F. W. HEMPELMANN.

WINDING MECHANISM.

APPLICATION FILED MAY 22, 1912.

1,055,276.

Patented Mar. 4, 1913.

4 SHEETS—SHEET 1.

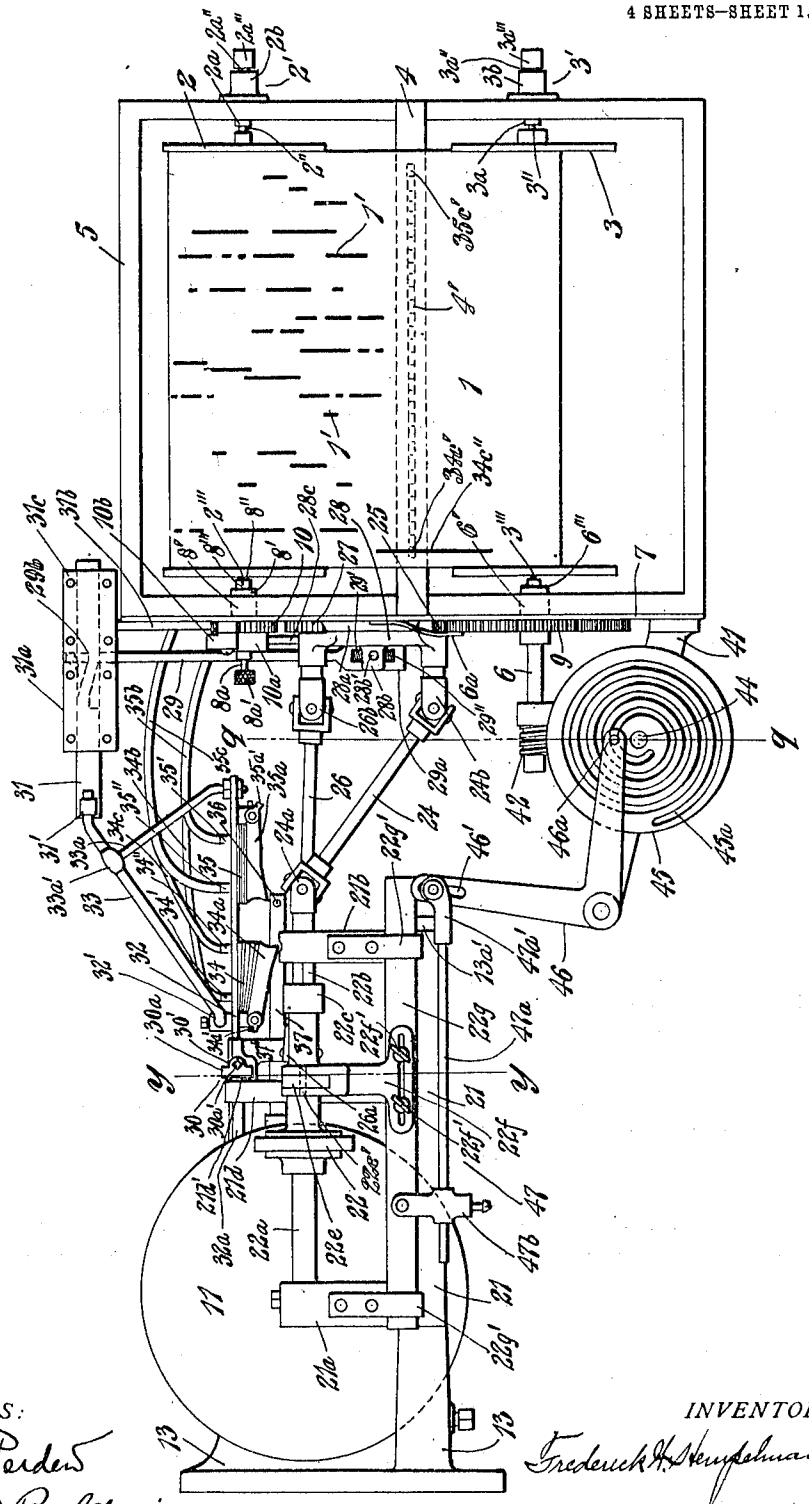

Fig. 1.

WITNESSES:

Clarence Perdew

James A. Baldwin

INVENTOR.

Frederick W. Hempelmann

F. W. HEMPELMANN.

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4 SHEETS—SHEET 2.

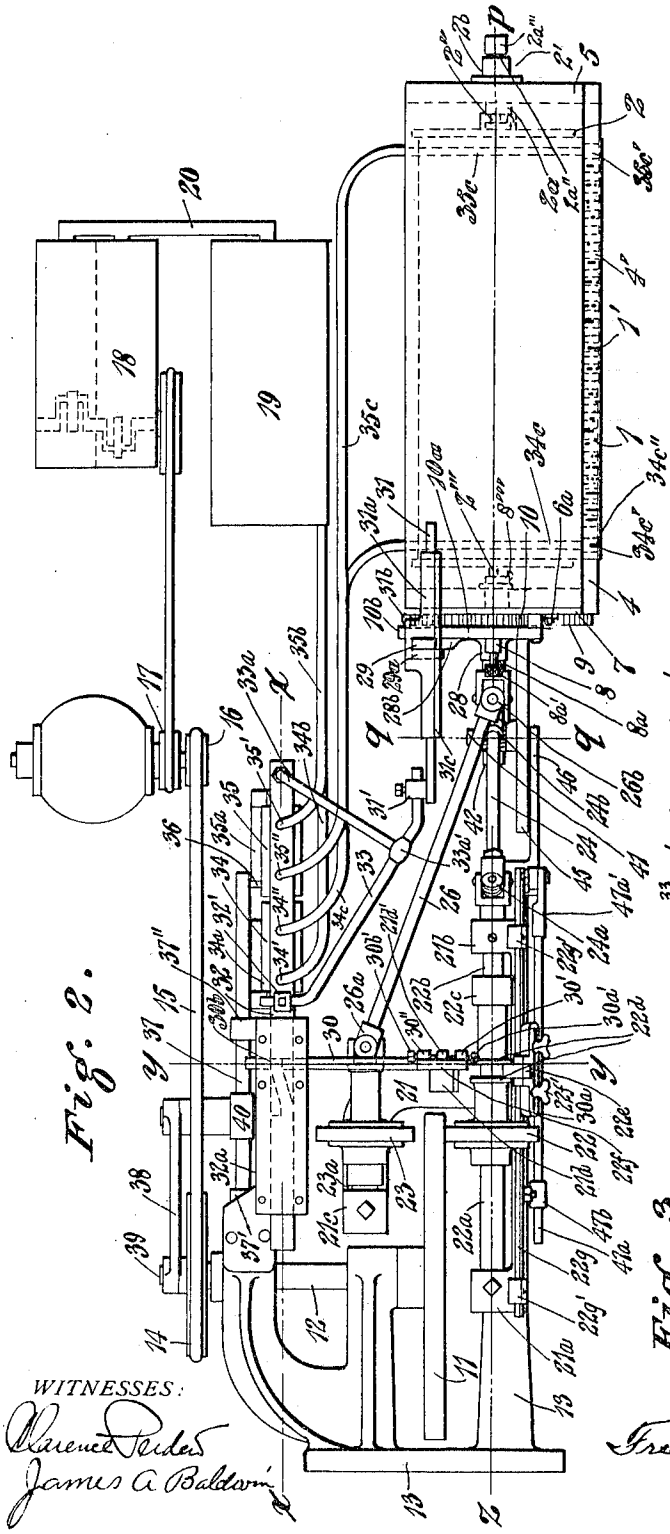

Fig. 2.

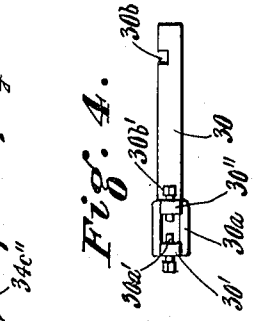

Fig. 4.

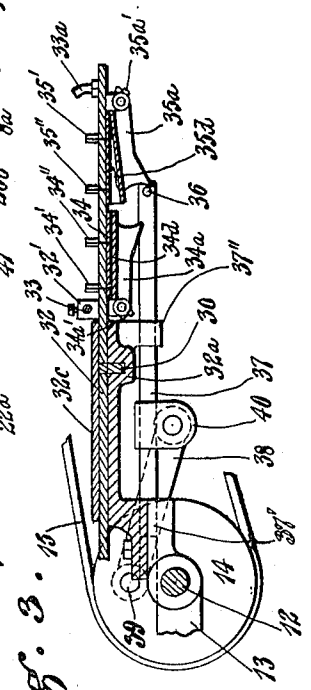

Fig. 3.

WITNESSES:

Clarence Rider

James A. Baldwin

INVENTOR.

Frederick W. Hempelmann

F. W. HEMPELMANN.

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4 SHEETS—SHEET 3.

Fig. 5.

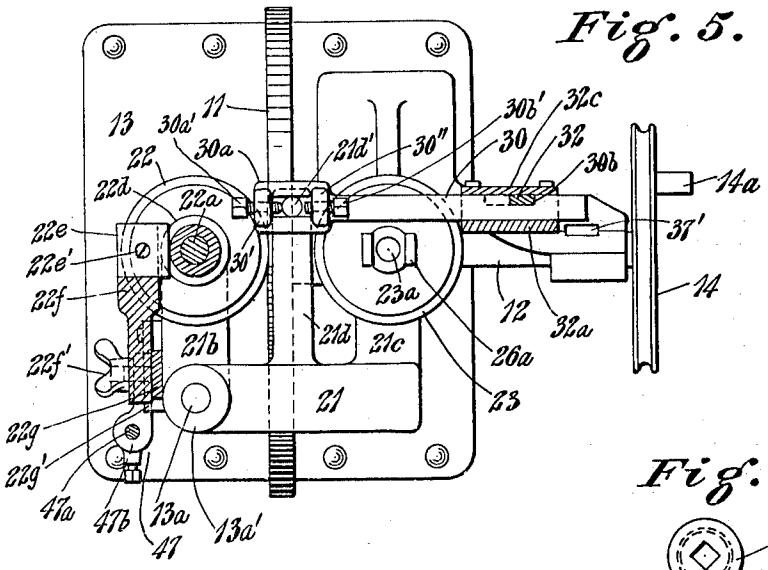


Fig. 7.

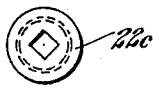


Fig. 6.

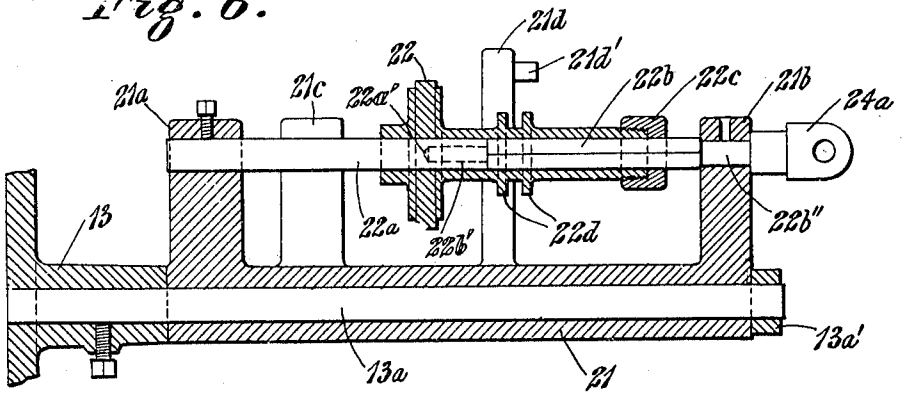
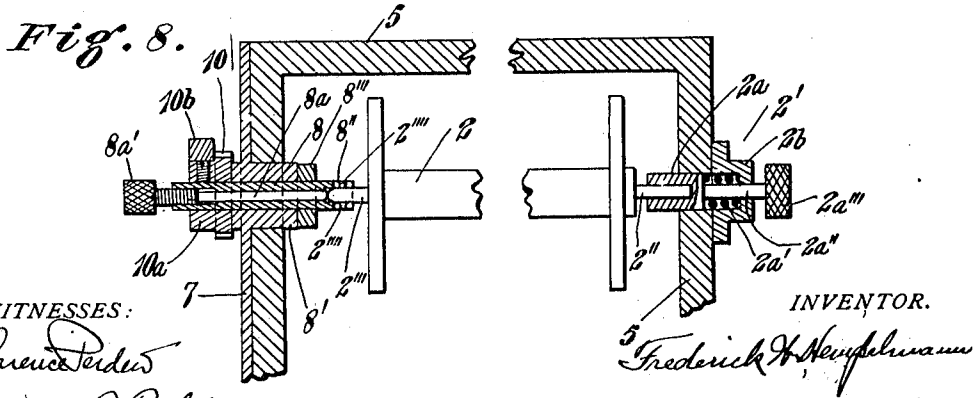


Fig. 8.



WITNESSES:

Clarence Perdue

James A. Baldwin

INVENTOR.

Frederick W. Hempelmann

F. W. HEMPELMANN.

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4 SHEETS—SHEET 4.

Fig. 9.

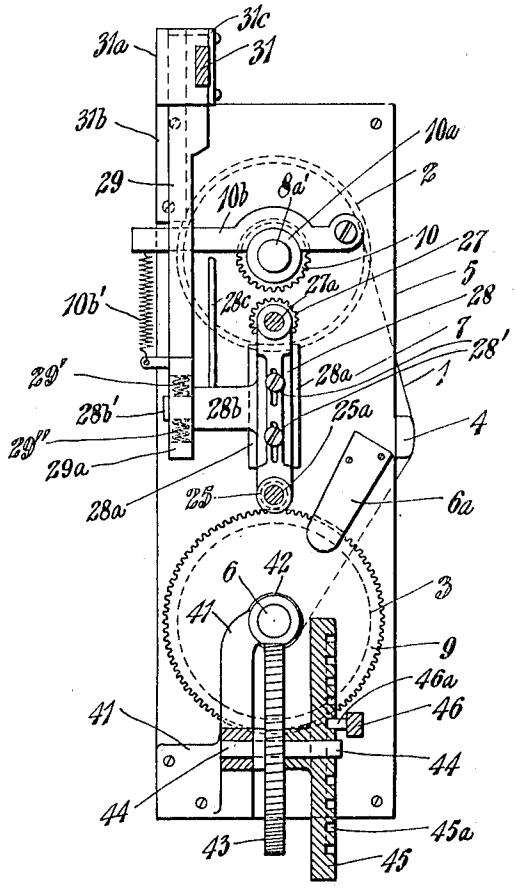
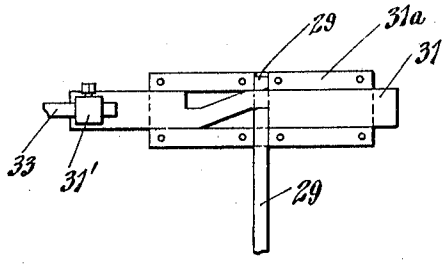


Fig. 10.



WITNESSES:

Clarence Peiden

James A. Baldwin

INVENTOR.

Frederick W. Hempelmann

UNITED STATES PATENT OFFICE.

FREDERICK W. HEMPELMANN, OF CINCINNATI, OHIO.

WINDING MECHANISM.

1,055,276. Specification of Letters Patent. Patented Mar. 4, 1913.

Application filed May 22, 1912. Serial No. 698,875.

To all whom it may concern:

Be it known that I, FREDERICK W. HEMPELMANN, a citizen of the United States, residing at Cincinnati, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Winding Mechanism, of which the following is a specification.

My invention relates to machine elements, and has for its object the control of speed of travel of an element being wound, and compensating, in ratio of driving speed to winding speed, for the increase in peripheral dimensions of the accumulation due to winding.

A further object is to provide for reversal of the winding operation with synchronous reverse operation of the compensating means during such reversal of the winding operation, and to also provide means for automatically effecting the change from the winding operation to the reversal thereof, or vice versa.

The invention consists in the parts and in the details of construction and arrangement of parts, as will hereinafter be more fully described and claimed.

In the drawings: Figure 1 is a front elevation of a winding mechanism for the sheet of a self-playing musical instrument, which application of my invention I have chosen for illustrating it. Fig. 2 is a plan view of the same. Fig. 3 is a section on the line *x*—*x* of Fig. 2. Fig. 4 is a detail of the cross-slide. Fig. 5 is a section on the line *y*—*y* of Figs. 1 and 2, looking to the left. Fig. 6 is a section on the line *z*—*z* of Fig. 2. Fig. 7 is a detail of the end-cap for the main friction-wheel shaft. Fig. 8 is a section on the line *p*—*p* of Fig. 2, parts being omitted for lack of space. Fig. 9 is a section on the line *q*—*q* of Figs. 1 and 2, looking to the right. Fig. 10 is a detail plan view of one of the slidable cams with its mounting, being represented as having its cover-plate removed. Figs. 5 to 10 inclusive are on a scale somewhat enlarged from that of Figs. 1 to 4, inclusive. The showing of the connections to the mechanism of the musical instrument proper is omitted for sake of clearness. It will be understood that such minor details may vary, according to the kind of instrument the mechanism is applied to.

In the device here exemplifying my invention, the perforated sheet 1 is wound from the upper spool 2 onto the lower spool 3 during the rendition of the music, passing over the tracker-board 4, which has a series of orifices 4′ through which air is admitted when the corresponding perforations 1′ of the sheet pass over them. Through these orifices the air acts, by means of suitable mechanism, upon the instrument, in any of a number of ways familiar to those skilled in the art of constructing self-playing musical instruments. When the playing of the piece of music has been completed, the sheet is re-wound onto the upper spool, for repetition. It is commonly desired that this re-wind, and also the repetition, may be started automatically, and my invention is concerned with this, as will be made plain herein. Another very important requirement is that the sheet, during the playing of the music, shall pass over the tracker-board, at a constant speed, allowing the predetermined positions of the perforations to have accurate control of the time of the music. It is with this accomplishment that my invention is primarily concerned.

As shown, the spools 2 and 3 are supported in a frame 5, which also supports the tracker-board. The lower spool 3 is simply mounted at one end on a yieldable bearing 3′, allowing it to be inserted in the frame, and makes engagement at the other or driving end with a main arbor 6, journaled in a bearing 6′ in a plate 7 that is fastened to the outside of the frame 5, said bearing projecting through the frame at this point. The upper spool 2 is mounted at one end on a yieldable bearing 2′, and at its driving end on a re-winding arbor 8, likewise journaled in a bearing 8′ in the plate 7, projecting inside the frame 5. The mounting of the upper spool is illustrated in detail in Fig. 8, and the mounting of the lower spool may be understood from the description of this upper mounting, especially with reference to the rear bearing. This rear bearing 2′ comprises a plunger 2^a which receives the spindle 2″ of the spool 2 and compresses a spring $2^{a'}$ in a casing 2^b around its stem $2^{a''}$ that extends through the rear end of the casing and has a knob $2^{a'''}$ for taking hold to manipulate the bearing during insertion of the spool as may well be understood from inspection of the drawing. The lower rear bearing 3′ is identical with the upper one,

having, as may be seen in Fig. 1, a plunger 3^a receiving the spindle $3''$ of the spool 3, and having a casing 3^b from which the stem $3^{a''}$ protrudes with the knob $3^{a'''}$ thereon. The upper driving-end mounting is different from the lower driving-end mounting chiefly in that the upper one is adjustable so that the upper spool may be accurately alined with the lower spool. Thus, the re-winding arbor 8 is hollow throughout, and has its bore somewhat enlarged at its rear end, to receive the forward spindle $2'''$ of the spool 2. A diametral slot $8''$ crosses this enlarged spindle-receiving part of the bore, opening from the rear end of the shaft, and receives diametrically extended lugs $2''''$ on the spindle. The slot $8''$ is long enough to allow enough movement of the lugs $2''''$ therein to provide the desired adjustment of the upper spool with respect to the lower one. The re-winding arbor 8 has another enlargement to its bore at its forward end, and this is threaded and receives an enlarged threaded part of a pin 8^a that extends its unenlarged part through the unenlarged part of the bore in the arbor, and engages its end with the end of the spindle $2'''$ of the spool 2. The forward end of this pin 8^a has a knob $8^{a'}$, and by turning the pin to screw it in or out, the spool 2 will move longitudinally, against or with the pressure of the spring $2^{a'}$ at the rear. The lower main arbor 6 receives the spindle $3'''$ of the lower spool 3 in the manner above described, but there is no pin for adjusting the spool. It will be seen that with the above-described mountings the spools will be rotated with their respective arbors, but may be removed and like spools with different perforated sheets inserted, which is a requirement peculiar to self-playing instruments here illustrated.

For driving the sheet on its downward travel, to play the music, the main arbor 6 has a spur-gear 9 fixed on it outside the bearing $6'$, and for re-winding the sheet, the re-winding arbor 8 has a spur-gear 10 fixed on it outside the bearing $8'$. Collars $6'''$ and $8'''$, inside the bearings, prevent end play of the arbors 6 and 8, respectively.

The gear 10 of the re-winding arbor has a sheave 10^a integral with it, by means of which it is screwed to the arbor, and a shoe 10^b bears on this sheave during the downward travel of the sheet, to prevent racing of the upper spool. A flat spring 6^a bears on the gear 9, below, to similarly control the lower spool during the re-winding. This flat spring is allowed to bear constantly, but the shoe 10^b, above, is controlled so as to be released from engagement with the sheave 10^a during the re-winding, as will presently be explained.

For driving the mechanism, either in playing or re-winding, a disk 11 is mounted on a shaft 12 journaled transversely in the stationary bracket 13, which may be fixed on the structure of the instrument in which the mechanism is used, as may also the frame 5 that supports the spools. A pulley 14 is fixed on the shaft 12, and a belt 15 passes therearound and around the pulley 16 of a motor. As shown, for sake of simplicity, this motor has another pulley 17 that drives suitable bellows 18 for exhausting air from a chest 19, through a pipe 20. This simple arrangement may represent any suitable pneumatic apparatus of a musical instrument, and is sufficient for illustrating the details of my invention, as they are to be described.

Mounted on the stationary bracket 13, on a longitudinal stud 13^a fixed in the bracket, is a tiltable bracket 21, held on the stud 13^a by a collar $13^{a'}$. This mounting is best shown in Fig. 6. This bracket has two main uprights 21^a and 21^b, supporting the main friction wheel 22 at one side of the disk 11, and it has a third upright 21^c which supports the re-winding friction-wheel 23 at the other side of said disk. The bracket, on tilting, with the stud 13^a as a pivot, will bring one or the other of the friction-wheels 22 and 23 into engagement with the adjacent face of the disk.

Referring again to Fig. 6, the main friction wheel 22 is journaled on a stud 22^a fixed in the upright 21^a, and extending about half the distance to the other upright 21^b. A square shaft 22^b has a reduced part $22^{b'}$ journaled in a bore $22^{a'}$ in the free end of the stud 22^a, and this square shaft has another reduced part $22^{b''}$ journaled in the other upright 21^b. The friction-wheel 22 has an elongated hub, which has a circular opening throughout, so that said wheel can slide the full exposed length of said stud 22^a and turn thereon as it slides. To cause it to turn with the square shaft, which also enters the circular bore of the wheel-hub, a cap 22^e is screwed onto the end of the hub, with a square hole that accurately engages with the square shaft and slides therealong. Thus, it will be seen that the friction-wheel 22 may engage with the face of the disk 11 throughout a considerable part of the radius of the disk, and the speed at which the friction-wheel is rotated by the disk will vary according to the position of the engagement. By sliding the friction-wheel at a given speed along its bearings, the speed of the friction-wheel may vary gradually, in exact accordance with its sliding.

A connecting shaft 24 has a universal joint 24^a with the square shaft 22^b, and has another universal joint 24^b with a small spur pinion 25 that is adapted to mesh with the spur gear 9 of the lower spool mechanism. The mounting of this small pinion 25 will be described presently.

The re-winding friction-wheel 23, best seen in Fig. 2, is simply mounted on a stud 23^a in the third upright 21^c, the wheel having an amply long hub to afford it a proper bearing on its stud, upon which it turns loosely, having suitable means to limit end play, not deemed necessary of detailed illustration herein. No longitudinal movement of this re-winding wheel is needed, it being merely mounted near the periphery of the disk 11 to impart to it the highest speed the disk affords, since the re-winding is to be performed in as short time as practicable, without concern as to the uniformity of speed of travel of the sheet upwardly. It will, of course, be understood that the music-producing mechanism is disconnected during the re-winding, as is well known to those skilled in the musical mechanism art.

A connecting shaft 26 has a universal joint 26^a with the hub of the wheel 23, and has another universal joint 26^b with a spur pinion 27 that is adapted to mesh with the spur gear 10 of the upper spool mechanism. This pinion 27 along with the before-mentioned pinion 25, is journaled in a slidable bracket 28, best seen in Fig. 9, each pinion being fixed on a short shaft 27^a or 25^a, to which the universal joints 26^b and 24^b are fixed, respectively. This bracket 28 slides vertically in guides 28^a on the plate 7, being held therein by screws 28′ taking through slots in the bracket. When the bracket slides down, the pinion 25 meshes with the gear 9, to drive the lower spool; and when the bracket slides up, the pinion 27 meshes with the gear 10, to drive the upper or re-winding spool. When either pinion meshes the other unmeshes. As shown, the ratio between the lower gear and pinion is much greater than that between the upper gear and pinion; this provides the requisite slowness of playing travel of the sheet, and the needed speed of re-winding travel, in addition to the provisions for the ratio of the main friction-wheel and of the re-winding friction-wheel, respectively, to the disk 11.

In meshing the gears and pinions, as just described, it is necessary to provide for the contingency of the teeth of a gear and pinion meeting end-on, and thus damaging the mechanism before they can slide out of such engagement into their proper meshing engagement, by the turning of the pinion. I provide for this by yieldingly engaging the bracket to move it. Thus, the extension 28^b on one side of the slidable bracket has a lug $28^{b'}$, and a vertical slide 29 has a stirrup 29^a that receives this lug and engages it with helical springs 29′ and 29″ above and below respectively. These springs yield enough to prevent damaging strain in the contingency above mentioned, but are firm enough to maintain the gears and pinions in mesh for performing their work.

The shoe 10^b bearing on the sheave 10^a during the playing travel of the sheet, is released during the re-winding, as before alluded to, by the engagement of a spur 28^c, fixed in the extension 28^b of the slidable bracket and engaging with the under side of said shoe. The shoe is engaged with the sheave by the pull of a helical spring $10^{b'}$, attached to the under side of the shoe by one end and to a lug on the stirrup 29^a of the slide 29 by the other end.

While, as above described, the meshing of the pinions 25 and 27 with their respective gears 9 and 10 is done by yieldable engagement, the tilting of the tiltable bracket 21, to engage either of the friction-wheels 22 and 23 with the disk 11 is, on the contrary, done by positive engagement, which, however, is made adjustable, so that exactly the right pressure of either friction-wheel may be maintained against the disk. This is accomplished by a cross-slide 30, with a stirrup 30^a, at the sides of the opening of which are lugs 30′ and 30″, in which are set-screws $30^{a'}$ and $30^{b'}$, pointing toward each other across the opening. An upright arm 21^d forms part of the tiltable bracket 21, near the periphery of the disk 11, and it has a lug $21^{d'}$ that extends into the opening of the stirrup 30^a of the cross-slide 30, to be engaged by one or the other of the set-screws $30^{a'}$ and $30^{b'}$, accordingly as the friction-wheel 22 or the friction-wheel 23 is to be engaged with the disk. A slight amount of lost motion will thus be involved, but the important requirement is that these set-screws be so adjusted at all times as to provide the required frictional engagement to impart the exact speed of any part of the face of the disk to the periphery of the friction-wheel. Such adjustment also will enable the slight wear of the friction wheels to be compensated, from time to time, although this wear is very slight, and will necessitate no frequent adjustment.

The friction-wheels 22 and 23 may have their peripheries composed of suitable fiber composition, well known in the art of friction transmission. These friction-wheels, with the engaging means above described, are found, in practice, to accurately transmit the motion of the disk, with no perceptible loss of motion. This dependence upon the uniform coöperation of the main friction-wheel 22 is an important factor in the success of my invention, as will later be made plain.

For shifting the slidable bracket 28 and tilting the tiltable bracket 21 simultaneously, their respective slides 29 and 30 are provided with slidable cams 31 and 32, respectively, connected by a strut 33, so that the two cams move as a unit. Swivel studs 31′ and 32′, respectively, are provided on the cams to receive the strut for proper adjustment, it be-

ing held in the studs by set-screws. The slidable cam 31 for shifting the slidable bracket 28 is mounted in a guide-block 31ª, which is attached to the plate 7 on the side of the frame 5, by means of a cleat 31ᵇ. This guide-block has a cross-slot in which the vertical slide 29 is accurately guided, the guide-block being mounted with its cross-slot vertical to receive the vertical slide. This vertical slide has a detent 29ᵇ that receives an inclined reduced part of the slidable cam 31. This inclined reduced part joins the main part of the cam at each end of said reduced part by a straight part. Either one or the other of said straight parts occupies the detent 29ᵇ, to hold the vertical slide up or down, as the case may be, and the passage of the inclined part through the detent raises or lowers the vertical slide, thus converting the motion of the slidable cam into motion of the vertical slide, at right-angles to the motion of the slidable cam.

The sides of the detent 29ᵇ are, in their major part, conformed to the straight parts of the cam, to provide for ample locking engagement with said straight parts. Minor parts of said sides, however, are inclined to conform to the inclined part of the cam, thus receiving the wear incident to the shifting. The straight parts of the cam are as long as the vertical slide is in thickness, so that there is some lost motion until the inclined parts engage. These details are readily seen in Fig. 10. A cover-plate 31ᶜ is secured to the guide-block 31ª, over the cam and the vertical slide.

The slidable cam 32 is identical in its construction and mounting with the cam 31, except that the guide-block 32ª, somewhat modified, is mounted horizontally, on the stationary bracket 13, over the bearing of the shaft 12. The cross-slide 30 is accurately guided in the cross-slot in the guide-block 32ª, and has a detent 30ᵇ receiving the reduced part of the cam, and acted upon by said cam as has been described in connection with the vertical slide 29. The inclined parts of the two cams 31 and 32 are, as shown, oppositely directed, to effect the proper simultaneous operation of the vertical slide and the cross-slide, respectively. The guide-block 32ª has a cover-plate 32ᶜ.

It is highly desirable that the shifting of the mechanisms from playing to re-winding operation and vice versa be effected automatically, in strict accordance with the conditions imposed by the particular sheet being carried. This is best effected by utilizing a pneumatically controlled device, actuated, in each instance, by the presence of a slot over an orifice in the tracker board. I carry out this by mounting on one of the cams, in this instance on the cam 32, a pair of bellows 34 and 35, with their expansible ends facing each other, and pivoting a pair of pawls 34ª and 35ª respectively on said cam, to be actuated by the respective bellows into and out of engagement with a stud 36 on a constantly reciprocating bar 37, as is best shown in Fig. 3. These bellows and pawls are mounted on the lower side of the cam 31, which is extended for the purpose, the pivots of the pawls being at the inexpansible ends of the respective bellows and being heavy enough and rigidly enough secured to the cam to withstand the somewhat heavy impact from the stud and thus transmit it to the shifting mechanisms. The engaging ends of the pawls are somewhat concave to counteract any tendency of the pawls to slip away from the stud, but the lower edges of said pawls are inclined upwardly from these engaging ends toward the pivots, so that when a pawl comes down, on the expansion of its bellows, and engages this lower edge with the stud 36, no operative engagement will occur here. In such event, the pawl is raised until the stud is reciprocated from under it, and then falls again to have its end engaged by the stud as it returns on its next reciprocation. Each bellows has two openings to its interior, 34′ and 34″ and 35′ and 35″, respectively. Tubes 34ᵇ and 35ᵇ lead from the openings 34′ and 35′ to the chest 19, in which vacuum is maintained by the bellows 18, before described; and tubes 34ᶜ and 35ᶜ lead from the openings 34″ and 35″ to orifices 34ᶜ′ and 35ᶜ′ in the tracker-board. The sheet 1 has a perforation 34ᶜ″, which is shown in the drawing as being over the orifice 34ᶜ′; it will be understood that the sheet 1 shall have another perforation, near the other end of the sheet, which is understood as being wound upon the upper spool 2 as shown in the drawing, and that this other perforation is near the other side of the sheet, to come over the other orifice 35ᶜ′ when the playing of the piece of music has been completed. As shown, the re-winding has just been completed, and the mechanisms have been shifted to begin the playing operation of the sheet. This device operates by the cessation of the vacuum which was maintained throughout the tube from the vacuum chest, the respective bellows on the cam, and the tube from there to the tracker-board; this cessation occurring as soon as the perforation in the sheet comes over the orifice, admitting atmospheric air to the above described spaces, which air had been excluded as long as the imperforate part of the sheet ran over the orifice. The rush of air into the spaces, destroying the vacuum, allows the pawl attached to the bellows to be forced down by the flat spring 34ᵈ or 35ᵈ, inside the bellows 34 or 35, as the case may be. Then, the stud 36 engaging with the pawl that has dropped, the mechanisms will be shifted at once, after which, the perforation leaving the orifice and the imperforate

parts of the moving sheet closing the orifice again against atmospheric pressure, the air will again be exhausted from the spaces, the bellows will again collapse, and the pawl will be raised again. Each pawl has a lug $34^{a'}$ or $35^{a'}$ adjacent its pivot, to limit the drop of the pawl. It will be seen that all strain is confined to the pawls, and the bellows need only perform the duty of controlling the positions of the pawls. The springs 34^{d} and 35^{d} may be dispensed with where the pawls are heavy in comparison to the efficacy of the vacuum maintained; thus, the pawls may drop of their own weight, and the effect of the vacuum need be only to overcome said weight. The bar 37 is reciprocated by a pitman 38 on a wrist-pin 39 in the pulley 14, said pitman being also connected to a block 40 rigid on the bar 37 between the two bearings 37′ and 37″ of the bar, in the stationary bracket 13 and on the guide-block 32^{a}. The stroke of this bar 37 is such that it equals the required movement of the cams 31 and 32 plus the distance between the engaging ends of the pawls 34^{a} and 35^{a} minus the diameter of the stud 36. Thus, when the stud has pushed the cam to the limit of its stroke in either direction it cannot act further in that direction, and the pawl may be raised at leisure, during the return travel of the sheet, either playing or rewinding. In actual practice, but a small fraction of the time thus allowed is required for the vacuum to be reëstablished and the pawl returned to its raised position. The outer end of the extension of the cam 32 is supported from the strut 33 by a brace 33^{a}, the head $33^{a'}$ of which may slide on the strut to allow the adjustment of the strut as before mentioned. It will be seen that by this combination of pneumatic and mechanical action, the intimacy of relation with the pneumatic action of the sheet is obtained, while the powerful and certain action of the driving mechanism is utilized under the accurate control assured by such intimate relation with the pneumatic action.

The major and minor details of the driving and reversing mechanism of my invention being described, the compensating mechanism, which is the crux of the invention, and which has not been confused with the other details, excepting to mention that the main friction-wheel 22 is slidable across the face of the disk 11, may now be described with facility, and its relation to the other factors clearly demonstrated.

The friction-wheel 22, slidable on its stationary stud 22^{a} and square shaft 22^{b}, and turning the latter at such speed as this wheel derives from contact with the face of the disk, has annular flanges 22^{d} on its hub, and a key 22^{e} fits accurately between these flanges at one side. This key is carried in a head 22^{f} mounted on a slide-rod 22^{g}, slidable in brackets $22^{g'}$ on the uprights 21^{a} and 21^{b} of the tiltable bracket 21.

The main arbor 6, of the lower spool 3, is extended forwardly and journaled in an arm of a bracket 41, mounted on the lower part of the frame 5. This arbor 6 has a worm 42 fixed on it, and this worm meshes with a worm-wheel 43, fixed on a shaft 44 journaled transversely in the bracket 41. On the end of this shaft 44 is fixed a spiral-cam 45, having a spiral groove 45^{a} cut in its face. Another extension of the bracket 41 carries a pivot for a bell-crank lever 46, one arm of which extends across the spirally grooved face of the cam 45 and has a stud 46^{a} entering the spiral groove. The other arm of this lever extends up and connects, by a suitable pitman arrangement 47, to the slide-rod 22^{g} that carries the head 22^{f} with the key 22^{e} engaging in the space between the annular flanges 22^{d} on the hub of the friction-wheel 22.

The pitman arrangement 47 comprises the pitman-rod 47^{a} received in a connection 47^{b} that is pivoted to the slide-rod 22^{g} and depends therefrom, said pitman-rod being adjustably held therein by a set-screw, allowing the pitman arrangement to be adjusted in length. Further longitudinal adjustment is provided by mounting the head 22^{f} on the slide-rod 22^{g} by thumb-screws $22^{f'}$ taking through slots in a lower widened part of the head. Thus the head, with its key, and consequently the friction-wheel 22 itself, may be adjusted longitudinally with respect to the slide-rod 22^{g}, and the slide-rod may be similarly adjusted with respect to the bell-crank lever 46. The other end of the pitman-rod 47^{a} has a head $47^{a'}$ which carries a clamping-stud to be adjustably held in a slot 46′ longitudinally of the arm of the lever 46, near the upper end of said arm. By this means, the movement of the friction-wheel 22 relative to the movement of the stud in the spiral groove 45^{a} may be adjusted.

The key 22^{e} in the head 22^{f} is preferably made of hard fiber, so that it will wear rather than the flanges 22^{d}. This key, as shown, is made equilateral, and may be removed from its socket in the head 22^{f} and rotated one-quarter turn, to present a new surface to the flanges 22^{d} when it has become worn excessively on the first edge. This rotation may be repeated until the four edges have been presented for use, and then may be renewed. A screw $22^{e'}$ passes centrally through the key and through the sides of the head, to hold the key in the socket.

It will be noted that the drawings illustrate the mechanism with the winding of the sheet onto the lower spool in its inception. Thus, the maximum speed has been utilized here, and is gradually diminishing

as the travel of the stud outward in the spiral groove 45ª causes the friction-wheel 22 to approach the center of the disk 11. The spiral groove 45ª is virtually a modification of the volutions of the sheet as it is wound on the spool—modified in that the number of turns of the spiral are reduced from those of the sheet, and the radial displacement which each turn effects is magnified proportionately, with the speed of rotation of the spiral-cam 45 relative to that of the spool 3, and the ratio between the friction-wheel and the disk, taken into consideration. The reduction of speed from spool to spiral cam by means of the worm and worm-wheel is such, with respect to the other factors, that the increase in peripheral velocity of the accumulating roll on the spool 2 is exactly compensated in reduced speed of rotation of that spool, by the movement of the friction-wheel 22 onto constantly slower regions of the disk 11, which is turned at constant speed. When the playing travel is concluded, and the reversal is effected, unmeshing the pinion that drives the lower spool and the spiral cam, and disengaging the friction-wheel 22 from the disk 11, the upper spool 2, unwinding the sheet from the lower spool 3, will, by driving this lower spool, drive the spiral-cam 45 backward, and the stud will travel radially inward in the spiral groove 45ª. This will return the friction-wheel 22 to the exact position for its reëngagement with the disk 11, when the re-winding is completed and the playing operation is to begin again, so that, in this position, it will again begin to rotate the lower spool 3 at the proper speed for the correct rendition of the music.

Variations to secure differences in speed of travel of the sheet may be made with the various adjustments described, but the constant speed of the sheet will be maintained at any adjustment, in the playing operation.

It will be understood that, while I have described in detail the application of my invention to the operation of a self-playing musical instrument, it also will be understood that it is applicable, with such minor modifications as may be found necessary or desirable, to various other uses, wherever such compensation of driving speed during winding of an element is needed. Therefore, while I have illustrated and described my specific application of my invention herein in detail, I do not wish to be understood as limiting myself to the precise details thus set forth; but

What I claim as new and desire to secure by Letters Patent is:

1. In winding mechanism, in combination with an element to be wound, a rotatable face, a wheel frictionally engaging the face whereby the winding of the element is effected by the rotation of the face, through said wheel, compensating means, actuated in accordance with the winding of said element, to move said wheel across said face while in engagement therewith and while rotated thereby, and means, actuated through the driving of said element, for disengaging said wheel from said face and reversely acting upon said element and reversely acting upon said compensating means through said element.

2. In winding mechanism, in combination with an element to be wound, a rotatable face, a wheel frictionally engaging the face whereby the winding of the element is effected by the rotation of the face, through said wheel, spiral engaging means rotated in accordance with the winding of said element, and connection between said spiral engaging means and said wheel, to move said wheel across said face while in engagement therewith and while rotated thereby.

3. In winding mechanism, in combination with an element to be wound, frictionally engaging means for driving said element, and volute guiding means actuated in accordance with the winding of said element, to vary the conditions of engagement of the driving means.

4. In winding mechanism, in combination with an element to be wound; frictionally engaging means for driving said element, volute guiding means actuated in accordance with the winding of said element, to vary the conditions of engagement of the driving means, and means for disengaging the driving means and driving said element reversely, and thereby acting reversely on said volute guiding means.

5. In winding mechanism, in combination with an element to be wound, frictionally engaging means for driving said element, volute guiding means actuated in accordance with the winding of said element, to vary the conditions of engagement of the driving means, means for disengaging the driving means and driving said element reversely, and thereby acting reversely on said volute guiding means, and means whereby said element controls the action of said disengaging and reversing means.

6. In winding mechanism, in combination with an element to be wound, frictionally engaging means for driving said element, volute guiding means and connection therefrom to said driving means, whereby the guiding means changes the conditions of frictional engagement of said driving means, a worm-wheel with which the volute guiding means rotates, and a worm turning with the element being wound and in mesh with said worm-wheel.

7. In winding mechanism, in combination with an element to be wound, frictionally engaging means for driving said element,

volute guiding means actuated in accordance with the winding of said element, to vary the conditions of engagement of the driving means, and means for regulating the degree of variation imparted by said guiding means.

8. In winding mechanism, in combination with an element to be wound, frictionally engaging means for driving said element, volute guiding means actuated in accordance with the winding of said element, and means for regulating the relative positions of said driving means and said guiding means.

9. In winding mechanism, in combination with an element to be wound, frictionally engaging means for driving said element, volute guiding means actuated in accordance with the winding of said element, means for regulating the degree of variation imparted by said guiding means, and means for regulating the relative positions of said driving means and said guiding means.

10. In winding mechanism, in combination with an element to be wound, a rotatable face, a friction-wheel engaging the face and slidable across the face while rotated thereby to drive said element, volute guiding means actuated in accordance with the winding of said element, connection from said guiding means to the slidable friction-wheel, and means for regulating the length of said connection.

11. In winding mechanism, in combination with an element to be wound, a rotatable face, a friction-wheel engaging the face and slidable across the face while rotated thereby to drive said element, volute guiding means actuated in accordance with the winding of said element, a lever actuated by said guiding means, connection from said lever to said slidable friction-wheel, and means for adjusting said connection with respect to said lever, whereby the degree of sliding of said friction-wheel is controlled by said lever under the guidance of said volute guiding means.

12. In winding mechanism, in combination with an element to be wound, a rotatable face, a friction-wheel engaging the face and slidable across the face while rotated thereby to drive said element, volute guiding means actuated in accordance with the winding of said element, a lever actuated by said guiding means, connection from said lever to said slidable friction wheel, means for adjusting said connection with respect to said lever, whereby the degree of sliding of said friction wheel is controlled by said lever under the guidance of said volute guiding means, and means for adjusting said connection whereby the relative positions of said friction-wheel and said lever are regulated.

13. In winding mechanism, in combination with an element to be wound, a rotatable face, a friction-wheel engaging the face and slidable across the face while rotated thereby to drive said element, volute guiding means actuated in accordance with the winding of said element, a bell-crank lever actuated through one of its arms by said volute guiding means, a slide-rod adjacent said friction wheel, a head longitudinally adjustable on the slide rod and means whereby said head slides said friction-wheel, a pitman pivotally and longitudinally adjustably connected to said slide-rod, and clamping means on said pitman, said bell-crank lever having a radial slot in its other arm, in which said clamping means engages and adjustably and pivotally connects said pitman to said arm, for the purposes set forth.

14. In winding mechanism, in combination with an element to be wound, a rotatable face, a friction wheel engaging the face, an elongated hub on the friction wheel having a bore of circular cross-section throughout its length, a stud of circular cross section received in said bore, a shaft of angular cross-section also received in said bore and meeting and being supported by said stud therein, connection between said shaft and the element to be wound, whereby the element is driven, and a cap on the end of the elongated hub of the friction-wheel having an opening fitting on said shaft whereby said friction wheel is turned with the shaft but may slide therealong and along said stud, and may have its main bearing on said stud, said friction-wheel being thus adapted to slide under the guidance of means actuated in accordance with the winding of said element.

15. In winding mechanism, in combination with an element to be wound, and with compensating means actuated in accordance with the winding of said element, a rotatable face, a friction-wheel slidably mounted to rotate with the face by engagement therewith but to move across said face, a hub on the friction-wheel, annular flanges on the hub, a head connected to said compensating means, and a key carried in said head and engaging between said flanges, whereby said head slides said wheel as moved by the compensating means, said key being adjustable in said head to present different parts of its surface between said flanges, for the purposes set forth.

16. In winding mechanism, in combination with an element to be wound, and with compensating means actuated in accordance with the winding of said element, a rotatable face, a friction-wheel slidably mounted to rotate with the face by engagement therewith but to move across said face, a stud on which said wheel is journaled and is longitudinally slidable, and a shaft on which said wheel is longitudinally slidable but

which is rotated with said wheel and connected to said element, whereby said element is driven by said wheel.

17. In winding mechanism, in combination with an element to be wound, and frictional engaging means for driving said element, a disk with a spiral groove in its face, a stud guided in said groove, connection between said stud and the frictional engaging means, and connection between said disk with the spiral groove and said element, whereby it is rotated in accordance with the winding of said element, for the purposes set forth.

18. In winding mechanism, spools, an element wound from either spool to the other, a rotatable face, a friction-wheel engageable with said face to be rotated thereby but to move across said face, connection from said friction wheel to one of said spools allowing said movement across said face, volute guiding means rotated in accordance with the rotation of said one of said spools, and connection from said guiding means to said friction wheel, moving it across said face but allowing it to rotate with the face.

19. In winding mechanism, spools, an element wound from either spool to the other, a rotatable face, a friction-wheel engageable with said face, a stud on which the friction-wheel rotates but is slidable to move across said face, a shaft on which the friction-wheel is also slidable but which rotates with the friction-wheel, connection from said shaft to one of said spools, a spiral cam, a worm-wheel with which the cam rotates, a worm meshing with the worm-wheel and rotating with said one of said spools, a lever, a stud on the lever engaging with the spiral cam, a head engaging said friction-wheel to slide it but to allow it to rotate, guiding means for said head, and connection between said head and said lever, for the purposes set forth.

20. In winding mechanism, spools, an element wound from either spool to the other, frictional engaging means with variable driving connection to one of said spools, compensating means actuated in accordance with the driving of said one of said spools, frictional engaging means with driving connection with the other spool, means for alternating the different frictional engaging means, and connection between said compensating means and the frictional-engaging means that has variable driving connection, said compensating means being actuated reversely during the action of said frictional engaging means driving said other spool, through said element being wound.

21. In winding mechanism, in combination with an element to be wound, driving means for the element alternately frictionally engageable to drive said element in one direction or the other, and intermeshing connecting means between the driving means and the element, alternately engageable simultaneously with the alternate frictional engagement, for the purposes set forth.

22. In winding mechanism, in combination with an element to be wound, driving means for the element alternately frictionally engageable to drive said element in one direction or the other, alternately engageable intermeshing connecting means between the driving means and the element, means for positively engaging the frictionally engageable means, and means for yieldably engaging the intermeshing means.

23. In winding mechanism, in combination with an element to be wound, driving means for the element alternately frictionally engageable to drive said element in one direction or the other, intermeshing connecting means between the driving means and the element, alternately engageable simultaneously with the alternate frictional engagement, means for positively engaging the frictionally engageable means, and means for yieldably engaging the intermeshing means.

24. In winding mechanism, in combination with an element to be wound, driving means for the element alternately frictionally engageable to drive said element in one direction or the other, alternately engageable intermeshing connecting means to the element, and articulated connection between the intermeshing connecting means and the frictionally engageable means.

25. In winding mechanism, in combination with an element to be wound, driving means and connecting means from the driving means to the element, each of said means being shiftable at an angle to the other to alternately drive said element in one direction or the other, and articulated connection between the driving means and the connecting means, for the purposes set forth.

26. In winding mechanism, in combination with an element to be wound, driving means and connecting means from the driving means to the element, both of said means being alternately operative simultaneously, to drive said element in one direction or the other, and compensating means, actuated through the winding of said element during the driving in either direction, and varying the conditions of operation of the driving means, or returning said driving means through the variations, accordingly as it is actuated through the winding of said element in one direction or the other.

27. In winding mechanism, in combination with an element to be wound, driving means and connecting means from the driving means to the element, both of said means being operative simultaneously, to drive said element in one direction or the other, and compensating means, varying said driving

means from an initial condition or restoring the driving means to said initial condition, accordingly as the element is driven in one direction or the other.

28. In winding mechanism, in combination with an element to be wound, a stationary bracket, a disk rotatably mounted in the stationary bracket, a tiltable bracket mounted on the stationary bracket, friction-wheels rotatably mounted on the tiltable bracket and alternately engageable with said disk as the bracket is tilted in one direction or the other, and connection between said friction-wheels and said element whereby each will drive the element in an opposite direction.

29. In winding mechanism, in combination with an element to be wound, a stationary bracket, a rotatable driving element mounted therein, a tiltable bracket, engaging means carried by the tiltable bracket alternately engaged with the driving element as the bracket is tilted in one direction or the other, and connection between said engaging means and said element whereby each will drive the element in an opposite direction.

30. In winding mechanism, in combination with an element to be wound, a stationary bracket, a rotatable driving element mounted therein, a tiltable bracket, engaging means carried by the tiltable bracket alternately engaged with the driving element as the bracket is tilted in one direction or the other, a slidable bracket, and connection from the respective engaging means on the tiltable bracket, carried by said slidable bracket and alternately engaged simultaneously with the alternate engagement of said engaging means, by the sliding of said bracket, to drive said element in one direction or the other, for the purposes set forth.

31. In winding mechanism, in combination with an element to be wound, a stationary bracket, a rotatable driving disk mounted therein, a tiltable bracket, engaging means carried by the tiltable bracket alternately engaged with the driving disk as the bracket is tilted in one direction or the other, a slidable bracket, connection from the respective engaging means on the tiltable bracket alternately engaged to drive said element in one direction or the other, by the sliding of said bracket, and connection between said tiltable bracket and said slidable bracket whereby they are moved simultaneously, for the purposes set forth.

32. In winding mechanism, in combination with an element to be wound, a stationary bracket, a rotatable driving disk mounted therein, a tiltable bracket, friction wheels rotatably mounted on the tiltable bracket and alternately engageable with said driving disk as the bracket is tilted in one direction or the other, a slidable bracket, intermeshing connecting means to said element, carried by said slidable bracket and alternately intermeshed to drive said element one way or the other as the bracket is shifted, articulated connections between the friction-wheels and the respective intermeshing means, and connection between the tiltable bracket and the slidable bracket whereby they are moved simultaneously, for the purposes set forth.

33. In winding mechanism, in combination with an element to be wound, and driving means, frictionally engageable means to alternately engage with said driving means, and intermeshing means to alternately connect with said element, articulated connections between respective ones of the frictionally engageable means and the intermeshing means, and means for alternately engaging and intermeshing the thus connected means, to drive said element in one direction or the other, for the purposes set forth.

34. In winding mechanism, in combination with an element to be wound, and driving means, frictionally engageable means to alternately engage with said driving means, intermeshing means to alternately connect with said element, articulated connections between respective ones of the frictionally engageable means and the intermeshing means, means for alternately engaging and intermeshing the thus connected means, one of the frictionally engageable means being capable of variation in its frictional engagement, and compensating means, actuated in accordance with the winding of said element, connected to said variable frictionally engageable means, to vary said engagement, said element being driven in one direction or the other as the respective engaging and intermeshing means are engaged and intermeshed, and said compensating means being actuated in either direction, in accordance with the driving of said element, for the purposes set forth.

35. In winding mechanism, in combination with an element to be wound, alternately frictionally engageable driving means, one of which may be varied in its frictional engagement, means whereby either driving means is connected with said element directly only when it is engaged for driving, each driving means driving the element in opposite direction, and compensating means, actuated in accordance with the winding of said element under the driving action of said variable driving means, and connected to this driving means to vary it, said compensating means being reversely actuated when said element is driven by the other driving means in an opposite direction, for the purposes set forth.

36. In winding mechanism, in combination with an element to be wound, alternately enagageable driving means therefor, shifting means to alternately engage said driving means, and controlling means for

said shifting means actuated through said element.

37. In winding mechanism, in combination with an element to be wound, alternately engageable driving means therefor, shifting means to alternately engage said driving means, controlling means for said shifting means actuated through said element, and compensating means for one of said driving means actuated through said element.

38. In winding mechanism, a main spool, a re-winding spool, arbors for the respective spools, spur gears fixed on the respective arbors, a sheave turning with the rewinding arbor, a shoe bearing on the sheave, a slidable bracket mounted between the arbors, shafts journaled in the bracket and pinions on the respective shafts to alternately mesh with the gears on the respective arbors as the bracket is shifted, a spur on said bracket to engage with the shoe and disengage it from the sheave on the re-winding arbor when the pinion meshes with the gear on said re-winding arbor, and a spring connected to said shoe to engage it with said sheave.

39. In winding mechanism, a main spool, a re-winding spool, a frame, yieldable bearings for the spools in the frame, a main arbor for the main spool, a re-winding arbor for the re-winding spool, means for engagement and disengagement of said spools with their respective arbors as permitted by their yieldable bearings, and whereby said spools are rotated by said arbors, said re-winding arbor having a central bore, and a pin screwed into said arbor through said bore, engaging to adjust said re-winding spool axially.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FREDERICK W. HEMPELMANN.

Witnesses:

CLARENCE PERDEW,

JAMES A. BALDWIN.