

Aug. 25, 1964

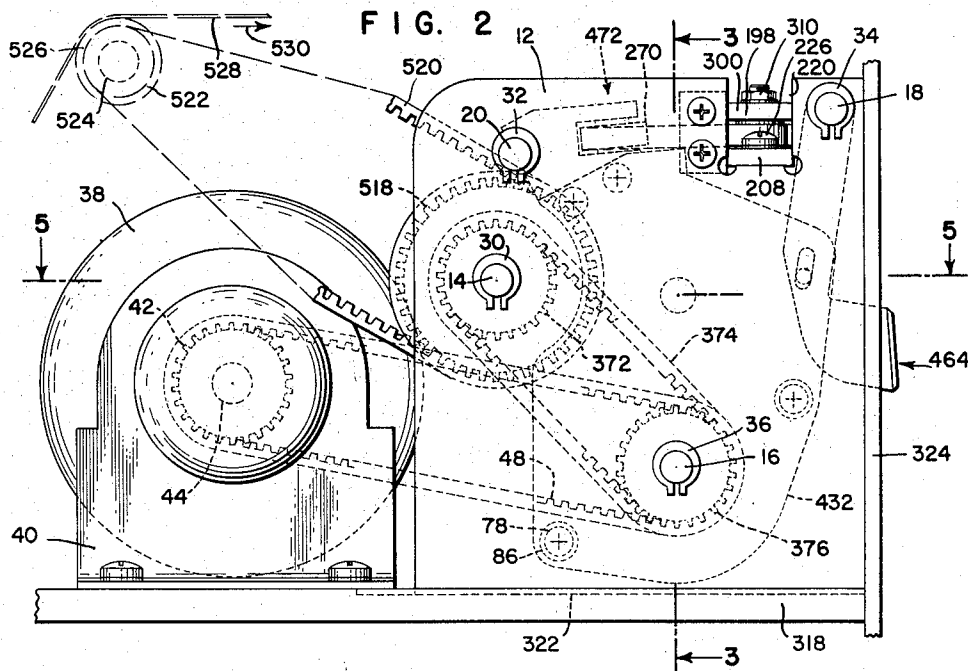
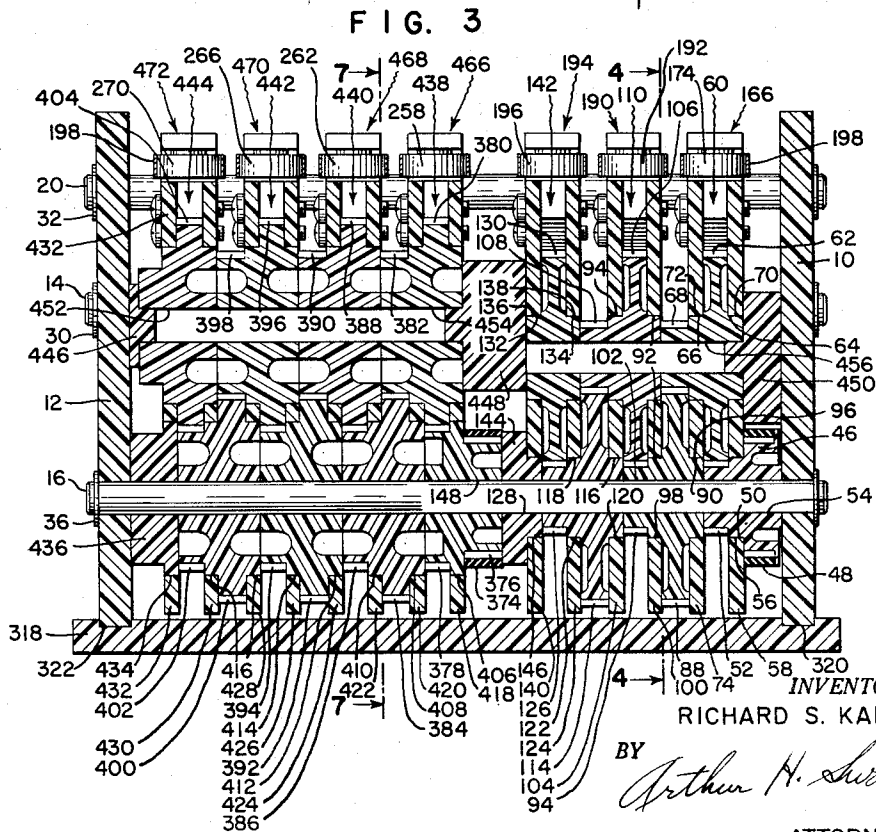
R. S. KAMPF

3,145,578

RECORDER

Filed Jan. 16, 1962

6 Sheets-Sheet 3



INVENTOR.
RICHARD S. KAMPF

BY
Arthur H. Sherman

ATTORNEY.

Aug. 25, 1964

R. S. KAMPF
RECORDER

3,145,578

Filed Jan. 16, 1962

6 Sheets-Sheet 4

FIG. 7

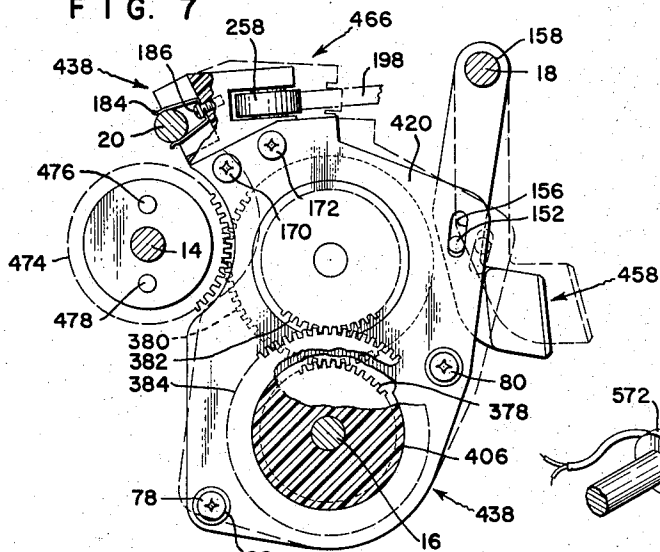


FIG. 10

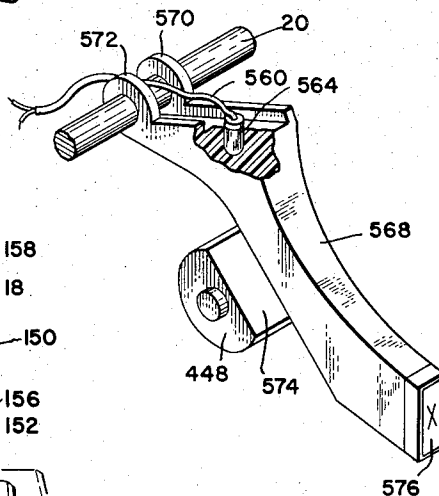


FIG. 4

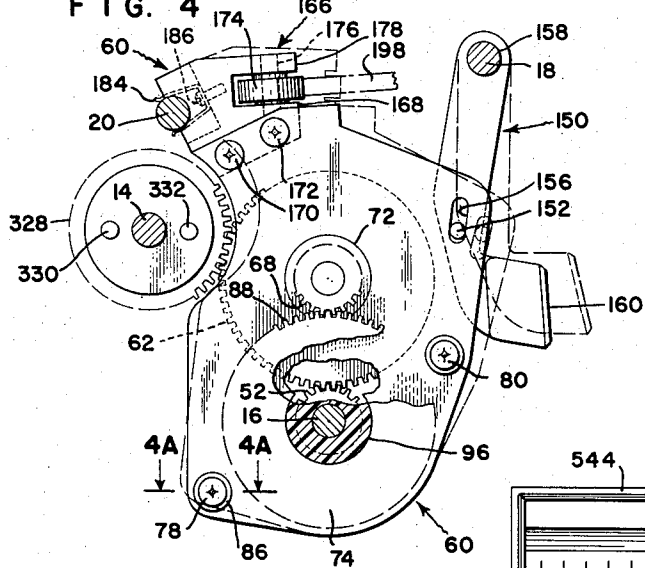


FIG. 4A

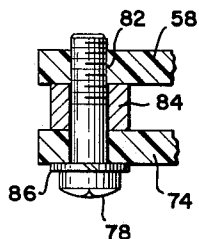
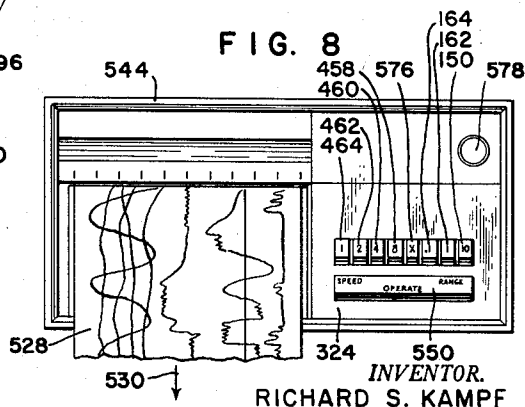


FIG. 8



INVENTOR.
RICHARD S. KAMPF

BY

Arthur H. Swanson

ATTORNEY.

Aug. 25, 1964

R. S. KAMPF

3,145,578

RECORDER

Filed Jan. 16, 1962

6 Sheets-Sheet 5

FIG. 5

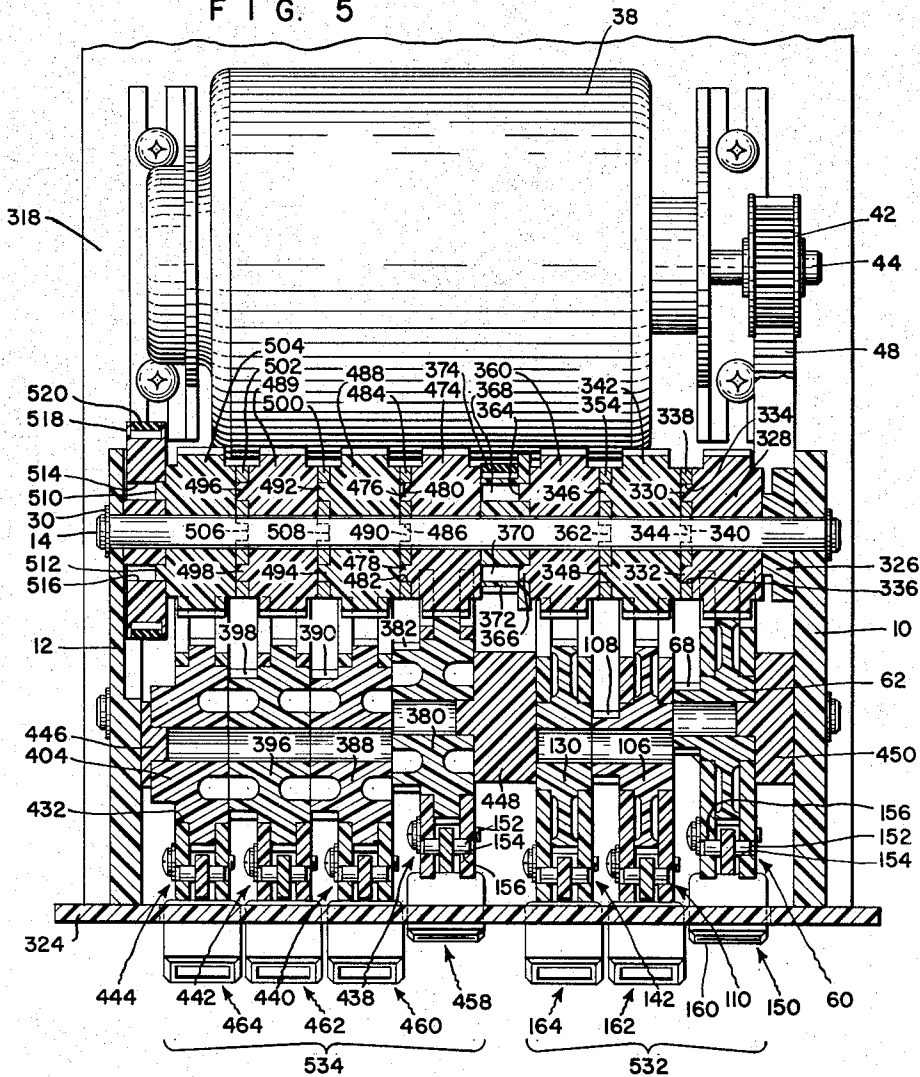
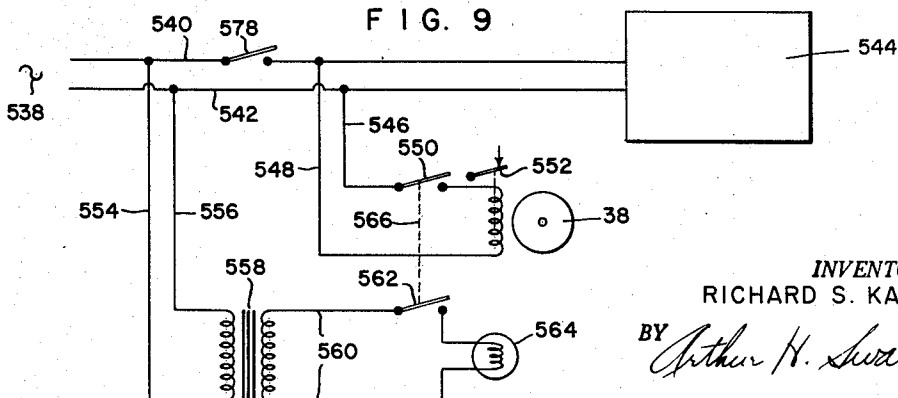


FIG. 9



INVENTOR.
RICHARD S. KAMPF

BY *Arthur H. Swanson*

ATTORNEY.

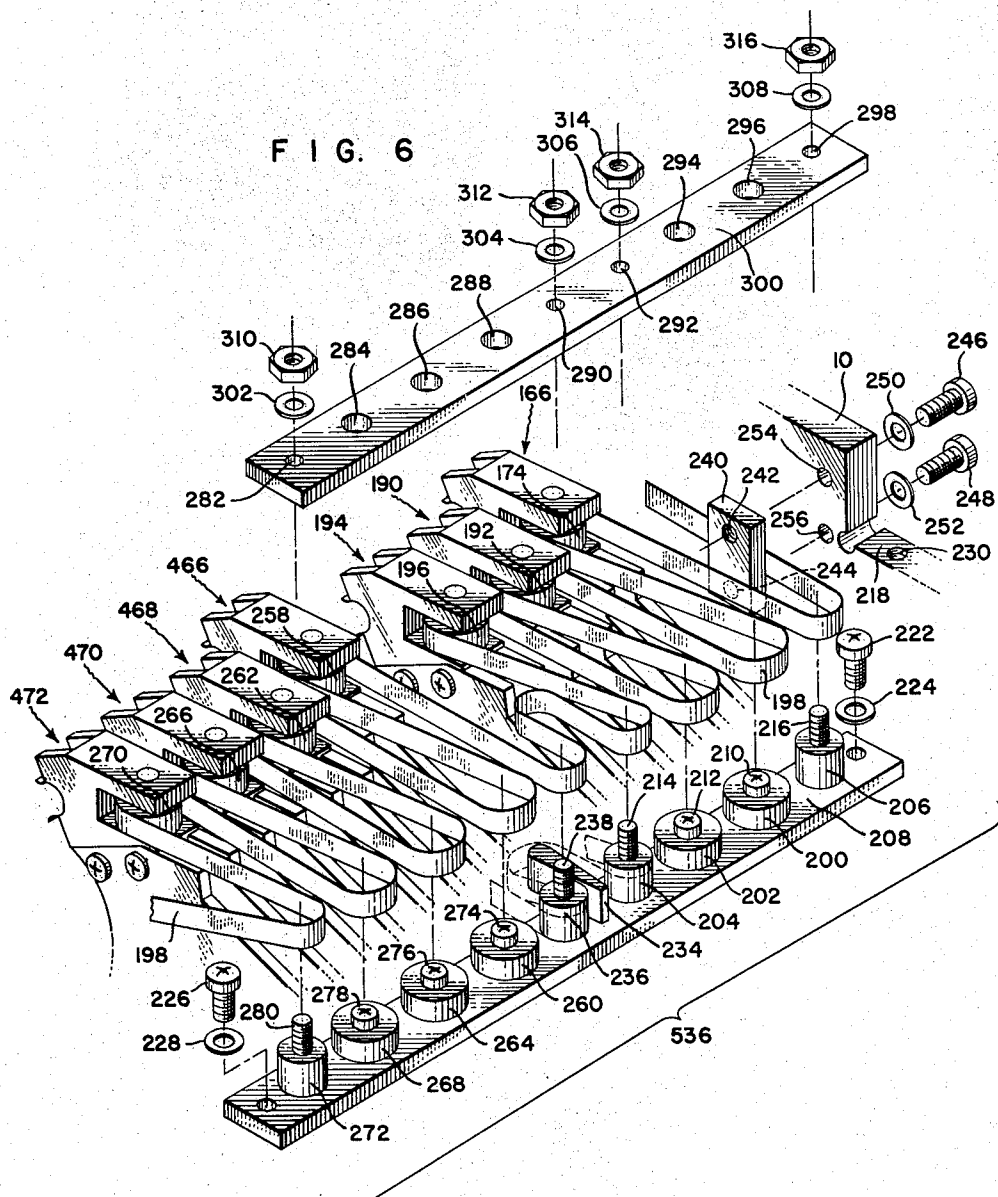
Aug. 25, 1964

R. S. KAMPF
RECORDER

3,145,578

Filed Jan. 16, 1962

6 Sheets-Sheet 6



INVENTOR.
RICHARD S. KAMPF
BY *Arthur H. Swanson*
ATTORNEY.

1

3,145,578 RECORDER

Richard S. Kampf, Denver, Colo., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Filed Jan. 16, 1962, Ser. No. 166,498

14 Claims. (Cl. 74-354)

This invention relates to an apparatus for altering the output speed of a torque transmitting unit.

An object of the present invention is to provide a multi push-button actuated speed changing transmission unit for altering the speed of an apparatus over wide speed ranges of operation, and having particular utility in driving charts employed in recording and/or controlling instruments.

Another object of the present invention is to provide an interlock for a speed changing unit, said interlock comprising a push-button actuated web and roller mechanism which permits the speed changing unit to be shifted to a selected one only of a number of different operating positions.

It is still another object of the invention to provide such a multi-speed driving apparatus with a push-button actuated web and roller interlocking mechanism for a series of range gear and speed gear drive assembly units and an output drive gear system of the multi-speed driving apparatus so that selected gear range drive unit and/or gear speed drive units can be simultaneously brought into driving engagement with the output drive gear system at the same instant of time that another gear range and/or gear speed drive unit is disengaged from the output drive gear system.

It is another object of the invention to provide a multi-gear speed driving apparatus which, because of its unique rugged shock absorbing construction can be advantageously used to safely effect a large instantaneous step up or step down change in speed of a rotating member.

A further object of the present invention is to provide a multi-speed driving apparatus that is capable of being rapidly shifted through a spectrum of two or more speeds that extend from extremely low to extremely high speed ranges, by merely depressing a selected one of three range push-buttons and a selected one of four speed push-buttons.

Another object of the invention is to provide a novel gear and bearing material combination characterized by its satisfactory operation over long periods without lubrication.

A specific object of the invention is to provide a gear and bearing material combination consisting of glass-molydisulfide-filled nylon, for example, as the hub on a gear, running against molydisulfide-filled nylon, for example, as the fixed bearing surface or support. If desired, the fixed surface may be composed of the glass-molydisulfide-filled nylon, and the running part composed of molydisulfide-filled nylon. Nylon is a widely used one of a group of plastics of nitrogenous structure known as polyamides.

Another object of the present invention is to provide a multiplying button between a series of range gear actuating push-buttons and a series of speed gear actuating push-buttons which multiplying button will light up only after a power supply switch, supplying power to the instrument, has been closed and a second independently oper-

2

ated switch, supplying power to a chart drive motor, has also been closed so that the operator can be visually informed that the chart paper is able to be squirted out of the instrument.

Of the drawing:

FIG. 1 shows in block diagram form the manner in which the right and left end portions of the multi-speed transmitting units shown in FIGS. 1A and 1B are assembled.

FIG. 1A discloses an exploded isometric view of the right end of the adjustable multi-speed transmitting unit with the front plate removed;

FIG. 1B discloses an exploded isometric view of the left end of the adjustable multi-speed transmitting unit with the front plate removed;

FIG. 2 shows the left end view of the apparatus shown in FIGS. 1A and 1B with the front plate included therein;

FIG. 3 is a section taken through section 3-3 of FIGS. 1A, 1B as well as along section 3-3 of FIG. 2;

FIG. 4 shows a clutched and unclutched left end view of one of the three range drive assembly units shown in FIG. 1A and FIG. 3;

FIG. 4A is a section taken through section 4A-4A of FIG. 4;

FIG. 5 is a section taken through section 5-5 of FIGS. 1A, 1B as well as along section 5-5 of FIG. 2;

FIG. 6 shows an interlock latch and roller assembly for clutching in selected portions of the multi-speed transmitting apparatus shown e.g. in FIG. 1A and FIG. 1B;

FIG. 7 shows a clutched and unclutched left end view of one of the four speed drive assembly units shown in FIG. 1B and FIG. 3;

FIG. 8 shows the push-button actuated multi-speed transmitting apparatus disclosed herein arranged to drive a strip chart over a wide range of speeds and

FIG. 9 is a schematic of an electric circuit for switching-in and switching-out the chart driving motor with an electric power source;

FIG. 10 is a view showing an X button assembly unit that is associated with the electric circuit shown in FIG. 9 which will light up to visually indicate when power is being transmitted to the chart driving motor.

FIGS. 1A, 1B of the drawing shows two stationary side plates 10, 12. These figures also show shafts 14, 16, 18 and 20 extending between the plates 10 and 12. The left ends of each of these shafts 14, 16, 18 and 20 pass through the holes 22, 24-26, and 28 forming apertures in the side plate 12. The left end of each of the shafts 14, 16, 18 and 20 are fixedly retained in the side plate 12 by horse-shoe shaped spring clips 30, 32; 34, 36. Similar apertures and clips are employed to fixedly retain the right ends of shafts 14, 16, 18 and 20 in the side wall 10.

An electric motor 38 that is operable to rotate at a predetermined speed is schematically shown in FIG. 1A fixedly connected to a stationary support member 40. A belt drive input pulley 42 containing pulley drive teeth on its outer peripheral surface is shown fixedly mounted on one end of the motor drive shaft 44.

Preferably the material from which this pulley 42 is made is of a Nylafil G3 plus four percent molydisulfide material. This is glass-filled nylon with four percent molydisulfide material added, a product of Fiberfil Inc., Foxfarm Road, Warsaw, Indiana.

The center of the drive pulley 42 as shown in FIG.

3

1A and FIG. 2 is conveniently located at a position which is slightly higher than the center of the range input pulley 46 which it rotates about shaft 16 by means of the timing belt 48. The pulley 46 may be of the same diameter as the drive pulley 42. As shown in the drawing, the pulley 46 comprises a smooth cylindrical hub portion 50, a pinion 52, and a hole 54 through which a shaft 16 fits, enabling the pulley to turn freely on the shaft 16. The pulley 46 is made of a unitary piece of the same type of material as that from which the pulley 42 is made.

When the integral part 46, 50, 52 shown in the exploded isometric view of FIG. 1A is in an assembled operating position as shown in FIG. 3, the bearing surface or bore 56 of the gear, right pivot plate 58, which forms one portion of the first pivot plate gear range drive assembly unit 60, will be brought into rotatable supporting engagement with the hub portion 50. The gear pivot plate 58 preferably is made of Nylatron GS, which is a product of Polymer Corporation of Pennsylvania, Reading, Pa., and is molydisulfide-filled nylon. The combination of the pulleys and gears made of the materials indicated provides a desirable inherent dry lubrication. Initially, oil may be used for "break-in," following which no further lubrication is required.

When the parts shown in FIG. 1A are in the aforementioned assembled position, the teeth of the pinion 52 will be in driving engagement with the gear 62.

The gear 62 as shown in FIG. 1A and FIG. 3 has integrally connected therewith two smooth cylindrical hub portions 64, 66 extending from the right and left side thereof. A gear 68 is shown forming an integral part of the extreme left end of hub portion 66. When in an assembled position as shown in FIG. 3 it can be seen that the outer smooth cylindrical surfaces of the hub portions 64, 66 will rotatably support the gears 62, 68 that are integral therewith on the cylindrically-shaped bearing surfaces 70, 72 of the pivot plates 58, 74.

As is best shown in FIGS. 4 and 4A the pivot plates 58, 74 are held in a fixed spaced apart relationship with one another by tightening screws 78, 80. Each of these screws 78, 80 are threadably connected to the pivot plate 58 at 82 so that the ends of a spacer sleeve 84 associated therewith will be brought into snug surface-to-surface engagement with the pivot plates 58, 74. A split spring washer 86 of commercial manufacture is employed as shown to maintain each of the screws 78, 80 in their tightened position. The gears 62 and 68 and all of the other gears and belt driving and/or driven pulleys previously referred to or to be hereinafter described are preferably made of the previously referred to Nylafil G3 plus four percent molydisulfide material.

FIG. 3 shows the teeth of gear 68 in mesh with the gear 88. This gear 88 is turn is provided with smooth cylindrical hub portions 90, 92 protruding from its right and left ends. A gear 94 is shown forming an integral part of the extreme left end of hub portion 92. When in the assembled position as shown in FIG. 3 the outer smooth cylindrical hub portions 90, 92 will rotatably support the gears 88, 94 that are integral therewith on the cylindrically-shaped bearing surface 96, 98 of the pivot plates 74, 100.

A central bearing surface or bore 102 extends through the entire compound gear unit 88-94 and permits the gear 68 to freely rotate this unit 88-94 on the stationary shaft 16.

The construction of the plates 100 and 104, their associated plate spacing units and the gears 94, 106, 108 supported thereby which form a second gear drive assembly unit 110 are identical to the side plates, gears and plate spacing unit construction which has been previously described for the first pivot plate gear drive assembly 60.

It should be noted at this point that by employing different lengths for the shafts 14, 16, 18 and 20 other

4

additional pivot plate gear range drive assemblies may be used as desired by successively moving each of these additional assemblies along the stationary shaft 16, 18 so they can be stacked one against each other to the left of the second pivot plate gear drive assembly 110. It should also be understood that the shafts 14, 16, 18 and 20 can be shortened to accommodate a fewer number of pivot plate drive assembly units than that shown.

After the desired number of gear drive assembly units 60, 106 etc. have been arranged in the above-mentioned fashion on the shaft 16 the end gear drive assembly unit 112 is then moved to the right along the shafts 16, 18 against the last one of the stacked gear drive assembly unit e.g. 106. The gear 108 will then be in mesh with the compound gear 114 and the right and left end hub portions 116, 118 of this compound gear 114 are thereby brought into rotatable supporting engagement with the cylindrical bearing surfaces 120, 122 of the pivot plates 104 and 124.

The gear 126 is shown forming an integral part of the extreme left end of hub portion 118. This compound gear and hub unit 114, 126, 118, 116 is identical to the compound gear and hub unit 88-94 that is shown located between the first and second pivot plate gear drive assembly unit 110. The unit 114, 126, 118, 116 also has a bearing surface or central bore 128 which is of a slightly greater diameter than that of shaft 16.

The gear 126 meshes with a gear 130. The gear 130 is shown having smooth cylindrical hub portions 132, 134 extending from its right and left ends that are in contact with cylindrically-shaped bearing surface portions 136 and 138 of the pivot plates 124, 140.

The left side wall of the pivot plate 140 which forms the left side of the last gear range drive assembly unit 142 is shown having a cylindrical spacer 144 that has a hub portion 146 that engages the wall surface which forms an aperture in the pivot plate 140. This spacer 144 also is provided with a wall 148 forming an aperture in its central portion so that it can be freely mounted for rotation on shaft 16. The purpose of this spacer 144 is to separate the pulley and range gear drive assembly unit which has already been described from the pulley and speed regulating gear drive assembly unit to be described which are mounted on the remaining left end portion of the shaft 16.

As shown in FIG. 1A, FIGS. 4 and 5, a push-button actuated lever unit 150 is located between the pivot plates 58, 74 of the plate range gear drive assembly 60. A central portion of this lever 150 has a cylindrical pin 152 integral therewith and protruding away from its opposite side surfaces. This pin 152 is best shown in FIGS. 4 and 5 as being mounted in sliding contact with the wall surfaces 154, 156 which form oppositely positioned elongated slots in the pivot plates 58, 74. As best seen in FIG. 4 the wall surface 158 in the upper portion of this lever unit 150 forms a cylindrical aperture of a diameter that will allow the lever 150 to be rotatably moved about the stationary lever support shaft 18. The lower end portion of the lever 150 is shown bent and then protruding in a horizontal direction away from the pivot plates 58, 74. As is best shown in FIG. 4 the other end 159 of the lever 150 is shown fixedly connected in any suitable manner, such as by welding material, to the rear surface of a push-button 160.

The plate range gear drive assembly 110 is provided with a push-button actuator lever unit 162 and the plate range gear drive assembly 142 is provided with a lever unit 164 which are each identical to and function in the same manner as the previously described push-button actuated lever unit 150.

FIG. 1A and FIG. 4 show an interlock latch and roller assembly unit 166. This unit 166 is comprised of a T-shaped base portion 168 that is shown inserted between two upper surfaces of the pivot plate 58, 74 as a spacer

5

in a manner similar to the previously described spacer sleeve 84 shown in FIG. 4A of the drawing.

The lower part of this T-shaped base portion is also fixedly retained between these plates by means of the screws 170, 172 which may be threadedly connected to plate 58 in a manner similar to the way screw 78 is shown connected to plate 58 in FIG. 4A. The unit 166 is also comprised of a ball bearing 174 that is mounted to rotate about a stationary pin 176 that is shown extending between a lug portion 178 and the T-shaped base portion 168. The rear end of the unit 166 has spaced apart forked wall portions 180, 182 as is beset shown in FIG. 1A. Inserted between these forked wall portions 180, 182 there is shown a substantially U-shaped clip 184 made from a strip of spring steel or other material having similar spring characteristics. The rear closed end of this clip 184 is fixedly connected by means of welding material or can be fixed as shown by the removable screw 186 to the rear end of the lug 178.

Each of the inner edges of the spaced apart wall portions 180, 182 are of a radially arc-shaped construction such as is shown at 188 to enable these edges to engage substantially one-half of the outer surface of stationary shaft 20 when the push-button 160 is pushed in and the lever 150 is thereby moved in an inward direction from the phantom line position shown in FIG. 4 to the solid line position shown in FIG. 1A and FIG. 4. Pushing in the push-button in this manner will thus cause the pivot plate gear range drive assembly unit 60 to be rotated in a counter-clockwise direction on its smooth rotatable bearing surfaces 56 and 96 and about the center of the stationary shaft 16. This counter-clockwise rotary motion will thus bring the open ends of spring clip 184 into engagement with the stationary shaft 20.

The pivot plate gear drive assembly unit 110 contains interlocked assembly unit 190 which is identical to the previously described interlock latch assembly unit 152 used with the pivot plate gear drive assembly unit 60. This assembly unit 110 also contains a ball bearing 192 which is identical to, and mounted in the same manner as that shown for the previously described bearing 174.

The pivot gear drive assembly unit 142 also is provided with an interlock assembly unit 194 which is identical to the previously referred to interlock latch and roller assembly unit 166. This assembly unit 194 is also shown containing a ball bearing 196 which is also identical to the bearing 174.

The right half portion of FIG. 6 shows the position that the ball bearings 174, 192 and 196 will be in when the push-button 160 of the lever unit 150 is pushed in and the spring clip 184 of the first pivot plate gear range drive unit 60 is thereby brought into spring tight clamping engagement with stationary shaft 20.

FIG. 6 shows a web 198 of an elongated strip shape configuration which is preferably made of a substantially non-expandable material. The strip 198 is shown alternately wrapped over ball bearings 174, 192, 196 and associated bearings 200, 202 and two stationary cylindrically-shaped strip guide blocks 204, 206. The ball bearings 200, 202 are threadedly mounted on a stationary base plate member 208 by means of their respective screws 210, 212. The lowermost surface of the stationary blocks 204, 206 are fixedly retained against the upper surface of plate 208 by means of screw members 214, 216 whose respective shanks are shown protruding in an upward direction from the bottom surface of base plate member 208.

When the base plate 208 is in an assembled position the right end of this base plate 208 fits into the wall surface portions 218 shown in FIGS. 6 and 1A and the left end of the plate 208 is fitted into and in engagement with the wall surface portions 220 shown in FIG. 1B. Suitable screw and lock washer connections 222, 224 and 226, 228 are employed as shown in FIG. 6 to maintain the ends of the base plate 208 in tight threaded engage-

6

ment with the tapped threaded holes 230 and 232 in the side plates 10, 12 that are shown in FIG. 1A and FIG. 1B.

The strip 198 is shown in FIG. 6 as being fixedly attached midway between its ends by means of a wedge-shaped member 234 which is purposely shown in a jammed position between the previously described stationary strip guide block 204 and another stationary block 236 that is retained in a fixed position on base plate member 208 by means of the threaded screw member 238.

FIG. 6 shows the right end of the strip 198 retained in a fixed position against the right side plate 10 by means of a friction plate 240 having two tapped wall surfaces 242, 244 into which associated threaded connecting members 246, 248 are engaged. Each of these threaded connecting members 246, 248 are slid through their associated lock washers 250, 252 and assembled in the aforementioned threaded position. The shank of each of these threaded connecting members 246, 248 is passed through apertures 254, 256 formed in the side plate 10. Tightening of the threaded connecting members 246, 248 thus enables the right side surface of the plate 240 to press the right end of the strip 198 into fixed engagement against the side wall 10.

To place the right half of the strip 198 in its assembled position the right end of the strip is first placed in a fixed position against the side plate 10 by means of the screw and plate connections 240-252. The strip 198 is then sequentially interwoven between the cylindrical surface of the first stationary guide 206, the outer cylindrical surface of the roller bearings 174, 200, 192, 202, 196 and thence over a second stationary cylindrical surface of the guide 204 as is indicated in broken line form in FIG. 6 of the drawing. The wedge 234 is then moved to a position in which it is wedged into surface-to-surface contact with the stationary guides 204, 236.

The left half of the strip 198 is then sequentially interwoven between the previously-mentioned stationary guides 236, roller bearings 258, 260, 262, 264, 266, 268, 270 and another stationary guide 272. The extreme left end portion of the strip 198 is maintained in fixed relation with the end plate 12 in the same manner as the extreme right end of the strip 198 is attached to the end plate 10. The roller bearings 260, 264 and 268 are threadedly mounted on the base plate unit 208 by means of their associated screw members 274, 276, 278. The construction of these roller and pin connections are identical to the roller and screw connections 200, 210; 202, 212 which have been previously described. A screw member 280 is employed to retain the roller 272 in a stationary position on plate 208 in a manner identical to the previously described way the screw member 216 retains roller 206 on the plate 208.

After the strip 198 has been interwoven between all of the bearing and stationary guides previously referred to and the ends of the strips have been fixed to their associated end plates 10, 12 the apertured wall portions 282-298 formed in the strip retaining plate 300 is lowered so that the threaded ends of the screws 214, 216, 238, 280 and the heads of the threaded pin connections 210, 212, 274, 276, and 278 are surrounded by these wall portions. When assembled the bottom of the strip retaining plate 300 will rest on the top surface of the stationary rollers 204, 206, 236, 272 and on the inner stationary face of the ball bearings 200, 202, 260, 264 and 268. The strip retaining plate is maintained in this assembled position by sliding shake-proof lock washers 302, 304, 306, 308 over the associated threaded portions of the screws 280, 238, 214 and 216 that protrude above the top surface of the plate 300 and then rotatably tightening the associated nuts 310, 312, 314, 316 along these shank portions so that the spring washers 302-308 will be compressed against the upper surface of the plate 300.

FIG. 1A, FIG. 4 and FIG. 5 of the drawing show the stationary shaft 14 which extends between the end plates

10 and 12. These end plates 10, 12 are in turn supported on a base plate 318. As is best shown in FIGS. 2 and 3 this base plate 318 is provided with grooved-out portions 320, 322 to maintain these plates in fixed spaced apart relation with one another.

FIGS. 2 and 5 of the drawing shows a front plate 324 fixedly joined to the base plate 318 and to the end plates 10, 12. Any suitable connecting means such as welding material or a screw connection may be used to provide a fixed connection between the aforementioned front plate 324, base plate 318 and the end plates 10 and 12.

As is shown best in FIG. 1A and FIG. 5 the shaft 14 carries on its right end an embossed spacer 326. FIG. 5 shows the left end surface of the spacer 326 in surface-to-surface engagement with the gear 328 which gear is slidably mounted for rotation on the stationary shaft 14. Two diametrically opposed cylindrical bosses 330, 332 form a left side wall portion of the gear 328. These bosses are shown protruding through wall surface portions 334, 336 that form two diametrically opposed apertures in a Neoprene shock washer 338 which is of a medium hardness. This shock washer 338 is provided with two additional apertures which are similar in size to the apertures formed by the wall surface 334, 336. One of these apertures 340 is shown in FIG. 1A and FIG. 5 spaced at the same distance from the center of shaft 14 as the previously-mentioned apertures 334, 336. These two additional apertures are however spaced ninety degrees away from the apertures 334, 336 shown in FIG. 1A and FIG. 5.

The bosses 330, 332 are of a smaller length than the thickness of the washer 338 that is made of a medium hard material such as Neoprene so that the washer can act as a friction shock absorbing drive plate between the gear 328 and the gear 342.

The right end of the gear 342 has protruding therefrom two diametrically opposed cylindrical bosses spaced circumferentially one hundred and eighty degrees apart from one another, one boss 344 of which is shown dotted in FIG. 5. These last-mentioned bosses fit into their associated apertures 340 and another aperture not shown that is displaced one hundred and eighty degrees therefrom. The last-mentioned bosses are shown of a smaller length than the thickness of the Neoprene washer 338.

The left end of the gear 342 is shown having two diametrically opposed cylindrical bosses 346, 348. These cylindrical bosses protrude into two associated apertures 350, 352 formed in a second Neoprene shock washer 354. This shock washer 354 construction is identical to shock washer 338 previously described. Two apertures 350, 352 are shown in FIG. 1A as being displaced ninety degrees from the two apertures 356, 358.

The left side surface of the Neoprene shock washer 354 is shown best in FIG. 5 as being in surface-to-surface engagement with the right surface of the gear 360. Protruding away from the right side of the gear 360 and into the aperture 356, 358 there is shown a pair of bosses spaced circumferentially one hundred and eighty degrees apart from one another. One of these last-mentioned bosses 362 is shown in dotted line form in FIG. 5. The aforementioned bosses 346, 348, 362, the boss not shown which is displaced one hundred and eighty degrees from boss 362, and the disc 354 thus provide a friction disc drive connection between the gear 342 and the gear 360.

The left end of the gear 360 is provided with a plurality of cylindrical bosses such as the bosses 364, 366 which are shown protruding into associated apertures 368, 370 of the hub portion of a second belt drive pulley 372. This is best shown in FIG. 1A and FIG. 5 of the drawing. A belt 374 is shown engaged with the drive pulley 372 at one end and in driving engagement with a driven pulley 376 at its other end. A gear 378 is shown forming a left end portion of the gear pulley 376.

FIG. 3 of the drawing shows the gear 378 in driving engagement with the gear 380. Gear 380 has a gear

382 formed integral therewith that is in driving engagement with the gear 384. The gear 384 is provided with a gear 386 formed integral therewith that is in driving engagement with the gear 388. The gear 388 is provided with a gear 390 formed integral therewith that is in driving engagement with the gear 392. The gear 392 is also provided with a gear 394 formed integral therewith that is in driving engagement with the gear 396. One end of the gear 396 is shown having a gear 398 formed integral therewith that is in driving engagement with the gear 400. Gear 400 is also shown having a gear 402 formed integral therewith that is in driving engagement with the gear 404.

The outer cylindrical hub portion of the aforementioned gears 376, 378; 384, 386; 392, 394; 400, 402; are best shown in FIGS. 1B and 3 as being mounted for rotation on the wall portions 406, 408, 410, 412, 414 and 416 of the pivot plates 418, 420, 422, 424, 426, 428, and 430. The pivot plate 432 shown at the left end of the shaft 16 has a cylindrical bearing surface 434 which carries an embossed cylindrically-shaped spacer 436.

The aforementioned pivot plate 418, 420; 422, 424; 426, 428; 430, 432 form a first, second, third and fourth pivot plate speed gear drive assembly units 438, 440; 442, 444.

It should be noted at this point that by employing different lengths for the shafts 14, 16, 18 and 20 other additional pivot plate gear speed drive assemblies may be used as desired by successively moving each of these additional assemblies along the stationary shaft 16, 18 so they can be stacked one against each other to the left of the third pivot plate gear speed drive assembly 442 before the speed drive assembly 444 is placed in its assembled position on these shafts. It should also be understood that the shafts 14, 16, 18 and 20 can be shortened to accommodate a fewer number of pivot plate drive assembly units than that shown.

FIG. 3 shows embossed cylindrical spacers 446, 448, 450 inserted in the central apertured wall portions 452, 454, 456 of the gears 404, 380 and 62 with which these spacers are associated. The right end of the spacer 448 is shown in contact with the pivot plate 140 and the left end of the spacer 450 is shown in contact with the pivot plate 58.

Each pivot plate speed gear drive assembly unit 438-444 is comprised of an associated push-button actuator lever unit 458, 460, 462 or 464 which is best shown in FIGS. 1B and FIG. 5. Each of these push-button lever actuated units 458-464 are pivotally connected to the shaft 18 and its associated pivot plate unit in the same manner as that shown for the speed gear pivot plate unit 444 in FIG. 7.

It can be seen that the mounting of each of these push-button lever actuated units 458-464 is the same as that previously described in detail for the push-button actuating lever pivot plate units 150, 162, 164.

Each of the pivot plate speed gear drive assembly units 438-444 are also comprised of an associated interlock latch and roller assembly unit 466, 468, 470, 472 which are each structurally and functionally identical to the interlock latch and roller assembly units 166, 190, 194 that were previously referred to under the description of the pivot plate range gear drive assembly unit 60, 110, 112. As is best shown in FIGS. 1B and 5 the shaft 14 has a gear 474 rotatably mounted thereon. The right side of the gears 474 is shown in FIG. 5 in surface-to-surface contact with the flat left end surface of the drive pulley 372. The left side of the gear 474 is shown having diametrically opposed cylindrical bosses 476, 478 which protrude into associated wall surfaces 480, 482 which form two apertures in a Neoprene shock washer 484.

The shock washer 484 is also provided with two additional apertures which are similar in size to the apertures formed by the wall surfaces 480, 482. One of these apertures, 486 is shown in FIGS. 1B and 5 spaced at the

same distance from the center of the shaft 14 as the previously mentioned apertures 480, 482. These additional apertures 486 and the aperture which is diametrically opposite this aperture are spaced ninety degrees away from the apertures 480, 482 shown in FIGS. 1B and 5.

The bosses 476, 478 are of a smaller length than the thickness of the washer 484 which is made of a medium-hard material such as Neoprene referred to supra so that the washer can act as a friction shock absorbing drive pulley between the gear 474 and the gear 488.

The right end of the gear 488 has protruding therefrom two diametrically opposed cylindrical bosses spaced circumferentially one hundred and eighty degrees apart from one another, one boss 490 is shown in FIG. 5. The last-mentioned bosses fit into their associated apertures 486 and another aperture, not shown, that is displaced one hundred and eighty degrees therefrom. The last-mentioned bosses are similar to the bosses 476, 478 in that they are of a smaller length than the thickness of the washer 484.

The left ends of the gears 488, 489 each have two associated bosses 492, 494; 496, 498 protruding therefrom which are shown passing into associated diametrically displaced apertures formed in a medium-hard shock washer material 500, or 502 in a manner similar to that previously described for the bosses 476, 478 and the washer 484.

Preferably the shock washers 500, 502 are made of NEMA grade G10 glass epoxy which is commercially available in epoxy glass laminated sheet form.

The right side of the gears 489 and 504 are also each shown as having a pair of cylindrical diametrically opposed bosses protruding therefrom. One of each of these pair of bosses 506, 508 is shown protruding into another pair of associated apertures in a manner similar to the manner which the bosses 476, 478 protrude into their apertures 480 and 482 as previously described.

The left end of the gear 504 which is rotatably mounted on shaft 14 has two cylindrical bosses 510, 512 protruding therefrom and pass through the apertured wall portions 514, 516 in the right end of the driving pulley 518.

As is best seen in FIG. 2 the timing belt 520 is shown in engagement with the driving pulley 518 at one end and is schematically shown in driving engagement with a chart driving pulley 522 that is mounted on one end of a spindle 524 that in turn is fixedly connected to a driven member such as a chart drive roller 526. It can thus be seen that the multi-speed driving apparatus disclosed herein can be used to drive a spindle 524 and chart drive roller 526 associated therewith so that the chart drive roller can withdraw the free end portions of a strip chart 528 at a number of speeds from a chart supply roll, not shown, in the direction of the arrow 530 shown in FIGS. 2 and 8. It should be understood that the speed of the multi-speed driving apparatus disclosed herein can be increased from the twelve speed push-button arrangement shown in the drawings to an apparatus that is provided with additional speed regulating push-buttons by increasing the length of the shafts 14-20 and adding more pivot plate gear range drive assemblies and/or gear speed drive assemblies thereon in the manner previously described.

The purpose of FIGS. 1 to 8 are to illustrate one example of how the multi-speed drive ideas disclosed herein can be employed as a seven push-button—twelve speed transmission unit.

As can be seen best in FIGS. 1A, 1B and 6 this transmission unit is comprised of a range section 532, a speed section 534 and a push-button actuated interlocked system 536 which prevents the use of more than one range push-button and one speed push-button at any one time.

The transmission unit uses a series of compound reduction gear supporting pivot plate assemblies 60, 110, 112, 438, 440, 442 and 444. Range push-buttons 160, 162, 164 and speed push-buttons 458, 460, 462 and 464

are attached directly to these gear plate assemblies 60, 110, 112, 438, 440, 442 and 444. The range section gears supported by these pivot plate assemblies are ten-to-one reduction gears and the speed gear supported by these plate assemblies are two-to-one reduction gears.

Before operating the aforementioned range and speed gears a single application of breaking in lubricant, such as oil, is applied between the side surfaces of these gears and the inner side surfaces of the pivot plates which support these gears. This breaking in lubricant is also applied to any of the other parts of the aforementioned plate assemblies which are shown in contact with or in close proximity to the other surfaces of these side plates.

A major advantage that is gained from making use of lubricated gears made of glass molydisulfide-filled nylon material with lubricated pivot plates which are of a molydisulfide-filled material is that these parts will never need any further lubrication.

The range section 532 is driven directly by a drive motor 38 and contains two ten-to-one reduction stages which provide a one hundred-to-one overall reduction and range speed.

By way of example it can be seen that when the range push-button 160 is depressed to place it in engaged position as shown in FIG. 5 and in the solid line position illustrated in FIG. 4, the pin 152 fixedly attached to the push-button lever 150 will be moved from the dotted line position to its solid line position. As this occurs the pin will force the plates 58, 74 in a counter-clockwise direction so as to move the interlock latch and roller assembly unit 166 into spring engagement with the shaft 20 in the manner shown in FIGS. 4 and 6.

If the push-button 162 was in a depressed position before the push-button 160 was depressed then upon the depression of the push-button 160 the roller bearing 174 will pull the strip 198 inwardly to the position shown in FIG. 6. Since the strip 198 is of a fixed length this pulling of the strip 198 by roller bearing 174 will cause the roller bearing 192 of the interlock latch and roller assembly unit 190 to be withdrawn from a position in which it is in spring engagement with the shaft 20 to a disengaged position as is shown in FIG. 6.

While the aforementioned simultaneous engagement of unit 166 and the disengagement of unit 190 occurs it can be seen that the gear 62 which is carried by the range pivot plate unit 60 will be brought into engagement with the gear 328 while the gear 106 which is carried by the pivot plate unit 110 is simultaneously disengaged from gear 342. This last-mentioned position of the gear 62 and 106 is best shown in FIG. 5 of the drawing.

Under the aforementioned condition in which the push-button 160 is depressed it can be seen that the motor, as shown in FIGS. 1 and 5, which is driven at a constant speed, will transmit its rotary motion by way of the drive pulley 42, belt 48, range gears 54, 62, 328, shock washer 338, gear 342, shock washer 354, gear 360, drive pulley 372, belt 374 to the speed gear 148.

If the speed push-button 460 was in a depressed position before the push-button 458 was depressed to the position shown in FIG. 5 then upon the depression of the push-button 458 the roller bearing will pull the strip 198 inwardly to the position shown in FIG. 6. Since the strip 198 is of a fixed length this pulling of the strip 198 by roller bearing 258 will cause the roller bearing 262 of the interlock latch and roller assembly unit 468 to be withdrawn from a position in which it is in spring engagement with the shaft 20 to a disengaged position as shown in FIG. 6.

While the aforementioned simultaneous engagement of unit 466 and the disengagement of the unit 468 occurs it can be seen that the gear 380 which is carried by the speed pivot plate unit 438 will be brought into engagement with the gear 474 while the gear 388 which is carried by the pivot plate unit 440 is simultaneously disengaged from gear 488. This last-mentioned position of

the gears 380 and 388 is best shown in FIG. 5 of the drawing.

Under the aforementioned condition in which the push-button 458 is depressed it can be seen that the previously mentioned rotary motion from the motor 38 being transmitted from the range unit by way of the gear belt drive unit 372, 374, 376 will cause this rotary motion to be transmitted by way of gears 378, 380, 474, shock washers 484, gear 488, shock washers 500, gear 489, shock washers 502, gear 504, driving pulley 518, belt 520 to the chart driving pulley 522.

The speed at which the strip chart 528 will be driven under the aforementioned conditions will be a direct result of the rotary motion of the motor 38 that the gears of the unit 60 of the range section 532 transmits to the speed unit 438 of the speed section 534 and will also depend on how much of this last-mentioned rotary motion this speed unit 438 transmits to the chart driving pulley 522 as previously explained.

From the aforementioned description it can be seen that the depression of the range and speed push-buttons 160, and 458 enable the output shaft of this multi-speed transmitting apparatus to be driven at one preselected speed. It can also be seen that the depression of the speed push-buttons 460 or 462 or 464 can be combined with the already depressed range push-button 160 to give three additional speeds.

It is also possible to have the transmission unit disclosed herein arranged to transmit four additional speeds by depressing range push-button 162 and speed push-button 458; push-buttons 162 and 460; push-buttons 162 and 462; and push-buttons 162 and 464.

Four additional transmission unit speeds are obtained by depressing the range push-button 164 and speed push-button 458; push-buttons 164 and 460; push-buttons 164 and 462 and push-buttons 164 and 464.

More specifically the speed section 534 is coupled to the range section 532 by a belt 374 and consists of three two-to-one reduction stages which provide an eight-to-one overall reduction of the range output speed. Depressing the speed buttons 458-464 provides net reduction of eight-to-one, four-to-one, two-to-one, and one-to-one, respectively. The output of this speed selection can thus be connected to any member which is desired to be driven at any one of twelve different speeds.

Twelve push-button selected positive chart drive speeds can thus be provided through the use of the transmission unit disclosed herein namely, .1, .2, .4, .8, 1, 2, 4, 8, 10, 20, 40, and 80 inches per second which speeds may be readily changed during operation.

FIG. 9 shows a power source 538, a pair of power line conductors 540, 542 between the power source 538 and electrically operated parts such as a vapor lamp which may be contained in the recording section 544 of the instrument shown in FIG. 8.

FIG. 9 also shows a second pair of conductors 546, 548 connected to the power line 540, 542 at one of their ends and connected at their other ends by way of an "operate" switch 550 to a relay 552 which can be energized and deenergized so as to cause rotation or no rotation of the shaft of the chart driving motor 38.

A third pair of conductors 554, 556 are connected at one of their ends to the power line 540, 542 and connected with the transformer 558 at their other ends. Leads 560 from the secondary winding of the transformer 558 are in turn connected by way of switch 562 to an electric light source 564. The switch 562 is shown connected by means of a mechanical connection 566 to the switch 550 so that when the "operate" switch 550 is moved to an open or closed position the switch 562 will likewise be moved to the same open or closed position.

The light source 564 shown in the form of an electric light bulb in FIG. 10 is supported on a top portion of the arm 568. The arm 568 is of a good light transmitting material such as quartz, an acrylin resin or methyl-

methacrylate plastic materials of a thermoplastic type such as for example commercially available materials sold under the name of Plexiglas or Lucite. The upper end of this arm 568 is provided with two apertured lugs 570, 572 which are shown slid into position on the shaft 20 between the left end of the range gear pivot plate units 532 and the right end of the speed gear pivot plate units 534.

An underside surface portion of the arm 568 is shown resting on a flat surface portion 574 of the spacer 448 and the front end 576 of the arm is shown having an X, or multiplying sign, imprinted thereon.

The electric circuit shown in FIG. 9 at the front of the instrument as shown in FIG. 8 is provided with a power switch 578 to supply electric power by way of conductors 540, 542 to a recording section 544 of the instrument when this switch 578 is rotated in one direction and to cut off this power to section 544 when rotated in an opposite direction.

It can also be seen from the circuit diagram shown in FIG. 9 and the push-button arrangement shown in FIG. 8 of the drawing that this electric power will also be supplied to the motor 38 by way of the conductors 546, 548 an delay 552 when the "operate" push-button switch 550 has been moved to a closed position. The mechanical linkage 566 is arranged to cause switch 562 to close at the same instant of time that the switch 550 is moved to its closed position so that the electric light bulb 564 will light up and transmit light through the arm 568 to and out of the end of the arm 576 which is marked with an X.

Lighting of the X button will thus indicate to the operator that the chart drive motor has been turned on and that the chart 528 is in a condition to be squirted out of the front of the instrument at the chart speed the operator had heretofore selected by depressing one of the range gear push-buttons 160, 162 or 164 and one of the speed gear push-buttons 458, 460, 462 or 464. The apparatus further provides a dual push-button actuated switch that is operative in one position to rotate a drive motor of the transmitting apparatus and to transmit light to a light indicator and which is operative in a second position to stop the motor from rotating and to cut-off the transmitted light to the light indicator.

From the aforementioned description of the apparatus it can be seen that the present invention is concerned with a self-lubricated multi-speed transmission apparatus of a rugged shock absorbing construction having a range section, a speed section and an interlock system which is provided with a plurality of push-buttons, selected ones of which can be depressed to rapidly shift the transmission unit through a spectrum of speeds that can extend between extremely low and extremely high speed ranges.

What is claimed is:

1. Apparatus for driving a recording chart of an instrument at any selected one of a plurality of speeds, comprising a chart drive motor having an output drive gear, a first series of rotatable range gear and speed gear units each having a different input speed to output speed ratio, each of said gear units having an output gear, said output motor drive gear being operably connected to simultaneously transmit its output motion through each of the range and speed gear units, a stationary shaft, a second series of gears rotatably mounted on the stationary shaft to rotate as a single gear and at a position that is adjacent said range gear unit, a third series of gears that are rotatably mounted on the stationary shaft to rotate as a single gear at a position that is adjacent said speed gear unit, a mechanically actuated interlocking means connected to each of said range gear units and to each of said speed gear units to effect an engagement of only a selected one of the output gears of the range and speed units at any one time with their associated output gear in the second and third gear series, a chart driving gear and a motion transmitting means between said third gear series and said chart driving gear.

2. The multi-speed chart driving apparatus as defined in claim 1 wherein a motion transmitting means is operably connected to said second series of gears and an input end of one of said speed gear units to transmit the output motion of said range gear to said speed gear units.

3. The multi-speed chart driving apparatus as defined by claim 1 wherein the mechanical actuation of the interlocking means of any one of said range gear units and the mechanical actuation of different ones of the interlocking means on said speed gear units provide a means to alter the speed at which the chart driving gear is driven by said second motion transmitting means.

4. The multi-speed chart driving apparatus as defined by claim 1 wherein said apparatus is provided with a number of range gear units and speed gear units that will provide a minimum of twelve selective chart speed means when selected pairs of said interlocking means connected to said range gear and speed gear units are mechanically actuated.

5. The multi-speed chart driving apparatus defined by claim 1 wherein the mechanically actuated interlocking means comprises an interlocked latch and rotatably mounted roller bearing assembly associated with each of said range and speed gear units, a roller associated with each of said first rollers juxtapositioned on a stationary member that is spaced from said first rollers, a flexible strip, said strip having stationary end portions and being of a fixed length, the portion between the ends of the strip being interwoven between the first and second mentioned rollers of said range unit and the first and second mentioned rollers of said speed unit, a pivotally mounted push-button actuated lever operably connected to each of said units to force any one of said interlocked latches and associated rotatably mounted roller bearing of said range and speed units into latched engagement with a stationary member while any one of the remaining interlocked latches and associated rotatably mounted roller bearings of said range and speed units which are in an interlocked position with said stationary member is simultaneously disengaged therefrom.

6. A multi-speed transmission unit, comprising a plurality of range gear reduction units wherein each unit thereof rotates an associated output driving gear at a different speed, a plurality of speed gear reduction units wherein each unit thereof rotates an associated output second driving gear at a different speed than said first-mentioned driving gears or the remaining second driving gears, a stationary transmitting shaft, two groups of gears each separately mounted to rotate as a single unit on said shaft, a push-button actuated interlocked mechanism interposed between each of said range and speed gear reduction units to effect simultaneous engagement of one of said driving gears of said range gear units with a gear in a first one of said group of gears and the engagement of one of said driving gears of said speed gear units with a gear in the other of said group of gears while another of said range and speed driving gears are withdrawn from engagement with the gear it is associated with in said gear group, a first motion transmitting means between said gears forming said first one of said group of gears and the speed input end of the speed reduction unit and a second motion transmitting means operably connected for rotation with said second group of gears for transmitting output motion therefrom.

7. The multi-speed transmitting unit defined by claim 6 wherein each of said range gear reduction units are comprised of gears which provide a ten-to-one speed reduction and wherein each of the speed gear reduction units are comprised of gears which provide a two-to-one speed reduction.

8. The multi-speed transmitting unit defined by claim 6 wherein shock washers are employed as friction discs to separate the side surfaces of adjacent gears of said group of gears on said transmission shaft, said washers being provided with a plurality of passageways between

its gear contacting side surfaces and wherein each of said last-mentioned gear surfaces are provided with spaced apart cylindrical bosses which alternately protrude through said passageways.

9. The multi-speed transmitting unit defined by claim 6 wherein shock washers are employed as friction discs to separate the side surfaces of adjacent gears of said group of gears on said transmission shaft, said washers being provided with a plurality of passageways between its gear contacting side surfaces, each of said last-mentioned gear surfaces being provided with spaced-apart cylindrical bosses which alternately protrude through said passageways, and wherein said gears are constructed of a Nylafil G4 plus four percent molydisulfide material and wherein certain of said shock washers are constructed of a medium hard shock resistant NEMA grade G10 glass epoxy material and others of said shock washers are constructed of a different medium hard shock resistant material.

10. The multi-speed chart driving apparatus as defined by claim 6 wherein each of said range and speed gear reduction units are provided with spaced apart gear supporting pivot plates constructed of Nylafil G4 plus four percent molydisulfide material, said plates being spaced apart to accommodate the rotation of the output driving gear thereon and said plates having opposite apertured wall portions to rotatably support cylindrical boss portions which protrude from opposite side surfaces of the output driving gear.

11. An interlocking mechanism for selectively connecting a first output driving gear of a first gear reduction unit into engagement with a driven member while another output driving gear of a second gear reduction unit is simultaneously disengaged from said driven member, said interlocked mechanism comprising a rotatable member mounted on each of said units, two additional rotatable members spaced in fixed relation with said first-mentioned rotatable members, a flexible strip having fixed end portions, the portion of the strip extending between its ends being interwoven alternately about peripheral portions of said two sets of rotatable members, push-button actuated lever means associated with each of said units, and each of said lever means when actuated being operable to selectively move the rotatable member and the unit it is associated therewith in a direction which will engage its output member with said driven member while the roller mounted on the remaining unit is simultaneously moved by the resulting pull of such strip in a direction to disengage its output driving gear with said driven member.

12. The multi-speed chart driving apparatus defined by claim 1, wherein said apparatus comprises a visible light indicating means, terminals providing a source of energizing electric current, a switch having two operating positions, said switch operating to connect said terminals in an energizing relationship to said chart driving motor and said indicating means when in a first operating position, and operating to disconnect said terminals from said chart driving motor and said light indicating means when in a second operating position.

13. The multi-speed chart driving apparatus defined by claim 1 wherein the rotatable range gear and speed gear units are comprised of gears constructed of molydisulfide-filled nylon rotatably supported in pairs of spaced-apart aperture plates that are constructed of a glass-molydisulfide filled nylon.

14. A self-lubricating, multi-speed, transmitting apparatus, comprising a first series of units each containing range gears, a second series of units each containing speed gears, a stationary shaft, each of the gears in said units being supported by plates that are pivotally mounted for movement about the stationary shaft, a second stationary shaft, a first series of gears positioned adjacent one of said units and operably connected to rotate as a single gear on one longitudinal portion of the second stationary shaft, a second series of gears positioned adjacent the

15

other of said units and operably connected to rotate as a single gear on another opposite longitudinal end portion of the last-mentioned stationary shaft, interlocking means connected to each of the units to rotate a selected one of the range gears and a selected one of the speed gear units into engagement with one of each series of gears with which each unit is associated, a driving means for rotating a gear of one of said gear units and the gears of the range and speed gear units, and the first and second series of gears being constructed of glass-filled nylon

5

10

16

and substantially four percent molydisulfide material and the gear supporting plate being constructed of an oil-impregnated molydisulfide-filled nylon material.

References Cited in the file of this patent

UNITED STATES PATENTS

2,344,275	Straub	Mar. 14, 1944
2,448,341	Yeomans	Aug. 31, 1948
2,538,625	Moore	Jan. 16, 1951
2,856,787	Haupt	Oct. 21, 1958