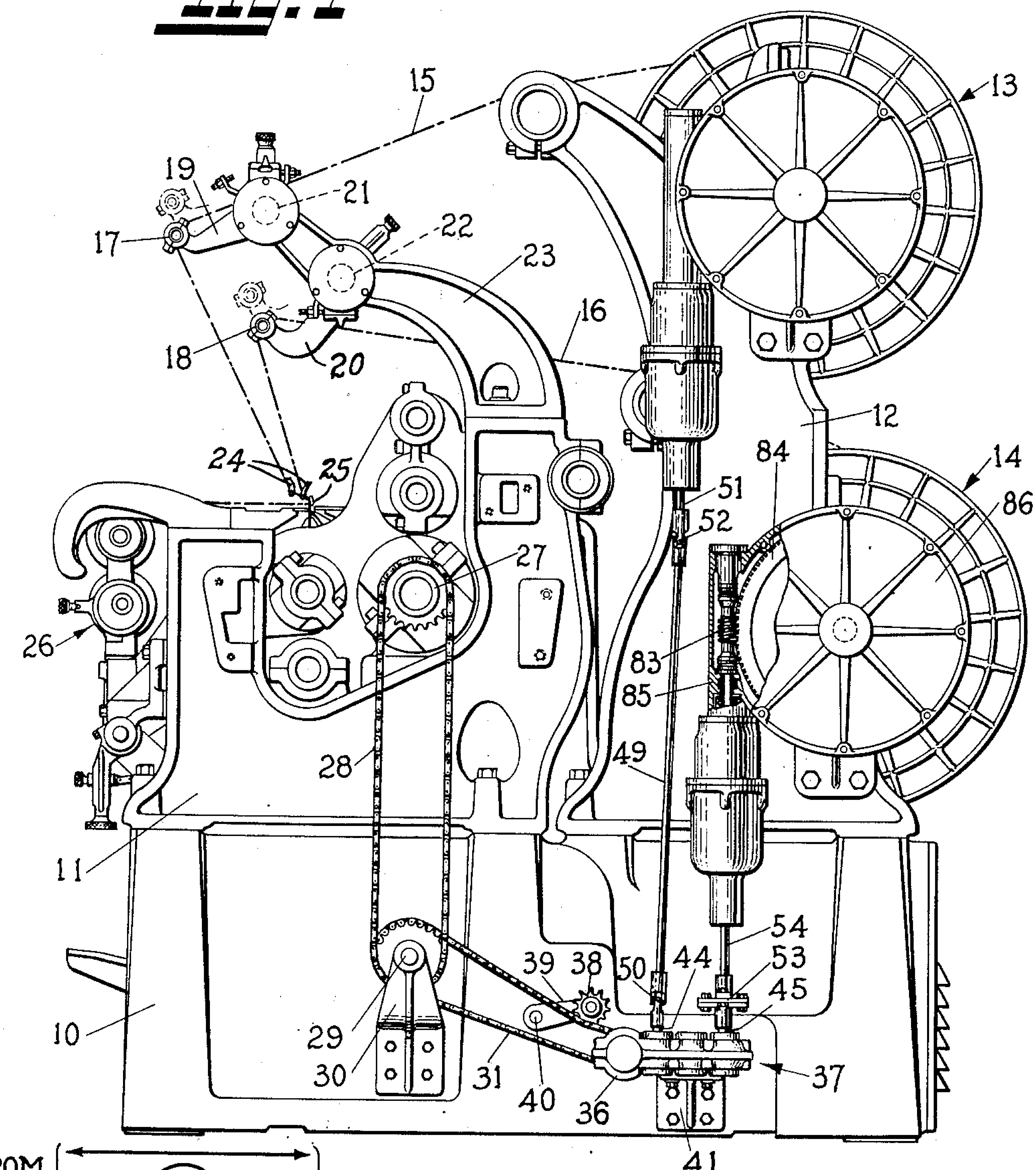
Jan. 23, 1951 G. E. CLENTIMACK 2,539,296

WARP LETOFF MECHANISM

Filed April 28, 1949 3 Sheets-Sheet 1

FIG. 1



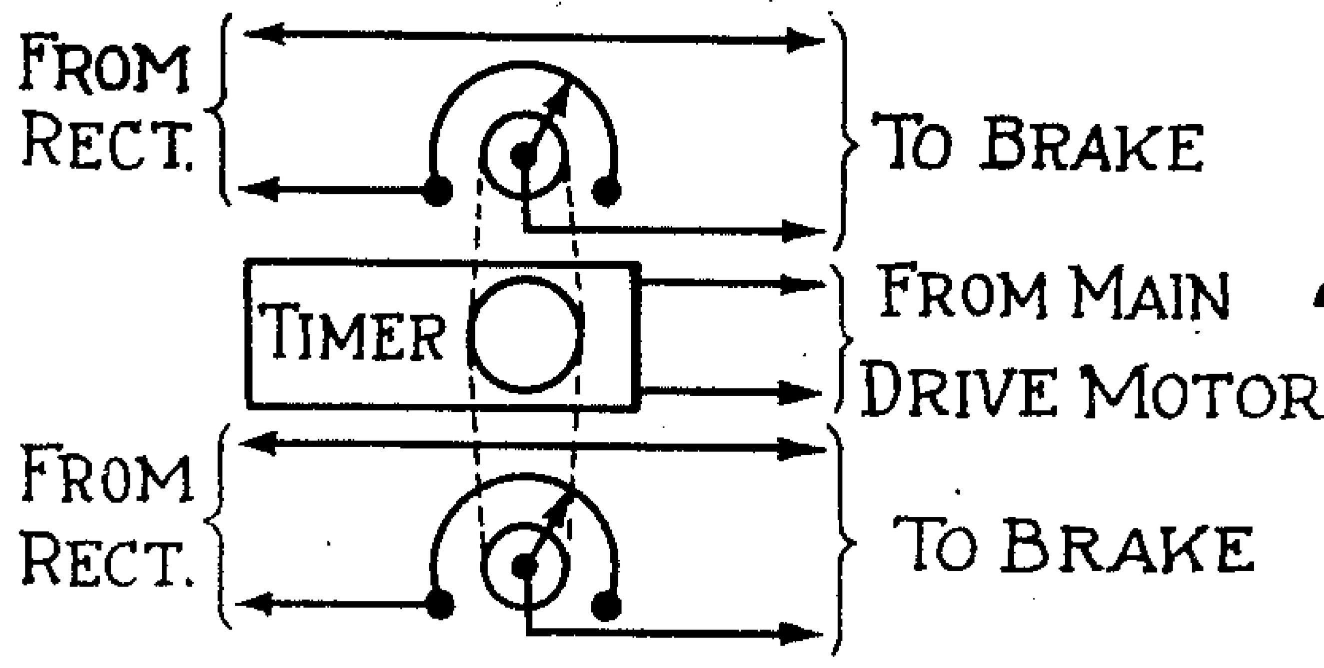


FIG. 3

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WARP LETOFF MECHANISM

Filed April 28, 1949 3 Sheets-Sheet 2

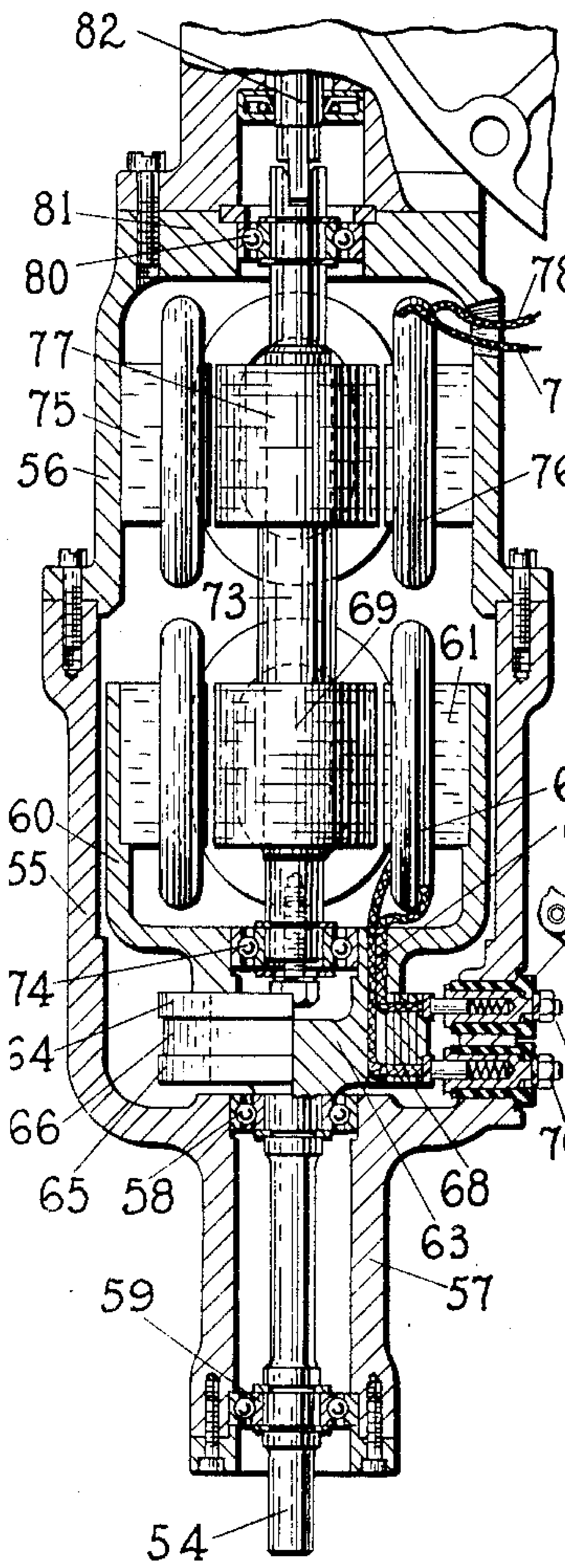

FIG. 2

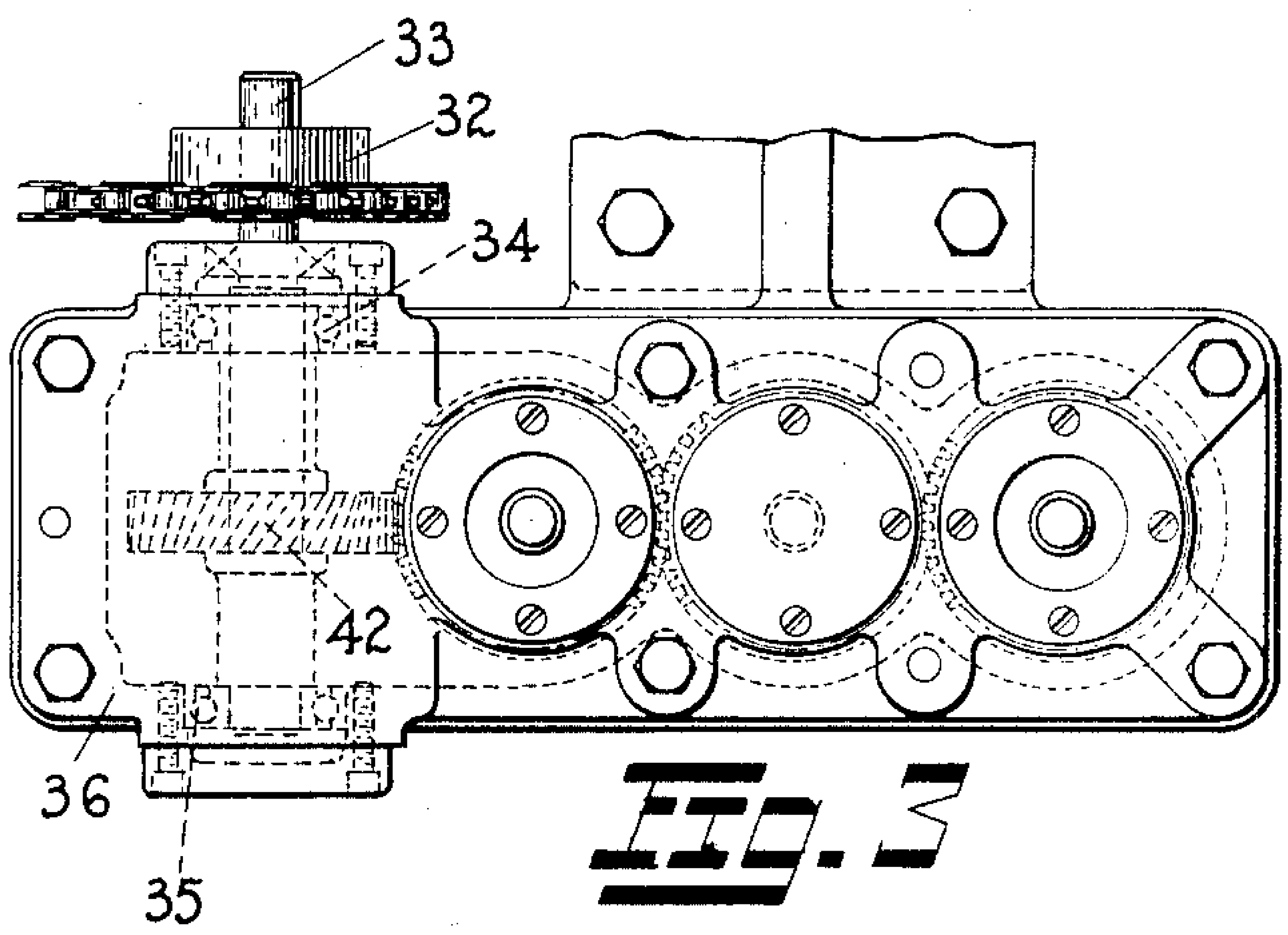

FIG. 3

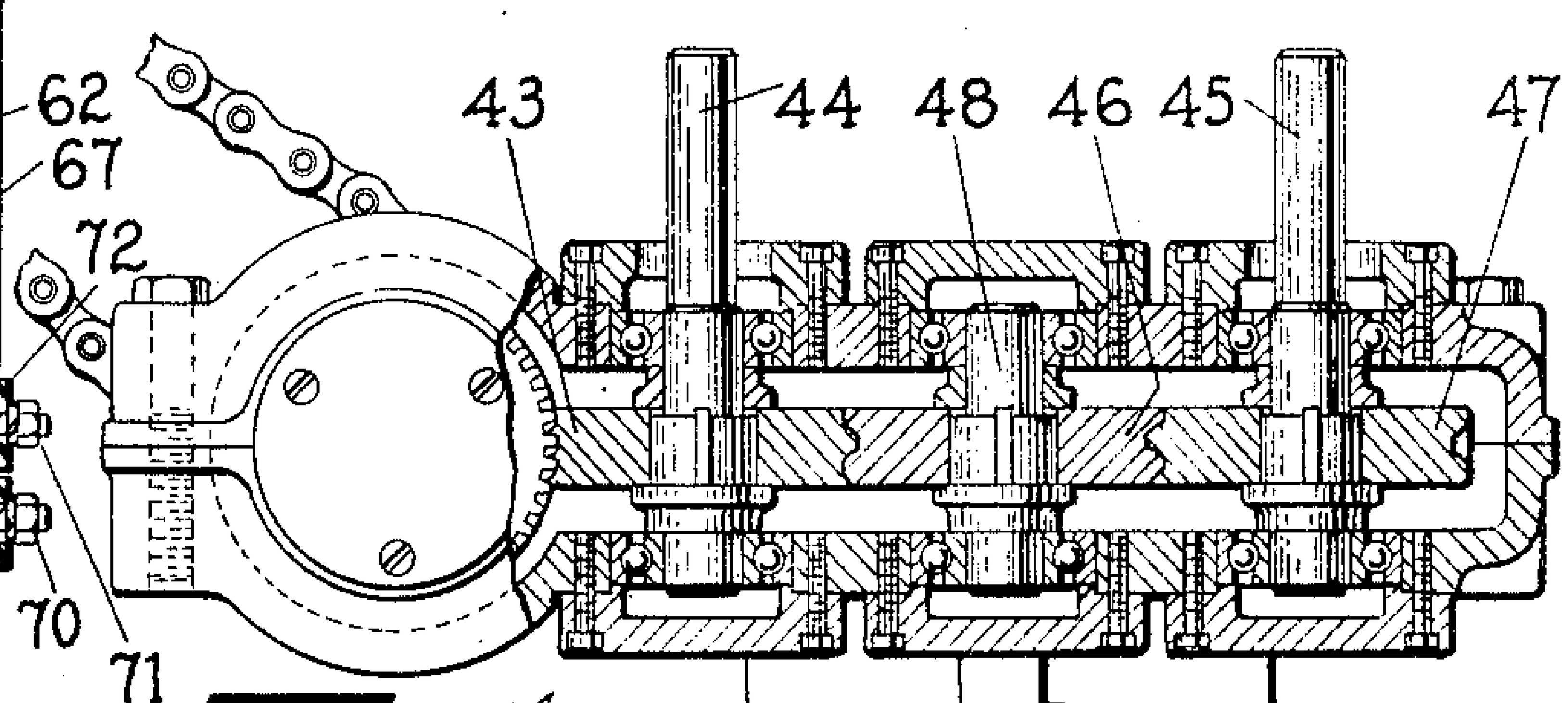

FIG. 4

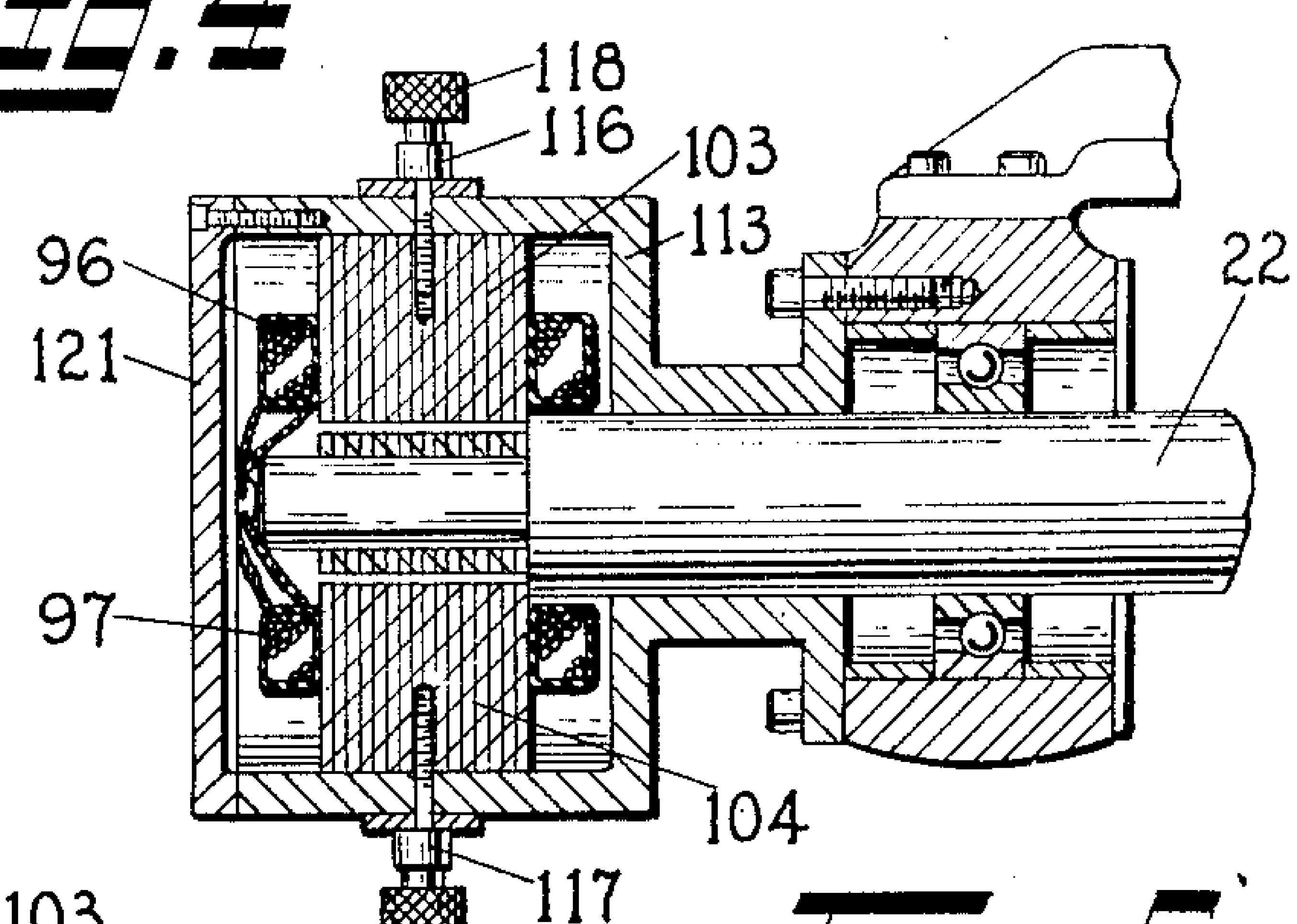

FIG. 5

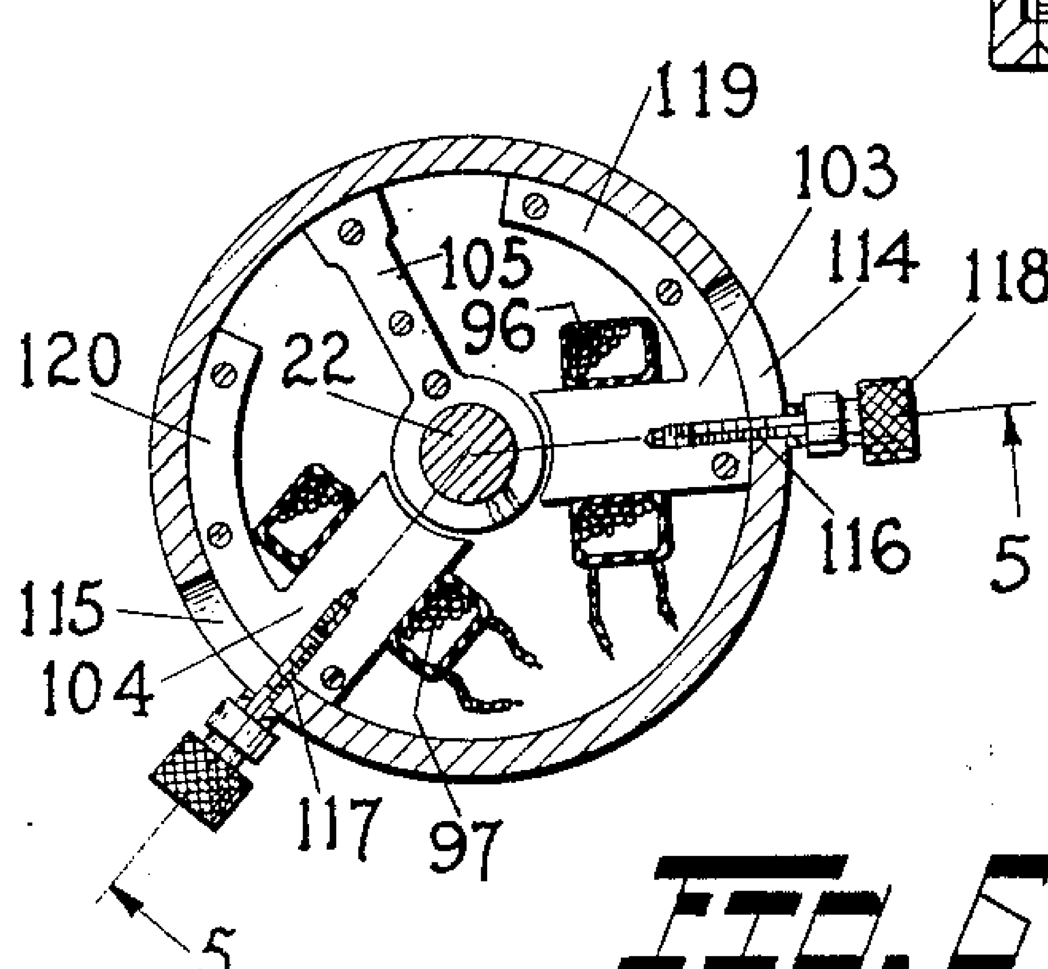

FIG. 6

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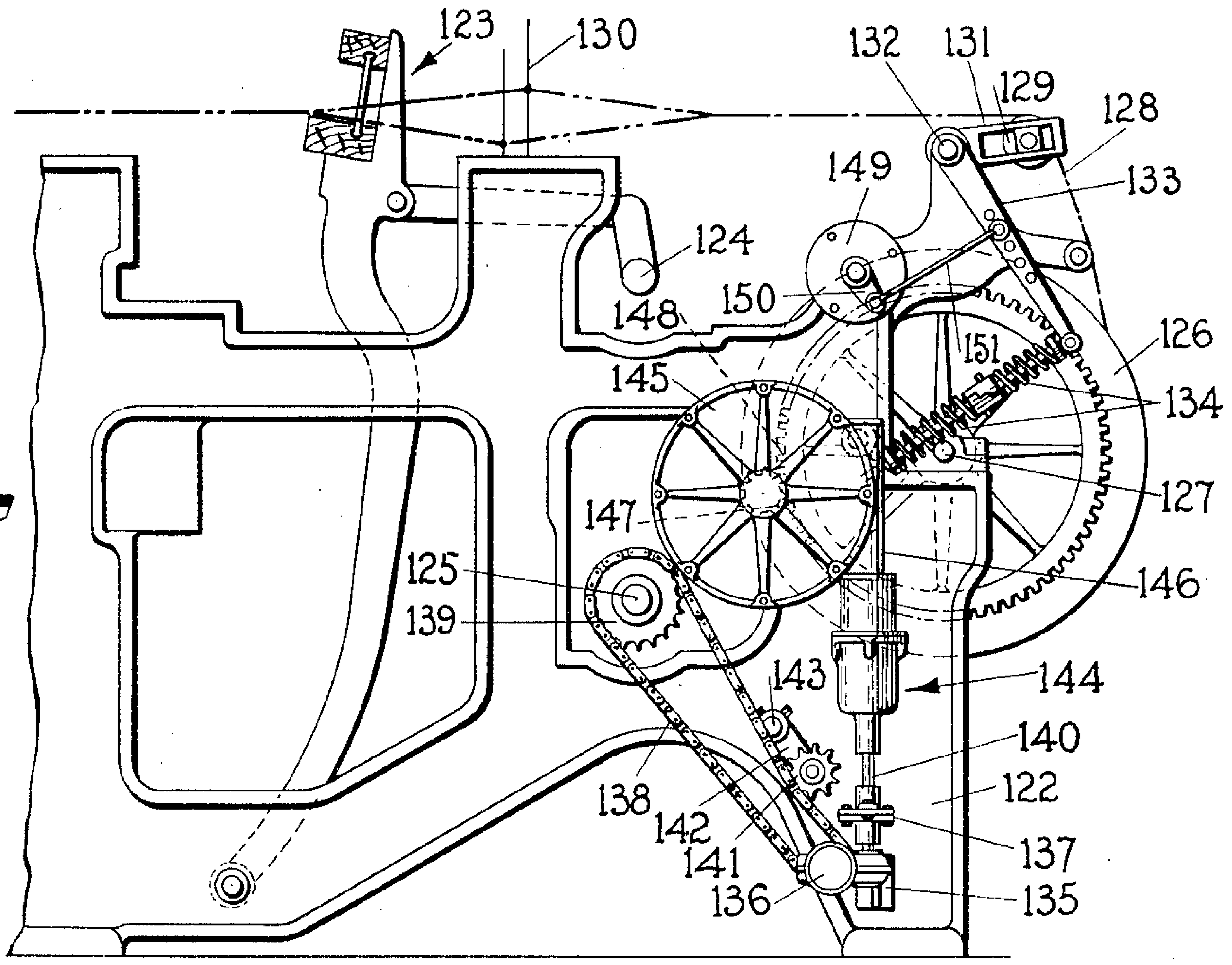

FIG. 8

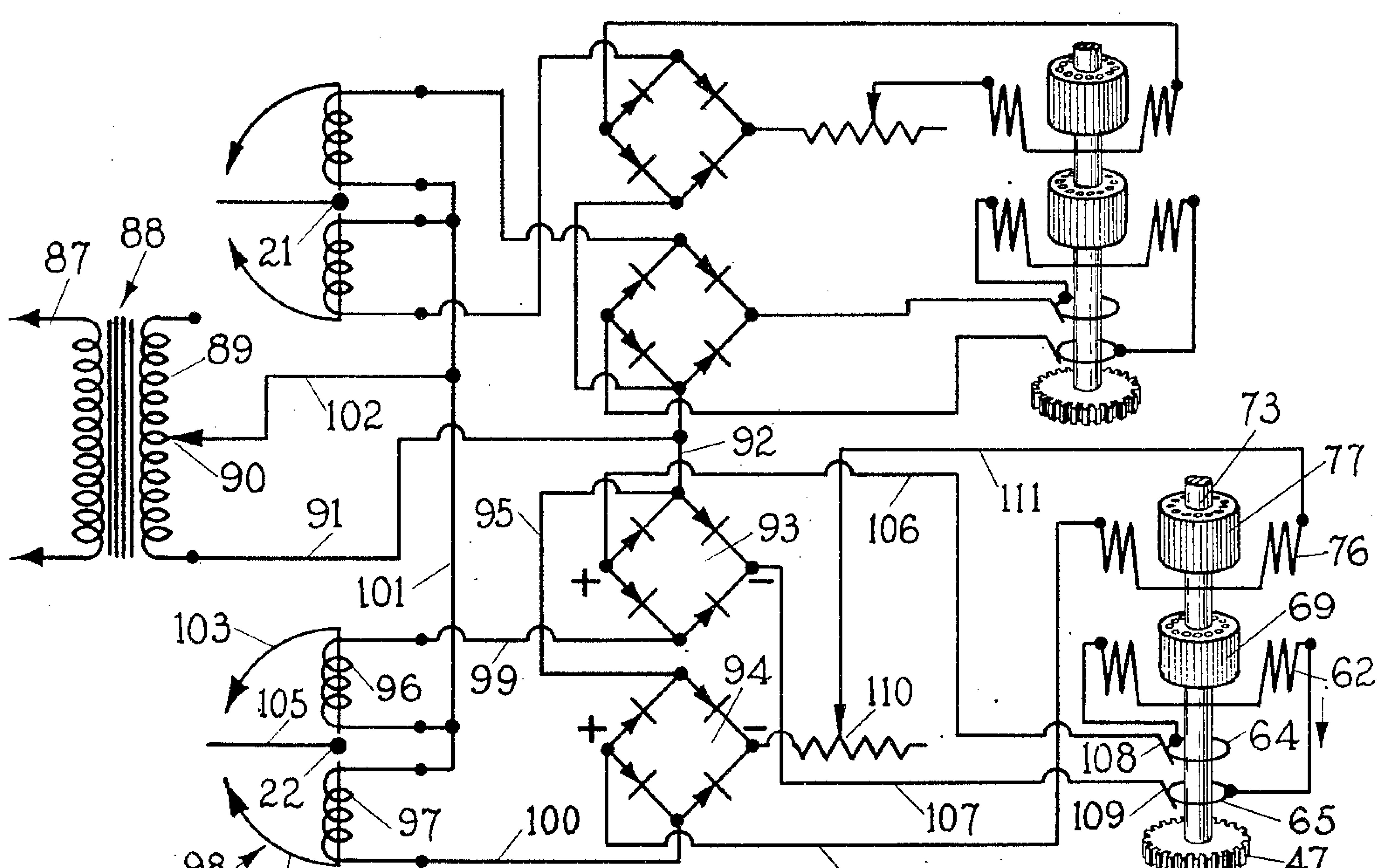

FIG. 7

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WARP LETOFF MECHANISM

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Application April 28, 1949, Serial No. 90,065

18 Claims. (Cl. 66—86)

1

This invention pertains to a warp beam driving and warp let-off mechanism for textile machinery in general, and more specifically, to such beam driving and let-off means as may be applied to knitting machines and to looms.

In many types of textile machinery a relatively great number of separate threads are wound on large spools generally known as warp beams, and are drawn from or fed from these beams under tension, the control for let-off from the beam heretofore having taken widely varied forms, but in many instances, having involved a driving means for the beam, the control for which has been derived from many and varied mechanisms.

It is a general object of the invention to devise warp beam driving means which shall function to control the rotation of such beams in textile machinery in a manner to let off the warp threads under a uniform tension for all conditions of operation.

It is a further object of the invention to provide a warp let-off mechanism which is of relatively simple and compact form and which shall have ample power to advance the beam to let off the warp threads during acceleration of the machine upon starting and to synchronize the acceleration of the beam itself with the acceleration of the other elements of the machine so that tension conditions in the warp threads are not noticeably different during starting conditions than they are during normal operation of the machine under running conditions.

It is a further object of the invention to provide warp let-off and warp beam driving means which may be operated with a minimum amount of power and which may be controlled from the warp thread tensioning devices themselves in a manner so that the normal fluctuation of the warp threads and slight changes in tension therein during the knitting or other textile fabric-forming cycle are not reflected in changes in warp let-off speed, but which shall be very sensitive to any increase or decrease over normal operating tension and effective for rapidly re-establishing the normal condition.

It is a further object of the invention to devise a warp let-off mechanism which functions upon a plurality of warp beams and which affects each of said beams and the warp threads let off therefrom in substantially the same manner.

A further object is that of devising a warp beam rotating and warp let-off device which is adapted to prevent any overrunning of the beams upon sudden stopping of the machine to which it is applied or of which it forms a part, thereby

2

to prevent building up of a slackness in the warp threads during stopping which would, of course, be reflected in the quality of fabric produced when the machine was again started.

It is a more specific object of the invention to devise a warp let-off for a warp knitting machine wherein the let-off of the warp threads from the several beams shall be precisely controlled during the starting of the machine, during normal running thereof and upon stopping so that there shall be no undue tension or slackness in the warp threads such as might result in the so-called "stop marks" which are frequently obvious in warp knitted fabrics and indicate that point at which the machine was stopped, these marks frequently being of such pronounced character that they cannot be removed upon finishing.

Other objects of the invention will be evident from the following more detailed disclosure of the invention as applied to a warp knitting machine and to a loom.

In textile machinery such as warp knitting machines and looms, a plurality of threads which go to form the fabric or a portion of the fabric, are frequently wound on beams which are actually very large spools and which are rotatably mounted in the machine or on a supporting structure adjacent thereto. In some instances the warp threads are drawn from the beams which are merely retarded by various types of brake mechanisms. However, it is more customary in machines of later type to drive the beams positively in such manner that the warp threads are let off at substantially the rate of consumption thereof at the fabric-forming instrumentalities in the machine.

Upon starting a textile machine it is always difficult to avoid an excess of tension or an undue slackness in the warp threads since the acceleration of the machine itself and that of the beam do not always follow the same curve, but are, in many instances, dependent upon the position at which the machine itself was stopped and other variables. It is also difficult to stop the machine and beam without some tendency for the latter to overrun or to decelerate too quickly if sufficient driving force is not provided for a required period of time. Under any of these conditions the tension of the warp threads being disturbed as it would be either to give rise to excessive tension or to slackness, results in certain imperfections in the fabric produced which are normally termed "stop marks." If these marks are not very pronounced, they may disappear to a great extent upon finishing the material, but more often it is not possible to eliminate them in any way and therefore, the material has inherent therein a defect at each point at which the machine has stopped. Obviously, this is something which is most desirably to be avoided.

According to the invention, the driving of the warp beam or beams is accomplished through what will hereinafter be more generally termed clutch and brake devices, or magnetic couplings, one of which is devised to transmit power from a positively driven element to the warp beam and the other of which is devised for resisting or cancelling out part of the output of the first. These magnetic couplings or clutch and brake devices comprise a unit one member of which, the clutch, includes a driven, electrically energized stator and a rotor, and the other of which is of substantially the same physical form, except that the stator is fixed in position rather than being rotated or driven. These rotors are preferably spaced along the same shaft and are adapted to convey the power of the driven stator or electrically energized portion of the clutch through to the warp beam by means of intermeshing gearing or the like, preferably irreversible gearing. One unit comprising a driving and retarding member is provided for each beam and as many units as are employed are themselves connected so that their driven, electrically energized stators may be rotated from some common source of power at the machine, for example, from a shaft therein which is driven in synchronism with other parts such as the cam shaft in a warp knitting machine, or a similar cam shaft or the crank shaft in a loom. It is, however, preferable that these units be driven from some part of the textile machine itself which is driven in synchronism with the entire machine, at least to the extent that during acceleration and deceleration positively driven electrically energized stators of said units will accelerate and decelerate at the same relative rate as the machine itself.

The warp beams as commonly employed have a relatively great mass of thread wound thereon and are of appreciably greater diameter when full than when empty. The speed at which a warp beam must be driven when approaching its empty condition is therefore much greater than its speed when substantially full. The positively driven stator of each unit is therefore necessarily driven at a speed at least as great as is necessary to rotate the beam fast enough when it has approached its virtually empty condition. In fact, the actual speed of rotation of the positively driven part of the clutch is slightly greater than the theoretical maximum required, for example, five or ten per cent over that figure, especially since there may be some slip in the clutch even under conditions where it is delivering its maximum output.

The control for these driving units is such that at the start and during acceleration, the warp beams have delivered thereto a considerable excess of torque over what would be necessary once they have arrived at a uniform speed equivalent to that required during normal operation of the machine. It is one of the features of the instant invention that these driving units are capable of an output in the order of five or more times greater than is required during normal operation and, at least, should be capable of an output more than sufficient to accelerate the beam at the same relative rate as the machine itself is accelerated. That is accomplished through the clutch and brake devices and through a control means hereinafter to be described in greater detail and which in the description is generally referred to as current dividing means one form of which is technically termed an impedance bridge.

During acceleration, the impedance bridge or other current controlling or dividing means functions to energize the clutch or the magnetic driving portion of the unit with considerably more current than is furnished to the brake or retarding part of the unit. Upon arriving at full speed and during normal running conditions, an amount of current is fed to each element of the unit such that the output thereof as applied to the warp beam is just sufficient, considering the tension desired in the warp threads and considering the frictional resistance, amount of warp thread on the beam, and other factors, to rotate that beam continuously and at a speed consistent with the actual amount of thread being consumed at the fabric-forming instrumentalities. When the machine is stopped, the reverse takes place, that is, the controlling mechanism automatically functions under slight change in position of the yarn tension controlling means to switch the balance of current to the retarding part of the unit so that there shall be no tendency toward overrunning or to development of slack in the warp threads such as might result in a noticeable line in the fabric upon subsequent starting.

The invention is applicable to all types of textile machinery in which warp beams are employed or in which warp or other similar threads are to be withdrawn from a rotary supply and advanced toward fabric-forming instrumentalities or other thread-consuming means at some given rate and under prescribed tension conditions. It is herein described in detail as to one form thereof which may advantageously be employed in a warp knitting machine and a modification thereof as applied to a typical fly shuttle loom. It is to be understood that the following disclosure is illustrative and that other modifications of the mechanical parts and that different electrical circuits may be availed of without departing from the original concept. The invention will be described in detail by reference to the accompanying figures of drawing wherein like parts are indicated by identical reference numerals.

In the figures of drawing:

Fig. 1 is an end view of as much of a warp knitting machine as is necessary to show the application of the invention thereto.

Fig. 2 is a sectional view through one of the clutch and brake units showing certain essential details thereof.

Fig. 3 is a plan view of gear driving means employed for conveying power from a convenient part of the machine to a driving unit such as that illustrated in Fig. 2.

Fig. 4 is a section taken through the vertical center line of a part of the gear mechanism of Fig. 3.

Fig. 5 is a longitudinal section taken in the planes indicated at lines 5—5, Fig. 6, showing certain details of the current dividing or control means.

Fig. 6 is a transverse section taken through the center of the controller unit of Fig. 5.

Fig. 7 is an electrical diagram illustrating the controlling devices and the manner in which the current is rectified and apportioned to the clutch and brake members of a unit.

Fig. 8 is an elevation showing one end of a typical loom and the let-off mechanism applied thereto.

Fig. 9 is a diagrammatic view of an automatic timing device arranged to vary the voltage to the brake of each driving unit.

Now referring to Fig. 1, the invention is shown applied to a warp knitting machine having a base 10, transverse frames 11 and a rear supporting structure 12 upon which two warp beams 13 and 14 are pivotally mounted. These warp beams are comprised of hub or core members and end flanges and are frequently made from aluminum alloy or other light metal to reduce the mass of the warp structure which is necessarily relatively heavy when the beams are full. These beams preferably rotate on antifriction bearings, but that is not entirely essential and, in fact, any warp beam structure and any workable pivot or journal bearing in which the said beam may be rotated is adapted to be employed and the driving means hereinafter described in detail will serve effectively for rotating and letting off the warp threads therefrom. Some knitting machines may have only a single warp while others frequently have two as herein illustrated, and in certain instances a still greater number of beams are used.

The warp threads are drawn from the beam and form what is generally termed a warp sheet 15 from the upper beam and a second warp sheet 16 from the lower beam. These warp sheets are drawn over or are passed about tension bars 17 and 18 which are mounted in or at the ends of tension arms 19 and 20 pivoted at 21 and 22 in a forwardly extending part 23 of the transverse frame structure. While not shown here since it forms no particular part of the present invention, these tension bars are urged in a general upward direction or in a direction to exert a tensioning force on the warp threads by springs or other biasing means, and are provided for delicate adjustment as is well known to those skilled in the art. The warp threads are then carried downwardly to be threaded through individual warp yarn feeders 24 which wrap the threads about needles 25 at which point the fabric itself is actually formed. After formation of the fabric it is carried forwardly to be drawn from the knitting point under the influence of fabric take-up means generally indicated by numeral 26 and to be wound on a take-up roll or beam not shown since these are, of course, conventional parts of warp knitting machines and need not be further illustrated or described at this point.

There are several shafts in a warp knitting machine of this type which are continuously driven and from which the movements for the several parts including the needles and other knitting instruments are taken. One of these shafts, the main cam shaft 27, is driven at the same speed as the knitting instruments and it is preferably from this shaft that a drive is taken for the rotating element in the clutch hereinafter to be described in greater detail. Specifically, a chain drive is employed for conveying the movement of the cam shaft to a plurality of intermeshing gears, but it is contemplated that gears or other driving means may be used depending upon particular conditions. A chain 28 driven by a sprocket on the end of the cam shaft 27, or in fact, from any other convenient driving element on the machine, rotates a second sprocket and a shaft 29 carried in bearings forming a part of the bracket 30 bolted to the end of the base 10. Shaft 29 has a second sprocket thereon which has a second chain 31 passed about it and driving a sprocket 32, Figs. 1 and 3, on a short spindle 33 supported in suitable bearings 34 and 35 in one end portion 36 of a gear casing generally indicated by numeral 37 and illustrated in greater detail in Figs. 3 and 4. The chain 31 is maintained taut under the influence of a tightener sprocket or roller 38 freely rotatable at one end of an arm 39 which is adjustable about the pivot 40. This tightener may be spring-urged into contact with the chain, but is more preferably movable to and from different positions and adjustable in any one of them so as to regulate the tightness of the chain, but not to impose thereon any undue strain or set up undue frictional forces in the driving connections from the cam shaft to the gear box. The gear box 37 is mounted in any convenient manner, as herein shown, on a bracket 41 which is also bolted to the base 10.

It is desired that each of the warp beam driving units be rotated under precisely the same driving influence and therefore the gears in the gear box 37, as will be described by reference to Figs. 3 and 4, are adapted to rotate at a speed consistent with that at which the clutch element in the driving units must rotate for maximum driving speed necessary when the warp beams are substantially emptied and under the greatest speeds at which the knitting machine is to be operated. The shaft 33 rotated as above described, carries a spiral gear 42 which in turn meshes with a gear 43, this gear 43 being one of three similar gears all mounted to mesh as illustrated and by means of which the shafts 44 and 45 are driven at the same speed and in the same relative direction. The gear 43 meshes with an idler gear 46 which in turn drives the gear 47 keyed to shaft 45. As is evident each of these shafts 44 and 45 is mounted in bearings, preferably of antifriction type such as the ball bearings illustrated, although any other type may be used depending upon the conditions of operation which may be encountered in any particular installation. The idler 46 is mounted on a short spindle 48 which is rotatable upon similar bearings, but this shaft 48 does not project through the gear casing since it does not need to be attached to any outer parts.

The unit just described is self-contained and may be mounted in any convenient position on a machine to which the mechanism is applied and it is one of the advantages of the invention that it may be applied to existing machines with very little alteration of the present structure thereof. The drive taken from any convenient rotating element in the knitting machine or other machine employing some type of warp beam or the like is first carried to this gear box unit from which the necessary power may be conveyed to as many units as are required depending upon the number of separate warp beams which it is desired to drive. The unit taken by way of example is one adapted to function with two separate warp beams or groups of interconnected warp beams as may sometimes be employed, and if different numbers are used then a corresponding number of shafts 44 or 45 and similar gearing may be utilized. A greater number of beams merely calls for more gearing and the number of idlers and the number of projecting shafts are to be increased accordingly.

Again referring to Fig. 1, the short projecting shaft 44 is interconnected to a shaft 49 by means of a universal joint 50 and the shaft 49 is in turn connected to spindle 51 by a second universal joint 52, these universal joints being employed here to take care of misalignment between the shaft 44 and spindle 51, although in some installations these may be so aligned that no such joints are necessary.

The short shaft 45 is connected to that unit in alignment therewith through a coupling 53 which is also fixed to the lower end of spindle 54. It can be seen that the spindles 51 and 54 are thus rotated at the same speed and in the same relative direction. These spindles are a part of or are directly connected for positive driving engagement with the electrically energized stator or the positively rotated element of the clutch portion of each driving unit.

Now referring to Fig. 2, one of these units will be described in greater detail and that description serves for both units since they are preferably identical, although in some instances it may be understood that different units may be employed in the event the warp beams are not of the same size or are to be driven at widely different speeds, although it is one of the advantages of the present construction that it is adapted to take care of unusually varied driving requirements while operated under a more or less standard and unchanged set of operating conditions.

The clutch and brake unit is housed within a two-part casing having a lower portion 55 and an upper part 56, the lower casing member 55 being reduced in diameter and projecting downwardly as at 57 to mount antifriction or other bearings 58 and 59 upon which the spindle 54 is freely rotatable. Spindle 54 is either an integral part of or is perhaps more preferably keyed or otherwise fixed to a cup-shaped element 60 which actually comprises the stator of the driving clutch which is, in effect, a magnetic clutch devised as an induction motor of the squirrel-cage type. This element 60 carries pole pieces 61 and windings 62, there being four such poles employed here, although it is to be understood that any convenient number may be used. The stator unit also comprises a reduced portion 63 upon which are carried a plurality of collector rings 64 and 65 insulated from the rotating portion of the unit of which they form a part by any suitable insulating material formed as a ring 66. These rings 64 and 65 have connected thereto conductors 67 and 68, respectively, by means of which current is introduced to the coils 62 of the stator.

The current by which the positively driven clutch element or stator is caused to rotate the armature or rotor 69 which cooperates therewith is introduced through a circuit hereinafter to be described in detail to the binder posts 70 and 71 and is then carried to the rings 64 and 65 through more or less conventional brush units one of which is indicated by the numeral 72 and which is carried within a suitable insulating housing, these brush units being of more or less standard construction in use for purposes of this type. It is not necessary that they be described at length here.

The rotor 69 is keyed to a shaft 73 which is rotatable at its lower end in a bearing 74 housed within a suitable recess in the positively driven stator unit. This rotor 69 is actually comprised as a series of laminations at the outer peripheral portion of which are positioned the usual conductor bars such as are employed in squirrel-cage type, induction motors. In fact, this clutch, so-called, is, in form, an alternating current motor of self-starting type and is adapted to function on either alternating current or on pulsating, direct current. The latter is employed for various reasons, although alternating current might be used throughout the entire circuit if desired.

The brake unit is in most respects very similar to and identical in some instances to the clutch. The stator here is stationary and is carried within the upper casing member 56 and comprises pole pieces 75, windings 76, also a rotor 77 keyed to the same shaft 73 to which the clutch rotor is fixed. In fact, these rotors and their fields are preferably identical in construction and have substantially the same power characteristics, although that may in certain instances be varied. Current is introduced through conductors 78 and 79 and there are four poles and four windings 76 as in the clutch.

The upper end of the shaft 73 is supported upon a bearing 80 similar to the bearing 74 and housed within the end portion 81 of the uppermost casing member.

In operation, the energization of the windings 62 and 76 is controlled through a circuit hereinafter to be described in detail and through a current divider by means of which the balance of driving or braking force may be switched from the clutch to the brake, or vice versa, as is required for rotating the warp beam in a manner such as may be necessary to establish and to maintain a substantially constant tension condition in the warp threads being drawn therefrom and consumed in the production of a fabric by knitting instrumentalities, weaving mechanism, or the like.

The power or the maximum capacity of both the clutch and brake unit is preferably several times that actually necessary for driving the warp beam and for letting off the warp thread under normal conditions. For example, it has been found in one particular installation that five times as much power may be available and may be advantageously controlled so that upon starting the knitting or other machine, rapid acceleration of the parts thereof will be accompanied by at least the same relative acceleration for the warp beam and the warp let-off. In other words there is no possibility that the warp beam may lag the fabric-forming function in building up its maximum speed, it being obvious that if that were the case as has heretofore frequently occurred, that an undesirable tension condition would exist momentarily during acceleration and that would, of course, result in a different stitch or pick structure depending upon the type of fabric being made. This possibility of a relatively great excess in the power output is accompanied by precise control characteristics between the clutch and brake so that just as soon as the maximum speed of operation has been reached, the balance of power input to these elements is rapidly and smoothly altered so that the power output from the unit to the beam at all times follows quite precisely the necessary requirements for advancing the warp to maintain a constant tension.

As the running speed is approached, a slight change in the position of the tension bars 17 or 18, Fig. 1, effects a different current distribution in each circuit so that the output of the clutch is decreased and at the same time the retarding effect of the brake increased thereby to cancel out a greater part of the clutch output, that effect being carried throughout a wide range of conditions for taking care of acceleration during starting of the machine, levelling off of the acceleration to a normal running condition, and for different speeds of rotation for the warp beam itself as the outside diameter of the yarn mass thereon decreased from a maximum toward an empty condition.

Upon stopping the machine, the parts rapidly decelerate and since the warp beam has considerable inertia, although it does not rotate rapidly, any slight tendency toward overrunning would naturally give rise to a temporary slack condition, especially just at the point of stopping the fabric-forming instrumentalities at which time a slight overtravel of the beam would give just enough excess thread for the production of a loose course of knitting or for an abnormal spacing between picks in weaving, that being generally referred to as an open-type stop mark and obviously something to be avoided if possible. During stopping the brake unit may receive the predominant portion of the available current and is in most instances the controlling factor or at least is sufficiently effective at that time to retard any tendency of the beam to overrun thereby eliminating the so-called stop mark and leaving the warp threads and tension bar in such position as to permit restarting of the machine without the production of any noticeably different type of fabric structure than is produced under normal running conditions.

Now referring to Figs. 1 and 2, the shaft **73** is connected to an extending shaft **82** which has keyed thereto as illustrated in Fig. 1, a worm **83** which meshes with a worm wheel **84**, the latter being preferably attached by means of a dog or other driving element, to the core portion of the beam **14**, or other beam to be driven. The shaft **82** and worm **83** are enclosed within an extension casing **85** which is fixedly attached at the upper end of the casing **56** and also forms a part of a cylindrical casing **86** within which the worm **83** is housed. The shaft also rotates on suitable antifriction or other bearings and is adjustable in several respects for proper functioning with the clutch and brake unit and with the worm which it drives. This worm and worm wheel drive for a warp beam is not new and forms no essential part of the invention other than that it is one means by which the driving impulse from the unit may be carried through to the beam.

Now referring to Fig. 7, one circuit and the electrical characteristics of the apparatus will be described. Preferably alternating current is supplied to the primary **87** of a transformer generally indicated by numeral **88** and from the secondary **89** this current is carried in reduced voltage as determined by a variable tap **90**, to a plurality of full wave rectifiers through impedance bridges, only one of which will be specifically referred to here since both are alike. In fact, the upper and lower portions of this electrical diagram are substantially the same and the lowermost only will be described in detail since that is sufficient for a complete understanding of the invention. A conductor **91** carries current from the lowermost tap on the secondary **89** to a central conductor **92** by which it is taken to the rectifiers for the upper circuit and also those for the lowermost circuit. Rectifiers indicated by numerals **93** and **94** are interconnected by conductor **95** and also are connected through to the coils **96** and **97** forming a part of the impedance bridge generally indicated by numeral **98** by conductors **99** and **100** which complete the circuit from the rectifiers to the transformer secondary through conductors **101** and **102** to the tap **90**. These rectifiers are of selenium barrier type but it is to be understood that any suitable full wave rectifiers may be substituted.

The impedance bridge **98** is only diagrammatically illustrated here and will be described as to its physical details in later paragraphs and by reference to the accompanying Figures 5 and 6. The principle of operation of this bridge is that of introducing into the circuit for either rectifier **93** or **94** as the case may be, an amount of inductive reactance which in addition to the resistance in the circuit will vary the current so that in effect, the bridge is a current divider capable of being varied within limits. The coils **96** and **97** have passing through them magnetic cores **103** and **104** which terminate in arcuate portions which may be adjusted to and from one another as will later be described. A vane **105** is attached to the end of its respective shaft **21** or **22** as the case may be, and is thus capable of being swung throughout a limited angular extent as the tension bar mounted to swing with that shaft is moved up or down under the varying tension tendencies existing in the warp threads which pass thereover. As this vane **105** approaches closer to or recedes from one of the cores **103** or **104**, the inductance and therefore the impedance in the circuit controlled thereby is correspondingly varied. Increase in the inductive reactance, of course, decreases the current passing through that branch of the circuit and since the vane, to approach closer to one core, must recede from the other, there will be a corresponding increase in the flow of current in the other branch of the circuit.

The full wave rectifiers have their output connected through to the stators of the clutch and brake, the upper rectifier in the diagram indicated by numeral **93** is interconnected by conductors **106** and **107** to the slip rings **64** and **65** through brushes **108** and **109**. The current from the rings passes through the stator windings **62** as is evident from the diagram and, of course, this circuit is completed from the ring, through the windings and back through the other ring and conductor to the rectifier. The current from the rectifier is a pulsating direct current such as is quite effective for operating the type of induction motor herein employed. The electrical characteristics of the apparatus are such that even under maximum output conditions and under a relatively great amount of slip for one or the other elements, no excessive heating is experienced.

Current from the rectifier **94** is conveyed through a potentiometer **110** and conductor **111** to the stationary windings **76** for the brake and then through conductor **112** and back through the remainder of the circuit thereby to complete it. No slip rings are necessary at the brake since the stator is maintained in stationary position. The potentiometer **110** is employed for effecting an initial balance or adjustment between the brake and clutch for particular operating conditions to which the unit is applied. It is normally unnecessary to provide any adjustment to be effected during operation of a particular machine over a wide range of operating conditions, but in some instances, it may be found that conditions are so different, for example, when widely different speeds of operation of the machine itself or widely different types of material are to be produced, that some change of setting will be found advantageous. The current direction is so disposed that the brake opposes the rotational tendencies of the clutch.

Now referring to Figs. 5 and 6, the specific construction of one of the impedance bridges is shown and includes the vane 105 which is keyed or fixed in position by set screws, or in any other manner held to the reduced end of the shaft 21 or 22, as the case may be. The entire impedance unit is housed within a casing 113 of non-magnetic material such as aluminum and which is attached by suitable screws or in any other convenient manner to one of the end bearings, or to some other part of the structure at the end of the supporting arms 23 as herein illustrated. The casing 113 is slotted as at 114 and 115 for reception of a locking and adjusting screw 116 or 117 by means of which the cores 103 and 104 are held in that particular angular position at which they are found to affect the current in coils 96 or 97 as is desired. The cores 103 and 104 are formed of laminated, magnetic material such as silicon steel or any other of the typical transformer irons or steels and comprise a central portion which passes through the coil or winding and is formed as a pole piece to provide a small air gap between that end and the outer cylindrical part of the vane hub. The core then extends in an arc of about 80°, more or less, and has an outer diameter such that it fits snugly within the interior of casing 113. By loosening the screw 116 which is easily turned by a knurled head 118, the entire core and winding 96 may be swung throughout an arc as provided by the slot 114. When properly adjusted, the threaded adjusting screw is tightened and the parts are then retained in that fixed position. A scale is provided at the outer surface of the casing and, in certain instances, is very useful for effecting the same setting of the parts after a change, or for other purposes. In some instances it may be desirable to provide a finer adjustment and in that event any one of the various micrometer type adjustments may be employed and the scales varied accordingly for expediting the more minute setting.

The vane 105 is formed of laminated iron or steel of similar form to the core members and extends outwardly so that the end thereof may be brought into close proximity to the ends of the arcuate portions 119 or 120. As above described with respect to Fig. 7, the positioning of the vane varies the amount of inductive reactance to cut down or to increase the current flowing through the windings 96 or 97. Casing 113 is closed by a cover 121.

Now referring to Fig. 8, the invention is shown therein as applied to the conventional fly shuttle loom. Such a loom includes among other parts, loomsides 122, a lay structure generally indicated by numeral 123, a crank shaft 124 and a cam shaft 125. These parts are driven by a main power means such as a motor, and continuously rotate during machine operation at some speed consistent with the functioning of the parts they control during the weaving operation.

A warp beam 126 is mounted at the rear of the loom frame in a journal or other suitable bearing 127 and a plurality of warp threads forming what is generally termed a warp sheet 128 pass from the beam over a whip roll 129 and through heddles 130 toward the front part of the loom at which point the fabric itself is formed upon the conventional motion of a shuttle through the warp threads which are separated into groups and form a shed as is well known to those skilled in the art. The fabric is taken up at the front part of the machine. Normally the warp sheet is under a degree of tension consistent with weaving goods of whatever quality or type is concerned and the whip roll 129 mounted in an arm 131 pivoted at 132 is urged in a direction to tension the warp sheet in any one of several manners well known to those conversant with this particular art. As here shown, a second arm 133 is also attached at the pivot 132 so that it moves with the whip roll arm 131 and under the influence of a spring 134, always tends to maintain the whip roll in a position such that the tension in the warp sheet is maintained.

In applying the invention to a loom it is necessary only that a single unit be provided since most looms utilize only a single warp beam. The structure shown for support of the beam, the whip roll and other parts herein illustrated are duplicated at the opposite end of the loom, although it is to be understood that there is no requirement for driving the beam at more than one side, although that unit may function at whichever side or end of the loom is found to be most convenient.

The gear unit 135 is attached by a suitable bracket to the loomside 122 and comprises a sprocket 136 similar to the sprocket 32, Figs. 1 and 2, and a shaft passing transversely through the gear box, corresponding to the shaft 33 and having a spiral gear thereon. That gear meshes with a single gear (not shown) but which corresponds to the gear 43, Fig. 4, and is enclosed within the box. It has a short shaft keyed thereto and projecting from the gear box to be fixed within one end of a coupling 137. A chain 138 passes about a sprocket 139 fixed to the projecting end of the cam shaft 125 and also about sprocket 136 for driving the elements just above described at such a speed that under the maximum requirements, a shaft 140 keyed within the opposite end of the coupling 137 will be driven at a speed slightly greater than the maximum necessary. A chain tightener sprocket or roll 141 pivoted at one end of arm 142 movable about a center 143 serves the same purpose as the similar tightener described heretofore and illustrated in Fig. 1. If found more convenient, the drive may be taken from the cam shaft 124, but that shaft is more remote and it is more likely that a double chain would have to be employed if the drive were taken from that particular element. In some cases it may be more satisfactory to employ spiral gearing at the end of the shaft and to convey the rotative impulse derived therefrom to the gears within the unit 135 by means of a shaft carried in suitable bearings and extending along the loom side 122.

A unit generally designated by numeral 144 is precisely the same in general physical form and is operated in the same manner as the unit illustrated in Fig. 2 and described above. It is unnecessary to make further description thereof at this point. This unit drives a worm and a worm wheel enclosed within the casings 145 and 146 and which correspond to similar parts illustrated in Fig. 1 and described with respect to the warp knitting machine therein shown. Since in a loom the speed of forming fabric is considerably slower than the speed at which a fabric is formed in a knitting machine and, since there are no loops formed of the warp threads themselves, the beam 126 is actually rotated at a much slower rate than one of the beams in a warp knitting machine, that is, considering a beam filled to the same outside diameter. For that reason, a double reduction is preferably employed at this point, and in bringing about that reduction, the shaft upon which the worm wheel turns is provided with a pinion 147 which meshes with the ring gear 148 attached to or formed as an integral part of the end flange at that end of the warp beam 126. It is, of course, quite possible to rotate the unit 144 faster or slower and, if desired, this double reduction may be dispensed with and the worm gear may drive the warp beam through some sort of dog connection in which event the center of the worm gear will conform to the center of the warp beam just as in the case of the beams employed with the warp knitting machine.

The controller unit indicated by numeral 149 may be positioned concentrically with the whip roll pivot 132 and the vane employed therewith may be attached to an extending part of that pivot, however, it is preferable that in a loom the range of movement for the vane be slightly greater than the angular movement generally imparted to the whip roll itself. For that reason the unit 149 is mounted independently of other elements at a convenient point at the loomside and the shaft on which the vane is fixed extends through the casing of the unit and has secured thereto a short arm 150 which is interconnected by means of a link 151 to the arm 133, there being several holes in that arm so that the link may be adjusted to take advantage of different ratios of leverage between the two arms thereby to adjust or change the range of movement in the controller unit.

No wiring is illustrated here, but it is to be understood that the general electrical wiring mechanism is the same as or substantially similar to one of the control units employed with the warp knitting machine and therefore similar to either of the units diagrammatically illustrated in Fig. 7.

Operation

The operation of the device will be described briefly and it is to be understood that in most textile machinery of this type the warp beam is prepared and inserted in the machine being connected to the driving mechanism therefor either by means of a driving dog which engages the end of the beam or shaft portion thereof which is frequently hollow, or driving connection is established by meshing gears as in the case of the loom, Fig. 8. Assuming that an initial adjustment has been made at the potentiometers 110, the machine is started and the yarn tension bars 17 or 18, or the whip roll 129, Fig. 8, would at that time be positioned as they were left when the machine stopped.

Upon starting the machine, the positively rotated stator in each clutch unit should accelerate at the same rate as the machine itself accelerates. The knitting or weaving instrumentalities naturally start to consume an amount of warp thread immediately and that has a tendency to pull downwardly on the tension bars or whip roll and therefore moves the vanes in the impedance bridge circuits toward that side of the device which brings about an increase of impedance to the flow of current to the brake and a decrease in impedance at the side or coil through which the current is conducted to the power unit or clutch. That causes the predominating portion of the current to energize the clutch thereby increasing greatly the driving output of the unit and rapidly bringing the warp beam up to speed so that there will be no marked tendency of the yarn tension mechanism to move from its normal operating position. This all takes place in a relatively smooth fashion and, of course, the tension bars and whip rolls always have a small amplitude of movement which is incidental to their function in the particular fabric-forming process with which they are utilized. The setting of the impedance bridge cores and the vane is such that that small amount of movement has very little effect. However, any general rotation of the tension bars about their pivots so that the vane then occupies a different relationship with respect to the arcuate portions of the cores 103 or 104 brings about an immediate change in the energization of the clutch and brake devices so that the net output thereof is varied in accordance with the requirements for yarn to establish the normal running position of the tension controlling parts.

During normal operation there is no acceleration or deceleration and the tension bars or whip roll in normal operating position maintains just the proper relationship within the impedance bridge circuits so that the output of the clutch and brake mechanisms is just sufficient to rotate the beams at that speed necessary to furnish thread at the proper rate demanded for fabric production of the requisite quality.

Upon stopping the machine the reverse takes place and since there will always be a tendency for the warp beams to overrun slightly, that tendency is accompanied by an upward movement of the tension bars or whip roll and the vane 105 then moves to the opposite side of the bridge structure thereby to throw into the brake a greater portion of the current and to slow down or decelerate the rotation of the beam at substantially the same rate as the machine itself is decelerated. It is to be understood that a slight amount of movement to either side of normal running position for either of the tension bars or of the whip roll, will make substantially no difference in the quality of material produced on the machine, but that any further change from normal operating position must necessarily be accompanied by either a greater tension in the warp threads or in a relative slackness or less tension than is normally contemplated. The response of the device is such that the movement of the tension bars, once these mechanisms have been properly balanced, never extends beyond that small range of oscillation which is quite permissible and will not be accompanied by a noticeable difference in the quality of the material produced especially upon stopping and starting the machine.

It is not necessary to stop the machine in a particular position as has sometimes been done as the principles of operation of the let-off assure that it will function to maintain proper warp tension under all practical operating conditions.

It is a fact that with beams of normal size and in most machines there is no need for control other than that heretofore described. In some cases, however, it may be found desirable to control the variable resistances or potentiometers which govern the voltage to the brakes by means such as that diagrammatically depicted in Fig. 9.

There a timer is connected to the main drive motor or other part operating synchronously therewith, and thus as knitting progresses, the timer is actuated. There are several such timers available on the market and the requirements here are for extremely slow movement at the output as compared to that at the input control. A mechanically or electrically connected device may be used, but the internal mechanism is not necessary of description here.

The output side of the timer is mechanically connected as by gears or chains to a rheostat or other voltage drop controlling element which is interposed in the supply line to the brake, preferably, although it might be in the clutch circuit if desired. This rheostat will gradually vary the balance between brake and clutch from the start of knitting with a full beam to the empty condition, for example, for perhaps one hundred hours. The beam is rotated faster as the diameter decreases, but the mass thereof also varies at a different rate and the moment arm also diminishes. These factors may be taken care of by such supplemental means as just described, rather than to rely upon one median setting of the potentiometer or rheostat, and a wide range of control through the impedance bridge. In such case the bridge need be designed to operate under less varied conditions.

While one embodiment and a modification of the invention have been disclosed and while the invention has been disclosed as applied to particular types of textile machines, it is to be understood that these are merely given by way of example and that the inventive concept may be carried out in a number of ways. Various modifications in the electrical circuit and in the construction of the electrical parts themselves may be effected without departing from the invention as conceived. This application is, therefore, not to be limited to the precise details described, but is intended to cover all variations and modifications thereof falling within the spirit of the invention and the scope of the claims.

I claim:

1. In a textile machine, a warp beam and means to drive said warp beam which comprises an electrically energized power means having a capacity substantially greater than that required to drive the beam during normal operation of the said machine and an electrically energized retarding means coupled to the said power means for opposing the driving force thereof, a circuit for supplying current from a source to the power means and retarding means, and a controlling means in said circuit for varying the current to each of said means to control the rotation of the beam in accordance with the tension in the warp threads drawn from said beam.

2. In a textile machine, a warp beam and means to drive said warp beam which comprises an electrically energized power means having a capacity substantially greater than that required to drive the beam under normal operating conditions of the said machine and an electrically energized retarding means coupled to said power means and having a capacity substantially equal to that of the said power means for opposing the driving force thereof, a circuit for supplying electric current to the power means and retarding means, and a controlling means in said circuit for dividing the current in such proportion as is necessary between the power and retarding means to rotate the beam at a speed consistent with the tension existing in the warp threads drawn from said beam.

3. In a textile machine, a warp beam and means to drive said warp beam which comprises a positively driven clutch element, a second clutch element and a brake means coupled to said second clutch element which comprises a stationary and a driven element, the latter of which is rotatable with and at the same speed as the said second clutch element, and means for energizing the said positively driven clutch element and the stationary brake element which includes a circuit and a current dividing means therein, and control means for said current dividing means functioning to apportion the current between the said clutch and brake means in such manner as to control the rotation of the beam in accordance with the tension in warp threads being drawn from the beam.

4. In a textile machine, a warp beam and means to drive said warp beam which comprises a shaft interconnected for driving engagement with the beam, an electrically energized clutch one element of which is fixed to said shaft and the other element of which is positively rotated, an electrically energized brake, one element of which is fixed to said shaft and the other element of which is maintained in a relatively stationary position, a circuit for conducting electric current to said positively rotated clutch element and to the stationary element of said brake, and an impedance bridge forming a part of said circuit and through which current passing to said clutch and brake is divided in accordance with the instantaneous position of a part of said bridge provided for movement thereby to vary the inductive reactance in said bridge circuit, and means for moving said bridge part in accordance with the tension in warp threads drawn from said beam.

5. In a textile machine, a warp beam and means to drive said warp beam which comprises a power means and a retarding means, said power means and retarding means being interconnected for operation upon a single driving element which in turn is interconnected to the beam for driving it, and said power means comprising an electrically energized, positively rotated member and a rotor, connections for driving said electrically energized, positively rotated member at a definite speed with respect to the speed at which the said textile machine is driven, a circuit through which current from a source is supplied to both the power means and the brake, and a current dividing means in said circuit, said current dividing means being controlled in response to movements of a tension member over which the warp threads drawn from the beam are passed and in accordance with changes in position of said tension means to apportion the amount of current between the power means and brake in such manner as to feed the warp threads from the beam under a substantially constant tension.

6. In a knitting machine, the combination of knitting instrumentalities, a main drive means for said machine, a warp beam carrying warp threads which extend in a sheet from the beam to the instrumentalities, a resiliently controlled tension means over which said warp sheet is passed, and means for rotating said warp beam comprising a member driven in synchronism with said knitting machine and main driving motor, said member forming a part of an electrically energized clutch for conveying power to the beam, an electrically energized brake effective for retarding the driving force imparted through the clutch, current conducting means from a common source of supply to said clutch and brake and current dividing means controlled by the said tension means for determining the propor-

tional parts of the current which shall energize the said clutch and brake to vary the net beam driving effect thereof for maintaining a uniform warp tension.

7. In a textile machine, a warp beam and means to drive said warp beam which comprises an electrically energized power means having a capacity substantially greater than that required to drive the beam during normal operation of the said machine and an electrically energized retarding means coupled to the said power means for opposing the driving force thereof, a circuit for supplying current from a source to the power means and retarding means, and a controlling means in said circuit for varying the current to each of said means which comprises an impedance bridge through which the passing current is divided in accordance with the position of a variable element in said bridge, thereby to control the rotation of the beam in accordance with the tension in the warp threads drawn from said beam.

8. In a textile machine, a warp beam and means to drive said warp beam which comprises an electrically energized power means having a capacity substantially greater than that required to drive the beam during normal operation of the said machine and an electrically energized retarding means coupled to the said power means for opposing the driving force thereof, a circuit for supplying current from a source to the power and retarding means, and a controlling means in said circuit for varying the current to said power means and retarding means which comprises an impedance bridge having two coils, a core for each coil and a vane movable to different positions with respect to said cores for varying the inductive reactance effective upon the current in said coils, and a connection from said vane to tension control means affected by the said warp threads drawn from the beam, thereby to divide the current at the said impedance bridge in accordance with the requirements of the power means and the said retarding means for maintaining a substantially constant tension in the said warp threads.

9. In a textile machine, a warp beam and means to drive said warp beam which comprises a shaft and interconnecting gears for imparting the rotation of said shaft to the said beam, rotors in spaced relation on said shaft, a rotatable, electrically energized, field member for one said rotor and a stationary, electrically energized, field member for the other said rotor, means for positively driving the first mentioned field member at a speed such that when its rotor is electrically coupled and driven at substantially the same speed, the rate of drive would then be slightly greater than the maximum speed necessary for rotating the warp beam at the greatest speed required therefor, a circuit for supplying current from a source comprising therein a control means including an impedance bridge by which current supplied to each of said field members is divided in accordance with the tension in warp thread drawn from said beam thereby to balance the net driving output to the said warp beam for establishing and maintaining the requisite rotational speed thereof and a substantially uniform tension in the warp threads.

10. In a textile machine, a warp beam and means to drive said warp beam which comprises a shaft interconnected for driving engagement with the beam, an electrically energized clutch one element of which is fixed to said shaft and the other element of which is positively rotated, and an electrically energized brake, one element of which is fixed to said shaft and the other element of which is maintained in a relatively stationary position, a circuit for conducting electric current to said positively rotated clutch element and to the stationary element of said brake, and means for controlling the amount of current supplied to the clutch and to the brake including an impedance bridge in said circuit and by which current passing to the clutch and brake is divided, said impedance bridge comprising two coils, cores in said coils and a movable vane effective in its different positions for inducing a greater or lesser amount of reactance to the current in said coils depending upon its proximity to one or the other of the cores, and tension control means for varying the position of said vane thereby to feed the greater proportion of said current to the clutch or to the brake in accordance with the requirements for rotation of the beam for establishing and maintaining a uniform tension in the warp threads.

11. In a knitting machine, the combination of knitting instrumentalities, a main drive means for said machine, a warp beam carrying warp threads which extend in a sheet from the beam to the instrumentalities, a resiliently controlled tension means over which said warp sheet is passed, and means for rotating said warp beam comprising an electrically energized clutch and an electrically energized brake, said clutch including a positively driven member rotated in synchronism with the said knitting machine and its main driving means, and said electrically energized brake including a stationary member and each of said clutch and brake means having a rotor mounted in adjacent relationship on a single shaft interconnected to the beam for imparting its rotational effect thereto, current conducting means from a common source of supply to the said positively rotated clutch member and to the stationary brake member and current dividing means for determining that proportional part of the current which is to be effective upon the clutch and upon the brake, comprising an impedance bridge and means forming part of said bridge and movable throughout a relatively small angular extent with the movement of said resiliently controlled tension means for dividing the current.

12. In a knitting machine the combination of knitting instrumentalities, a main drive means for said machine, a warp beam carrying warp threads which extend in a sheet from the beam to the instrumentalities, a resiliently controlled tension means over which said warp sheet is passed, and means for rotating said warp beam comprising a clutch and a brake each of which is comprised of a rotor and an electrically energized field member, the said field member for the clutch having positive driving connection to the said knitting machine for rotating in synchronism therewith, the said field member of the brake being mounted in relatively stationary position, and means for energizing said clutch and brake from a source of electric current comprising a circuit including an impedance bridge through which current passing to the said clutch and brake is divided in accordance with the requirements therefor so that the net output from the clutch and its opposed brake shall be governed in accordance with the rotational requirements of the beam for establishing and maintaining a uniform tension in the warp threads, and rectifiers in said circuit the current for which

is supplied through said impedance bridge, said rectifiers serving to convert the alternating current from the bridge to a pulsating direct current for the electrically energized field members of the clutch and brake.

13. In a textile machine, a warp beam and means to drive said warp beam which comprises an electrically energized power means having a capacity several times greater than that required to drive the beam during normal operation of the machine and an electrically energized retarding means coupled to the said power means and having a similar capacity for opposing the output torque of the power means, a circuit for supplying current from a source to the power and retarding means and control means in said circuit which comprises variably positionable inductive means, one for a branch of the circuit to the power means and one for a branch of the circuit to the retarding means, and tension responsive devices for establishing the relative position of said variably positionable inductive means.

14. In a textile machine, a warp beam and means to drive said warp beam which comprises an electrically energized power means having a capacity several times greater than that required to drive the beam during normal operation of the machine and an electrically energized retarding means coupled to the said power means and having a similar capacity for opposing the output torque of the power means, a circuit for supplying current from a source to the power and retarding means, said circuit having in one line thereof a bridge through which the current is divided, and tension responsive control means for shifting the balance of impedance from one side of said bridge to the other thereby to vary the energization of said power and retarding means.

15. Warp beam driving means which comprises an electrically energized power means having a capacity several times greater than that required to drive the beam during normal operation of the machine and an electrically energized retarding means coupled to the said power means and having a similar capacity for opposing the output torque of the power means, a circuit for supplying current from a source to the power and retarding means and control means in said circuit which comprises variably positionable inductive means, one for a branch of the circuit to the power means and one for a branch of the circuit to the retarding means, and tension responsive devices for establishing the relative position of said variably positionable inductive means.

16. Warp beam driving means which comprises a rotor shaft and induction motor rotors in spaced relation fixed to said shaft, reduction gears for interconnecting said shaft to the beam, a positively rotated stator operatively positioned to impart a rotational impulse to one said rotor and a fixed stator so positioned to the other rotor as to retard the rotational impulse of the first rotor and the shaft, and a circuit including a bridge within which the impedance to the current with which said stators are energized may be varied thereby to cause the output torque from the shaft to the beam to vary in accordance with tension in warp threads let off from the beam and to maintain that tension at a substantially uniform value.

17. Warp beam driving means which comprises a rotor shaft and induction motor rotors in spaced relation fixed to said shaft, reduction gears for interconnecting said shaft to the beam, a positively rotated stator operatively positioned to impart a rotational impulse to one said rotor and a fixed stator so positioned to the other rotor as to retard the rotational impulse of the first rotor and the shaft, and a circuit for conducting current from a source to energize said rotated and fixed stators which includes rectifiers, one for each stator, and conductors from each rectifier to its respective stator, an impedance bridge in said circuit from the power source to the rectifiers, said bridge having two branches in which the current is divided, variable inductance means effective on each branch of said bridge circuit and a common member forming a part of said inductance means and movable to different positions to vary the balance of current input to said rectifiers and thus, the output torque from said shaft to the beam.

18. In a weaving loom, the combination of weaving instrumentalities, a main drive means for said loom, a warp beam carrying warp threads which extend in a sheet from the beam to the instrumentalities, a resiliently controlled whip roll over which said warp sheet is passed, and means for rotating said warp beam comprising a member driven in synchronism with said loom and main driving motor, said member forming a part of an electrically energized clutch for conveying power to the beam, an electrically energized brake effective for retarding the torque from the clutch, a current conducting circuit for supplying current from a common source to said clutch and brake and a current dividing means in said circuit comprising a bridge and variable impedance means effective upon the current in the separate branches of said bridge, and connecting means from said whip roll to said variable impedance means for changing its effect on the current input to the clutch and brake thereby to vary the output torque therefrom to the beam as a function of the tension in the warp sheet.

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