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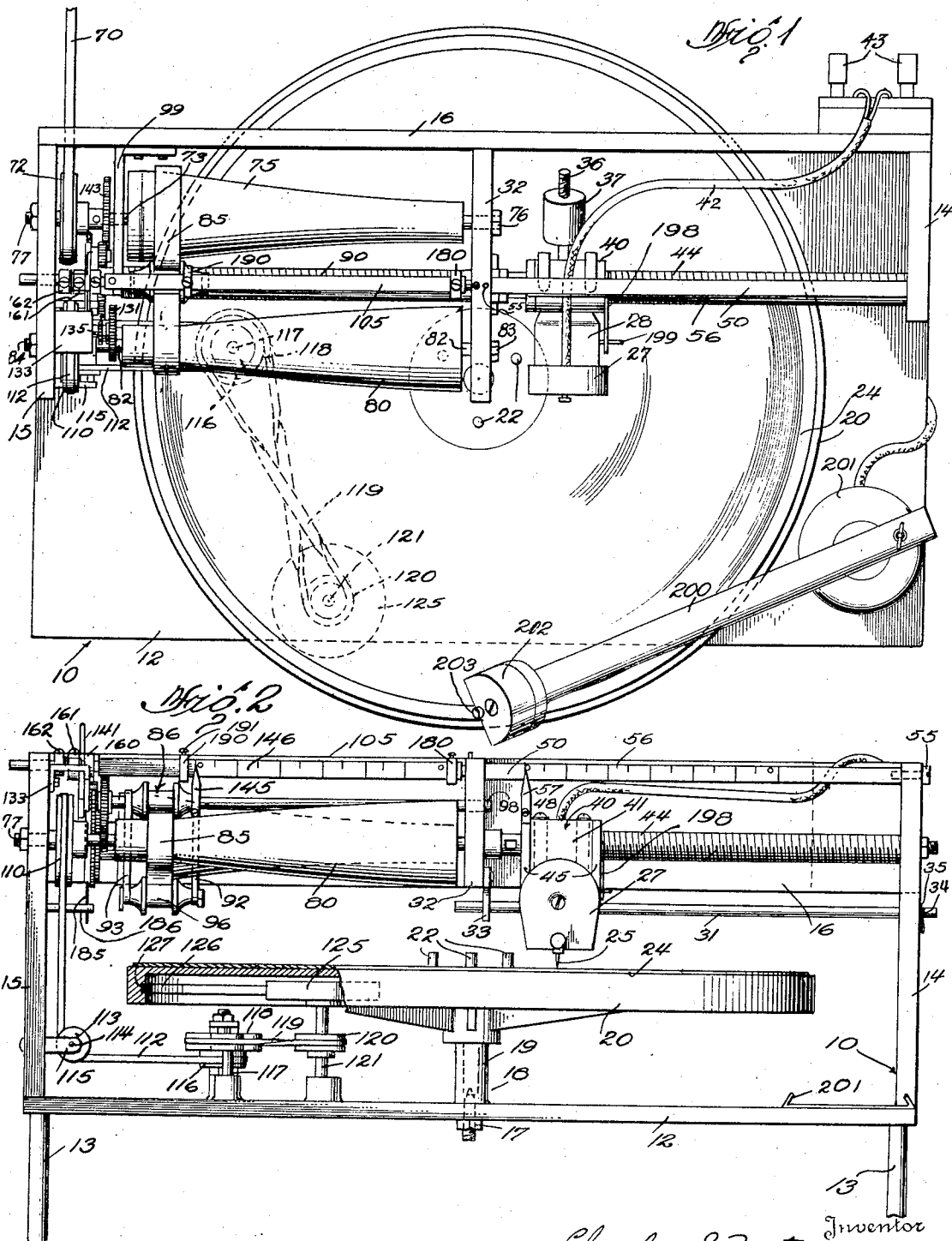
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SOUND RECORDING AND REPRODUCING MECHANISM

Filed May 13, 1939

3 Sheets-Sheet 1



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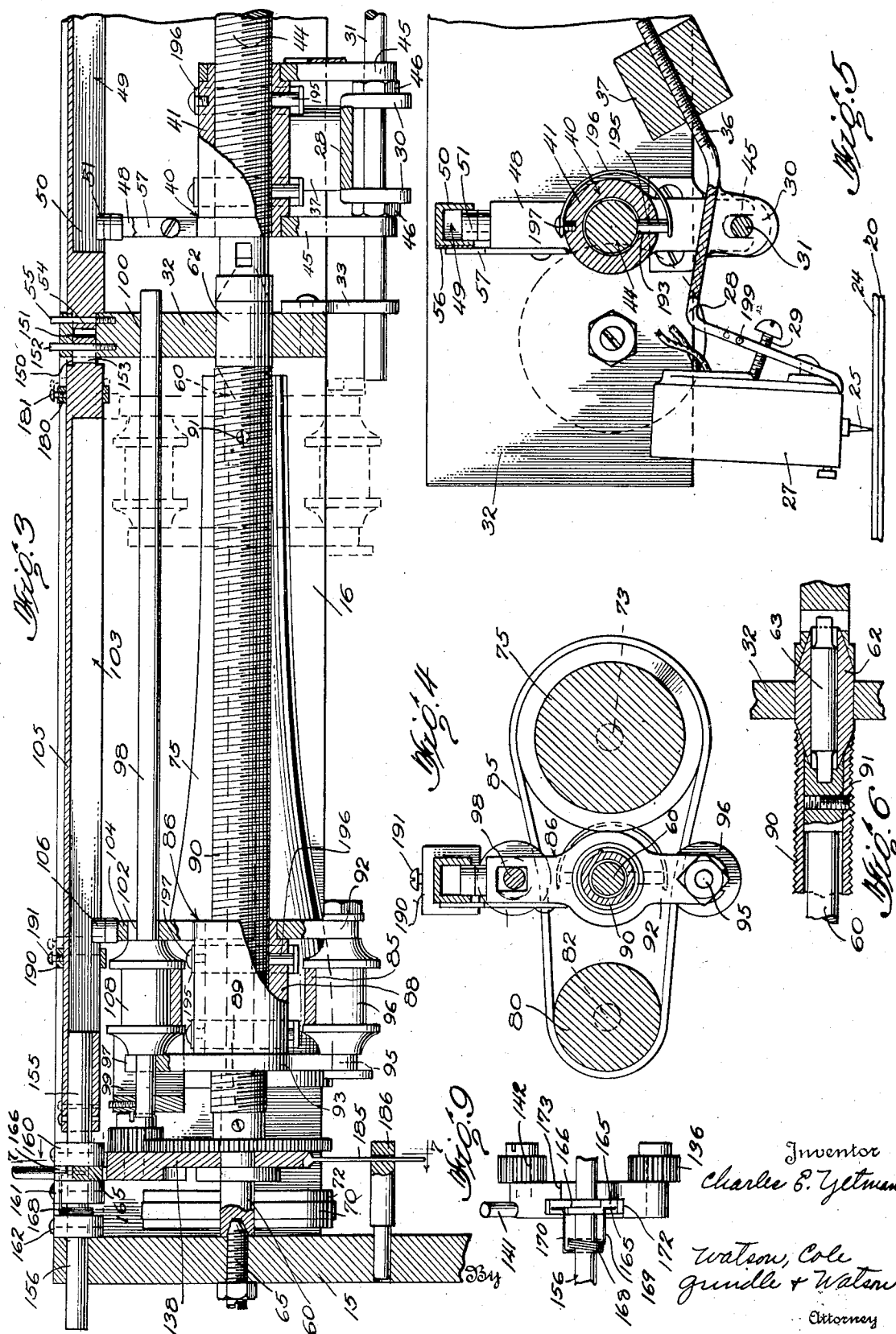
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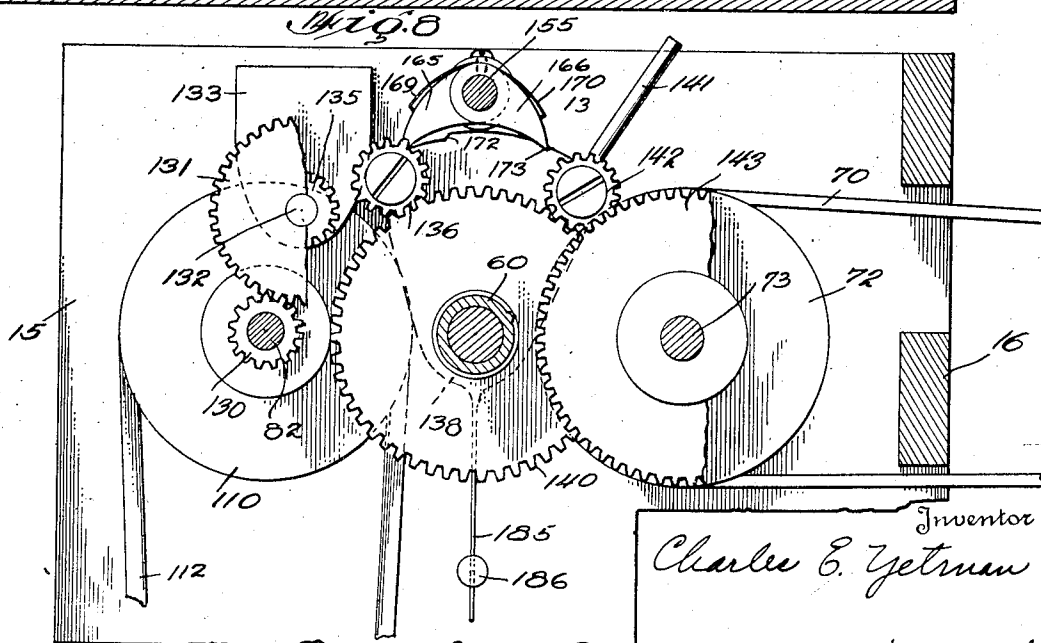
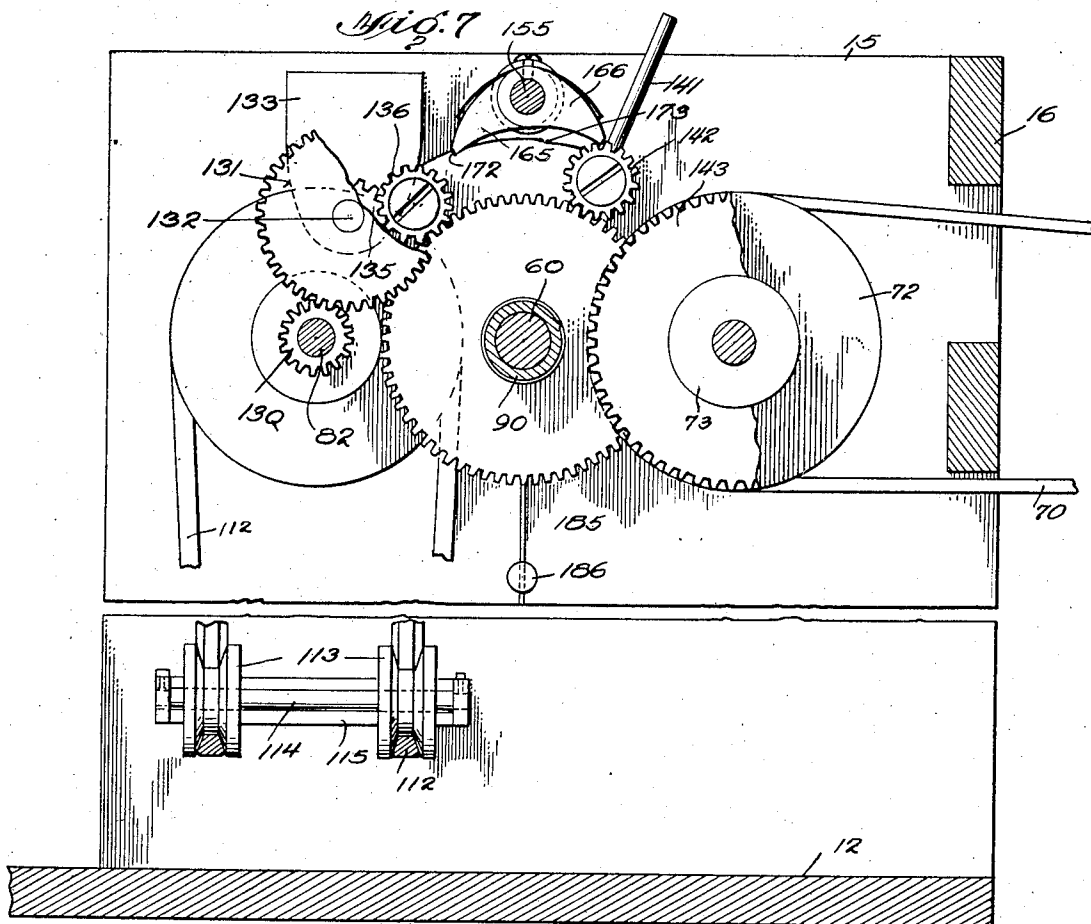
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SOUND RECORDING AND REPRODUCING
MECHANISM

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18 Claims. (Cl. 74-393)

This invention relates to sound recording and/or reproducing methods and apparatus, and more particularly to those which involve the use of disc records.

The general object of the invention is to provide a novel and improved process and apparatus for accurately cutting and playing disc records, wherein the disc is moved in contact with the cutting or reproducing needle at a constant linear speed regardless of the change in the radial position of the needle as it follows successive laps of the spiral groove in the disc.

All rotary disc recording and reproducing devices now on the market are provided with turntables which are rotated at a uniform angular velocity and therefore the recording and reproducing instrumentality will follow the sound groove at varying linear speeds. It is obvious that the smallest circle or lap of the spiral near the center of the record will pass beneath the needle during the same time interval as the largest circle adjacent the outer periphery of the disc, even though the largest circle may be several times the circumference of the smallest circle. For example, if the sound record of a given word or syllable occupies one inch of the circumference of the smallest lap or circle near the center of the disc,—usually about four inches in diameter,—it will occupy about four inches of the circumference of the outermost lap in the case of a sixteen-inch disc. This results in a very considerable waste of space on the record, and gives rise to further disadvantages which may be obviated by the provision of a truly accurate device for providing constant linear speed.

At least three important advantages follow the use of a constant linear speed machine. First, in a disc record of a diameter of sixteen inches, approximately three times the amount of sound can be recorded thereon as is now possible on the uniform angular velocity type of record of the same size. There results therefrom an enormous saving in record blank material and the elimination of the necessity for the frequent and annoying interruptions for changing records during long musical selections, such as symphonic recordings comprising several movements. Second, since any given sound would utilize the same space on all parts of the record, the mechanical action of the cutting or reproducing needle would be the same for that particular sound at all times, and disagreeable variations in tone quality would be eliminated. Third, the cutting needle running at uniform relative speed through the material of the disc would ef-

fect a truer or more accurate record of the sound and would hold its cutting edge for a relatively longer time.

Certain of these advantages have probably been recognized heretofore, and various proposals have been made for attaining them, but machines designed to carry these proposals into effect have failed in actual practice for one reason or another, and no system of constant linear speed sound recording has even been adapted, so far as the applicant is aware.

The present invention is designed to overcome the difficulties which have confronted prior workers in this field, and in its preferred embodiment contemplates the provision of a novel and improved recording and/or reproducing device by means of which the angular velocity of the turntable upon which the disc is supported is varied continually at a rate which will insure that the relative speed between the surface of the disc and the needle at the point of contact is uniform. Although the other method may be employed by suitable modifications of the device, in this particular embodiment the record is cut from the center outwardly toward the periphery, instead of in the opposite direction as in the usual case, because it has been found that the shavings resulting from cutting the record are more likely to fall out of the path of the cutter when this is done. Therefore, means are provided for gradually reducing the angular velocity of the turntable at the same rate that the cutting needle is moved outwardly from the center of the disc to form the successive spiral laps of the sound grooves. In other words, the rate of change in angular velocity is varied in accordance with the radial movement of the needle with respect to the disc.

To attain this continually varying angular velocity, the present embodiment of the invention provides a variable speed drive for both the turntable and the means for feeding the cutting needle which involves the use of cone pulleys or similar devices, in which the operative connection between the driving and driven elements of the speed change device is moved continually along the effective surfaces thereof at the same accelerated or decelerated rate of advance as the feed of the needle. Although the dimensions of the variable speed gearing may be proportionately changed by the interposition of multiplying and diminishing devices, it is preferred that the length of the variable speed driving and driven elements be substantially the same as the radius of the annular portion of the disc record

which is to be inscribed. This provision aids in the proper proportioning of the speed changing elements in direct relation to the distance of the recording needle from the beginning and end of the sound groove. In other words, at any given point which the needle may occupy on the disc the movable operative connection of the variable speed gearing occupies a corresponding point along the surfaces of the elements thereof which will yield the proper angular velocity of the turntable for effecting the constant speed of that portion of the disc beneath the needle.

The method of computing the rate of change of speed of the mechanism to add or subtract the proper increments for each lap or multiples thereof to attain the desired constant linear speed will now be set forth.

Sound recorders, phonographs, and so-called "play-backs" as now designed usually run at the rate of 78 revolutions per minute. Some devices have been built to run at the rate of $33\frac{1}{3}$ R. P. M. in attempting to make possible an increase in the playing time of the record, but this slow speed gives rise to very serious difficulties in recording and sacrifice of tone quality. In calculating the dimensions and proportions of the illustrative example of the present invention, 80 R. P. M. has been adopted as being sufficiently close to an ideal initial speed, and one from which it is easy to make the somewhat intricate calculations involved in the present speed reducing mechanism. Also, for purposes of illustration, the device described is adapted to operate upon a disc record of approximately sixteen inches in diameter, the inner smallest circle of the groove of which has a diameter of four inches. If the smallest circle or lap of the spiral of the record is cut at the rate of 80 R. P. M., its running time is three-quarters of a second. Its approximate circumference is 12.6292 inches, and therefore its average rate of linear speed is 16.75 inches per second. The present device is constructed to attain this rate of linear surface speed on all portions of all records which are being cut or played. The laps of the grooves of the record are $\frac{1}{100}$ of an inch apart, making one hundred laps or approximate circles to the inch of inscribed radius of the disc. On a sixteen-inch record, it is evident that this involves the cutting of six hundred circles from the four-inch inner circle to the outermost sixteen-inch circle.

To determine the running time and the amount of sound capacity for the record, it is necessary to compute the total length of the sound groove, and this may be readily done to a very high degree of accuracy by the following method. Since there are one hundred circles in each inch of the record, between the inner four-inch circle and the outer sixteen-inch circle, it is evident that the next larger circle to the smallest four-inch one is .02 inch greater in diameter, and .062832 inch greater in circumference than the four-inch circle, and this difference is the same for each circle of the disc as compared with the next smaller one. It is convenient to calculate the lengths and running time of the spirals for each inch of surface of the record. In calculating these quantities for the first inch, we find that for the ninety-nine circles in the surface from four to six inches in diameter, one should add the numbers from one to ninety-nine and this sum, 4950, representing the total number of circumference increments for all the subsequent ninety-nine circles, is multiplied by the circumference increment .0628. This gives 31.1018 inches, the total

circular length by which the ninety-nine circumferences exceed the circumference of the four-inch circle. Since each of the ninety-nine circles have included the circumference of the four-inch circle also, we multiply the circumference of the four-inch circle, 12.5664, by one hundred. This gives 1256.64 inches, and this must be added to a total excess length, 31.1018 inches, the sum being 1567.65 inches, the total length of the groove between the four and six-inch diameters. Since the uniform rate of speed of the record beneath the cutter is 16.75 inches per second, the total running time for this space is 1.55 minutes. Therefore, a program of a length of 1.55 minutes could be recorded in this one inch space on the record. The running time of each of the subsequent five inches of space can be computed in the same way and the results will be as follows:

Circular spaces between diameters designated by diameters	Circumference of smallest circle in each inch of space	Total length of 100 circumferences in each inch of space	Running time or capacity for sound recording for each inch of space
	Inches	Inches	Minutes
4 to 6 inches.....	12.57	1567.66	1.60
6 to 8 inches.....	18.85	2195.98	2.24
8 to 10 inches.....	25.13	2824.30	2.88
10 to 12 inches.....	31.42	3452.62	3.52
12 to 14 inches.....	37.70	4080.94	4.16
14 to 16 inches.....	43.98	4709.26	4.80
Total length.....		18830.76	
Total running time.....			19.20 (16" record)

Running time of constant angular velocity record of these dimensions, 7.50 minutes.

It will thus be seen that a complete fifteen-minute radio broadcast can be recorded on one side of a sixteen-inch record with space to spare. If a $33\frac{1}{3}$ R. P. M. rate is used, the savings and advantages are proportionately great.

Another object of the invention is to provide means for reversing the movement of the driving mechanism so that the same cycle of movement of the cutting element and the turntable is traversed, but in less time than for the forward movement. Automatically actuated means are provided for disconnecting the drive at predetermined points along the cycle of movement in either direction. These features are important in insuring that the starting point for the "play-back" is identical with the starting point used in cutting the record, and to provide on each part of the record the same speed in playing back as was used in cutting, thus avoiding distortion in pitch in the reproduced tones.

In this connection, there is also provided novel gaging means whereby the synchronized travel of the cutter and of the variable speed gear connector may be readily determined at any point. This gaging means also enables the determining of starting and ending points for record discs of different sizes and also facilitates the re-synchronization of the belt movement with that of the cutter after the device has been disconnected, as for working on records of the conventional constant angular velocity type.

A further object is the provision of means for adjusting the change speed gearing to render a part thereof inactive, whereby records of the conventional type may be inscribed or played.

A still-further object is to provide driving connections for the stylus and also for the change speed controller, which are always in mesh, so that these elements cannot inadvertently get

out of synchronism, as in the case of conventional detachable connections.

A further object of the invention is the provision of novel constructional details in connection with the feed of the cutter and also of the speed change element.

Additional features of novelty and purposes of the present invention will be apparent from the following specification, when read in connection with the accompanying drawings, in which one embodiment of the invention is illustrated by way of example.

In the drawings,

Figure 1 is a plan view of a sound recording and reproducing device embodying the principles of the invention;

Figure 2 is a view in elevation of the same device, a part of the turntable being shown in section;

Figure 3 is a vertical sectional view through the device, taken on line 3—3 of Figure 1, and on an enlarged scale;

Figures 4 and 5 are transverse sectional views taken on lines 4—4 of 5—5 of Figure 3, respectively;

Figure 6 is a fragmentary sectional view of the coupling and bearing arrangements for certain driving shafts shown in Figure 3;

Figure 7 is a transverse sectional view on a further enlarged scale, and taken on line 7—7 of Figure 3;

Figure 8 is a similar view showing the gearing in a shifted position; and

Figure 9 is a fragmentary plan view of a clutch element employed in the apparatus.

In the device which has been chosen to illustrate the principles of the present invention, the mechanism is supported upon a suitable frame 10 which comprises a base plate 12 having the feet 13. At each end of the base plate 12 there are provided the end plates 14 and 15 which are connected by means of the back plate 16. Secured substantially at the center of the base plate 12, as by the bolt and nut connection 17, is the hollow post 18 which is adapted to receive the spindle 19 of the turntable 20. Suitable provisions for properly centering and lubricating the spindle are made, and the turntable 20 is accurately balanced so as to rotate freely upon the post 18 during operation of the machine. Pins 22 are provided near the center of the turntable and are adapted to enter correspondingly spaced holes in the disc 24 in order to positively rotate the disc with respect to the recording or inscribing device.

The cutting needle or stylus 25 is carried by the sound box 27 which is of conventional construction and adapted to convert the electrical impulses received from a microphone or amplifying device into vibrations which cause the stylus to cut a corresponding pattern upon the surface of the disc. The sound box 27 is attached to one end of the angle bracket 28 and is adjustable with relation thereto as by means of the screw 29. The bracket 28 is provided with downwardly turned ears 30 which are rotatably and slidably supported upon the guide rod 31; the rod 31 being removably supported in the end plate 14, and from the center plate 32 as by means of the clip 33. The outwardly projecting end of the guide rod 31 is provided with a notch 34 into which a spring latch 35, secured to the outer face of the plate 14, is adapted to enter. Secured to the rear end of the bracket 28 is a threaded rod or stem 36 upon which is adjustably

carried the counterweight 37 for the purpose of balancing the box 27 and regulating the pressure of the cutting stylus upon the disc.

For the purpose of guiding the bracket 28 and its attached sound box 27 along the shaft 31, there is provided a carriage or rider 40 which comprises a tubular member or sleeve 41 which is threaded upon the screw shaft 44, this shaft being rotatably supported in the frame, as will be later described. The rider 40 further includes the depending bifurcated arms 45 which straddle the rod 31 and embrace the bracket 28, the arms 45 and the projections 30 being spaced by means of the sleeves 46. This arrangement provides means for moving the sound box and also effectively prevents the rotation of the rider 40 upon the shaft 44.

When the machine is not in operation, or when the movement is reversed so as to bring the stylus back to its original position upon the record, the sound box 27 may be supported in an elevated position by means of the latch or hook element 198 which engages the pin 199 upon the sound box. The wires 42 lead to the sound box from the terminals 43 secured to the back plate 16 of the apparatus and adapted to be connected to the electrical transcribing means which in turn is placed in communication with the microphone or other source of the sound to be recorded.

An upwardly projecting arm 48 extends from the rider 40 and enters the slot 49 formed in the inverted channel bar 50 which extends from the center plate 32 to the end plate 14 at the top of the frame. Sleeves or rollers 51 are provided upon the end of the arm 48 for engaging within the slot 49 as the rider moves therealong. The channel bar 50 is rigidly supported in the center plate 32 and the end plate 14, as indicated at 54 and by means of the screw 55. The forward side of the channel bar 50 is provided with a graduated scale 56, and a pointer 57 is secured to the arm 48 of the rider 40 and indicates the exact point in its cycle of movement which the cutting stylus 25 occupies at any time.

As already explained, the stylus 25 is moved radially of the disc 24 at a suitable decelerated or continually retarded speed which is necessary to maintain the proper constant linear velocity between the disc 24 and the stylus 25. In order to accomplish this, the screw shaft 44 must be rotated at a continually varying rate and for this purpose the shaft is coupled to the end of a driving shaft 60. The shafts 60 and 44 are each provided with hollow conical ends which bear upon respective conical ends of the hollow bearing member 62 which is seated in the center frame plate 32. The central portions of the hollow conical ends of the shafts 44 and 60 are squared to receive the squared ends of the coupling pin 63 which rotates within the bore of the bearing piece 62. The shaft 60 extends from the plate 32 to the end plate 15 in which it is provided with trunnion bearing means 65. The shaft 60 is connected to the power transmission mechanism by mechanism which will presently be described.

The mechanism for transmitting the driving force from a suitable source of power to both the turntable and the stylus feed will now be described. The source of power, such as an electric motor (not shown), may be operatively connected to the recording device by means of the belt 70 which passes around the pulley 72 carried by the axle 73 of the input or driving element 75 of the change speed gearing mechanism, which in this case comprises a cone of varying taper.

The axle or shaft 73 is provided with trunnion or shaft supporting bearings 76 and 77 in the center plate 32 and in the end plate 15, respectively. The driven element or output member 80 is a complementary shaped cone element which is provided with an axle shaft 82 provided with similar bearing members 83 and 84 in the respective plates 32 and 15, and is disposed in parallel relation with the axle 73 of the driving element 75. The bearing elements 76, 77, 83 and 84 are preferably formed with conical ends received within the respective axles or shafts 73 and 82, just as in the case of the trunnion or shaft supporting member 65, previously described. The two cone pulleys 75 and 80 are operatively connected by means of an endless belt 85 which is adapted to be moved longitudinally of the pulleys to vary the output speed of the gearing. For this purpose, the belt is guided by the rider member or carriage designated generally by the reference numeral 86. This belt guiding rider 86 is best shown in Figures 3 and 4 of the drawings and comprises the tubular element 88 which is threaded upon the hollow tubular shaft 90 which serves a function similar to that of the screw shaft 44 in moving the rider longitudinally therealong.

One end of the tubular shaft 90 is seated upon the shoulder or hub 89 formed on the shaft 60 near its left-hand end (Figure 3) and the other end is rotatably seated on the conical end of the bearing member 82 exteriorly of the similar bearing of the shaft 60. During normal operation of the machine as a constant linear speed device, the tubular shaft 90 is keyed to the driving shaft 60 by means of one or more screws 91 threaded into registering openings in the two shafts.

Upon each end of the tubular member 88 there are secured the vertically extending members 92 and 93. The downwardly projecting portions of these members 92 and 93 provide bearings for the shaft 95 upon which the flanged spool idler pulley 96 is adapted to freely rotate. The upwardly extending end of the member 93 is bifurcated as at 97 to receive the guide rod 98 which is secured at one end in the bracket 99, extending forwardly from the rear plate 16, and passes through the plate 32 as at 100. The other member 92 of the rider 86 is provided with an opening 102 adapted to receive the guide rod 98 and is formed with an upwardly extending arm 104 adapted to enter the slot 103 of the channel member 105, which is similar to the member 50 described in connection with the stylus or needle carrier. Upon the upper end of the arm 104 there are rotatably placed the rollers 106 for engaging within the slot 103, and for effecting a purpose to be later described.

Between the upper ends of the arms of the members 92 and 93 there is disposed the flanged guiding pulley or spool 108 which is rotatably and slidably mounted upon the rod 98 and guided between the arms 92 and 93. The belt 85 passes between the flanges of the two pulleys 75 and 108 and in contact with the barrels thereof. It is obvious from this description that as the belt-carrying rider 86 is moved along the guide rod 98, by the rotation of the threaded member 90, the belt will be moved along the conical pulleys 75 and 80 in order to vary the speed of the driven parts of the mechanism in accordance with the variations in relative diameters of the pulleys. For obtaining better frictional contact along the tapered surfaces of the cones, two or more nar-

rower belts might be employed instead of one wide one.

The shaft of the driven pulley 80 carries a grooved pulley 110 about which is trained the belt 112. In order to effect a right-angle change of direction, the endless belt 112 is trained about two small grooved pulleys 113 which are carried by the shaft 114 which has bearings in the bracket 115 secured to the end plate 15. The opposite bight of the belt 112 passes around the pulley 116 which is rotatably carried by the post 117 disposed upon the base plate 12. A larger pulley 118 carried by the same post 117 and rotating in unison with the pulley 116 is operatively connected by means of a belt 119 with the pulley 120 carried by the post 121 also secured to the base 12. Upon the upper end of the post 121 there is fixed a friction wheel 125 which bears against the annular ring 126 seated in a groove 127 within the inner periphery of the margin of the turntable 20. The ring 126 is preferably made of suitable friction material whereby a firm and non-slipping connection may be made between the driving mechanism and the turntable. The relative proportions of the pulleys 110, 116, 118, and 120, and the dimensions of the wheel 125 are all selected so as to attain the proper speed of rotation of the turntable at a given speed of the output or driven cone 80.

Upon the driven pulley shaft 82 between the cone pulley 80 and the grooved pulley 110 there is fixed the pinion 130 which meshes with the gear 131 carried by the countershaft 132 which is supported by the bracket 133 secured to the end plate 15. Another smaller gear or pinion 135 is fixed to this countershaft 132 and is adapted to be alternatively engaged by the pinion 136 which is rotatably carried by the shiftable plate 138, which is rockably mounted with respect to the driving shaft 60. The plate 138 is mounted concentrically with the gear 140 which is fixed upon the shaft 60 so as to rotate therewith in either direction. The pinion 136 is always in mesh with the gear 140 and is adapted to be thrown into mesh with the pinion 135 by the shifting of the plate 138 as by means of the handle 141 secured thereto, all as clearly shown in Figures 7 and 8 of the drawings. Upon another portion of the plate 138, and at the same distance from the center of rotation as the pinion 136, is the pinion 142 which is also continually in mesh with the gear 140 and is adapted to be alternatively engaged with the gear 143 which is fixed upon the axle 73 of the driving cone 75 at a point between the bracket 99 and the pulley 72. By shifting the plate 138 so that the pinions 136 and 142 are alternatively meshed with the pinion 135 or the gear 143 respectively, it will be seen that the shaft 60 may be driven either at a constant angular velocity from the input shaft or axle 73 of the change speed gearing or at a variable angular velocity from the output axle 82 of the variable speed driven element 80 for purposes which will be described hereinafter.

When the pinion 136 is meshed with the pinion 135 and the hollow screw shaft 90 is secured to the drive shaft 60 by means of the set screws 91, the belt-carrying rider 86 will move along the cones in exact synchronism with the stylus-carrying carriage 40, as indicated by the pointer 145 as it moves along the scale 146. The scales 146 and 56 are identical since the movement of the belt carrier 86 and the cutting needle and sound box carrier 40 are the same in view of the iden-

tical pitch of the threads on the propelling shafts 80 and 44.

The calculation of the dimensions of the cone pulleys 75 and 80, in order to insure the feeding of the cutting stylus along the disc at the proper diminishing rate of speed, and for rotating the turntable with the same diminishing angular velocity, will now be explained. The sum of the diameters of the constant speed driving or input cone 75 and the variable speed driven or output cone 80 is arbitrarily adopted as some convenient figure, in this case three inches, and this sum of the diameters will remain constant throughout the length of the cones, so that as the diameter of one of the cones diminishes, the diameter of the other will proportionately increase. Since the belt carrier 86, which effects the variation in ratio of the drive, moves along the cones at the same rate of progress as the cutting needle moves radially of the disc, it is apparent that for each point upon the indicating scale that the cutting disc occupies, there is a definite speed ratio to be developed in the cone drive which will yield the proper angular velocity in the turntable for that particular position of the cutting needle. The gear ratio between the output cone 80 and the turntable is so selected that at the start of the recording upon the four-inch circle of the disc, the constant speed cone 75 is rotated at 80 R. P. M., and the variable cone is run at 160 R. P. M. The sum of the diameters of the cones being three inches, the diameter of the variable cone 80 must be one inch, and that of the constant speed driving cone 75 must be two inches.

At this point it may be well to note that in calculating the proper diameters of the cone pulleys, account must be taken of the thickness of the belt, and this thickness added to the diameters of the respective cones in developing the ratios at all points of contact of the belt.

In designing the cones to produce the proper speed ratios at all successive positions of the cutting needle, it is sufficient to select conveniently spaced points, calculate the relative diameters at these points and then connect the resulting circumferences of the respective cones by smooth surfaces. For example, assuming the diameters of the two cones to be two inches and one inch respectively at the start,—or at the position of the four-inch circle,—the diameters at intervals of one-half inch, or one inch, or even at shorter intervals may be computed and the cones shaped accordingly. The computation of the diameters of the cones for the six-inch circle will illustrate the method. The circumference of the sound groove at this point is 6π or 18.496 inches. Dividing this circumference by 16.755, the standard linear speed in inches per second, gives 1.125 as the number of seconds required for this circle to pass under the cutter at the proper linear speed. This is equivalent to a speed of 53.33 R. P. M. in the variable cone to produce the required speed in the six-inch circle. Thus the diameter of the variable or output cone 80 at this six-inch point should be 1.285 inches and the diameter of the constant speed driving cone 75 should be 1.715 inches. In a similar manner the proper diameters of the cones for successive positions of the cutting needle may be computed.

A general rule for this computation may be stated thus: Knowing the desired speed in R. P. M., the sum of the diameters of the cones, and the constant speed of the input cone, take such part of the sum of the diameters of both

cones as the known constant speed of the driving cone is a part of the sum of the speeds of both cones, and the result is the diameter of the variable speed or driven cone, which is required to produce the desired speed of the variable. This result, subtracted from the sum of the diameters of both cones, is of course the required diameter of the constant speed cone. The following table illustrates the computation of the dimensions of the variable speed driving means in the particular example illustrated herein, in which the initial speed of the turntable is 80 R. P. M. and the final speed for the sixteen-inch disc is 20 R. P. M.:

Inch intervals of disc diameter	Speed of turntable (R. P. M.)	Speed of driven cone (R. P. M.)	Diameters of driven cone	Diameters of driving cone
4	80	160	1	2
6	53.333	106.666	1.285	1.715
8	40	80	1.500	1.500
10	32	64	1.667	1.333
12	26.666	53.332	1.800	1.200
14	22.857	45.714	1.908	1.092
16	20	40	2	1

This table is merely illustrative of the method of computing the dimensions of the cones and the particular dimensions will of course vary in other embodiments depending upon the constants adopted.

Means are provided for reversing the drive so as to bring the cutting needle or stylus 25 back to the exact starting point on the record, and this may be accomplished at a much faster speed than the actual cutting operation. To effect this reversal the plate 138 is shifted by manipulating the handle or lever 141, so that the pinion 142 meshes with the gear 143 carried by the input cone shaft 73. It will be seen that due to the relative proportioning of the gears and the arrangement of the driving connections, the initial driving means will effect the reverse rotation of the screw shafts 90 and 44 at a more rapid speed than during the opposite movement, and that since these shafts are rigidly connected, the needle 25 will be returned to its initial position in exact synchronism with the return of the belt carrier 86 to the left-hand end of the cones.

In order to throw out the driving connection at predetermined points, for example at the end of the recording space on the given record, the following means are provided. The channel member 105 which serves to guide and calibrate the movement of the belt carrier 86 is mounted in the plates 15 and 32 of the frame of the device so as to reciprocate longitudinally. The narrowed end 150 of the channel bar 105 is seated in the opening 151 in the frame plate 32, and is secured for limited reciprocating movement therein by means of the pin 152 which passes through the vertical slot 153 in the member. The opposite end of the member 105 is provided with a socket to receive the shaft 155 which projects through an opening 156 in the end frame 15 and carries three sleeves 160, 161, and 162, fixed rigidly thereon by means of set screws. Between the two sleeves 160 and 161 there is disposed a pair of pawls 165 and 166 which are arranged in overlapping relation and adapted for independent movement. A spring element 168 is coiled about the shaft 155 between the sleeves 161 and 162 and oppositely diverging ends 169 and 170 thereof press upon the respective pawls 165 and 166 to urge them downwardly toward the plate 138. In the upper surface of the plate 138 there are formed the notches 172 and 173 which

are laterally offset from each other as illustrated in Figure 9 of the drawings.

Upon the channel bar 105 there is adjustably secured a stop element 180, as by means of a set screw 181. This element completely surrounds the bar 105 and is adapted to be contacted by the arm 104 of the belt guiding rider 86 which carries the rollers 106. During the recording or playing movement of the apparatus, the channel bar 105 and its attached devices are in the extreme left-hand position as shown in Figure 3 of the drawings, the pawl 165 is in engagement with the shoulder of notch 172, having been moved into engagement by means of the lever 141, as shown in Figure 7 of the drawings, and the gearing is in mesh for effecting the variable drive. When the belt-carrying member 86 reaches its ultimate position at the end of the recording operation, the carriage will strike the stop member 180 and shift the bar 105 toward the right. When the bar 105 is shifted, the pawl 165 is moved from above the notch or shoulder 172 and through the influence of the spring 185 which passes through an opening in the stud 186 supported by the plate 15, the shiftable plate 138 is moved to its neutral mid-position, halfway between the position occupied in Figure 7, and that shown in Figure 8. This will cause a cessation of the drive of both the recording or cutting needle and the belt carrier.

Similarly, when the machine is in the "re-wind" or reverse position, shown in Figure 8, the plate 138 is held in proper position for engagement of the pinion 142, by means of the engagement of the pawl 166 in the notch 173. A stop element 190 is adjustably secured by means of the set screw 191 to the channel bar 105, and is adapted to be contacted and moved toward the left (Figure 3) by the rollers 106 on the belt carrier 86. Thus the bar 105 is moved toward the left, the notch 173 shifted from beneath the pawl 166, and the shifter plate 138 is again permitted to assume its neutral position under the influence of a spring 185. After the automatic disconnection is effected, the plate 138 may be shifted to reengage the gearing for reversing movement by means of the handle 141.

It is to be noted that the driving connection in either direction may be effected at any time by a manual shifting of the bar 105.

The arrangement above described insures that the belt carrier and the cutter move through identical cycles of movement at all times and insures that the proper angular velocity of the rotatable is attained for each radial position of the stylus to insure uniform relative linear or surface speed of the disc relative to the stylus at said points.

Also important in this connection is the employment of completely annular threaded members for guiding the stylus and the belt shifter along their respective threaded driving shafts, whereby inadvertent disconnection of these elements from the shaft and a resulting break in their synchronized relation is prevented.

To eliminate backlash in these threaded connections, the following device is provided. Each of the tubular members 41 and 88 are drilled as at 193 for the reception of the pressure pins 195, the upper ends of which bear against the lower side of the screw shafts 44 and 90. In order to exert pressure on the pins 195, semi-circular leaf springs 196 are secured as at 197 to the upper sides of the members 41 and 88 and their lower ends extend beneath the pins and urge them up-

wardly and by their reaction tend to cause the upper part of the sleeves or threaded members to engage the threaded shafts more firmly and thus prevent lost motion or backlash, and effect a more accurate feed.

In Figure 1 of the drawings there is diagrammatically shown a tone arm 200 which is pivotally supported upon a base 201 and is provided with a sound box 202 and an appropriate needle 203 for playing the records which have been cut by the means described. This tone arm needs no feeding means since it will be guided by the contact of the needle with the sound groove on the disc.

It will be understood that various modifications may be made in the embodiment illustrated and described herein without departing from the scope of the invention as defined by the following claims.

In the claims the term "acceleration" is employed to indicate either a positive or a negative quantity, that is, either a rate of increase in velocity or a rate of decrease in velocity, according to whether the records or discs are inscribed from the periphery inwardly, or from the center outwardly.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. For use in connection with a recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of a primary driving means for both rotating said support and feeding said stylus radially thereof, transmission means connected between said primary driving means and said support and stylus, and in advance of the latter two elements, for continually and synchronously varying the angular velocity of said support and the rate of radial feeding of said stylus across the record, so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, means for connecting said transmission to said rotatable support at a single invariable point, and means for automatically interrupting the driving connection in said transmission means at a predetermined time, as upon completion of the record.

2. For use in connection with a sound recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of a primary driving means for both rotating said support and for feeding said stylus radially thereof, transmission means connected between said primary driving means and said support and stylus for continually and synchronously varying the angular velocity of said support and the rate of radial feeding of said stylus across the record, so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, means for reversing the stylus through the same cycle of movement and out of contact with the disc, whereby the stylus may be brought to the identical starting point upon the disc and the transmission restored to its initial condition for repeating exactly the forward cycle of movement, and means for automatically interrupting the driving connection of the transmission to the stylus only, at predetermined points in both the forward and reverse movements of said device.

3. For use in connection with a recording device of the class described, which includes a ro-

tatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of a primary driving means for rotating said support and for feeding said stylus radially thereof, transmission means connected between said primary driving means and said support and stylus, and in advance of the latter two elements, for continually and synchronously varying the angular velocity of said support and the rate of radial feeding of said stylus across the record, so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, means for connecting said transmission to said rotatable support at a single invariable point, and means for adjusting said same transmission means for alternatively rotating said support at constant angular velocity and positively feeding said stylus at a constant speed across the disc.

4. For use in connection with a sound recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of a primary driving means for rotating said support and for feeding said stylus radially thereof, transmission means connected between said primary driving means and said support and stylus for continually and synchronously varying the angular velocity of said support and the rate of radial feeding of said stylus across the record, so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said transmission means including a driving element and a driven element, and a connecting member between said elements for transmitting driving force from the one to the other, said elements being so shaped as to yield varying speed ratios as the connecting member is moved relatively thereto, and gearing for operatively connecting said driven element and said connecting member for moving the latter at a continually varying rate.

5. For use in connection with a sound recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of a primary driving means for rotating said support and for feeding said stylus radially thereof, transmission means connected between said primary driving means and said support and stylus for continually and synchronously varying the angular velocity of said support and the rate of radial feeding of said stylus across the record, so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said transmission means including a driving element and a driven element, and a connecting member between said elements for transmitting driving force from the one to the other, said elements being so shaped as to yield varying speed ratios as the connecting member is moved relatively thereto, operative connections between the driven element of the transmission and said connecting member for positively moving the stylus and the connecting member at proportionately and continually varying rates of speed.

6. For use in connection with a recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of means for moving said stylus at a continually accelerated speed radially of the disc and means for rotating the disc support at a continually accelerated angular velocity for in-

5 ensuring a constant linear velocity of movement between the surface of the disc and the stylus, said second named means including a change speed device comprising a pair of complementary tapered parallel cone pulleys, one cone adapted to be driven at a constant angular velocity, a connecting member movable along said cones to transmit the driving force from said constant velocity cone to the other or driven cone, and means for positively moving said member in exact synchronism with the stylus moving means, each successive diameters of the cones past which said member moves being so proportioned as to yield velocities of the disc support necessary at the corresponding position of the stylus to give the desired constant linear velocity of the disc beneath the stylus.

7. For use in connection with a recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of means for moving said stylus at a continually accelerated speed radially of the disc and means for rotating the disc support at a continually accelerated angular velocity for insuring a constant linear velocity of movement between the surface of the disc and the stylus, both of said means including a common change speed device comprising a pair of complementary tapered parallel cone pulleys, one cone adapted to be driven at a constant angular velocity, a connecting member movable along said cones to transmit the driving force from said constant velocity cone to the other or driven cone, and means for operatively connecting said member with the output element of said change speed gearing so that it is positively moved along said cones at the same accelerated rate as that of the disc support and the stylus.

8. For use in connection with a recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of a primary driving means for both rotating said support and feeding said stylus radially thereof, variable speed transmission means connected between said primary driving means and said support and stylus for continually and synchronously varying the angular velocity of said support and the rate of radial feeding of said stylus across the record, so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said transmission means comprising a pair of complementary tapered cone pulleys mounted on parallel driving and driven shafts respectively, a belt operatively connecting said pulleys and movable longitudinally of the same for varying the speed ratio of the transmission means, means for positively moving said belt along said cones in exact synchronism with the movement of said stylus radially of the disc, identical graduated scales disposed adjacent the paths of movement of said belt and said stylus respectively, and indicators partaking of the movements of the belt and stylus and adapted to follow the respective scales, whereby the positions of the moving elements may be synchronized.

9. For use in connection with a recording device of the class described, which includes a turntable for rotatably supporting a disc to be spirally inscribed and a stylus or the like for inscribing the disc; the combination of a primary driving means for both rotating said turntable and feeding said stylus radially thereof,

variable speed gearing disposed between said driving means and said stylus and turntable, and in advance of the latter, for continually and synchronously accelerating the movement of said latter elements so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said gearing comprising a driving shaft rotated at a constant angular velocity by said primary driving means, and a driven shaft, tapered cone pulleys carried by said shafts and operatively connected by a belt, said belt adapted to be positively moved along said pulleys at a continually varied rate, successive diameters of said pulleys traversed by said belt being so proportioned as to yield the proper angular velocity of said turntable at each successive position of said stylus, shiftable gearing for connecting said stylus and said belt with said driven shaft for synchronized accelerated movement during the inscribing of the disc and for alternatively connecting said elements with said driving shaft for synchronized movement in the reverse direction for returning the elements to the same starting point.

10. A device as set forth in claim 9 in which there is provided adjustable means for automatically interrupting the drive of said stylus and belt at predetermined points in their cycle of movement in either direction.

11. A device as set forth in claim 9 in which there is provided adjustable means for automatically interrupting the drive of said stylus and belt at predetermined points in their cycle of movement in either direction, and without interrupting the turntable drive.

12. A device as set forth in claim 9 in which there is provided adjustable means for automatically interrupting the drive of said stylus and belt at predetermined points in their cycle of movement in either direction, said last named means comprising an oscillatable member carrying two pinions which are continually in mesh with a gear connected with said stylus and belt, and adapted to be alternatively brought into operative engagement with gears driven respectively by said driving and said driven shafts, spring means for biasing said member toward a neutral position in which neither pinion is engaged, catches adapted to engage portions of said member to hold it in positions in which said pinions are engaged with one or the other of their driving gears, means adapted to be tripped by one of said elements for releasing said catches, and means for moving said oscillatable member for re-engaging said pinions.

13. For use in connection with a recording device of the class described, which includes a turntable for rotatably supporting a disc to be spirally inscribed and a stylus or the like for inscribing the disc; the combination of a primary driving means for both rotating said turntable and feeding said stylus radially thereof, variable speed gearing disposed between said driving means and said turntable and stylus for continually and synchronously accelerating the movement of said latter elements so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said gearing comprising a driving shaft, rotated at a constant angular velocity by said primary driving means, and a driven shaft, variably tapered cone pulleys carried by said shafts and operatively connected by a belt or the like, means for guiding said belt along said pulleys at a continually varied rate, successive diameters of said pulleys

traversed by said belt being so proportioned as to yield the appropriate angular velocity of said turntable for each successive position of said stylus, a screw shaft disposed parallel with said pulleys, said belt guiding means being threaded upon said shaft, means detachably connecting said screw shaft with said driven pulley shaft to feed said belt guiding means along the pulleys, another screw shaft detachably connected with said driven pulley shaft, and stylus supporting means threaded upon the second screw shaft, and means for connecting and disconnecting said shafts to and from said gearing.

14. The device as set forth in claim 13 in which means are provided for disconnecting the belt moving screw shaft only from the driving gearing, whereby the turntable may be rotated and the stylus fed at a uniform speed.

15. For use in connection with a recording device of the class described, which includes a rotatable support for a disc to be spirally inscribed and a stylus or the like for inscribing said disc; the combination of a primary driving means for both rotating said support and feeding said stylus radially thereof, variable speed transmission means connected between said primary driving means and said stylus and support, and in advance of the latter, for continually and synchronously varying the angular velocity of said support and the rate of radial feeding of said stylus across the record, so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said transmission means comprising a pair of complementary tapered cone pulleys mounted on parallel driving and driven shafts respectively, an endless single loop belt operatively connecting said pulleys and movable longitudinally of the same for varying the speed ratio of the transmission means, means for positively moving said belt along said cones in exact synchronism with the movement of said stylus radially of the disc.

16. For use in connection with a recording device of the class described, which includes a turntable for rotatably supporting a disc to be spirally inscribed and a stylus or the like for inscribing the disc; the combination of a primary driving means for both rotating said turntable and feeding said stylus radially thereof, variable speed gearing disposed between said driving means and said turntable and stylus for continually and synchronously accelerating the movement of said latter elements so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said gearing comprising a driving shaft, rotated at a constant angular velocity by said primary driving means, and a driven shaft, variably tapered cone pulleys carried by said shafts and operatively connected by a belt, means for positively guiding said belt along said pulleys at a continually varied rate, successive diameters of said pulleys traversed by said belt being so proportioned as to yield the appropriate angular velocity of said turntable for each successive position of said stylus, a screw shaft disposed parallel with said pulleys, said belt guiding means being threaded upon said shaft, and means connecting said screw shaft with said driven pulley shaft to feed said belt guiding means along the pulleys.

17. For use in connection with a recording device of the class described, which includes a turntable for rotatably supporting a disc to be spirally inscribed and a stylus or the like for inscribing the disc; the combination of a primary driving

means for both rotating said turntable and feeding said stylus radially thereof, variable speed gearing disposed between said driving means and said turntable and stylus for continually and synchronously accelerating the movement of said latter elements so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said gearing comprising a driving shaft, rotated at a constant angular velocity by said primary driving means, and a driven shaft, variably tapered cone pulleys carried by said shafts and operatively connected by a belt, means for positively guiding said belt along said pulleys at a continually varied rate, successive diameters of said pulleys traversed by said belt being so proportioned as to yield the appropriate angular velocity of said turntable for each successive position of said stylus, a screw shaft disposed parallel with said pulleys, said belt guiding means being threaded upon said shaft, means connecting said screw shaft with said driven pulley shaft to feed said belt guiding means along the pulleys, another screw shaft detachably connected with said driven pulley shaft, and stylus supporting means threaded upon the second screw shaft, and means for connecting and disconnecting said shafts to and from said gearing, said screw shafts being disposed in axial alignment.

18. For use in connection with a recording device of the class described, which includes a turntable for rotatably supporting a disc to be spirally inscribed and a stylus or the like for inscribing the disc; the combination of a primary driving means for both rotating said turntable and feeding said stylus radially thereof, variable speed

gearing disposed between said driving means and said turntable and stylus for continually and synchronously accelerating the movement of said latter elements so that successive portions of the spiral being inscribed pass the stylus at a constant linear velocity, said gearing comprising a driving shaft, rotated at a constant angular velocity by said primary driving means, and a driven shaft, variably tapered cone pulleys carried by said shafts and operatively connected by a belt, means for positively guiding said belt along said pulleys at a continually varied rate, successive diameters of said pulleys traversed by said belt being so proportioned as to yield the appropriate angular velocity of said turntable for each successive position of said stylus, a screw shaft disposed parallel with said pulleys, said belt guiding means being threaded upon said shaft, means connecting said screw shaft with said driven pulley shaft to feed said belt guiding means along the pulleys, another screw shaft detachably connected with said driven pulley shaft, and stylus supporting means threaded upon the second screw shaft, and means for connecting and disconnecting said shafts to and from said gearing, said screw shafts being disposed in axial alignment, said second named screw shaft being provided with an extension passing axially through said first named screw shaft, and means for connecting and disconnecting said first named screw shaft and the extension of said second named screw shaft, whereby said belt may be held stationary and the turntable rotated at a uniform speed while the stylus is fed across the record.

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