponding to the desired linear speed of the thread.

3. An apparatus according to claim 2, in which two coaxial rotary members are provided, one engaging a thread one end of which is wound upon a thread beam which is arranged to drive one of said rotary members and means for driving said second rotary member at a substantially constant speed.

4. An apparatus according to claim 3, in which a pulley having a rim is provided for the thread one end of which is wound upon the beam to encircle in its passage with relation to the beam, the rim of a pulley wheel, said pulley wheel being of variable effective diameter so that the adjusted speed of the thread can be selected at different pre-determined values.

5. An apparatus according to claim 4, in which the pulley wheel comprises a rotary disc formed with spaced holes for receiving laterally extending pegs and pegs in spaced relation in said holes,

and a flexible rim supported on said pegs which thus forms the adjustable rim which is engaged by the thread.

6. A warp let-off motion for a warp knitting machine comprising an apparatus according to claim 1, in which a bobbin is provided for carrying a slave thread from which bobbin said slave thread passes to and drives said variable speed gearing control means and then passes to the warp beam after leaving which it is knitted into the fabric produced.

7. A warp let-off motion according to claim 6 arranged to control the speeds of a plurality of warp beams and having a plurality of control means therefor each including a rotary member which is provided with means for driving it at a substantially constant speed and which rotary members are respectively mounted upon one of a pair of shafts which are connected together by change gear wheels so that their relative speeds of rotation can be varied and cooperating each with a rotary member driven by a slave thread passing to the respective beams so that the latter are driven to let-off their respective threads at different speeds which are substantially constant.

8. Apparatus for controlling the movement of continuous flexible material in relation to a positively driven rotary member adapted to receive an accumulation of such material, comprising power driving means for said rotary member including infinitely variable gearing in combination with actuating means responsive to changes in the linear speed of said material as it passes in its movement with relation to said rotary member and including two coaxial rotary members around one of which a slave thread contacting said material receiving rotary member is passed and the other of which coaxial rotary members is driven at substantially constant speed, and means controlling said infinitely variable gearing responsive to differences in the speeds of said coaxial rotary members.

9. An apparatus according to claim 8 wherein one of the two coaxial rotary members carries at least one brush bearing on the other coaxial rotary member and coacting with conducting segments thereon, and electrical circuits so arranged that as the one coaxial rotary member or the other runs the faster, said electrical circuits are actuated by the cooperation of brush and segment so as to produce an increase or decrease in the ratio of the variable gearing.

10. An apparatus according to claim 9 in which a brush is constructed and mounted so that in moving in one direction on the surface of the member on which it bears, electrical contact is maintained but when the direction of relative movement is reversed, the brush quickly interrupts electrical contact with the said member.

11. An apparatus according to claim 10, in which the brush consists of a roller of insulating material with a conductive contact segment and mounted so as to turn to a limited extent when moving relatively to the surface on which it bears.

12. Apparatus for controlling the movement of continuous flexible material in relation to a positively driven rotary member adapted to receive an accumulation of such material, comprising power driving means for said rotary member including infinitely variable gearing in combination with actuating means responsive to changes in the linear speed of said material as it passes in its movement with relation to said rotary member, and means responsive to said actuating means operatively connecting said power driving means and said rotary member thereby to adjust the peripheral speed of the material accumulated on said rotary member, wherein the power driving means operates at constant speed and the actuating means comprises a control member operating at a speed proportioned to the linear speed of the material and means operated by electrical circuits responsive to differences in the speeds of said power driving means and said control member, said last named means including two coaxial rotary circuit establishing members one of which rotates at constant speed and the other rotates at a linear speed proportional to the linear speed of the material, and at least one current carrying means cooperating with said circuit establishing members.

13. An apparatus according to claim 12, in which the brush consists of a rocker having a face consisting of two plane surfaces meeting at an obtuse angle so as to form a ridge which bears on the rotary contact member, the rocker being pivoted about an axis parallel to the said ridge and carrying a contact point which bears on the rotary contact member when the relative movement between the two rotary members is in one direction but which leaves the rotary contact member abruptly when the direction of relative movement is reversed.

14. Apparatus for controlling the movement of thread in relation to a thread beam in a textile machine, comprising, in combination driving means for the thread beam including infinitely variable speed gearing, a first member driven at a speed corresponding to the actual linear speed of the thread, a second member adjacent to said first member and driven at a substantially constant speed corresponding to the desired linear speed of the thread, and means responsive to the difference of speed between said first member and said second member for controlling said variable speed gearing.

15. An apparatus according to claim 14 in which the infinitely variable speed gearing comprises driving and driven cones with parallel axes and a uniform narrow gap between their adjacent conical faces, a driving ring located in said gap which is shiftable in the direction of the axes of the cones in changing the gear ratio.

16. An apparatus according to claim 15, in which the driving ring has inner and outer surfaces in contact with the cones and which are inclined at a small angle to a plane at right angles to the axis of the ring.

17. An apparatus according to claim 16, in which the driving ring is shifted in the direction of the axes of the cones by means including a shifter, a nut and a lead screw, said shifter being carried by said nut which engages said lead screw, and means for rotating the latter during the changing period.

18. An apparatus according to claim 17, in which the lead screw is driven for gear-changing from a constantly rotating shaft, and a reversing member and clutch means are provided for connecting said shaft to the member driving the lead screw.

19. An apparatus according to claim 18, in which the constantly rotating shaft is driven from the driven cone so that the rate of changing the gearing ratio is proportional to the gearing ratio at any time.

20. An apparatus for controlling the movement of continuous flexible material including a positively driven rotary member for receiving the accumulation of such material and power driv-

ing means therefor comprising actuating means responsive to changes in the linear speed of said material and infinitely variable speed driving means controlled by said actuating means for rotating said rotary member, said driving means including driving and driven cones arranged with their axes parallel and a uniformly narrow gap between their adjacent conical faces, a driving ring located in said gap and means for shifting said ring in the direction of the axes of said cones comprising a nut and lead screw and electrical circuits actuated by two coaxial rotary members carrying contact segments and brushes one of which rotary members responds to variations in the linear speed of said material and the other of which rotates at constant speed, and as the one rotary member or the other runs the faster said electrical circuits energize an electromagnet, and in which the lead screw is connected to be driven in two directions by a clutch which is engaged for either direction of drive by the electromagnet thus energized by the electrical circuits energized by the cooperation of the brushes and the segments with which they engage.

21. An apparatus for controlling the movement of continuous flexible material in a textile machine comprising a positively driven rotary member for receiving an accumulation of such material and power driving means therefor, in combination with actuating means responsive to changes in the linear speed of said material as it moves through said machine, infinitely variable speed changing means controlled by said actuating means and interposed between said power driving means and said rotary member, said actuating means including electrical circuit means cooperating with a disc wheel driven by said flexible material and a rotor turning at constant speed, said disc wheel and rotor being provided with apertures through which photo-electric cells are illuminated when the flexible material is moving faster or more slowly than the predetermined speed and the said cells control circuits which cause the change in the gearing ratio to correct the speed of the thread.

22. An apparatus for controlling the movement of continuous flexible material in relation to a positively driven rotary member adapted to

receive an accumulation of such material, comprising power driving means for said rotary member and a speed indicating member rotated thereby at constant speed, in combination with actuating means responsive to changes in the linear speed of said material as it passes in its movement in relation to said rotary member as compared with the speed of said indicating member, and variable speed means responsive to said actuating means operatively connecting said power-driven means and said rotary member thereby to adjust the peripheral speed of the material accumulated on said rotary member.

23. Apparatus according to claim 22 wherein the power driving means operates at constant speed and the actuating means comprises a control member operating at a speed proportioned to the linear speed of the material and means responsive to differences in the speeds of said speed indicating member and said control member.

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