Jan. 23, 1951 G. E. CLENTIMACK 2,539,295

WARP LETOFF MECHANISM

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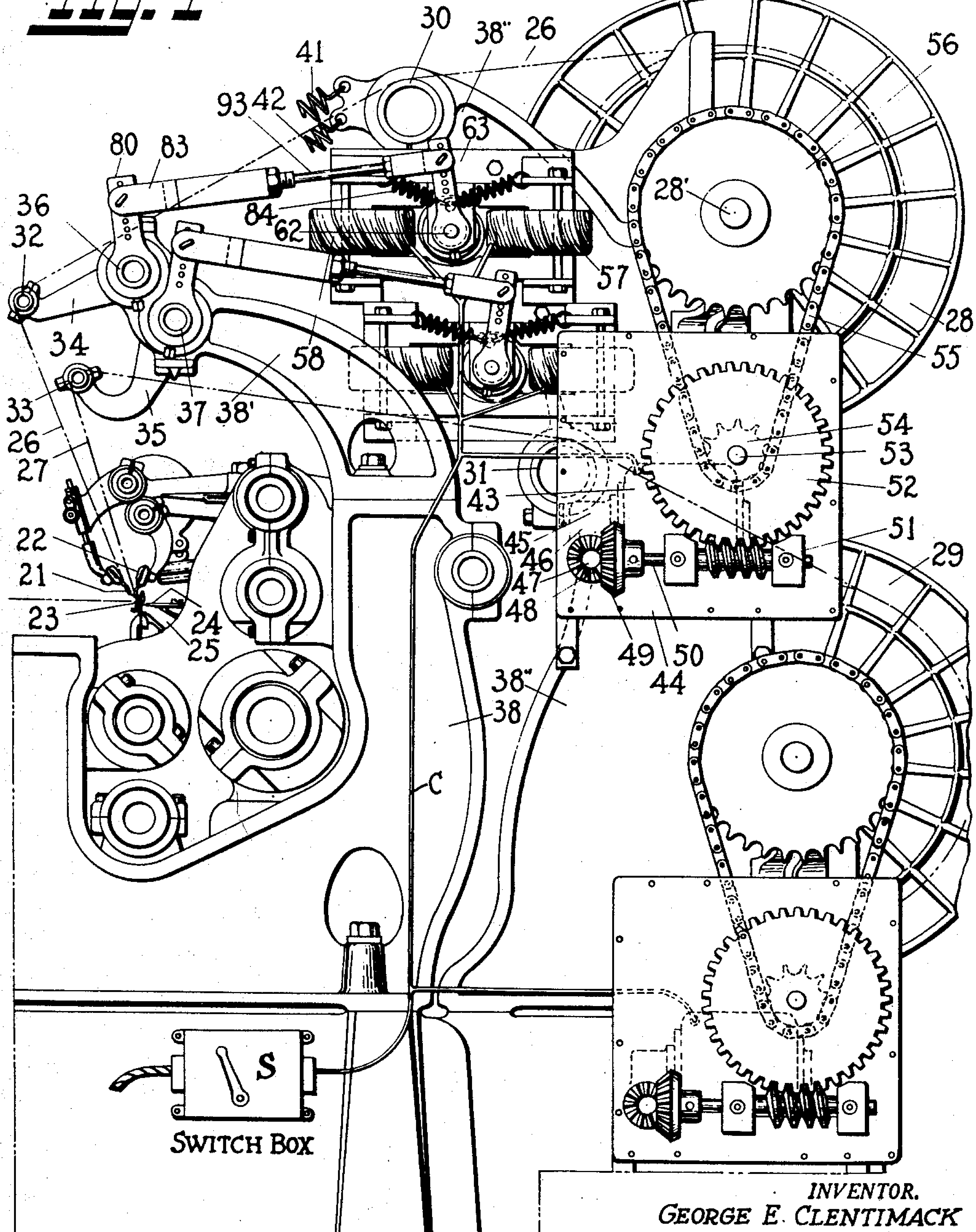
FIG. 1



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WARP LETOFF MECHANISM

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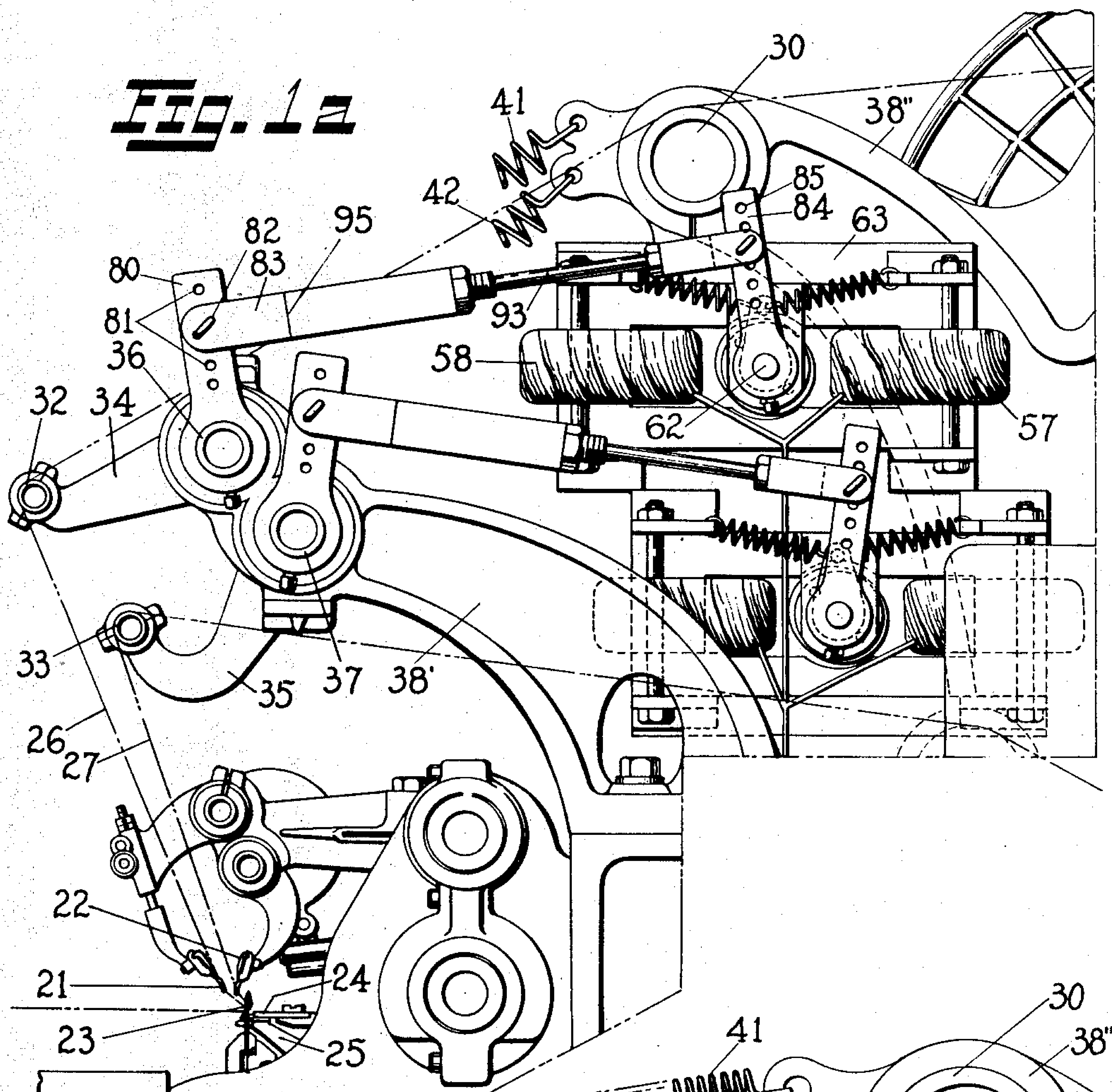
Fig. 1a



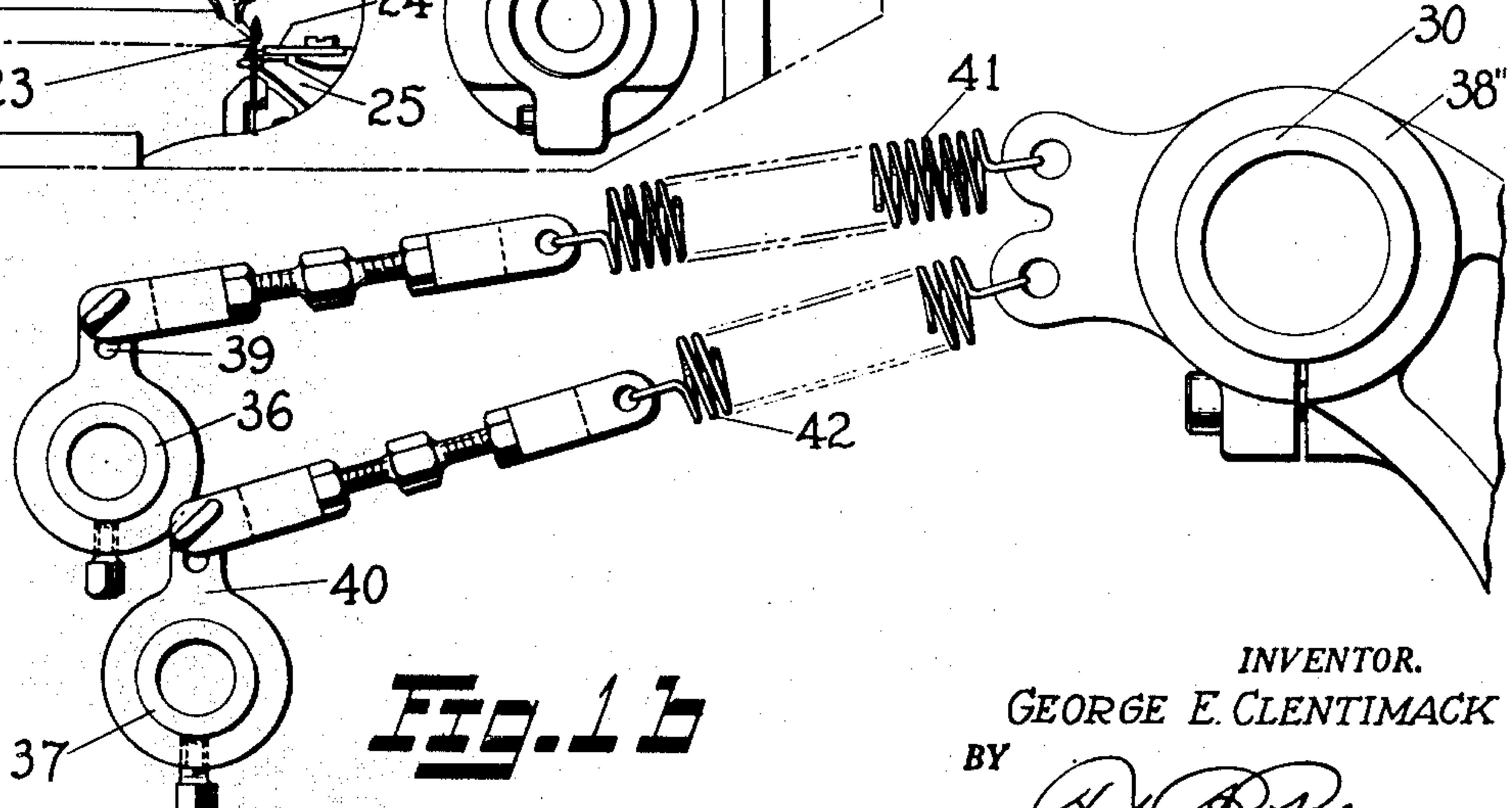


Fig. 1b

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WARP LETOFF MECHANISM

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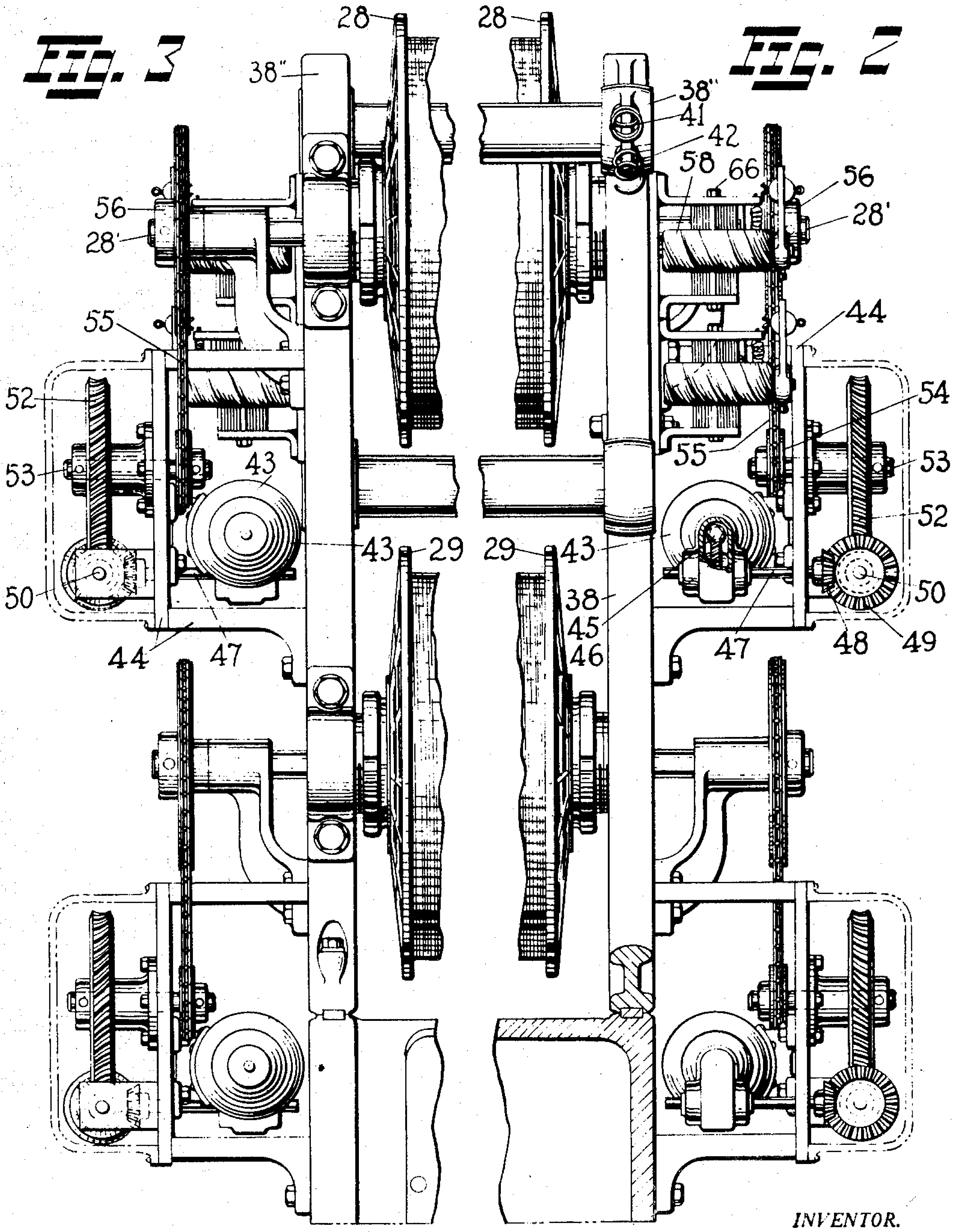

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WARP LETOFF MECHANISM

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Fig. 4

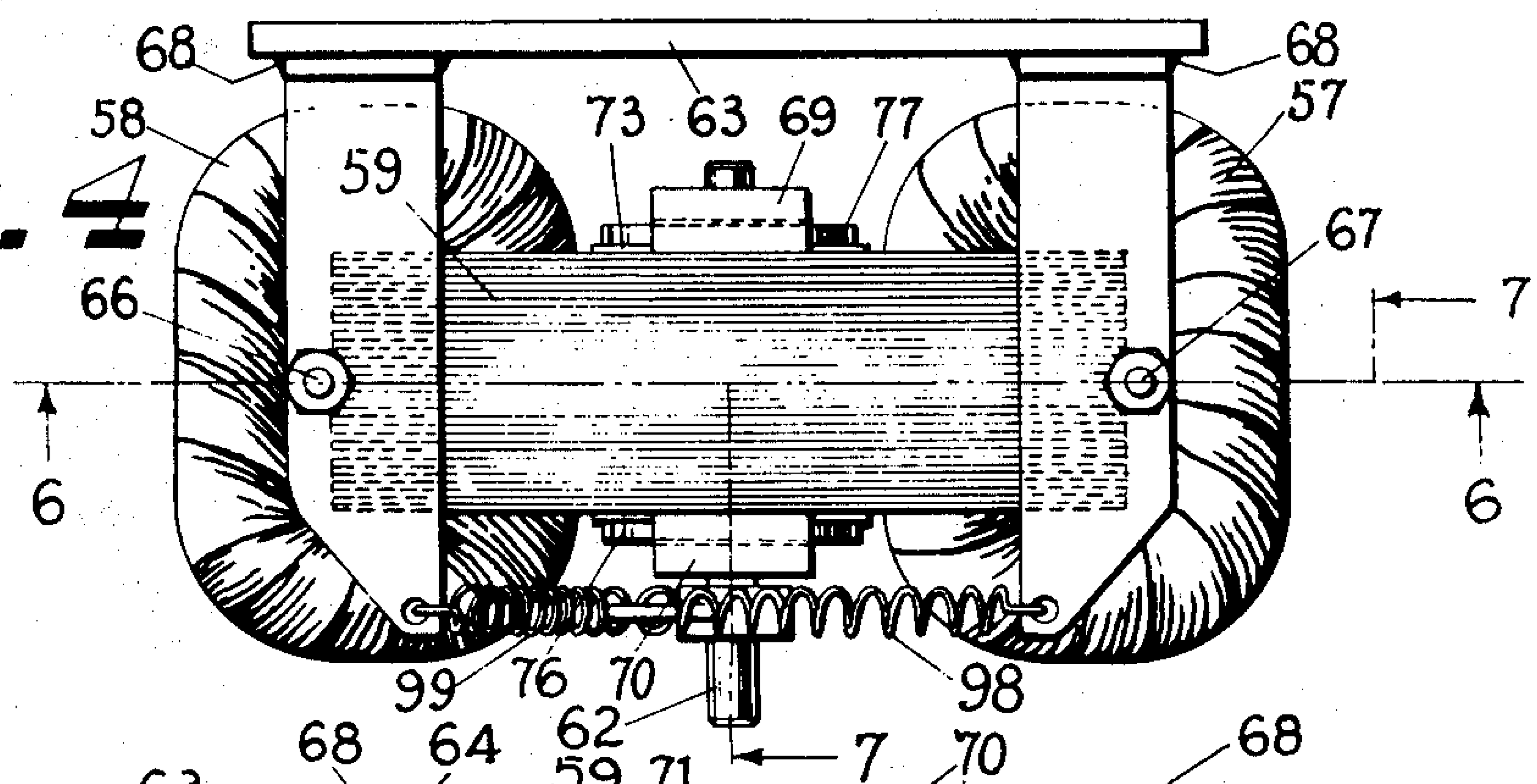


Fig. 5

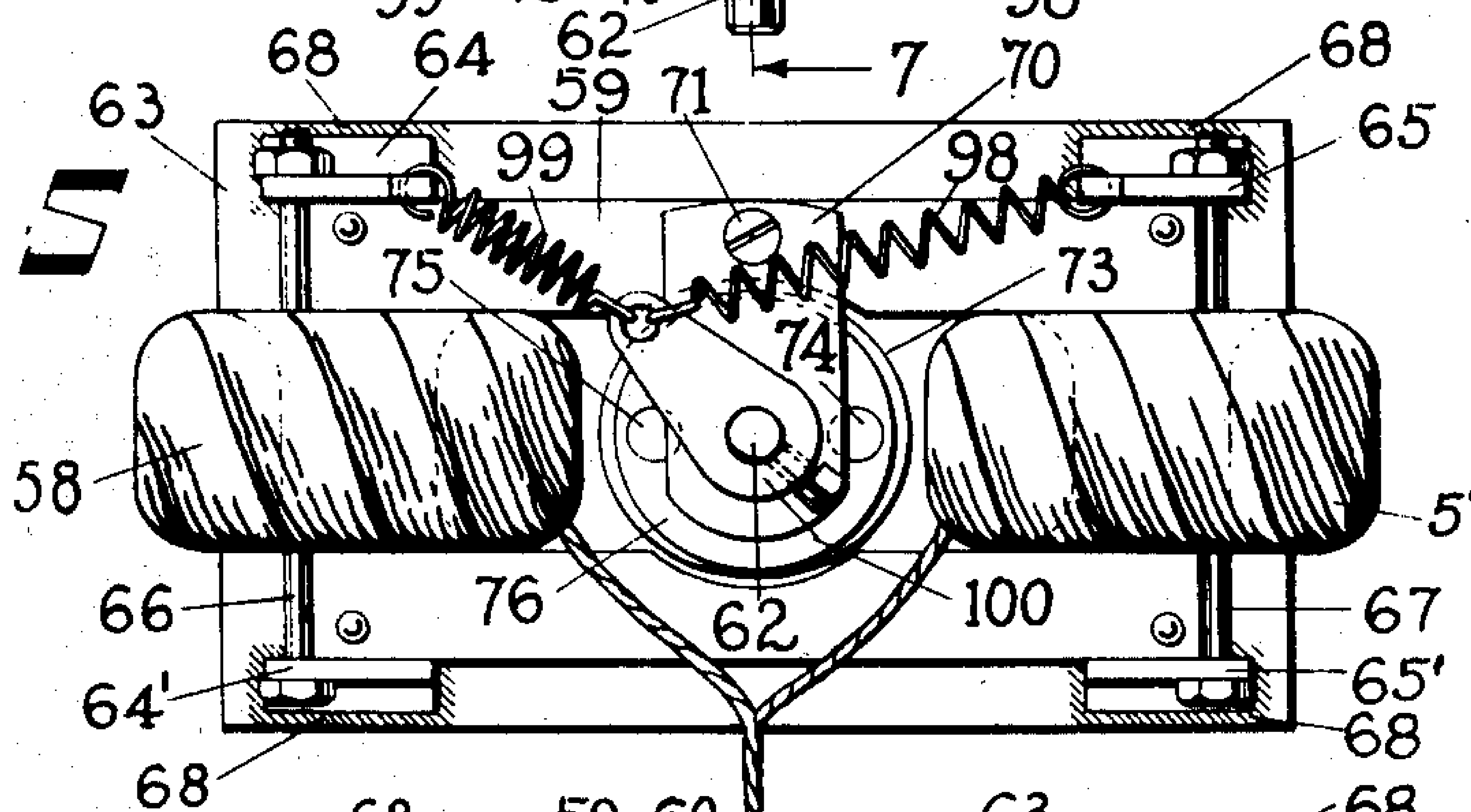


Fig. 6

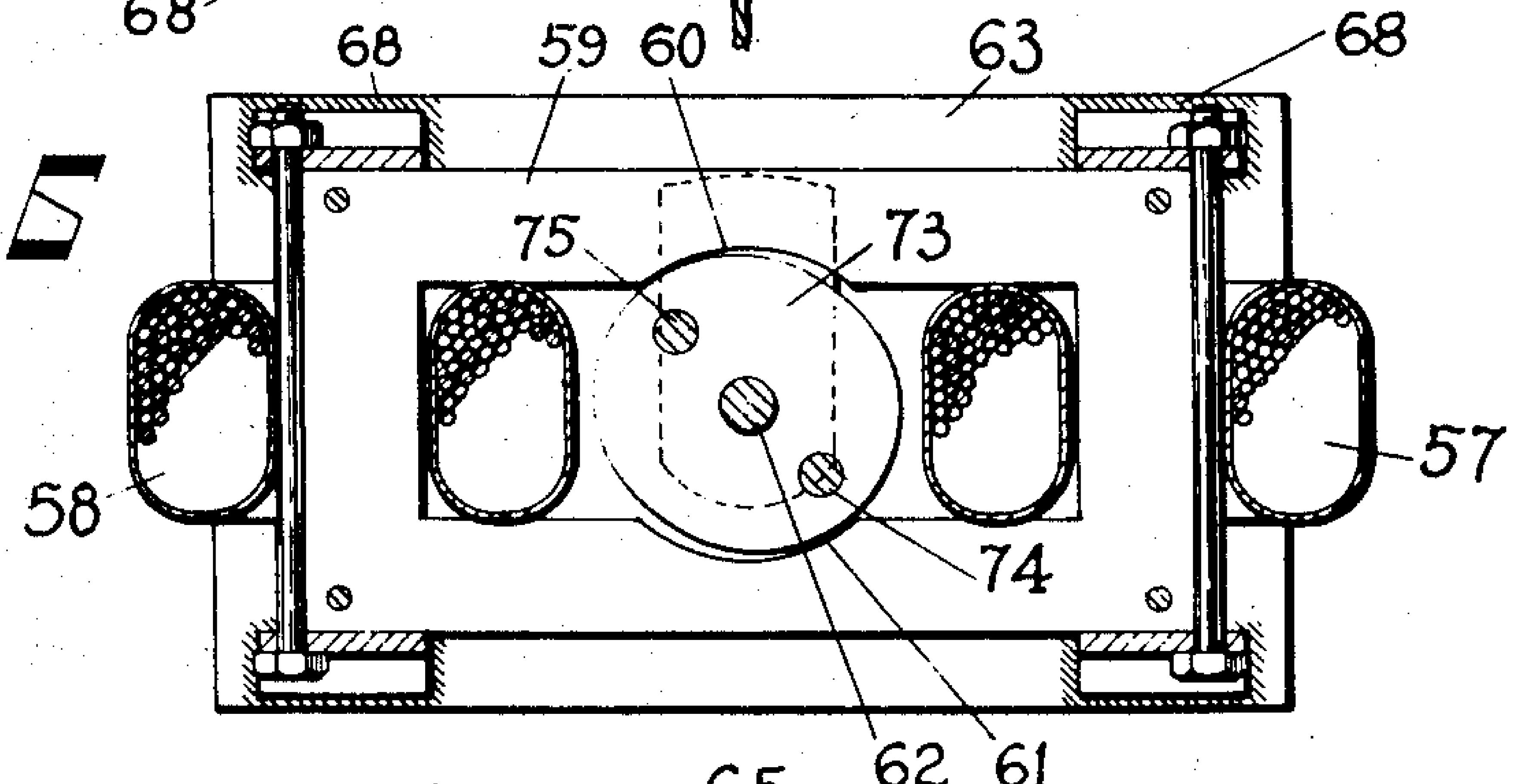
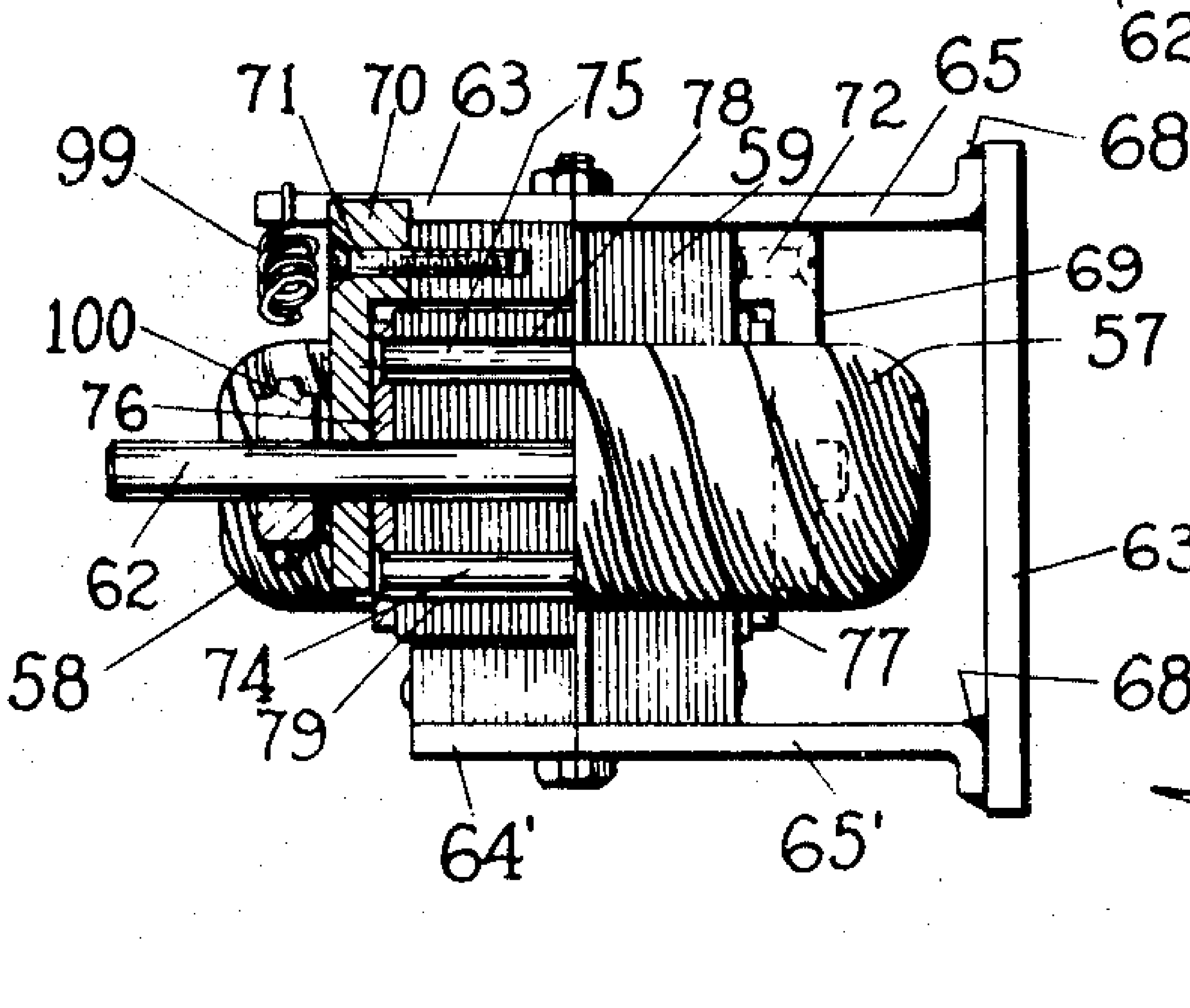


Fig. 7



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WARP LETOFF MECHANISM

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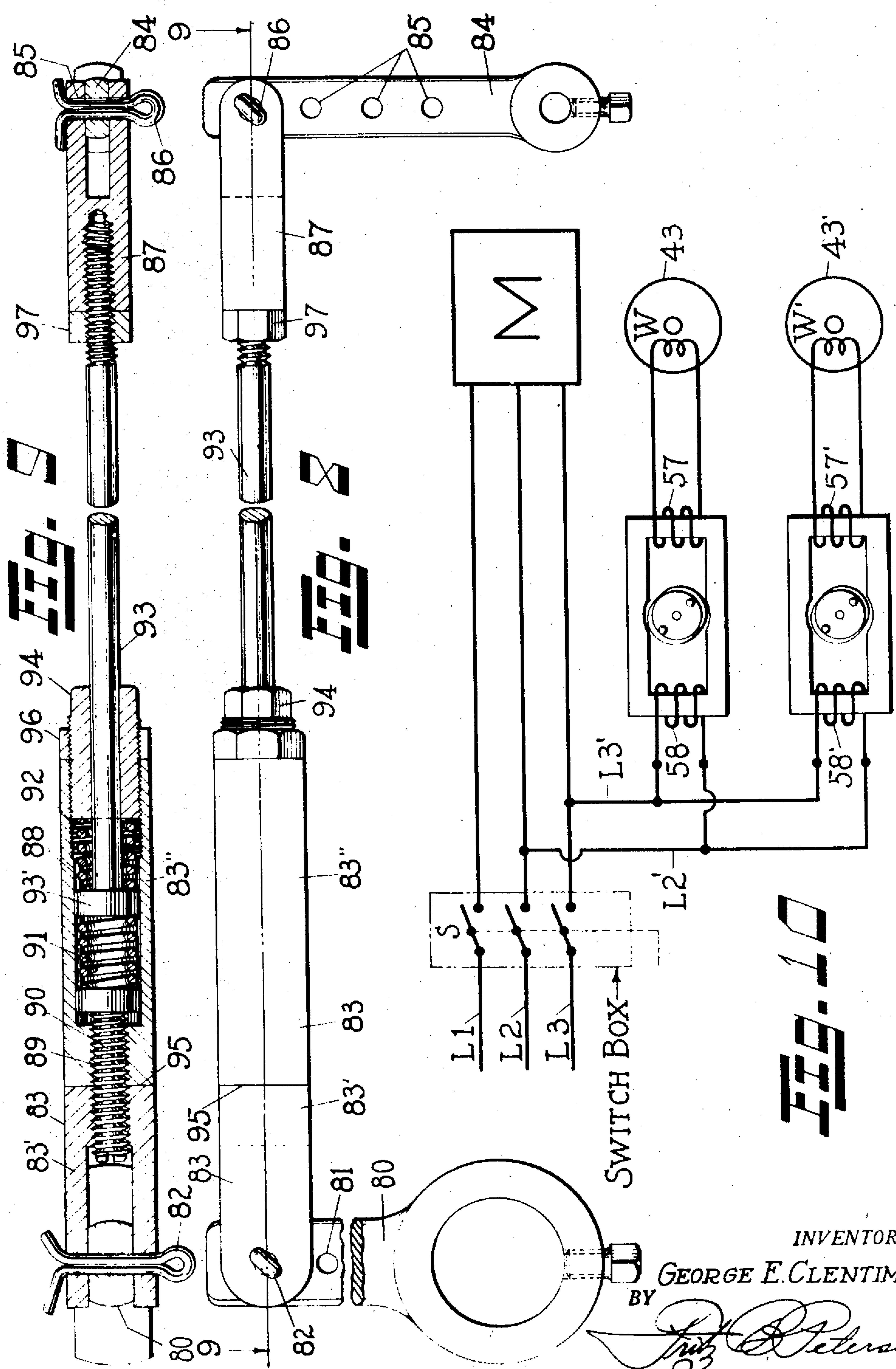

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Patented Jan. 23, 1951 2,539,295

UNITED STATES PATENT OFFICE

2,539,295

WARP LETOFF MECHANISM

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Application November 29, 1947, Serial No. 788,841

13 Claims. (Cl. 66—86)

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This invention relates to textile fabric producing machines employing warp yarns drawn from or supplied by a warp beam, and more particularly to a novel apparatus for controlling the tension in and the rate of let-off of the warp sheet to the fabric forming instrumentalities of the machine. While certain aspects and means of the invention are applicable to other fabric producing machines such as weaving looms, the invention is more particularly directed to improvements in warp knitting machines, and will be described and illustrated in connection with the latter type of machine.

In warp knitting machines a series of warp yarns are supplied to knitting needles in the form of a warp sheet extending in unwinding fashion from a warp beam. The warp yarns from a plurality of beams may be combined into a single warp sheet, the beams being either sectional in form and co-axially arranged or arranged upon different axes; or the machine may be constructed to employ a plurality of different warp sheets, each of which may be derived in the manner indicated above for a single warp sheet. The individual warp sheet extending from the warp beam to the fabric via the knitting instrumentalities is desirably maintained under tension, the degree of which may vary appreciably throughout each knitting cycle and the general average of which varies widely according to the quality and type of fabric being formed and for other reasons. The same considerations apply to each warp sheet used by the machine. Tension is produced in the warp sheet as the result of the combined pull exerted by the fabric take-up means and the drawing effect of the knitting instrumentalities at the fabric end of the warp sheet, combined with the drag exerted by the warp beam and let-off means. The tension thus produced varies throughout the knitting cycle, being when not otherwise modified greatest when the needles are fully retracted through loops of the previously formed fabric and least when the needles are at the opposite extremity of their movement. To reduce yarn and needle breakage and for other reasons it is desirable and customary to reduce the limits of this cyclical variation in tension. This generally is effected by passing the warp sheet over or about a movable tension bar which is yieldingly urged in a direction to take up slack or maintain the warp sheet under tension as the needles ease off or rise after pulling through the loops of yarn and which yields as the needles pull newly formed loops through previously formed loops. The tension bar customarily is held by

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arms which are secured to a rock shaft which allows the tension bar to partake of an oscillatory motion along an arcuate path in response to the tendency toward tightening and slackening of the warp sheet caused by the mentioned action of the knitting needles, the rock shaft in turn being suitably stressed as by means of springs in a manner to cause it to maintain tension in the warp sheet between the warp beam and the knitting instrumentalities. It will be understood that as the knitting needles draw newly formed loops of warp yarn through previously formed loops there is a drawing movement of the warp sheet effected, and as the needles return to position to have new loops formed thereon there is some slackening or reverse movement of the warp sheet, the latter being less in extent than the drawing movement due to consumption of yarn in forming the newly drawn in loops. A corresponding length of yarn is supplied at the other end of the sheet by being let off from the warp beam.

The manner in which the warp sheet is let off from the warp beam under tension varies somewhat, some machines merely placing a frictional drag as by brake means on the beam and other machines including positively driven gearing connected to drive the warp beam and driven in turn either by the machine itself through intermittently active clutch means or by a separate intermittently active motor means. An example of the first of these types of let-offs is illustrated in the patent to Kinsella et al. 2,014,530. An example of the second type of device is disclosed by the patent to Madden, 2,143,200. Examples of directly geared intermittently activated electric motor driven let off mechanisms are furnished by the disclosures of the patent to Klumpp et al., No. 2,340,889 and that to Carver, No. 807,721.

Each of the above mentioned types of warp let-off mechanisms, as well as all other types of which applicant is aware, suffers from the disadvantage that the let-off is intermittent, the warp beam being started and stopped alternately in a more or less rapid sequence depending upon the nature of the fabric being produced, the design of the knitting machine, and other factors. This more or less rapid starting and stopping of the beam is either purposely caused by, or the inherent result of, variations of relatively great magnitude in the tension of the warp sheet. Each start and stop of the beam produces an additional, momentary, and somewhat abrupt change in tension in the warp sheet. These more or less rapidly repeated, relatively great variations in tension which are relied upon to initiate action of means to positively rotate the beam, and the abrupt changes in tension which result from starting and stopping of the beam, whether caused by intermittently-acting clutch means, slipping of a brake means, or by starting and stopping of a beam driving means, cause undesirable changes in the structure or "quality" (appearance and weight per square foot) of the fabric. In certain fabrics and especially heavy fabrics knitted at low rates of knitting, these variations in quality of the fabric are ordinarily of only minor importance. In knitting finer grades of fabrics, however, and especially those knitted from certain types of yarns or at high rates of knitting, the mentioned variations in tension are the cause of objectionable variations in the quality of the fabrics knitted, these variations comprising visible lines and shade differences in the fabrics as well as variations not seen upon casual examination of the fabrics. An additional disadvantage of practically all, if not, in fact, all prior art let off mechanisms is the fact that as the warp mass on the beam decreases in outside diameter as the warp is let off, the tension produced by the drag of the beam or brake or let off mechanism increases, causing necessity for frequent manual adjustments. Even with frequent adjustment, relatively large variations in average warp sheet tension occur, with resulting undesirable differences in the quality of the fabric being knitted. With some brake type let off mechanism, frequent removal of weights or untensioning of spring means is required; and in some motor driven mechanisms adjustment of a rheostat or the like is necessary

Accordingly, with the above and other disadvantages of prior art warp let-off mechanisms in view, it is an object of the present invention to provide for or in a textile fabric forming machine a continuously operating warp let-off mechanism. It is a further object of the invention to provide a warp let off mechanism including a warp beam and means to so continuously drive the beam as to let off the warp sheet therefrom under a substantially constant average tension. Another object is to provide in a warp knitting machine having a warp beam and knitting instrumentalities and operating to incorporate into a fabric a warp sheet extending from the beam and operating to produce cyclical variations in the warp sheet tension within prescribed normal tension limits, a warp let off mechanism constructed and arranged to let off the warp sheet from the beam at a rate such that the warp sheet tension will not substantially vary outside said limits. Another object is to provide a warp let off mechanism operable to continuously and automatically let off a warp sheet from a warp beam under substantially uniform average tension.

Other objects are apparent and still others will become hereafter apparent in connection with consideration of the following description and related drawings together with the appended claims. In the drawings there is illustrated a preferred embodiment of the invention as applied to an otherwise conventional warp knitting machine; but it will be understood that the invention is applicable to other types of machines fabricating fabrics from yarns including a sheet of warp yarns.

In the drawings:

Fig. 1 is an end view of a warp knitting machine equipped with warp let off mechanism according to the invention, with certain conventional knitting machine parts, such as a pattern mechanism, removed for convenience in illustrating the novel mechanism;

Fig. 1*a* is a view on enlarged scale of structure depicted generally in Fig. 1;

Fig. 1*b* is a view of tension rod tensioning structure partly depicted in Fig. 1;

Fig. 2 is a front view of structure depicted in Fig. 1, with certain parts removed or partly removed;

Fig. 3 is a rear view of structure depicted in Fig. 1, with certain parts removed or partly removed;

Fig. 4 is a top view of a variable voltage transformer unit, with a rotor moved to an abnormal position;

Fig. 5 is a front view of structure depicted in Fig. 4;

Fig. 6 is a sectional view taken along line 6—6 of Fig. 4, viewed in the direction indicated by the arrows, but with the rotor rotated 45° into a substantially normal position;

Fig. 7 is a sectional view along line 7—7 of Fig. 4, but with the rotor moved to a position with its major axis in a vertical plane;

Fig. 8 is a detail view of governor structure depicted in Fig. 1 but on larger scale;

Fig. 9 is a sectional view on line 9—9 of Fig. 8; and

Fig. 10 is a schematic diagram of electrical components and circuits utilized in the invention.

Referring first to Fig. 1, there is shown in end view two series of eye needles **21**, **22**, a series of so-called knitting needles **23**, a press bar **24**, and a series of knockover bits **25**. These enumerated elements with the structure necessary for their operation are for convenience called the knitting instrumentalities, since they serve when operated in conjunction with a conventional pattern mechanism to form from one or more warp sheets a knitted fabric. Through the eyes of each series of eye needles **21**, **22** extends a respective warp sheet **26**, **27**. These warp sheets are each composed of a series of warp yarns and are let off from respective warp beams **28**, **29** from which they extend over respective guide bars **30**, **31** to and about respective tension bars **32**, **33**, and on to and through the respective series of eye needles, the individual warp yarns from there extending into the knitted fabric. During the repetitive cycles of knitting the knitting needles **23** are raised, have formed about them loops of yarn by wrapping movements of one or both series of eye needles, and are lowered to pull the newly formed loops of yarn through previously formed loops, these actions being accompanied by assisting movements and actions of the press bar and knockover bits. These movements of the instrumentalities, and especially the movements of the knitting needles and of the eye needles, act to pull a sheet of yarns during certain portions of each cycle and to let back or relieve the sheet during other portions of the cycle. To prevent creation in the sheet of tension of values such as might break some or all of the warp yarns or even break some of the knitting needles, the warp sheet is allowed to partake of yielding and return movements through action of the associated tension bar. The tension bars **32**, **33** are mounted on respective arms **34**, **35** secured in turn to respective rockshafts **36**, **37** which are rotatably mounted in suitable bearings carried by or formed in a bracket 38' carried by an end frame element 38. It will be understood that bars 32, 33 and shafts 36, 37 extend lengthwise of the machine and that there are a plurality of arms 34 and of arms 35. The rockshafts are suitably spring stressed as by means of arms 39, 40 secured to the respective shafts at suitable points along their lengths and adjustable springs 41, 42, respectively, the springs being adjustably anchored to a respective arm and to a machine frame element 38'' as shown in Fig. 1b; or by any other conventional means well known in the art. The stress applied by the respective springs is such as to allow downward or yielding movement of the associated tension bar as its warp sheet is pulled upon by the knitting instrumentalities and to allow of the bar to take up the warp sheet as it is slacked off by the instrumentalities. This yielding and returning, or oscillation, of the tension bar reduces the extent or range of the variation in warp sheet tension during each knitting cycle; that is, it reduces the maximum value of tension and raises the minimum value of tension that would prevail in the absence of the tension bar. There is, however, as is deemed to be obvious, a variation in the warp sheet tension during the individual normal knitting cycle, the tension increasing to an upper normal limit and decreasing to a lower normal limit and having a normal average value between those two limits. These normal cyclical variations in tension are as a practical matter unavoidable and may in fact be utilized in the cooperative action of the knitting instrumentalities.

The above mentioned knitting instrumentalities are supported and actuated by suitable bars, arms, shafts, cams and other structures in conventional fashion and as well known in the art. The tension bars likewise are supported and arranged in conventional fashion; and all of the above enumerated parts and the machine frame are or may be of conventional construction and operate in a manner well known in the art. Per se they are not a part of the present invention.

The preferred embodiment of the invention is depicted in the drawings as applied to a warp knitting machine employing two warp sheets and two warp let off mechanisms. Since the mechanism for letting off one warp sheet is like or similar to that for the other warp sheet, the description will largely be limited to one let off mechanism and only the important differences between the two will be pointed out. It will be understood that as many of the mechanisms may be used on a given machine as need therefor appears, which will in general mean one mechanism for each warp sheet.

The invention aims to substantially confine variation of tension in the warp sheet to values within the aforesaid normal limits and to maintain the average tension in the warp sheet substantially constant during operation of the machine, substantially eliminating all gradual changes in the average tension and entirely eliminating all impulse or sudden changes due to such causes as starting and stopping of the warp beam. These aims are accomplished by continuously rotating the beam at a slowly varying rate of rotation such that the time rate of let off of warp sheet therefrom and the average warp sheet tension quickly attain substantially constant values after the machine is started and are so maintained as long as the machine operates at a constant rate. The invention further provides a let off mechanism that almost instantly accommodates accidental or other changes in rate of operation of the machine by correspondingly changing the let off rate so as to maintain a substantially constant average warp sheet tension. By average tension is meant the integrated instantaneous warp sheet tension values throughout a normal knitting cycle, divided by the total number of such values integrated.

To accomplish continuous rotation of the warp beam throughout operation of the knitting machine, the beam is, according to the invention, driven by a continuously operating electric motor, that is, an electric motor that is so energized as to be operated continuously during all the time the machine is in operation. To vary the rate of rotation of the warp beam to provide a substantially constant let off rate and a substantially constant average tension, means are employed to vary the voltage applied to one or more of the windings of the motor to accelerate the latter, positively or negatively, whereby the speed of the motor is suitably varied. To regulate the variable voltage means so as to cause the motor to vary the warp beam rotation rate in proper manner to secure the aforementioned results, governor means are connected to the variable voltage means, the governor means being sensitive to, or responsive to, variations of the warp sheet tension outside the aforementioned limits and consequently sensitive to or responsive to shifting or variation of the average warp sheet tension. The electric motor for driving or rotating the warp beam preferably acts through reduction gearing, the latter preferably being of the so-called "irreversible" type, that is, including a high ratio worm and worm wheel gearing; the gearing being directly connected to the warp beam shaft either by a chain drive or by gears. The variable voltage means for varying the voltage applied to a motor winding preferably is a variable voltage transformer. The governor means preferably is a connection between the variable voltage means and structure that is moved upon occurrence of variation in tension in the warp sheet, is arranged to regulate the variable voltage means to cause the latter to vary its output voltage, and preferably but not necessarily is of a form which ignores the aforementioned cyclical changes in warp sheet tension and acts to regulate the variable voltage means only when the tension commences to shift outside the aforementioned limits.

Specifically, the means for letting off warp sheet 26 from beam 28 comprises an alternating current motor 43 mounted on an open ended housing 44 and driving reduction gearing comprising a worm 45 on the motor shaft which drives worm wheel 46 on a shaft 47 carrying a bevel gear 48 which in turn meshes with a bevel gear 49 on a shaft 50 carrying a worm 51 engaging a worm wheel 52 on a shaft 53 carrying a sprocket 54 engaging a chain 55 acting to drive a sprocket wheel 56 mounted on the warp beam shaft 28'. The several shafts of the gearing are suitably carried in bearings provided in the motor casing in the housing 44 and in brackets attached to those parts, as indicated; and the gears are suitably secured to their respective shafts, all in accord with ordinary principles of machine design. Housing 44 is suitably attached to end frame element 38' by means of cap screws as indicated. It will be understood that the nature and ratio of this gearing may be varied widely to suit the requirements of the individual knitting machine to which the gearing is to be applied and that any other equivalent reduction type of gearing may be employed, as the gearing is not, per se, part of the invention. Further it will be understood that in the embodiment depicted the warp beam 28 is made fast to shaft 28' but that the beam may be loosely mounted on the shaft and driven by means of a sleeve on the shaft and carrying sprocket 56 and having means engaging the beam head to positively rotate the beam or other equivalent gearing may be employed.

From the preceding paragraph it will be perceived that rotation of the shaft of motor 43 causes positive rotation of beam 28, this rotation being in direct proportion to the rotation of the motor and such as to let off the warp sheet 26 from the beam, and being continuous as long as the motor is energized. Obviously, as the yarn mass on the beam decreases in outside diameter, the beam must be rotated at a gradually increasing rate if a constant rate of warp sheet let off is to be maintained. Further, the let off rate must substantially exactly equal the yarn consumption rate of the knitting instrumentalities if the average warp sheet tension is to be maintained substantially constant. Hence the rotation rate of motor 43 must be controlled to secure those results.

The rate of rotation of motor 43 is controlled by varying the voltage applied to at least one of its windings by energizing the winding from the secondary 57 of an A. C. transformer. (See Figs. 1*a* and 4–7 inclusive.) The transformer is also provided with a primary 58, these windings each surrounding and being supported on a respective leg of a shell type core 59 as indicated. The primary is connected in a manner hereinafter more fully described to a source of A. C. power, so as to cause energization of motor 43 by the secondary. Core 59 preferably is made of thin stampings of transformer steel, the stampings being of the general shape shown in outline in Fig. 6 and having shallow segments cut out of the inner parts of each stamping to form opposed arcuate surfaces 60, 61 which are concentric about the axis of a shaft 62 of a rotor to be hereinafter more fully described. The transformer core is suitably attached to a transformer base 63 as by means of clamping plates 64, 64', 65, 65' and bolts 66, 67, the clamping plates being bent to form brackets and welded to base 63 as at 68. Base 63 is secured to frame element 38'' as by bolt means as shown. The transformer is thus firmly supported in fixed relationship relative to the axis of tension bar rock shaft 36 (see Fig. 1). Referring again to Figs. 4–7, rotor shaft 62 is rotatably supported in bearings formed or mounted in bearing brackets 69, 70 secured as by means of pins and screws 71, 72 to the core 59. The rotor shaft carries a rotor 73 of elliptical cross section formed preferably of laminations of transformer steel press fitted onto the shaft for rotation therewith. The rotor includes a low resistance short circuited electrical coil of a single turn formed by two rods 74, 75 and two rotor end plates 76, 77, these elements being formed of a low resistance non-magnetic electrically conducting material such as copper or aluminum and being electrically connected in any suitabe fashion, preferably as hereinafter indicated. Rods 74, 75 are fitted in respective apertures 78, 79 formed through the rotor on opposite sides of shaft 62 and near the periphery of the rotor, and are suitably joined to the end plates so as to form a low resistance electric coil, as by being passed through tightly fitting apertures in the end plates and being peened over or headed tightly against the end plates as indicated in Fig. 7. The rotor thus formed is, as mentioned, of elliptical cross section; and the cross section is of such major diameter as to barely allow clear rotation of the rotor in the opening formed by the opposed curved surfaces 60, 61 of the transformer shell, and of such minor diameter as to provide air gaps of considerable extent between the rotor and the shell when the rotor is positioned with the minor axis directly between the centers of surfaces 60, 61. Further, the apertures 78, 79 are placed on or near the major axis of the elliptical cross section of the rotor and parallel with rotor shaft 62, for a reason to be more fully explained hereinafter.

Referring more particularly to Figs. 5 and 6, it will be noted that with the axis of the short circuited single turn coil positioned parallel to the air gap between surfaces 60, 61, that is, with the plane of the coil horizontal as viewed in Fig. 5, the air gap will be a maximum; and with the coil positioned with its axis transverse to the air gap the air gap will be a minimum. Further, with the rotor and coil positioned as indicated in Fig. 5, the leakage across the air gap of magnetic flux created in the shell by primary 58 will be at a minimum due to the maximum air gap and the maximum inductive effect of the coil, and the secondary output voltage will be at a maximum value; and with the rotor positioned 90° from the Fig. 5 position, the flux leakage will be at a maximum due to the minimum air gap and the minimized inductive effect of the short circuited coil, and the secondary output voltage will be a minimum. Thus it is seen that by regulating the position of the rotor through one quarter of a turn thereof, the output voltage of the transformer may be varied from maximum to minimum values and vice versa. By varying the eccentricity of the rotor, the depth and extent of the cut outs forming surfaces 60, 61, the size and position of rods 74, 75 with respect to the major axis of the ellipse, and the windings of the transformer, a wide range of characteristics may be had in the transformer.

Thus it is feasible to provide a transformer which is more sensitive to movement of the rotor in one direction from a normal position than to a like degree of movement in the other direction from the normal position, yet which is increasingly sensitive to movement as the rotor is moved away from the normal position. The former characteristic is desirable since as the warp mass on the warp beam decreases in diameter the motor must rotate faster to compensate, and it is desirable to have the transformer act to accomplish this result with only a negligible shift in the average warp sheet tension value. Further it is seen that with the parts relatively proportioned and assembled as indicated in the drawings, but with the axis of the short circuited turn positioned intermediate the extreme positions indicated above, or approximately as indicated in Fig. 6, movement of the rotor in one direction (clockwise as viewed in Fig. 6) will result in decreasing the secondary output voltage and movement in the opposite direction will result in increasing the secondary output voltage. Thus it is shown that movement of the rotor in a first direction may be utilized to cause the motor and warp beam speeds to increase and movement in a second direction may be utilized to cause the motor and warp beam speeds to decrease.

The transformer is regulated by movement of its rotor as above described through the action of suitable governor means, which preferably but not necessarily is of a "lost motion" type, and which in the illustrated embodiment of the invention is in the form of a mechanical linkage connecting the rotor shaft to a means which is sensitive to, or responsive to, variations in the warp sheet tension. This tension variation responsive means may conveniently be the above described tension bar and tension bar rockshaft combination, which moves in one direction in response to an increase in warp sheet tension and in a second direction in response to a decrease in that tension, both within and outside of the normal cyclical variation limits as above defined. It will be understood, however, that another tension variation responsive means could be used, the tension bar merely forming an already existing means of satisfactory response characteristics. Referring to Figs. 1, 1*a* 8 and 9, the governor means includes an arm 80 affixed to rock shaft 36 near an end thereof, which arm may conveniently be affixed to the shaft by set screw means as indicated. The arm is provided with a series of apertures 81, through any of which a clevis pin 82 may be inserted. Clevis pin 82 acts to adjustably connect a clevis head 83 to the arm, the head forming one part of a lost-motion linkage connecting the arm with a second and similar but smaller arm 84 affixed to rotor shaft 62 as by a set screw as indicated. Arm 84 is similarly provided with a plurality of apertures 85 into any of which a clevis pin 86 of a clevis head 87 may be fitted to adjustably connect head 87 to arm 84. Clevis head 83, which may be of square cross section, is formed with a bifurcation at one end to accommodate arm 80, and is provided with a cylindrical bore 88 and a smaller bore 89 at the bottom thereof, bore 89 being threaded as indicated to receive a headed spring adjusting screw 90. Slidably accommodated in bore 88 are the head of screw 90, a pair of compression springs 91, 92, a piston-like head 93' of a rod 93, and a threaded plug 94 which is bored for free passage of rod 93 therethrough and is threaded into a threaded portion of bore 88. Plug 94 may be provided with a locking nut 96, to securely lock that element in fixed adjusted position. Clevis 83 may be formed in two pieces 83', 83'', whereby the two pieces may be turned into tight contact with each other at 95 and thus hold screw 90 firmly in position. At its opposite end rod 93 is threaded into a threaded bore in head 87 and held in adjusted position by a lock nut 97. The arrangement of this linkage is such that screw 90 and plug 94 may be so adjusted that as long as tension bar 32 oscillates within its normal range of movements induced by only normal cyclical variations in warp sheet tension, rod 93 will not be moved, springs 91 and 92 alternately yielding as arm 80 and head 83 oscillate with rockshaft 36. This action may be enhanced or insured by increasing if necessary the frictional effects of the rotor shaft bearings, or, preferably, by application of spring means such as 98, 99 (see Fig. 5) to the rotor shaft. Springs 98, 99 may conveniently be anchored to clamping plates 64, 65, respectively, and to a post formed on a collar 100 secured on rotor shaft 62, as indicated. Springs 91, 92 having been properly stressed by adjustment of screw 90 and plug 94 as above indicated, rotor 73 will not be appreciably moved by the governor means unless tension bar 32 tends to vary outside its normal range of movement. When the latter action commences, there is effected an immediate adjustment of the rotor and an immediate but normally very slight variation of the motor speed of such character as to restore the oscillations of the tension bar to within the normal cyclical limits. Thus any slight change in the average tension in the warp sheet is corrected long before any substantial average tension change can accumulate, that is, before more than a slight change has occurred; and hence the average tension in the warp sheet is maintained substantially constant. By slight change in average warp sheet tension I mean any change less than such as is required to produce a measurable change in the quality of the fabric being made. Since the yarn mass remaining on the warp beam is gradually reduced in diameter as the warp sheet is let off therefrom during operation of the machine the beam speed must very gradually be increased to provide a constant let off rate. Since it is necessary to provide for this increase in speed by increasing the speed of the motor, the transformer is constructed and arranged and the governor means adjusted so the transformer is highly sensitive or responsive to movements of the governor linkage induced by variations in the average warp sheet tension above the normal average, with the result that only a very small shift in the average tension value in the direction of an increase will suffice to cause increase in the motor speed to accommodate the reduction in yarn mass diameter. The particular rotational position of the transformer rotor for proper gradual increase of beam speed is different for different sizes of yarn and for different types of knitting, but is readily determinable by a trial run. The let off mechanism very quickly attains uniform let off rate after the machine is started; and will follow even abrupt accidental or intentional machine speed variations with almost instantaneous response. In Fig. 10 is shown a circuit diagram of the electric circuit employed in the illustrated embodiment of the invention. Therein M indicates the machine which is driven by a three phase motor as in conventional practice, the motor being supplied with electrical power from mains L1, L2 and L3 through a switch S enclosed in a switch box so labeled. The switch also controls the application of energy to motors 43, 43' and to primary 58 and the primary 58' of the transformers of the let off mechanism for beams 28 and 29 through branch leads L2', L3'. Thus the motors are energized only when the machine is operating, and are energized at all times the machine is operating to cause rotation of the respective warp beams. W and W' designate motor windings energizable through the transformer secondaries 57, 57' respectively and effective when energized at various different voltages to vary the respective motor speeds. It is evident that these windings may be the entire windings of the motors, or parts of such windings, or auxiliary windings, as is well understood in the electrical arts. The several wires or connectors may be suitably protected by conduit means as indicated at C in Fig. 1.

It will be understood that the let-off mechanism for beam 29 is similar to that for beam 28, the parts being generally the same. If beam 29 is employed to supply warps of a size different from those supplied by beam 28, or knitted at a different rate, the setting of the associated transformer must differ accordingly. The principles of construction and operation are, however, the same for the two let off mechanisms.

Briefly summarized, operation of the hereinabove described preferred embodiment of the invention is as follows: The knitting instrumentalities (which may include a fabric take-up device, not shown), act in any suitable conventional fashion to incorporate into a fabric the warp sheet and to produce a variable draft or "pull" thereon; and that pull, in conjunction with the action of the warp beam and associated structure, produces tension in the warp sheet. This tension would, if not modified, vary widely during any particular normal knitting cycle, but is modified by action of the stressed tension bar. The tension bar acts to reduce the maximum value of the tension that otherwise would obtain, and raises the minimum value. That is, action of the tension bar is effective to reduce the range of variation in warp sheet tension obtaining through a knitting cycle. In performing this function during a normal knitting cycle the tension bar moves through a normal range of positions between normal limits and the warp sheet tension varies in value within the range defined by an upper normal tension limit and a lower normal tension limit. In the event the warp sheet tends to be tensioned to a value either above the upper normal tension limit or below the lower normal tension limit, the tension bar is caused to move to an abnormal position not included in its normal range of positions. When such movement to an abnormal position occurs, motion is imparted to the rotor of the variable voltage transformer which in turn instantly changes the voltage of the power supplied by its secondary to the warp beam driving motor to thereby apply to the motor an acceleration influence (which may be either positive or negative, according to whether the abnormal position of the tension bar resulted from an increase in average warp sheet tension or a decrease thereof), whereupon the motor changes the rate of rotation of the warp beam to alleviate the change in average warp sheet tension before any substantial change in such average value can accumulate. Thus when the machine is started the average warp sheet tension is quickly brought to a substantially constant value by operation of the motor under control of the transformer and its governing mechanism, and the average tension value thus achieved is maintained with only inappreciable change from beginning to end of the operation of the machine, although such operation be so long as to consume an entire beam of warp.

While a lost-motion type of governor mechanism is disclosed as governing the transformer only upon movement of the tension bar to an abnormal position, it is evident that for certain classes of goods such nicety of control is not essential. Further, it is evident that a warp sheet tension-responsive means may be employed which is sensitive to only variations above and below the normal variation limits of warp sheet tension, in which case the governor mechanism need be only a direct mechanical connection between the tension-responsive means and the transformer. Additionally, it is considered to be evident that the transformer may be constructed so as to be relatively insensitive over a certain range of rotor movement corresponding to the normal range of movement of the tension bar but highly sensitive to rotor movement outside said certain range, thus allowing a direct, non-yielding mechanical connection between the tension bar and the transformer. Similarly it is evident that other types of variable voltage transformers may be employed, as long as the above described essential principle of continuous warp beam rotation is followed.

In the disclosed embodiment of the invention the average warp sheet tension that is desired is controlled by adjustment of the springs stressing the tension bars, as is usual in warp knitting machines. It is evident that when applied to a weaving loom the whip roll or a stressed tension bar may be used for that function, the weaving instrumentalities acting during each weaving cycle to produce in the warp sheet cyclical variations in tension as is well known.

Having fully disclosed a preferred embodiment of the invention it will be evident that from a consideration of the disclosure modifications of the structure will occur to those skilled in the textile arts. Accordingly my invention is not limited to the exact details of the disclosed embodiment of the invention, but what I claim is:

1. In a textile fabric producing machine: fabric forming instrumentalities; a warp beam from which a tensioned warp sheet extends to said instrumentalities; means including an electric motor arranged to rotate said beam at a rate dependent upon the voltage applied to a motor winding; means acting on said warp sheet and tending to reduce cyclical variations in the tension of said sheet to limit the tension to values within prescribed limits and including apparatus movable to an abnormal position upon said tension reaching a value outside said limits; a variable voltage transformer supplying energy to said winding; and means governed by said apparatus upon abnormal movement thereof and acting to regulate said variable voltage transformer to vary the voltage applied to said winding to change the rate of rotation of said beam to restore said tension to a value within said limits.

2. In a warp knitting machine: knitting instrumentalities; means to supply a warp sheet under substantially uniform average tension to the knitting instrumentalities and including a warp beam from which the warp sheet extends under tension to the knitting instrumentalities and a tension bar about which the warp sheet passes, said means further including an alternating current electric motor and appurtenant driving structure acting to continuously drive the warp beam to let off the warp sheet therefrom; means continuously supplying alternating electrical current to said motor during operation of the knitting machine, said last named means including a transformer; and means controlled by said tension bar to regulate said transformer to vary the output voltage thereof in proportion to changes in the average tension in the warp sheet, whereby the rotational speed of said motor and beam are varied to let off said warp sheet under substantially uniform average tension.

3. In a textile fabric producing machine: fabric forming instrumentalities; a warp beam from which a warp sheet extends to said instrumentalities, said instrumentalities acting during normal cyclically repeated operations to incorporate said warp sheet into the fabric and acting with said beam to produce in said warp sheet cyclically repeated variations in tension between upper and lower normal tension limits; rotary means comprising an electric motor acting to continuously rotate said warp beam during operation of the machine to continuously let off therefrom said warp sheet and susceptible to applied positive and nega-

tive acceleration influences to increase and decrease, respectively, the speed of rotation of the beam; tension variation responsive means sensitive to variation of the warp sheet tension above said upper normal limit and below said lower normal limit; and means comprising a variable voltage transformer governed by said last named means and acting upon sensing by the latter of variation of the warp sheet tension above said upper normal limit to apply a positive acceleration influence to said rotary means and acting upon sensing of the tension variation responsive means of variation in the warp sheet tension below said lower normal limit to apply a negative acceleration influence to said rotary means; whereby said warp beam is continuously rotated to let off said warp sheet under tensions varying not substantially above said upper limit or below said lower limit.

4. In a warp knitting machine, instrumentalities including needles and operable to form a fabric from yarns; a warp beam supplying at least a part of said yarns in a warp sheet to said needles; movable support means; a tension bar supported by said support means and about which said sheet extends, said bar being abnormally moved in a first direction in response to increase in average tension in said sheet and being abnormally moved in a second direction in response to decrease in said average tension; means including an electric motor connected to said beam and acting upon energization of the motor to rotate the beam to let off the warp sheet therefrom; a transformer supplying electrical energy to said motor and including a primary and a secondary; movable control means capable, upon movement, of varying the magnetic flux linking said primary and secondary; and means connecting said movable support means and said movable control means and moving the control means upon abnormal movement of the support means; whereby, upon abnormal movement of said tension bar in said first direction, said flux linkage will be regulated to cause increase in the rate of rotation of said warp beam and, upon abnormal movement in said second direction, said linkage will be regulated to decrease the rate of rotation of said warp beam, to let off the warp sheet from said beam under substantially constant average tension.

5. In a fabric forming machine, the combination of fabric forming instrumentalities, a rotary yarn supply and means for advancing said yarn supply, said means being responsive to voltage changes in current supplied thereto for varying the rate at which it rotates said yarn supply, an electrical circuit for supplying current from a substantially constant voltage source to said means for advancing the yarn supply, said circuit including a variable voltage transformer having a primary and a secondary, and means responsive to variations in yarn tension between said supply and instrumentalities which includes a relatively movable magnetic means for inducing a leakage of magnetic flux within that portion of the circuit between the primary and secondary of the transformer, thereby to vary the voltage at that portion of the circuit from which the means for rotating the yarn supply is energized.

6. In a fabric forming machine, the combination of fabric forming instrumentalities, a rotary yarn supply and electromotive means for advancing said yarn supply, said means being responsive to voltage changes in current supplied thereto for varying the rate at which it rotates said yarn supply, an electrical circuit for supplying current from a substantially constant voltage source to said electromotive means, a variable voltage transformer in said circuit comprising a primary coil and a secondary coil linked by a magnetic flux path, and variably positionable means within said flux path for causing leakage of flux in the path between said coils thereby to vary the voltage at said secondary coil from which the electromotive means is energized, and means responsive to tension in the yarn between said supply and instrumentalities and interconnected to the variably positionable means for determining the position and movement thereof.

7. In a fabric forming machine, the combination of fabric forming instrumentalities, a rotary yarn supply and electromotive means for advancing said yarn supply, said means being responsive to voltage changes in current supplied thereto for varying the rate at which it rotates said yarn supply, an electrical circuit for supplying current from a substantially constant voltage source to said electromotive means, a variable voltage transformer in said circuit comprising a primary coil and a secondary coil linked by a magnetic flux path, and variably positionable means within said flux path for causing the flux therein to vary which includes a short circuited coil of non-magnetic, current conducting material for interposing a variable inductance within the flux path between the said primary and secondary coils, thereby to vary the voltage at said secondary coil from which the electromotive means is energized, and means responsive to tension in the yarn between said supply and instrumentalities and interconnected to the variably positionable means for determining the position and movement thereof.

8. In a fabric forming machine, the combination of fabric forming instrumentalities, a rotary yarn supply and electromotive means for rotating said supply, said means being responsive to voltage changes in current supplied thereto for varying the rate at which it rotates said supply, an electrical circuit for supplying current from a substantially constant voltage source to said electromotive means, a transformer in said circuit comprising a primary energized from said source, a secondary from which said electromotive means is energized and a core defining a magnetic flux path linking said primary and secondary, and means for varying the output voltage of said transformer which comprises a movable member positioned within the core and adjustable for variably inducing flux leakage, and means responsive to tension in the yarn between said supply and instrumentalities and interconnected to the movable member for determining its position and effect upon the output voltage of the transformer in accordance with tension in the yarn.

9. Mechanism as defined in claim 8 wherein said means for varying the output voltage of the transformer includes both a magnetic portion for inducing flux leakage within the core and a short circuited, non-magnetic, conducting coil for interposing a variable inductance within the flux path.

10. Mechanism as defined in claim 8 wherein the means responsive to tension in the yarn and interconnected to the said movable member comprises an arm movable with the yarn in accordance with tension changes therein, a link connected to said arm and to the movable member.

said link having a lost motion means therein by which normal tension variations in the yarn are permitted without attendant voltage change at the output from the secondary of the transformer.

11. In a warp knitting machine having yarn knitting instrumentalities, a warp yarn supply beam, electromotive means responsive to changes in voltage of current supplied thereto for rotating said warp beam, and yarn tension responsive means effective upon the yarn between the said beam and knitting instrumentalities, an electrical circuit for supplying current from a substantially constant voltage source to said electromotive means, a variable voltage transformer having a primary and a secondary in said circuit and means interconnected to said yarn tension responsive means and positioned between said primary and secondary for varying the flux in a magnetic flux circuit linking the said primary and secondary, thereby to vary the voltage at that portion of the circuit from which the electromotive means is energized.

12. In a warp knitting machine having yarn knitting instrumentalities, a warp yarn supply beam, an electric motor for rotating said supply beam, said motor being responsive to changes in voltage of current supplied thereto for rotating the beam at different speeds, and a yarn tension responsive means effective upon the yarn between the said beam and knitting instrumentalities, an electrical circuit for supplying current from a substantially constant voltage source to said motor, a transformer in said circuit, said transformer having a primary connected to said source, a secondary from which said motor is energized and a core linking said primary and secondary and defining a magnetic flux pathway, and means interconnected to said yarn tension responsive means and comprising a rotatable magnetic member movable to different positions within said core and effective to cause leakage of magnetic flux intermediate the primary and secondary coils thereby to vary the voltage output at the secondary side of the circuit and consequently the speed at which said motor affects let-off from said warp yarn supply beam.

13. In a fabric forming machine, the combination of fabric forming instrumentalities, a rotary yarn supply and electromotive means for rotating said supply, said electromotive means being responsive to changes in voltage of current supplied thereto for varying the rate at which it rotates said yarn supply, and yarn tension responsive means effective upon the yarn between said supply and instrumentalities, an electrical circuit for conducting current from a substantially constant voltage source to said electromotive means, a variable voltage transformer having a primary and a secondary in said circuit and means interconnected to and variably positioned by said yarn tension responsive means and effective upon the variable voltage transformer to vary the magnetic flux linking the said primary and secondary thereof, thereby to vary the output voltage therefrom to the said electromotive means.

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