

May 25, 1965

K. E. SIHVONEN ETAL

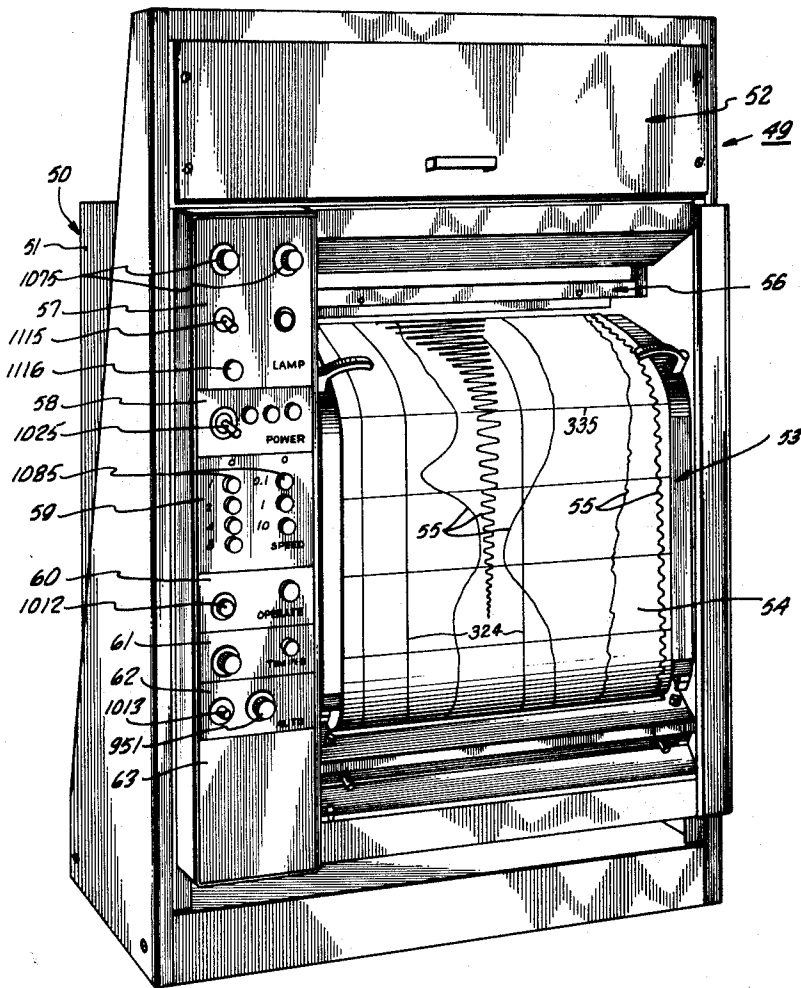
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MODULAR OSCILLOGRAPH

Filed Sept. 20, 1960

18 Sheets-Sheet 1

Fig. 1.



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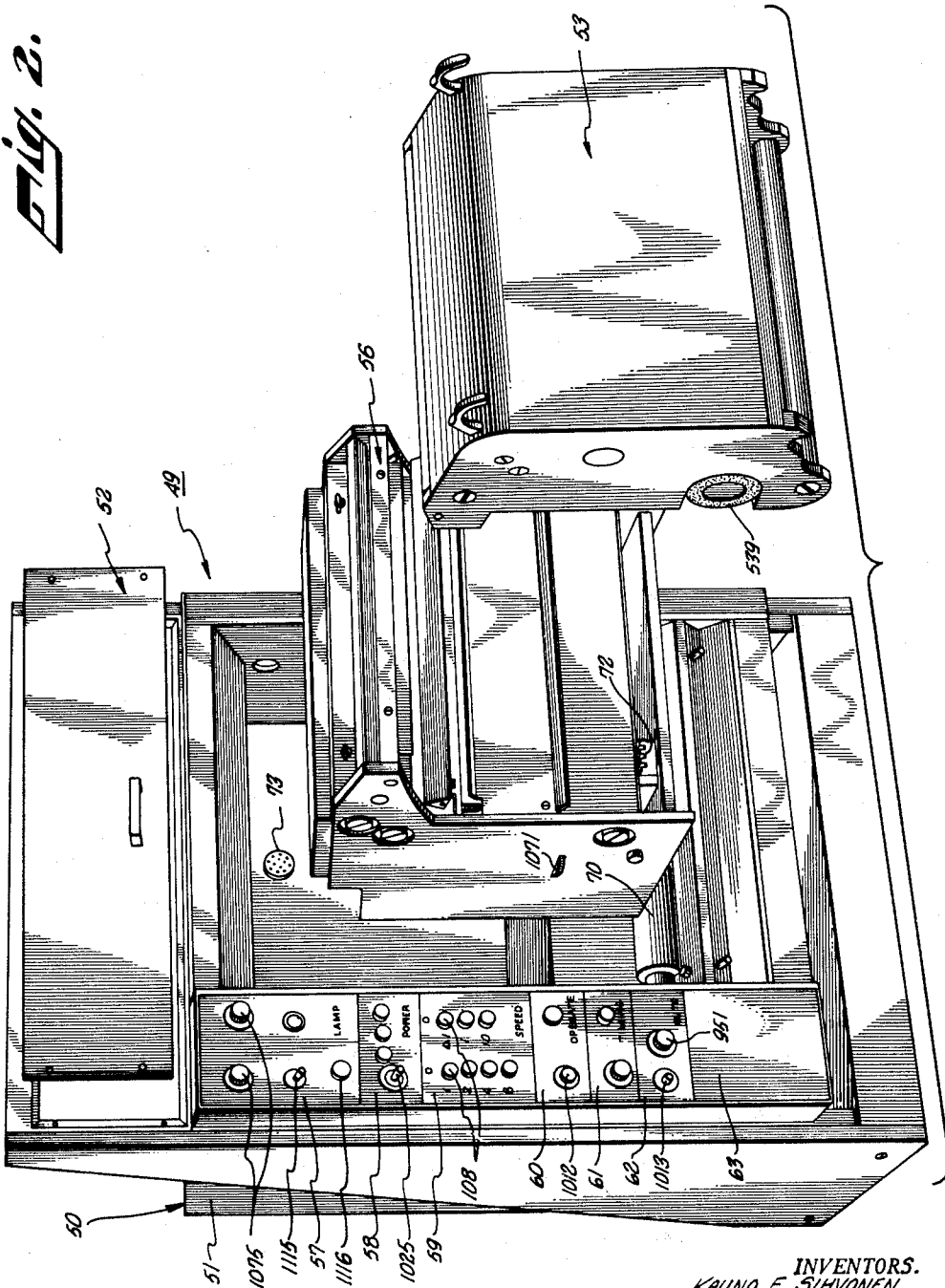
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18 Sheets-Sheet 2

Fig. 2.



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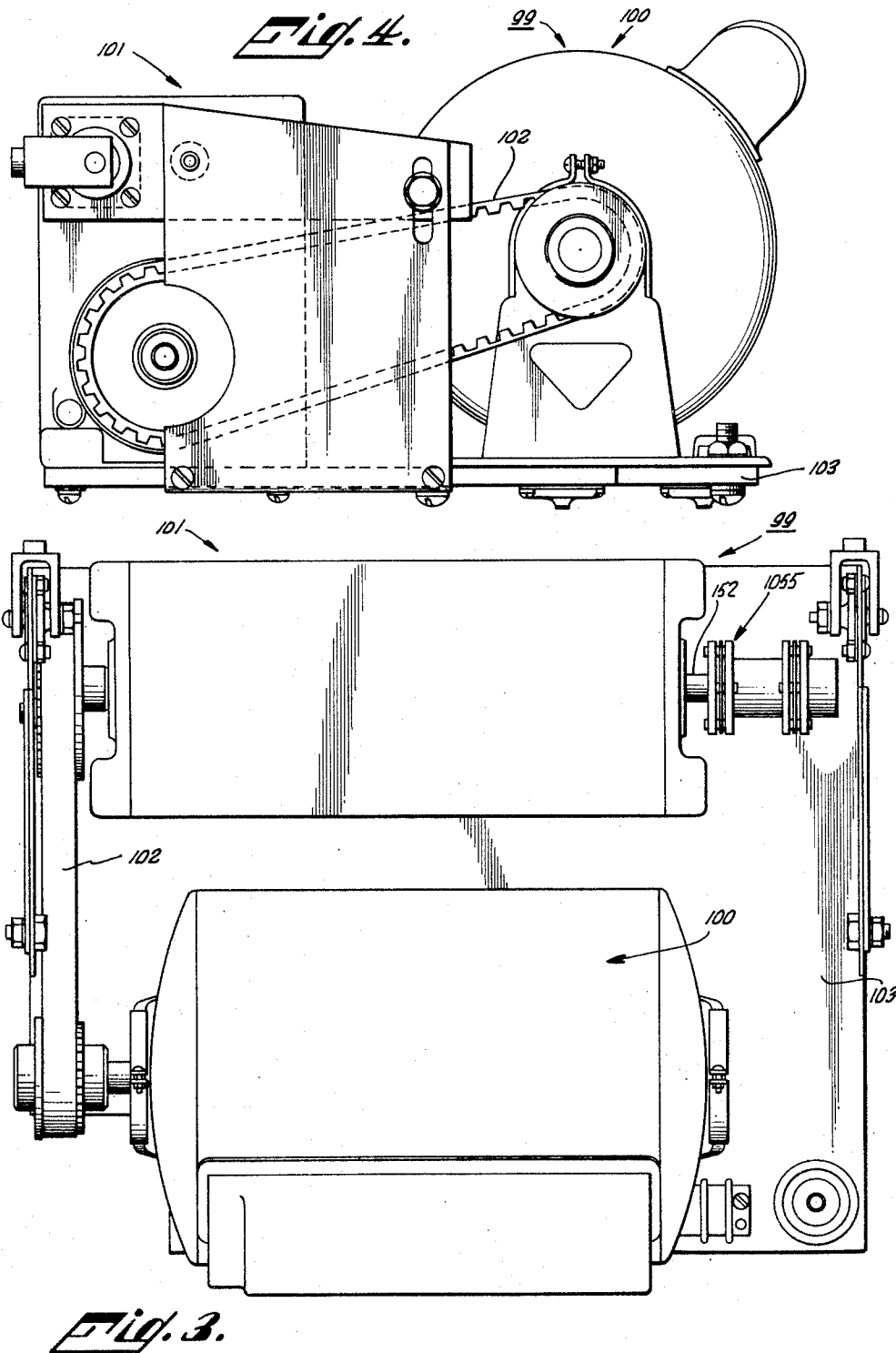
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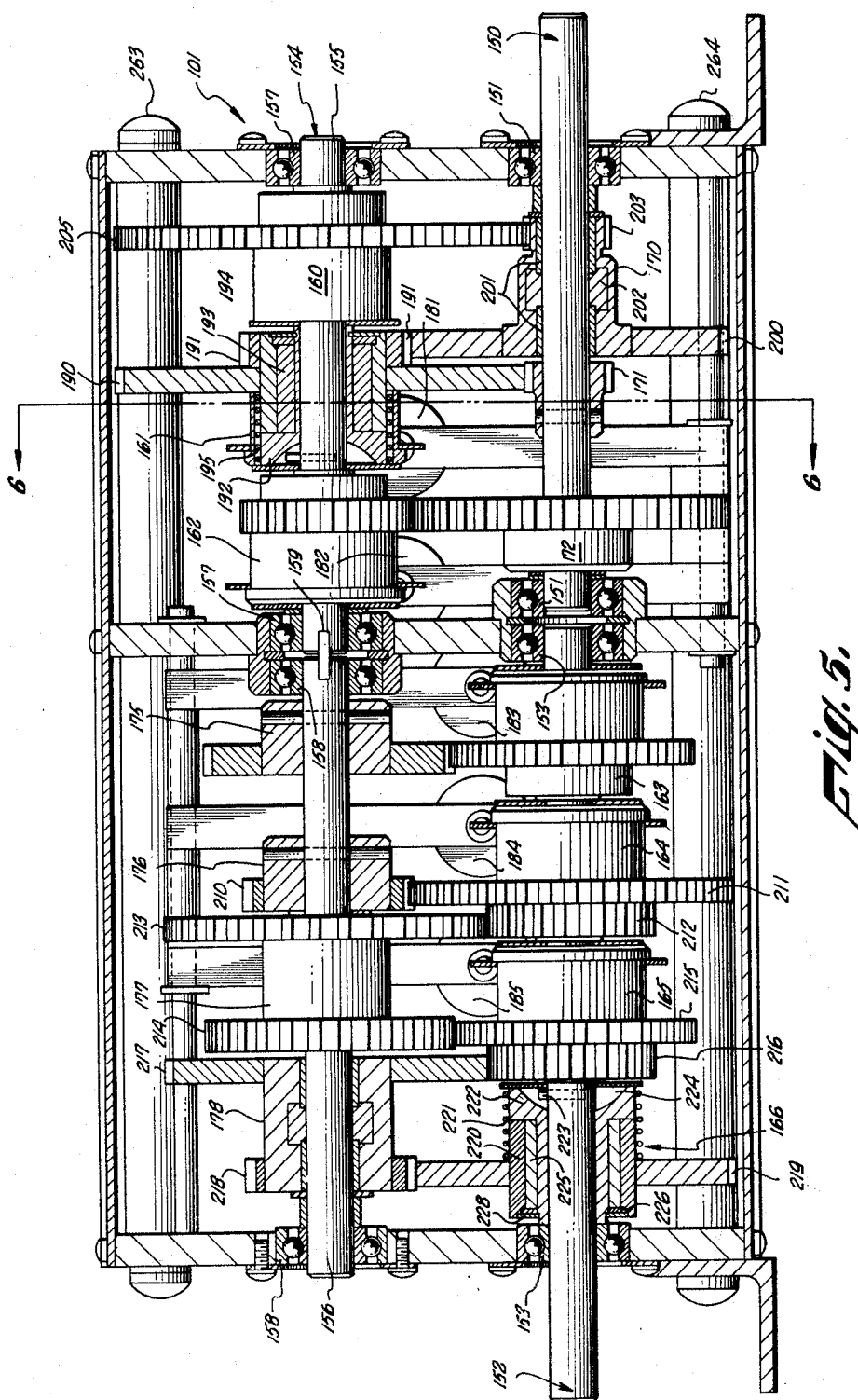
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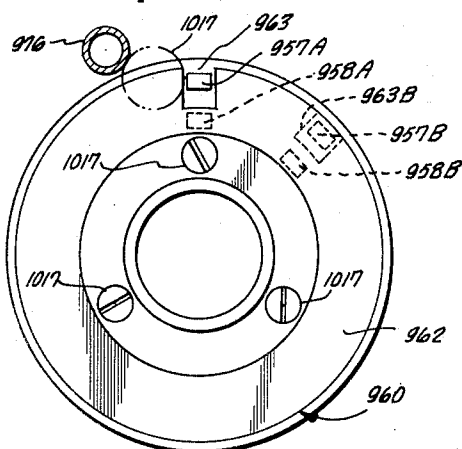


Fig. 25.

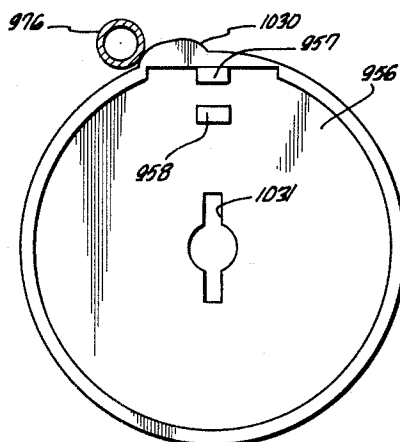


Fig. 24.

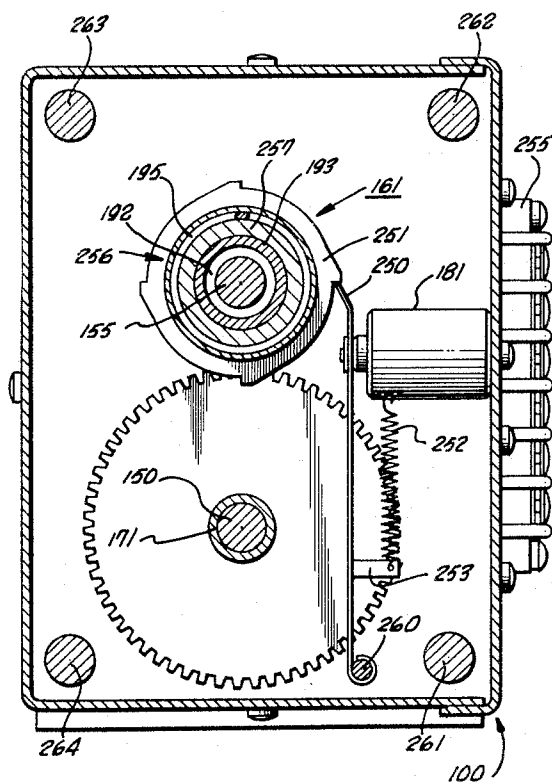


Fig. 6.

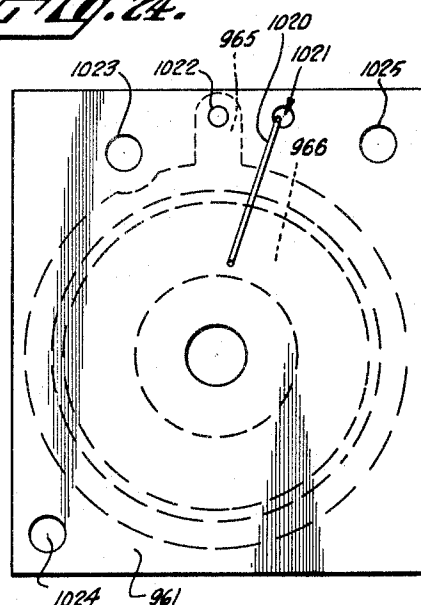


Fig. 23.

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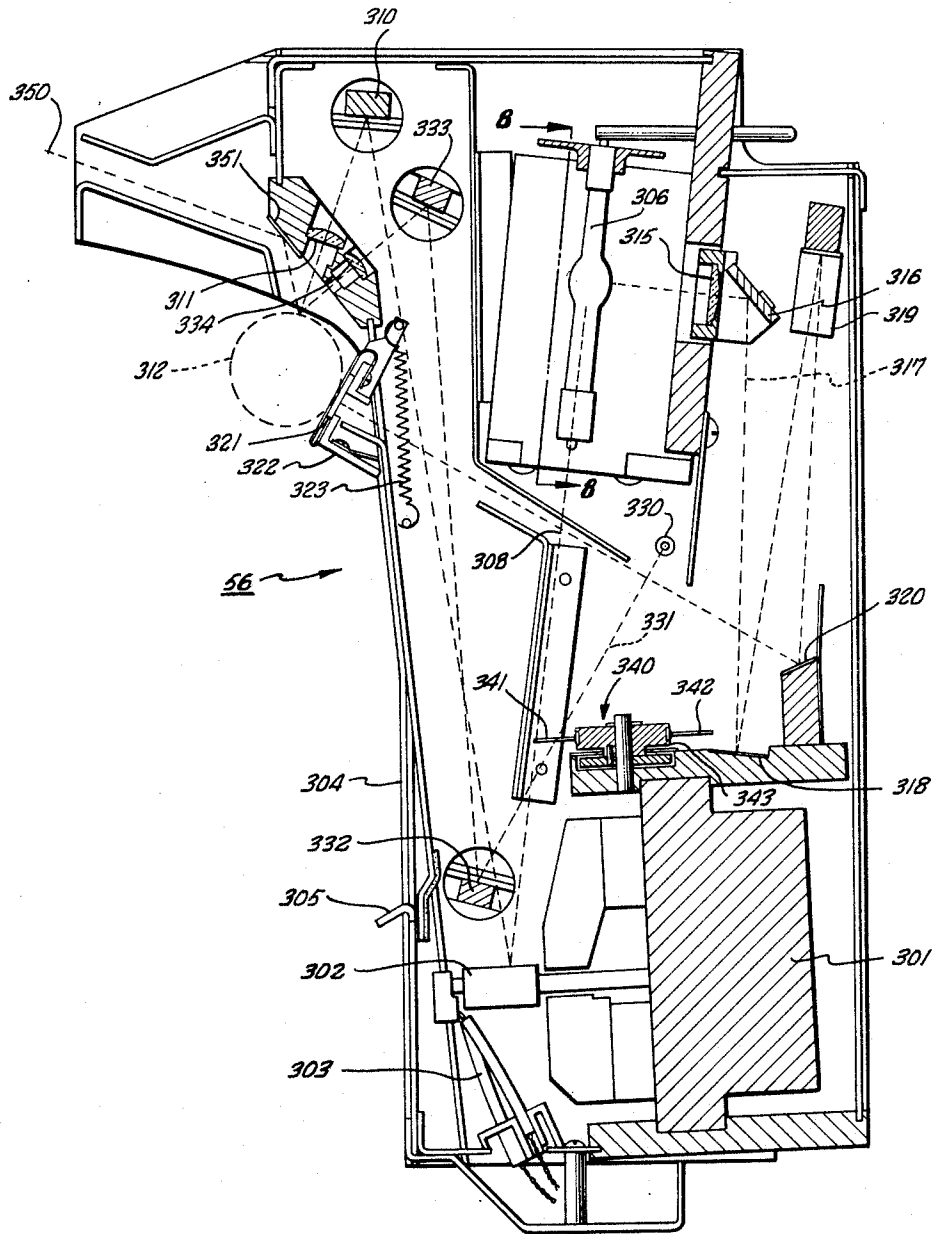


Fig. 7.

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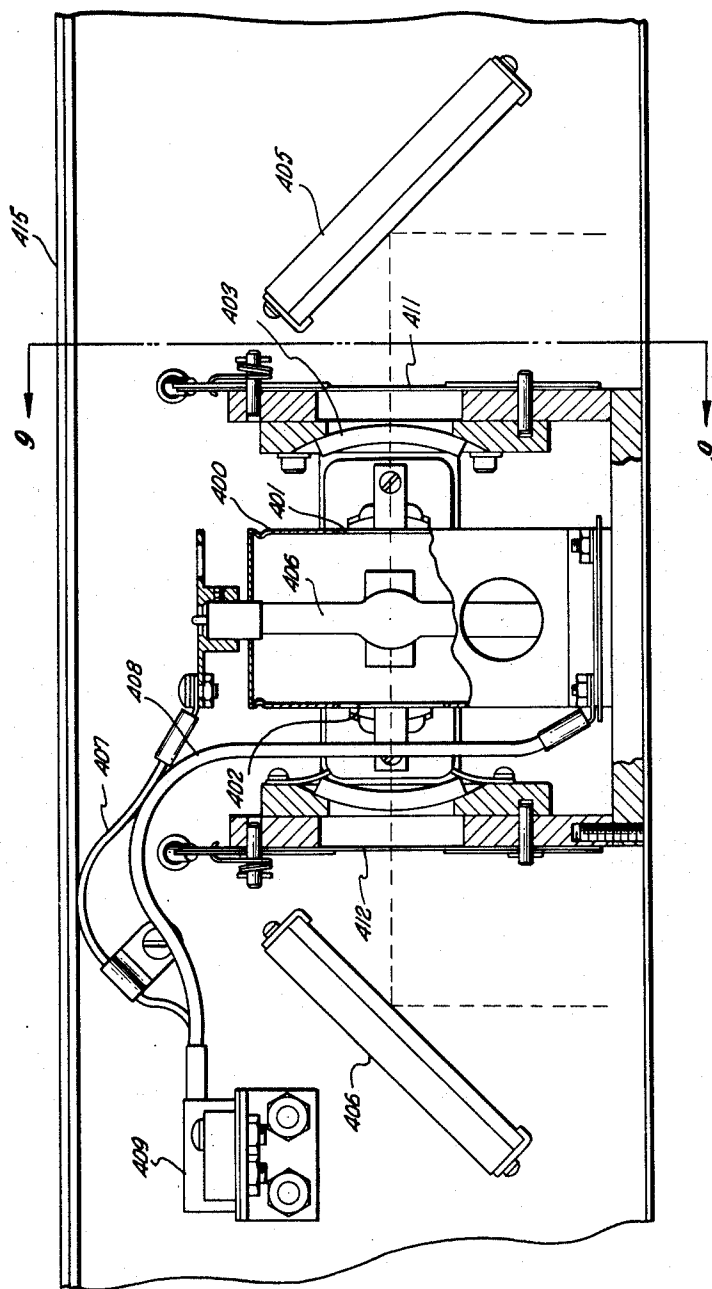


Fig. 8.

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Fig. 22.

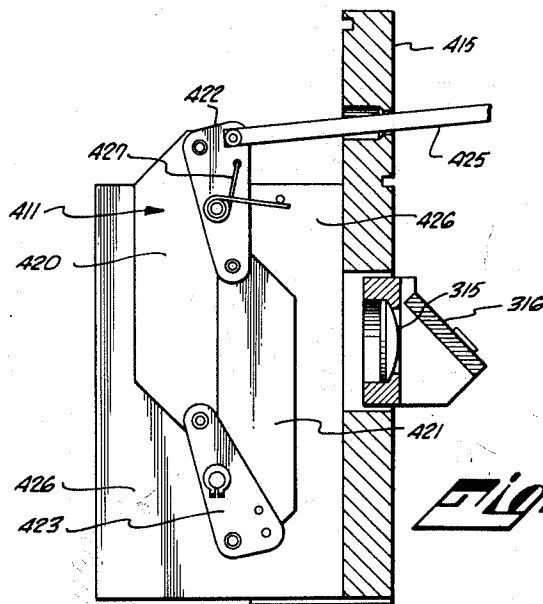
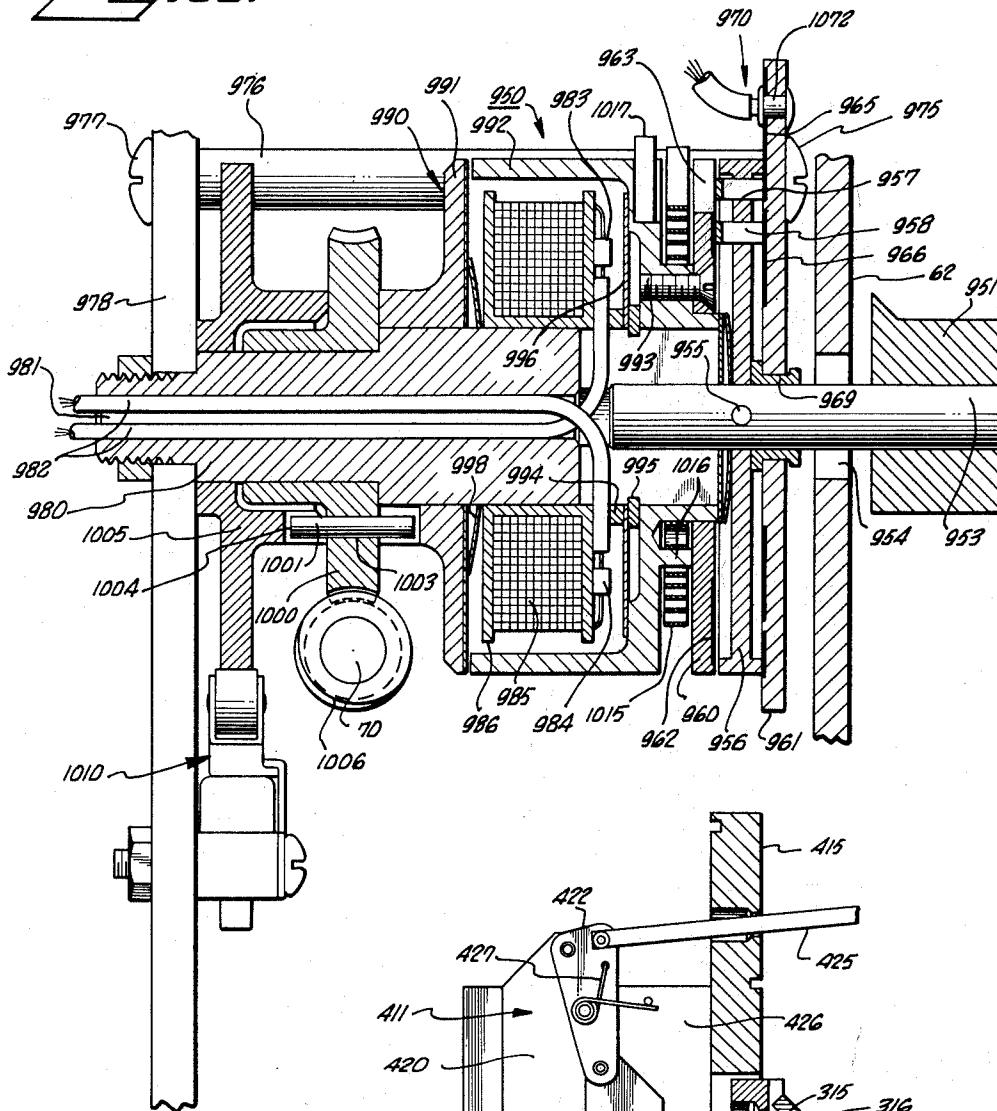


Fig. 9.

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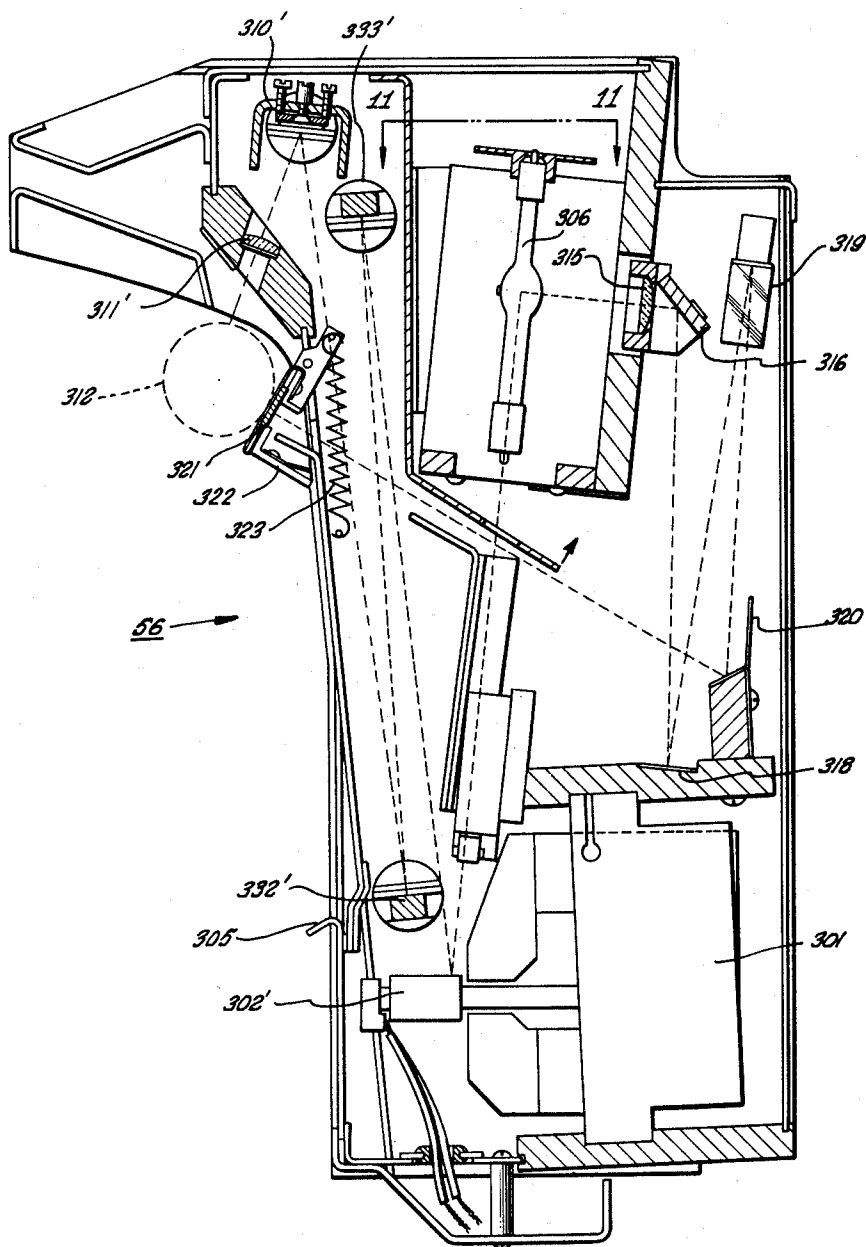


FIG. 10.

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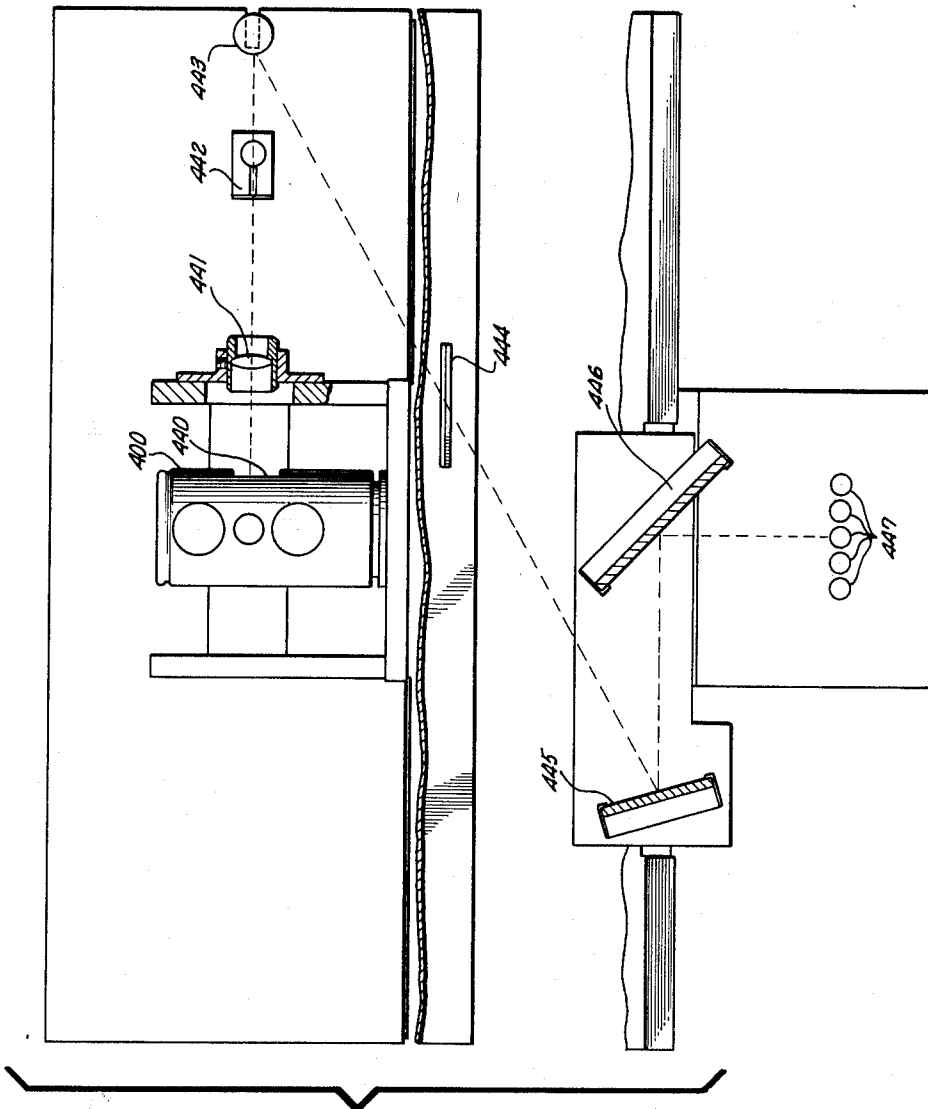


Fig. 11.

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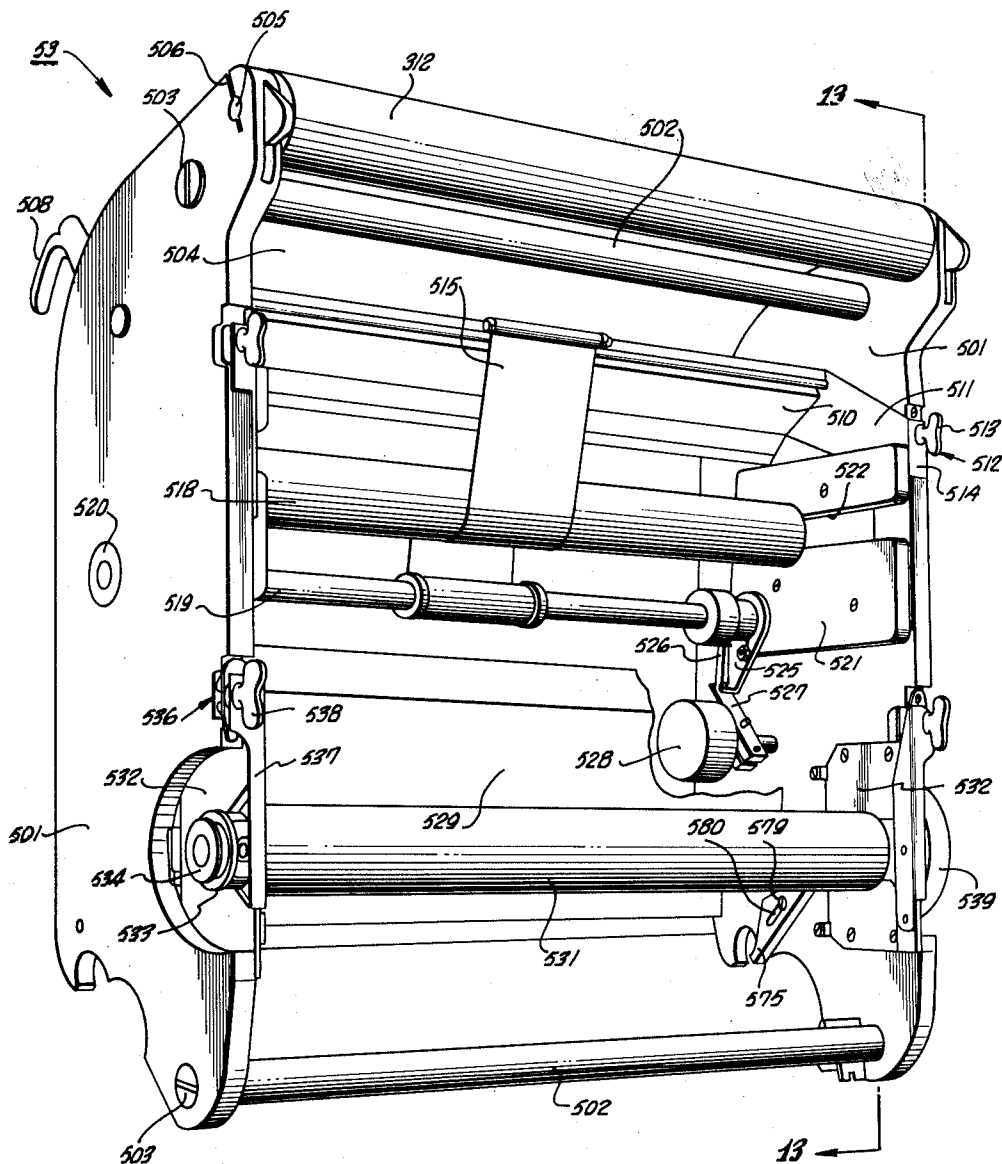


Fig. 12.

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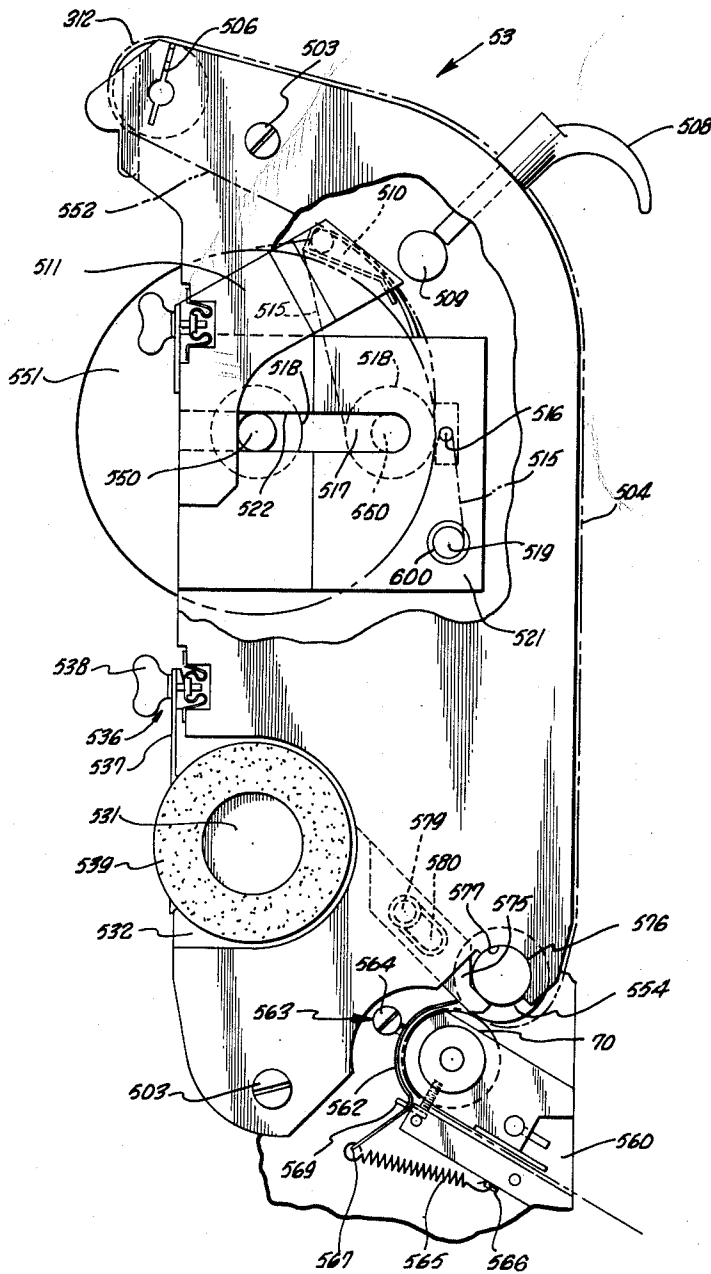


Fig. 13.

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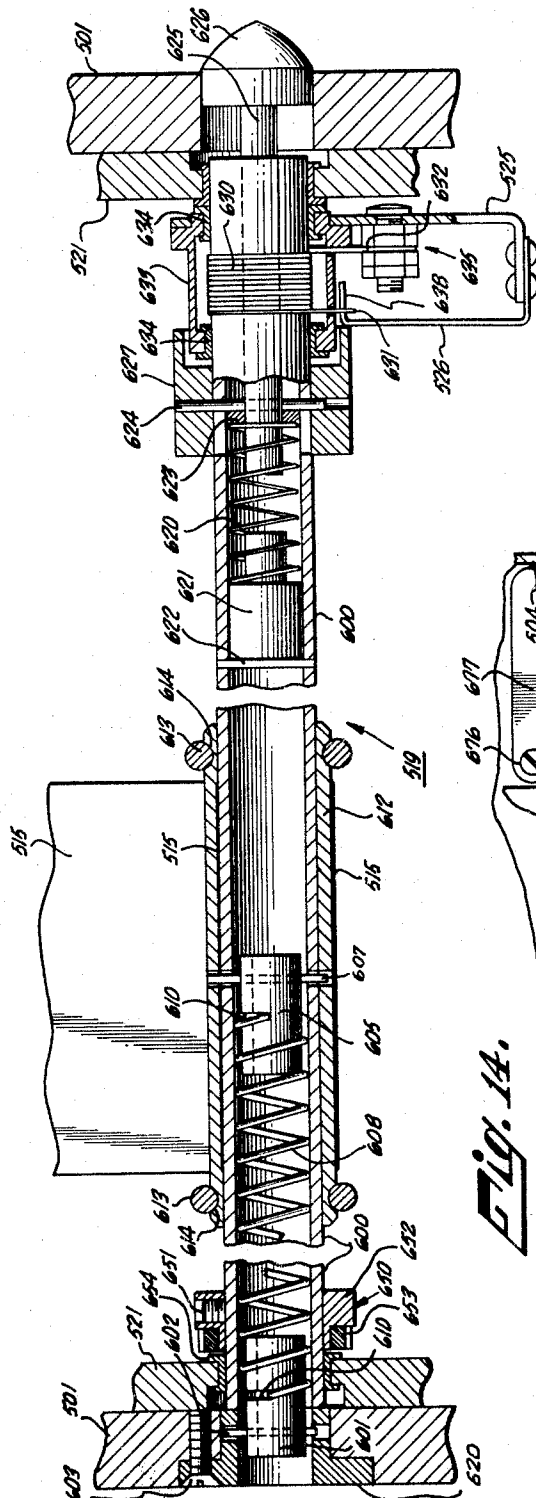


Fig. 14.

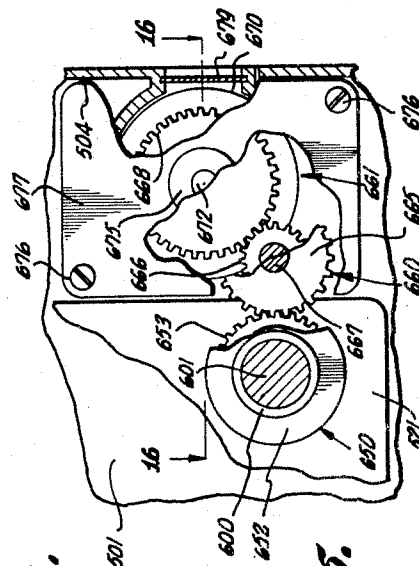


Fig. 15.

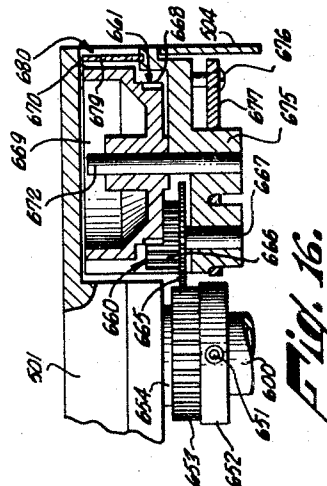


Fig. 16.

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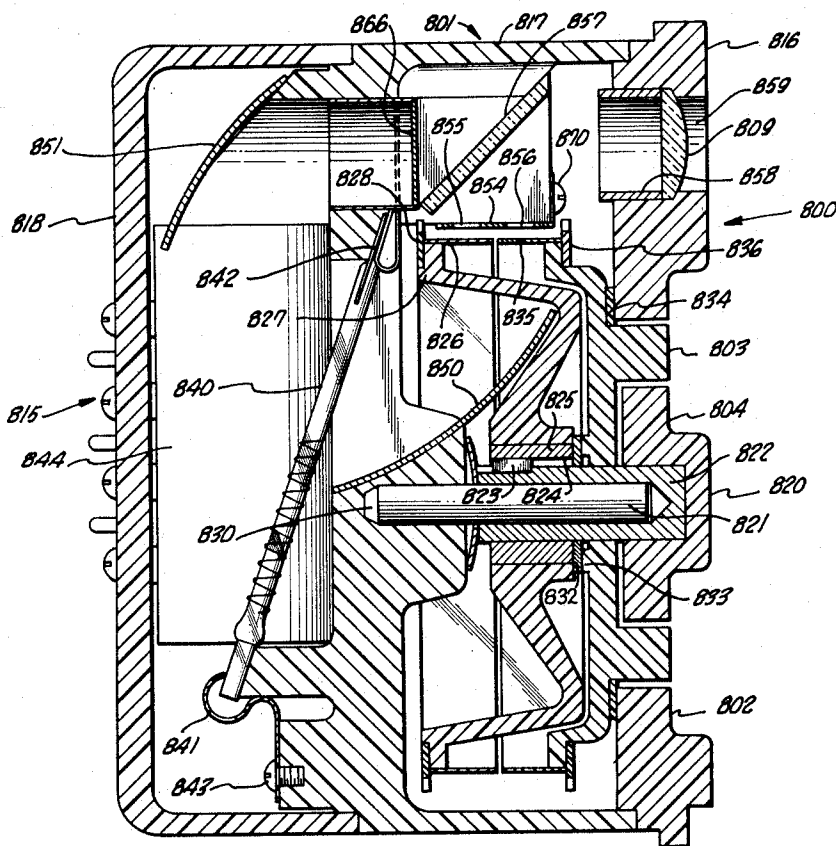


Fig. 18.

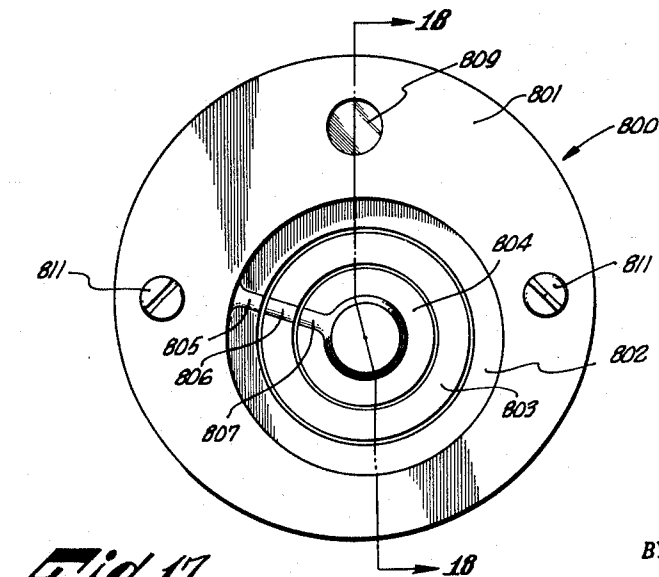


Fig. 17.

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Fig. 19.

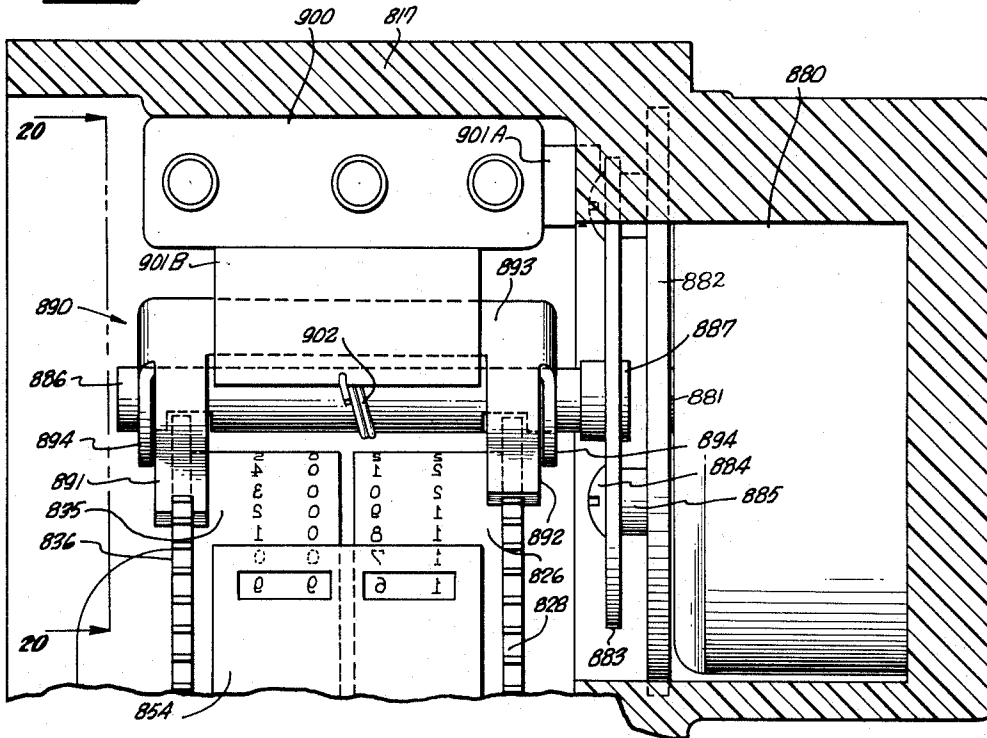
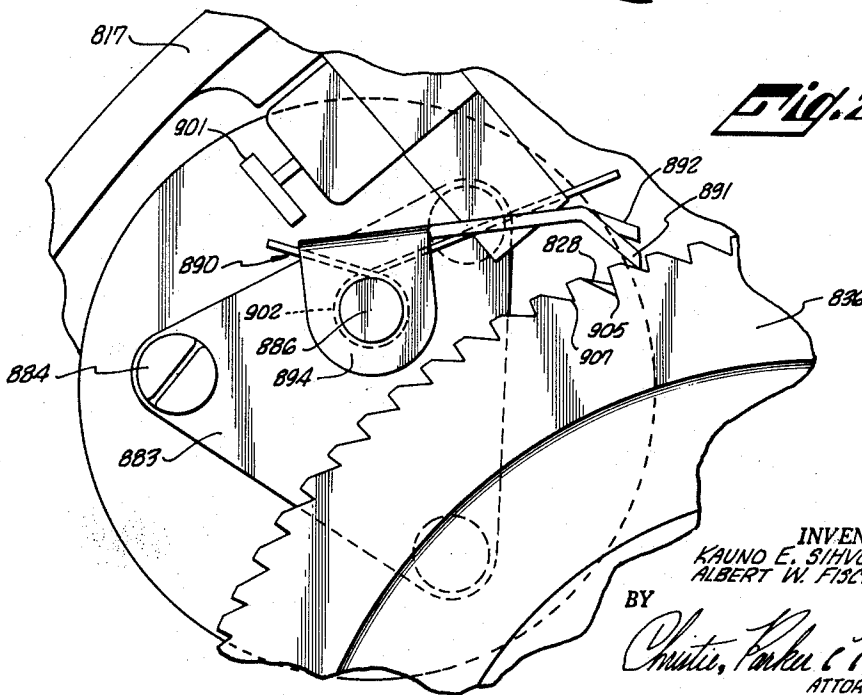


Fig. 20.



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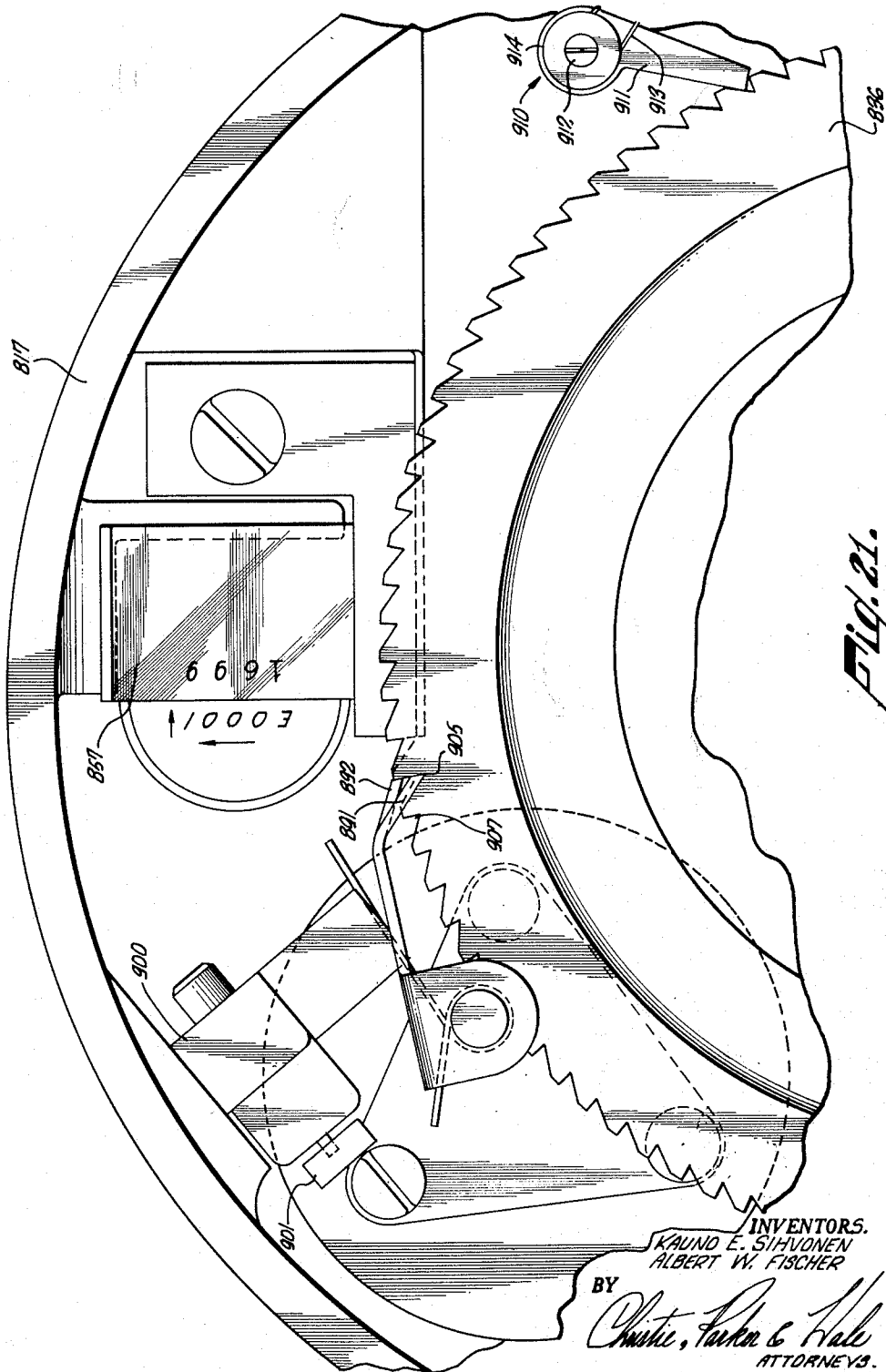
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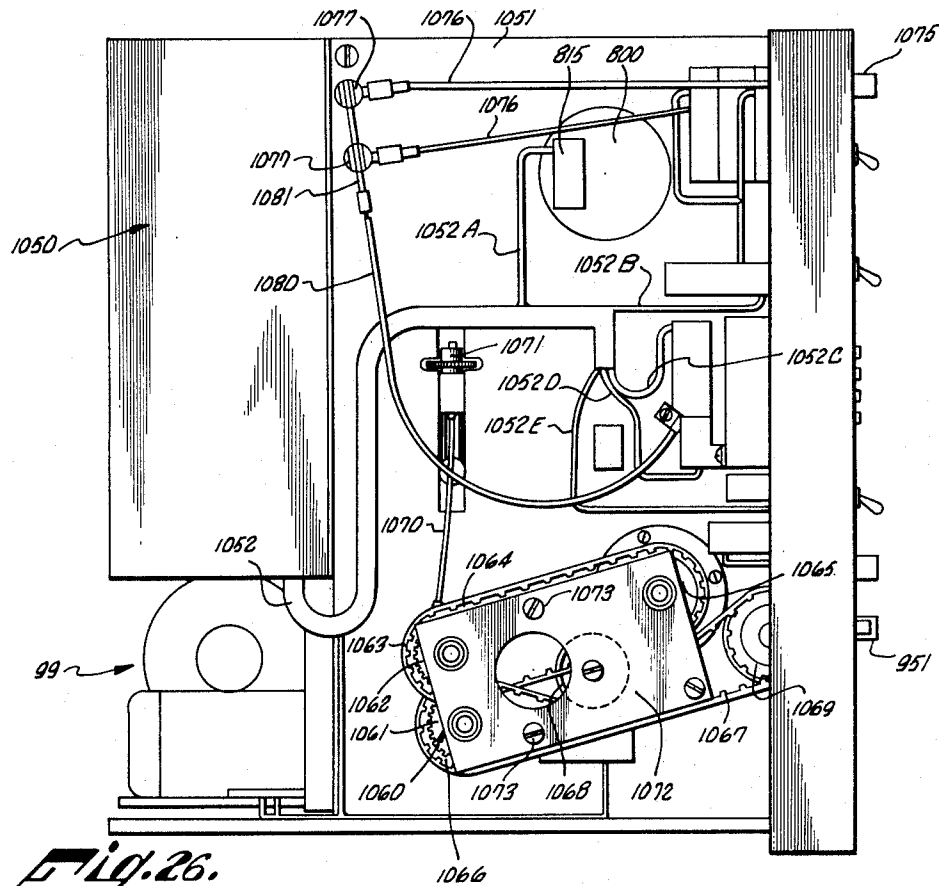
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18 Sheets-Sheet 17



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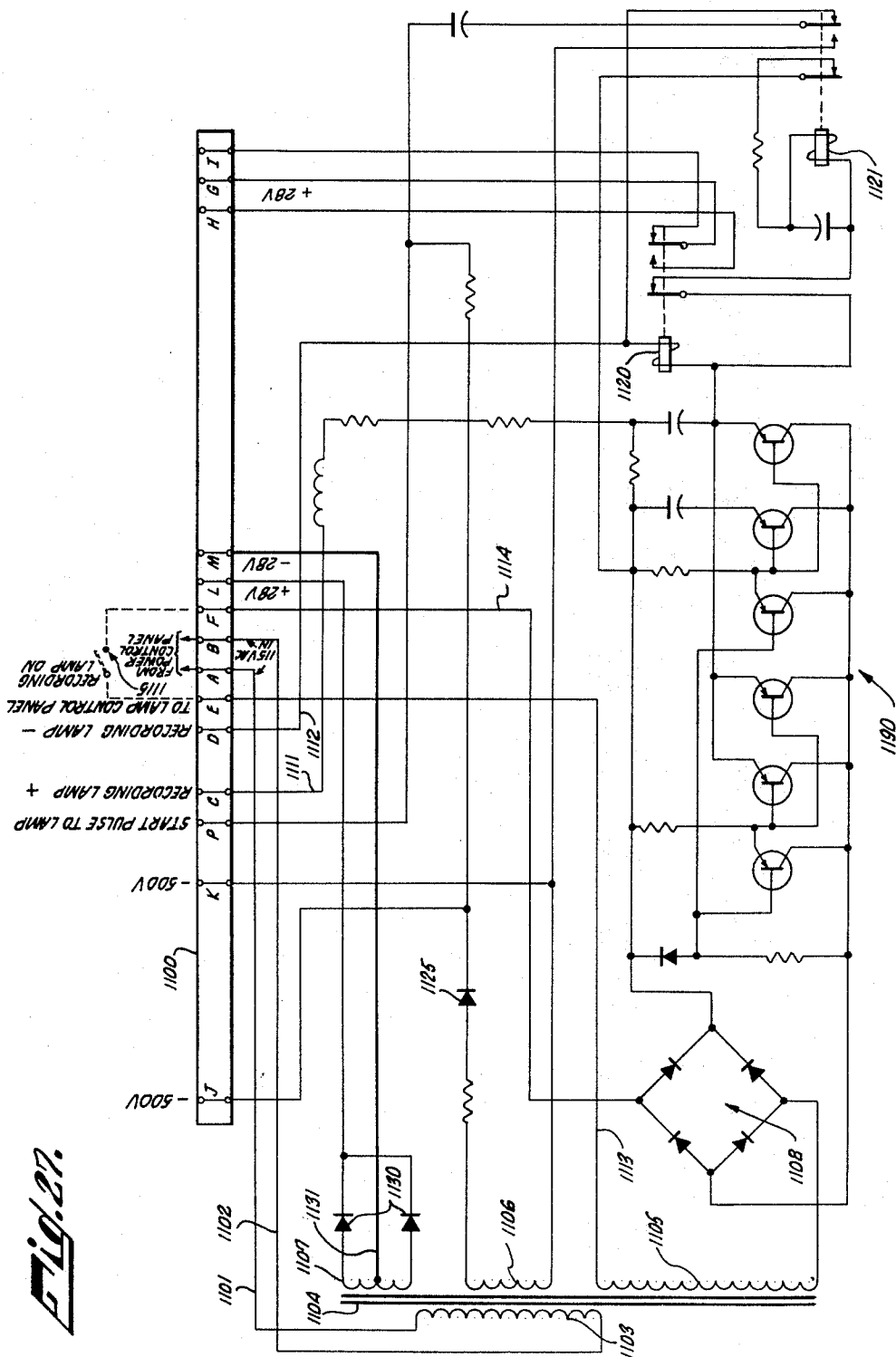
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MODULAR OSCILLOGRAPH

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dynamics Corporation, a corporation of California
Filed Sept. 20, 1960, Ser. No. 57,289
9 Claims. (Cl. 346-109)

This invention relates to oscillography, and more particularly, to an improved oscillograph whose components are modularized.

An oscillograph, that is, an apparatus for producing a graphic record representing the instantaneous values of a varying electrical quantity as a function of time, is an extremely complex instrument. The oscillograph consists basically of a galvanometer connected to an electric quantity source, and recording means adapted to produce a graphic record in response to the actuation of the galvanometer by the electric quantity. Modern oscillographs utilize a light beam reflected from a galvanometer mirror onto photosensitive recording material to produce the graphic record of the electric function, thereby providing a recording system which is inertialess with the exception of the galvanometer. Drive means are provided to move the photosensitive recording material, usually in the form of a roll of paper, past the recording light beam. Various systems for developing the recorded image on the photosensitive paper have been utilized, with the current objective of such developments being to render the image visible as soon as possible after recording. By the use of a roll of photosensitive paper, a method for providing a continuous record of the electric function is provided. Various control circuits conventionally are included in the oscillograph in order to give some versatility to the operation.

The oscillograph is a comparatively expensive device. In order to reduce the cost of such oscillographs, it has been the practice, in the past, to standardize the features offered in a particular apparatus, so as to permit the economy of assembly-line manufacture. However, this practice has resulted in the inclusion of features for which a particular purchaser may have no need. These features are purchased since it is more economical to include them in the apparatus as marketed, than to construct a customized oscillograph for the individual purchaser. Alternatively, a purchaser will often need a number of oscillographs, but will have a need of utilization of the oscillographs such that only a limited number of complex instruments are required, simple instruments ordinarily sufficing. However, the complex instruments may be required at different locations at various times. The purchaser must then either select all of his instruments to include the complex features required only occasionally or must transport a single instrument having these features to the various locations as required and substitute less complex instruments when these features are not required. In either case, the end result is that the purchaser is put to additional expense, both in time and in equipment, in order to meet his oscillographic needs.

According to the present invention, an oscillograph is divided into sub-assemblies which are modularized; that is, self contained and dimensionally standardized. These sub-assemblies are interchangeable between instruments and enable an oscillograph to be assembled for the particular application required. The modules (i.e., the dimensionally standardized sub-assemblies) include the oscillographic mechanisms themselves and the control circuits. Thus, modules for a drive power source, a recording mechanism, a paper transport mechanism, and galvanometer input connections are included in a housing for the oscillograph. The housing also contains the appropriate con-

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trol modules which include, for example, a paper transport speed control module, a light recording intensity control module, an on-off control module and an automatic recording length control module. Because of the novel concept of the invention, i.e., modularization of the oscillograph, the individual modules have novel structures themselves.

The invention may be more readily understood by referring to the accompanying drawings in which:

FIGURE 1 is a perspective view of a modular oscillograph according to the invention;

FIGURE 2 is an exploded perspective view of the oscillograph of FIG. 1;

FIGURE 3 is a plan view of the drive and transmission module for the oscillograph of FIG. 1;

FIGURE 4 is a side elevation of the module of FIG. 3;

FIGURE 5 is a sectional plan view of the drive transmission of FIG. 3;

FIGURE 6 is a section side elevation of the transmission;

FIGURE 7 is a sectional side elevation of an optical module for the oscillograph of FIG. 1;

FIGURE 8 is a partial plan view of the lamp mounting assembly of the optical module of FIG. 7;

FIGURE 9 is a sectional view taken along lines 9-9 of FIG. 8;

FIGURE 10 is a sectional side elevation of an alternate embodiment of the optical module;

FIGURE 11 is a partial plan view in section illustrating the path of reflection of the recording radiations;

FIGURE 12 is a rear perspective view of the paper transport module;

FIGURE 13 is a side elevation of a transport module of FIG. 12;

FIGURE 14 is a view in cross section of the roller spring assembly of the transport module;

FIGURE 15 is a side elevation partially in section of a paper supply indicator assembly;

FIGURE 16 is a plan view partially in section of the paper supply indicator assembly taken along lines 16-16 of FIG. 15;

FIGURE 17 is a side view of a record event numbering assembly;

FIGURE 18 is a sectional side elevation of the record event numbering assembly taken along lines 18-18 of FIG. 17;

FIGURE 19 is a detail sectional view of a portion of the record event numbering assembly;

FIGURE 20 is a detail sectional view of a portion of the record event numbering assembly;

FIGURE 21 is a detail sectional view of a portion of the record event numbering assembly;

FIGURE 22 is a sectional side elevation of an automatic record length control assembly;

FIGURE 23 is an elevation of the circuit input and output board of the automatic record length control assembly;

FIGURE 24 is an elevation of the contact mounting plate for the automatic record length control assembly;

FIGURE 25 is an elevation of the circuit interrupter plate for the automatic record length control assembly;

FIGURE 26 is a side elevation of the modular oscillograph; and

FIGURE 27 is a schematic of a diagram of a power supply utilizable with the modular oscillograph of the present invention.

Referring now to FIG. 1 there is shown a view in perspective of a modular oscillograph 49 according to the invention. The modular oscillograph 49 has a housing 50 which holds the chassis 51 containing various modules of the oscillograph. An input module 52 con-

tains input connections to which are connected the various electric functions to be recorded. A paper transport module 53 has recording paper 54 being transported across the open side thereof. The paper 54 has thereon various graphic representations 55 of varying electric function. An optical module 56, only a portion of which is visible in FIG. 1, is contained within the chassis 51 behind the paper transport module 53. Various control modules including a recording intensity module 57, a power on-off module 58, a paper transmission speed module 59, an operate-standby module 60, a timing control module 61, and an automatic record length module 62, are included. A blank section 63 permits the inclusion of additional control modules as may be required. A drive transmission module is included in the oscillograph 49, but being mounted in the rear portion of the oscillograph 49 is not visible in FIG. 1.

FIGURE 2 is an exploded view of the modular oscillograph 49 showing the input module 52, paper transport module 53, and the optical module 56 separated from the chassis 51 of the oscillograph 49. The control modules 57-62 remain in the positions shown in FIG. 1. A drive roller 70 in the chassis 51 is utilized in connection with an idler roller (not shown) to provide the tension required to unwind the recording paper from the paper roll (not shown) contained within the paper transport module 53. The optical module 56 contains a bank of galvanometers (not shown) to which are connected the electric functions to be recorded. Connecting wires (not shown) extend from the input module 52 to galvanometer assembly blocks 72 to make a direct connection between each input and the associated galvanometer. An optical module power connector 73 in the chassis 51 connects to an optical module connector (not shown) of the optical module 56.

FIGURES 3 and 4 depict a drive and transmission module 99. The drive and transmission module consists of a motor 100 and a transmission assembly 101 connected together by means of a drive belt 102. The motor 100 and transmission 101 are each mounted on a base plate 103 which serves as the base of the module 99. The motor 100 may be, for example, any conventional electric motor. However, the transmission assembly 101 is preferably the novel transmission assembly to be described with respect to FIGS. 5 and 6.

Referring to FIG. 5, there is shown a sectional view of the transmission 101 depicted in FIGS. 3 and 4. The transmission 101 has a drive shaft 150. The drive shaft 150 is held in position in the transmission assembly 101 by means of a pair of ball bearing assemblies 151, shown in section, within which the drive shaft 150 rides. An output drive shaft 152 is similarly held in position in the transmission 101 by a pair of ball bearing assemblies 153. A torque transfer shaft 154 consists of a first shaft section 155, which is aligned parallel to the input drive shaft 150, and a second shaft section 156, which is aligned parallel to the output drive shaft 152. The two torque transfer sections 155 and 156 are contained within the transmission assembly 101 by two pairs of ball bearing assemblies 157 and 158, respectively. The two torque transfer shaft sections 155 and 156 are connected together by means of a shaft coupling 159. The first torque transfer section 155 includes three clutch and gear assemblies 160, 161 and 162. The output shaft 152 contains four clutch and gear assemblies 163, 164, 165 and 166. A rotating pinion and gear assembly 170, a fixed pinion and gear assembly 171, and a fixed hub and gear assembly 172 are mounted on the input drive shaft 150 so as to engage the opposite aligned portions of the clutch and gear assemblies 160, 161 and 162. Similarly, two hub and gear assemblies 175, 176, and two rotatable hub and gear assemblies 177 and 178 are mounted on the second torque transfer shaft 156 so as to engage portions of the clutch and gear assem-

blies 163-166 aligned opposite therefrom on the output drive shaft 152. The clutch assemblies 160 and 166 differ from the clutch assemblies 161-165, in that the former are always in engagement with the shaft associated therewith, whereas the latter are normally disengaged by means of solenoids 181, 182, 183, 184 and 185 associated, respectively, with the clutch and gear assemblies 161-165. The operation of the solenoids 181-185 with regard to the clutch assemblies 161-165 is described with respect to FIG. 6.

By selecting one of the three clutches 160-162, and one of the four clutches 163-166, to drive their respective shafts, a selection of any one of twelve predetermined driving speeds can be applied by the output shaft 152 for a constant rotational input rate at the input shaft 150. Rotation of the input shaft 150 causes the fixed pinion and gear assembly 171 to rotate, thereby rotating the clutch 161 at a large gear 190 associated therewith. The large gear 190 is directly connected to a small gear 191 on an outer assembly of the clutch 161. The outer assembly, that is, the portion of the clutch 161 which contains the gears 190 and 191, is separated from an inner assembly 192, which engages the first torque transmission drive shaft section 154 directly, by means of a cylindrical bearing 193. The use of the bearing surface 193 prevents the transmission of torque directly from the outer portion of the clutch 161 which contains the gears to the inner portion 192. However, torque may be transmitted between these two sections of the clutch 161 by means of a coil spring 195 which encloses portions of both sections. Then the clutch 161 is engaged, the coil spring 195 transmits torque between the outer and inner sections of the clutch 161 and they, thereby rotate together. However, when the clutch 161 is disengaged, the coil spring 195 is unwound to the extent that the section of the clutch 161 containing the gears 190 and 191 may rotate comparatively freely with respect to the inner section 192. The gear 191 of the clutch 161 engages a gear 200 of the first rotatable pinion and gear assembly 170. The first rotatable pinion and gear 170 encloses the input shaft 150 and is freely rotatable thereabout, due to the use of a pair of cylindrical bearings 201 annularly enclosing the shaft intermediate between the shaft and the body of the pinion assembly 170. A lubricating wick 202 insures proper lubrication of the bearings. A second gear 203 of the pinion assembly 170 engages a gear 205 of the clutch assembly 160. The clutch assembly 160, as has been previously stated, continuously engages the first torque transmission shaft 154. The gear ratio of the gears 191, 200, 203 and 205 is such that the clutch 160, when driven, tends to drive the first torque transmission shaft section 154 at a much slower rate than the shaft 154 is driven when the clutch 161 is engaged. For example, a magnitude of 10 to 1 between these two driving speeds may be utilized. Disengagement of the clutch 160 when the first torque transmission shaft section 154 is being driven by the clutch 161 is not necessary since the rotation of the shaft 154, at the higher rate of speed due to the engagement of the clutch 161, furnishes an over-drive effect which eliminates the driving force applied by the clutch 160, and thereby tends to unwind the coil spring associated therewith. The rotation of the first torque transmission shaft section 154 is transmitted to the second torque transmission shaft section 156 by means of the shaft coupling key 159. Thus, the second torque transmission shaft 156 rotates at the same rate as the first torque transmission shaft section 154. The two fixed hub assemblies 175, 176 associated with this second torque transmission shaft section 156 also rotates at this same rate. However, the rotatable hub and gear assemblies 177 and 178, associated with the second torque transmission shaft 156, are driven in a manner similar to that described with respect to the driving of

the clutch 160 by means of the fixed hub and gear assembly 176.

Thus, clutch 166 is driven by the following process: The fixed hub and gear assembly 176 contains a gear 210 which engages a large gear 211 on the clutch assembly 164. A small gear 212 on the clutch assembly 164 engages a large gear on the first rotatable hub and gear assembly 177. A large gear 214 on the first rotatable hub and gear assembly engages a small gear 215 on the clutch assembly 165.

A small gear 216, on the clutch assembly 165 engages a large gear 217, on the hub and gear assembly 178, so as to rotate the hub and gear assembly 178 about the second torque transmission shaft 156. A small gear 218, on the hub and gear assembly 178, engages a large gear 219 on the clutch and gear assembly 166. The large gear 219, of the clutch assembly 166, is attached to an outer section 220 of the clutch and gear assembly 166. This outer assembly 220, therefore, rotates as it is driven by the gear 219. A clutch spring 221 engages the outer section 220, of the clutch and gear assembly 166, as well as an inner section 222 of that assembly so as to cause the inner assembly 222 to rotate in unison with the outer assembly 220. The inner assembly 222 is held in relative position to the output shaft 152 by means of a pin 223 which fits in a recess 224 of the inner portion 222. Thus, the output shaft 152 is caused to rotate in unison with the inner section 222, the outer section 220, and the large gear 219, of the clutch and gear assembly 166, when the clutch and gear assembly 166 is engaged. The outer assembly 220 is separated from the inner assembly 222 by means of a bearing 225 and a washer 226. A snap ring 228 holds the washer 226, in position. Thus, the outer portion 220 may rotate freely with respect to the inner portion 222 and the output shaft 152 when the clutch 221 is not engaged. However, as stated previously, the clutch and gear assembly 166 is continuously engaged. This clutch and gear assembly 166 provides the lowest output rotation rate, and is overdriven when any of the outer clutch and gear assemblies 163-165 are engaged.

Referring now to FIG. 6, there is shown a sectional view of a portion of the transmission assembly 100 which illustrates the manner in which the clutch assemblies 161-165 operate. The solenoid 181 has a solenoid arm 250 at one of four steps thereon so as to prevent movement of the clutch wheel 251 when so engaged. The solenoid arm 250 is held in the engaged position, as shown in FIG. 6, by means of a spring 252 attached, at one end, to the solenoid assembly and, at the other end, to the lug 253 extending from the solenoid arm 250. The action of the spring is such that the solenoid arm 250 is urged away from the solenoid 181. Actuation of the solenoid 181 by an appropriate electrical circuit draws the solenoid arm 250 to the solenoid 181 and disengages the arm 250 from the clutch wheel 251, thereby, allowing the clutch wheel 251 to rotate freely. Electrical circuits (not shown) appropriate to selectively actuate the solenoids 181-185 are connected at a barrier terminal strip 255. The clutch assembly 161 includes a housing 256 which encloses the coil spring 195. The housing 256 has a small aperture at one end, thereof, adapted to receive the end of the coil spring so as to hold the coil spring in a fixed position with respect to the housing. The coil spring firmly contacts an outer portion 257 of the clutch housing to which the gears are attached (see FIG. 5) so as to normally cause the outer portion 257 to rotate with the housing 256 and thus, the gears attached thereto. The spring 195 is attached to the housing 256 and wound about the outer gear clutch portion 257 such that clockwise movement of the first torque transmission shaft 155 with the respect to the outer clutch and gear housing 256 (the movement of the shaft 155 being transmitted directly

to the clutch and gear assembly intersection 192, as has been previously explained) causes the spring 195 to tend to unwind and no longer firmly contact the clutch and gear outer portion 257. Motion of the type just described is accomplished by causing the solenoid arm 250 to engage the gear wheel 251. When the solenoid arm 250 is retracted, the gear wheel 251 no longer causes the unwinding of the spring 195 and the spring 195 thereupon firmly encloses the clutch gear assembly outer portion 257. Rotation of the first torque transmission shaft 155 will then cause the outer gear assembly portion 257 to rotate in unison therewith. This rotational movement is transmitted to the gears connected to the outer gear assembly 257. When the solenoid arm 250 engages the gear wheel 251, free rotation of the torque transmission shaft 154 and gear assembly inner portion 192, with respect to the gear assembly outer portion 257, is assured by the use of the bearing 193. A solenoid arm mounting rod 260 is utilized for the mounting of the solenoid arms so that the solenoid arms may pivot thereabout. Four nut and bolt assemblies 261, 262, 263, 264 are utilized to assemble the various components of the transmission assembly 100.

FIGURE 7 shows one embodiment of the optical module 56. The optical module 56 contains a galvanometer block 301 which contains a bank of galvanometers 302, one of which is shown in FIG. 7. Galvanometer leads 303 connect the galvanometers 302 to the sources of the galvanometer inputs. An optical assembly frame 304 encloses the optical assembly 56 and has a slide door 305 adjacent the galvanometer 302 to provide access thereto. A point source lamp 306 acts as a light source within the optical module 56. Light from the lamp 306 is directed to the mirrors of the galvanometers 302 in a manner to be described with respect to FIG. 8. This light is indicated by the dotted line 308. The light reflected from the galvanometer mirrors strikes a first mirror 310, which is axially adjustable, and is reflected therefrom through a cylindrical convex lens 311 onto a roller 312. The roller 312 is described more fully with respect to the transport module 53.

Light from the lamp 306 also passes through a second convex lens 315 and falls onto a second mirror 316, as is indicated by the dotted line 317. The light reflected from the mirror 316 falls upon a third mirror 318, from which it is reflected to a fourth or collimating mirror 319. The light reflected from the fourth mirror 319 strikes a fifth mirror 320, from which it is reflected onto the roller 312 through an ordinate forming plate 321. The ordinate forming plate 321 is generally opaque, but has portions transparent to light from lamp 302 so that light passing through these portions records a series of parallel lines 324, corresponding to the signal amplitude or Y-axis coordinate lines, on a recording medium which passes over the roller 312. The amplitude ordinate plate 321 is held near the roller 312 by means of a plate holder 322 and a spring 323.

A timing lamp 330 is periodically flashed on by an electrical circuit (not shown). The frequency of the flashing is determined by the rate of transport of the recording medium, so that the light from the timing lamp 330 follows the path illustrated by the dotted line 331 and falls upon a sixth mirror 332 from which it is reflected onto a seventh mirror 333. The light reflected from the seventh mirror 333, which is axially adjustable, passes through a third convex cylindrical lens 334 and onto the roller 312 so as to form a lateral line across the recording medium corresponding to each flashing of the timing lamp, thereby, forming the time or abscissa line (see line 335 in FIGURE 1) on the recording medium. The ordinate lines are formed by the continuous passage of light through the ordinate-forming plate 321, as has been described in the preceding paragraph. It will be noted that the ordinate-forming exposure

occurs prior to the abscissa forming exposure. This lack of coincidence in the time of forming ordinates and abscissae is permissible since the ordinate line spacing is constant, and not time-dependent. However, the abscissa lines are time-dependent, and must be related to the information-forming exposure resulting from light passage through the cylindrical convex lens 311. Therefore, the axially rotated dispositions of the first mirror 310 and seventh mirror 333 are adjusted so that the points of light reflected from the galvanometers 302 and the first mirror 310 fall on the recording medium passing about the roller 312 so as to be superimposed on the abscissa-forming line of light reflected from the seventh mirror 333 through the lens 334, thus providing coincident timing of the recording and time base exposures.

In order to provide for identification of the individual galvanometer tracings on the recording medium, a trace interrupter mechanism 340 is utilized. This mechanism 340 consists essentially of a pair of trace interrupter fingers 341 and 342 mounted on a continuous belt 343. The belt is driven so that the fingers interrupt in sequence, the light beams passing from the lamp 306 onto the mirrors of the galvanometers 302.

A viewing path indicated by the dotted line 350 utilizes an eighth mirror 351 to provide for direct viewing of the point on the roller 312 at which the timing line radiation and information recording radiations coincidentally strike the roller. This viewing path 350 enables the viewer to ascertain whether or not the optical assembly is operating in a satisfactory manner and timing coincidence exists without the necessity of recording on the recording medium. Thus, the necessary adjustment for coincidence can be made prior to recording.

FIGURE 8 shows the assembly for mounting the lamp 306 together with the path along which light from the lamp 306 is reflected onto the galvanometer mirrors. The lamp 306 is housed in a lamp assembly housing 400. The housing 400 has a pair of apertures 401, 402 through which the light from the lamp 306 passes. The light passing these apertures 401 and 402 passes through one of a pair of concave-convex lenses 403, 404 and strikes one of a pair of mirrors 405, 406. The mirrors 405 and 406 are positioned at an angle so as to reflect the light downward (as shown in FIG. 7) to strike the galvanometer mirrors. Electrical power for the lamp 306 is provided through a pair of power leads 407, 408 which connect between the lamp 306 and a power input terminal 409. The quantity of light striking the mirrors 405 and 406 and, therefore, the intensity of the light striking the galvanometer mirrors is controlled by a pair of shutters 411 and 412. The operation of these shutters will be described more fully with respect to FIG. 9. The entire light assembly is contained in a housing 415.

FIGURE 9 is a sectional view taken along line 9-9 of FIG. 8 showing the shutter mechanism. The shutter 411 is divided into a first shutter portion 420 and a second shutter portion 421. A pair of triangular connecting elements 422, 429 each pivotally are connected to the first and second shutter portions 420, 421. The first triangular connecting element is also pivotally connected to an actuating arm 425. The second triangular connecting element is pivotally connected to a support frame 426 of the lamp assembly. A torsion spring 427 is connected to the first triangular connecting element 422 and to the support frame 426. Movement of the actuating arm 425 against the force exerted by the spring 427 opens the shutter by moving the portions 420, 421 apart while maintaining their parallel alignment.

FIGURE 10 illustrates an alternate embodiment of the optical module 56. The module shown in FIG. 10 has an optical arm more than twice the length of the optical arm of the embodiment shown in FIG. 7. However, this extra length is accomplished by eliminating the print-

ing of timing lines of the recording medium. In FIG. 10, the amplitude or ordinate markings are printed on the recording medium in the same manner as was described with respect to FIG. 7. In the embodiment of FIG. 10, light from a lamp 306' is deflected downward and strikes the galvanometer mirrors of galvanometers 302' from whence it is reflected upward to strike the seventh mirror 333'. The light is then reflected downward from 333' to strike the sixth mirror 332', from whence it is reflected upward to strike the first mirror 310'. The first mirror 310' is of a novel construction which compensates the error introduced by high amplitude signals, as is more fully set out in the copending application, Serial No. 825,120 of Albert W. Fischer, filed July 6, 1959, issued January 15, 1963, as United States Letters Patent 3,073,215, assigned to Consolidated Electrodynamics Corporation, the assignee of the present application. From the first mirror 310', the light passes through a cylindrical convex lens 311' and strikes the roller 312.

Referring now to FIG. 11, there is shown the structure by which the light from the lamp 306' is deflected so as to strike the mirrors of the galvanometers 302'. The light from the lamp 306' passes out an aperture 440 and through a double convex lens 441. An adjustment slit 442 is positioned at the focal point of the double convex lens 441. A cylindrical concave mirror 443 is positioned in the path of the light passing through the adjustment slit 442 so as to deflect the light through a light limiting aperture 444 in the light mounting assembly. The light passing through the aperture 444 strikes a first deflection mirror 445 from which it is reflected to a second deflection mirror 446 and thence downwardly to galvanometer mirrors 447. The first and second deflection mirrors 445 and 446 are not shown in FIG. 10. The cylindrical concave mirror 443 produces a thin line of light laterally across the galvanometer mirrors 447 by focusing the light to a line rather than a point at the galvanometer mirrors 447.

Referring now to FIG. 12, there is shown a rear perspective of the transport module 53. The transport module 53 includes a pair of sides 501, which are held apart by a pair of spacer rods 502. The spacer rods 502 are attached to the sides 501 by bolts 503. The transport module 53 has a platen 504, which extends from the top along the outer side of the module. The writing roller 312, previously referred to with respect to FIGS. 7 and 10, extends between the sides 501 and is held in position by means of a roller axle 505, which extends through slots 506 in the sides 501. A pair of locking handles 508 (only one of which is shown in FIG. 12) are utilized to lock the transport module into the oscillograph frame. The locking handles 508 selectively extend and retract spring-loaded lugs (see FIG. 13) 509 by camming surfaces (not shown).

A paper control assembly 510 is held in position between the sides 501 by means of a pair of attaching arms 511, which extend into an attaching clamp assembly 512 having a clamp 513, which selectively locks a cover 514 between the sides 501, to which it is pivotally connected. The paper control assembly 510 has a windup tape 515 attached thereto. The windup tape 515 extends around a paper supply 518 and, after passing over a tensioning bar 516 (see FIG. 13), is attached to a tape windup assembly 519. The tape windup assembly 519 is utilized to apply tension to paper held on the supply roller 518 during operation so as to prevent the paper from unrolling excessively. A plug 520 holds the takeup assembly 519 in position. The paper supply roller 518 is connected to the sides 501 by means of a pair of holders 521. The supply roller 518 is free to move laterally along a bifurcation 522 in each of the holders 521. However, the windup tape applies tension to the supply roller 518, so as to urge the supply roller 518 toward the closed end of the bifurcation 522.

An actuating arm 525 and a release arm 526 are attached to the tape windup assembly 519, and their functions will be more fully described with respect to FIG. 13. The actuating arm 525 rides against a solenoid arm 527 of a rotary solenoid 528. A cover 529 encloses an electrical supply circuit (not shown) of conventional design for the solenoid 528. A take-up roller 531 is attached to the side 501 by means of attaching plates 532 which have slots therein adapted to engage bearing assemblies 533 which are mounted on a roller axle 534. The take-up roller bearings 533 are held in position by a pair of take-up roller clamps 536, which consist of clamping arms 537 and rotary clamps 538 of conventional type. Each clamp 538 connects the attaching arm 537 associated therewith to the side 501. A magnetic clutch shoe 539 is attached to one end of the take-up roller 531.

Referring now to FIG. 13, there is shown a side elevation of the transport module 53, taken along line 13—13 of FIG. 12. The view of FIG. 13 is partially broken away in order to more clearly illustrate the paper supply roller and associated structure. The paper supply roller 518 is illustrated in both its loaded and its unloaded position. The unloaded position of the paper supply roller is illustrated by the dotted lead line, and the loaded position of the paper supply roller is illustrated by the solid lead line. A roller axle 550, which extends into the bifurcations 522 of the holder 521, is clearly shown both in the loaded and in the unloaded positions. It will be seen that the paper supply roller 518 is free to move in the direction of the platen 504 as paper 551, contained on the supply roller, is unrolled. The path of the unrolled paper is shown by a dotted line 552, which indicates the path of paper transport through the transport module 53, over the paper guide assembly 510, shown in dotted lines as behind the attaching plate 511, around the writing roller 312, and over the platen surface 504. At the lower end of the platen surface 504, the paper passes onto a metering roller 554, and between the metering roller 554 and the pinch roller 70. The metering roller 554 is driven at a regulated rate, and the pinch roller 70 rides against the metering roller 554 and is free to rotate. Thus, the rotational rate of the two rollers 554 and 70 is the same, and they provide traction to pull the paper from the paper roller 518 along the path just described.

As the paper issues from the junction of the two rollers 554 and 70, it may either pass out of the oscillograph by continuing to contact the pinch roller 70 and issue from a paper outlet 560, or may be directed to the take-up roller 531. A paper guide 562, adjacent the pinch roller 70, insures that the paper will follow the path around the pinch roller 70 and pass out the outlet 560, when it is desired to view the paper directly. When it is desired to feed the paper to the take-up roller 531, the paper guide 562 is moved away from the pinch roller 70 by rotating a paper guide set cam 563 one hundred and eighty degrees from the position shown. It will be seen that a portion 564, of the paper guide set cam 563, is recessed so that a maximum movement of the paper guide 562 away from the pinch roller 70 is provided when the cam 563 is rotated one hundred and eighty degrees from the position shown in FIG. 13. The paper guide 562 is urged away from the roller 70 by means of a spring 565 attached by an attaching lug 566 at one end, and to the paper guide at an arm 567 thereof at the other end. The paper guide 562 is attached to the frame at a pivot 569 so as to be free to move either toward or away from the pinch roller 70 in response to the urging of the spring 565 and movement of the set cam 563.

The metering roller 554 is attached to the apparatus frame. When it is desired to completely remove the module 53 from the frame, a slide lock 575, which contacts a bearing surface 576 of the pinch roller 554 so as to hold the bearing surface 576 in an arcuate indentation 577 in the side of the transport module 53, is loosened. Dotted lines indicate a set screw 579 which is inserted in

a slot 580 in the arm 575 so as to enable the arm 575 to be selectively fixed in the position shown, and to be loosened to permit the module 53 to be removed from the roller 554 by moving the arm 575 away from the indentation 577.

FIGURE 14 shows a cross sectional view of the roller spring assembly 519, the primary element of which is a tube 600. The plug 520 has positioned therewithin a spring holder 601 through which a pin 602 extends, so as to fix the spring holder 601 in position. An attaching screw 603 extends through the plug 520 and into a threaded aperture in the side 501. A second spring holder 605 is positioned in the central part of the tube 600 and is attached thereto by means of a pin 607 which extends through apertures in the tube 600 and the second spring holder 605. A torsion spring 608 extends between the two spring holders 601 and 605 and is held by slots 610 in each.

About the portion of the tube 600 in which the second spring holder 605 is positioned, a take-up tape holder 612 is held by a pair of O-rings 613, positioned in indentations 614 in the holder 612. The take-up tape 515 extends around the lower outer surface of the holder 612 and then is inserted through a slot (not shown) therein so as to be in contact with the inner upper surface of the holder 612 and the tube 600. The pin 607 extends through the take-up tape 515 and holder 612 so as to hold the tape and holder 612 fixed with respect to the tube 600.

A compression release spring 620 is held in position by a release spring holding block 621 which rides against a pin 622 extending through the rod 600. At its opposite end, the spring 620 abuts a washer 623 which rides against a clutch pin 624. The clutch pin 624 extends through an aperture in a releasing clutch actuating rod 625, the rod 625 terminating in a head 626. A clutch housing 627 is also held in position about the tube 600 by means of the clutch pin 624.

A drag torsion spring 630 is wrapped around the tube 600 so as to be frictionally engaged therewith. The spring 630 has two ends 631 and 632, which extend through apertures in a spring housing 633 enclosing the spring 630. The housing 633 is connected to the tube 600 by means of a pair of dual flange bearings 634. The drag torsion spring end 632 is clamped to the solenoid actuated arm 525 by means of a nut and bolt combination 635. The drag torsion spring end 631 extends through the housing 633 and contacts the clutch assembly housing 627 and the extension arm 526. With the clutch assembly housing 627 in the position shown, a camming surface 638 of the clutch assembly housing 627 forces the spring end 631 into an unwound position, so as to release the traction with which the spring 630 frictionally engages the tube 600. When the head 626 is pushed in, so as to be flush with the surface of the side 501, the camming surface 638 is forced away from the spring end 631, allowing the spring 630 to exert traction on the tube 600. In this position, with the spring 630 exerting traction against the tube 600, if the solenoid actuated arm 525 is rotated counterclockwise, the tube 600 will also be rotated counterclockwise. Insertion of the module 53 into the oscillograph frame positions the head 626 flush with the side 501 so as to cause the spring 630 to exert traction on the tube 600.

During the operation of the module 53, the spring 608 exerts a counterclockwise torque (reference being had to FIG. 12 regarding clockwise and counter-clockwise directions) on the take-up tape 515, thus pulling the tape tightly against the paper roll 551. During operation, paper is normally being pulled off of the roll at a high rate, for example, twenty inches per second. If the machine is deactivated, a certain amount of continued running off of the paper results, due to the inertia of the paper roll 551 itself. Thus, it is necessary to apply an additional stopping torque to the paper roll. This stopping torque is applied by rotating the tube 600 counter-

clockwise to cause the tape 515 to exert additional drag on the paper roll 551. The solenoid 523 is actuated so that the solenoid arm 527 moves the solenoid actuated arm 525 counterclockwise. This counterclockwise movement causes an angular displacement of the tube 600, thus exerting an additional tightening effect on the paper roll 551 by means of the take-up tape 515.

Adjacent the plug 520, a record supply gear assembly 650 is attached to the tube 600 by means of a set screw 651 which extends through an attaching flange 652 of the gear assembly 650. The gear assembly 650 includes a gear 653. A bearing 654 provides for easy rotation of the holders 521.

Referring now to FIGS. 15 and 16, the record supply mechanism is illustrated as consisting of the record supply gear assembly 650, an intermediate gear assembly 660, and a drive gear assembly 661. The intermediate gear assembly 660 includes a large intermediate gear 665 and a small intermediate gear 666 attached together and mounted on an axle 667. The drive gear assembly 661 includes a gear 668 and an indicator wheel 669 having record supply indicia impressed in a peripheral indicia surface 670 thereof. The record supply and gear assembly 661 is mounted on an axle 672. The axles 667 and 672 extend through a record supply mounting assembly 675. The record supply mounting assembly 675 is held in position by means of a pair of bolts 676 which extend through a cover plate 677 and the record supply mounting assembly 675 engages the transport module side 501. A transparent window 679 is attached to the record supply mounting assembly 675 so as to permit the viewing of the indicia surface 670 through the window 679 and an aperture 680 in the platen 504.

The indicia surface 670 is rotated to correspond to rotation of the tube 600 by the interengagement of the gears 653 and 665 and 666 and 668. As has been previously pointed out, the tube 600 rotates to apply tension to the paper supply 551 by means of the tape 515. Thus, when the paper supply 551 is at a maximum, the tube 600 is disposed in a maximum counterclockwise rotation. As the paper supply 551 diminishes, the tube 600 (as viewed in FIGS. 13 and 15) rotates clockwise in continuing to apply tension to the tape 515. This clockwise rotation is utilized to indicate the amount of paper remaining in the record supply. The exact gear ratios may be adjusted with respect to the thickness of the record material utilized in order to render absolutely accurate the indication of record length. However, in actual practice, rough approximation may be sufficiently accurate so that a preselected gear ratio may be utilized generally for a wide variety of types of recording paper. Alternatively, wheels containing indicia appropriate for different types of papers may be utilized for the indicia surface 670. Thus, the same amount of rotation will indicate differing amounts of paper supply for different wheels.

Referring now to FIG. 17, a side elevation of an event numbering assembly 800 is shown. The event numbering assembly 800 includes an outer shell 801 having a recess 802 therein, within which are disposed a tens dial aligning knob 803 and a hundreds dial aligning knob 804. An aligning protrusion 805 in the recess 802 is aligned with an aligning protrusion 806 of the tens dial aligning knob 803 and an aligning protrusion 807 of the tens dial 804 when it is desired to set the event numbering assembly to zero. A convex lens 809 is held in an aperture in the shell 801 and is utilized to project the event number from the assembly 800 onto the recording medium. A pair of bolts 811 are utilized to hold the assembly together.

FIGURE 18 is a sectional view of the event numbering assembly 800 taken along lines 18-18 of FIG. 17. A set of electrical terminals 815 are shown as disposed on the opposite side of the assembly 800 from the side shown in FIG. 17. The shell 801 consists of a face

portion 816, an intermediate portion 817, and a terminal attaching portion 818, to which the terminals 815 are attached. The hundreds dial 804 includes a knob portion 820, which is mounted to an axle 821 by a connecting assembly 822. The connecting assembly 822 includes a key 823 adapted to engage a slot 824 in a hundreds dial attaching ring 825. A hundreds dial 826 is attached to the hundreds dial attaching ring 825 by an attaching arm 827. A hundreds dial ratchet 828 is attached to the hundreds dial 826 and the attaching arm 827. The axle 821 is mounted in the intermediate shell portion 817 in a recess 830 thereof, so as to be rotatable there-within. Thus, the hundreds dial 826 may be rotated by rotating the knob portion 820.

The tens dial aligning knob 803 is rotatably mounted on the assembly attaching portion 822 and spaced from the hundreds dial attaching arm 827 by washers 832 riding against a shoulder 833. The tens dial aligning knob 803 is spaced from the shell portion 816 by a washer 834. A tens dial 835 and a tens dial ratchet 836 are attached to the tens dial knob 803.

A flash lamp 840 is held in place within the intermediate portion 817 by a pair of electrical contacts 841, 842. The electrical contacts 841, 842 are connected to the terminals 815 by connecting leads (not shown). The electrical contact 841 is held in position by a bolt 843 which engages the intermediate portion 817. The circuit (not shown) utilized to flash the lamp 840 is of conventional design and includes a charging capacitor 844.

Light from the lamp 840, when flashed, falls on an event number mirror 850 and an equipment identification mirror 851. The light reflected from the event number mirror 850 passes through the attaching arm 827 (which is made of transparent or translucent material) and falls upon the hundreds dial 826 and tens dial 835. The hundreds dial 826 and tens dial 835 have transparent portions therein which correspond to Arabic numbers. The light passing through these transparent portions falls on a number shield 854. The number shield 854 has a hundreds dial number selecting aperture 855 and a tens dial number selecting aperture 856 through which the light passes and falls on a reflecting mirror 857 in a disposition indicating the event number. This light is reflected from the reflecting mirror 857 through the convex lens 809, which is shown as held in the shell portion 816 by an annular fitting 85 so that the image passes through an aperture 859 in the shell portion 816 and falls on the recording medium to form an image of the event number.

The light reflected from the equipment identification mirror 851 passes through the intermediate portion 817 and falls on an equipment identification plate 866. The equipment identification plate 866 has transparent portions which correspond to the serial number of the equipment and arrows indicating the direction of travel of the recording medium and the instant of event recording. The light passing through these transparent portions passes by the mirror 857 and through the convex lens 809, then falls on the recording medium so as to provide a ready identification of the record when subsequently viewed. The tens and hundreds aperture forming plate 854 is held in position by a bolt and washer combination 870 which engages the intermediate portion 817 of the event numbering assembly 800.

Referring now to FIG. 19, there is shown the structure utilized to position the hundreds dial 826 and tens dial 835 in the proper position in accordance with the number of the event. A solenoid 880, of the type which rotates a shaft 881 upon actuation, is disposed within the intermediate portion 817. The shaft 881 is connected to a circular plate 882, to which, in turn, is attached a triangular plate 883 by means of three attaching bolts 884 and standoff lugs 885. The triangular attaching plate 883 is axially centered with respect to the shaft

883 by means of a bushing 887 which is disposed to one side to the triangular plate 883 so the axle is eccentrically positioned with respect to the shaft 881. Thus, when the solenoid 880 is actuated, the axle 886 is displaced laterally, rather than being solely angularly displaced. An actuating pawl assembly 890, consisting of a first pawl 891 and a second pawl 892, connected together by a central connecting portion 893, is connected to the axle 886 by a pair of attaching lugs 894, which enclose the axle 886. The pawls 891 and 892 engage the ratchets 828 and 836, respectively.

A snap action switch 900 has a switch arm 901A extending therefrom, so as to be engageable with one of the bolts 884 when the solenoid is actuated. The snap action switch 900 is utilized to actuate the flash lamp 840 which was described with respect to FIG. 18. The snap action switch 900 has attached thereto a biasing arm 901B, which engages one end of a biasing spring 902. The biasing spring 902 is disposed about the axle 886 and is utilized to bias the pawls 891 and 892 so as to urge the pawls against the ratchets 828 and 836.

FIGURE 20 is a partial section taken along lines 20—20 of FIG. 19, and illustrates the disposition of the ratches 828 and 836, triangular plate 883, snap action switch arm 900, arms 901, pawl assembly 890, and bias spring 902, when the solenoid 880 is in its deactuated position. The tens dial ratchet 836 is seen to have one tooth 905 which is deeper than the remainder of the teeth. It will be noted that the tens dial pawl 891 engages the tens ratchet 836 while the hundreds dial pawl 892 is retained above the hundreds dial ratchet 828, due to the greater angle of inclination of the pawl 891. However, when the pawl 891 engages the deeper tooth 905, the hundreds dial pawl 892 engages the ratchet 828. The actuation of the solenoid 880 causes the clockwise movement of the pawl assembly 890. The pawl 891 thus forces the ratchet 836 to move clockwise upon the actuation of the solenoid 880. Upon deactuation of the solenoid 880, the pawl assembly 890 moves in a counterclockwise direction to the position shown in FIG. 20. Thus, with respect to the disposition shown in FIG. 20, after the next succeeding actuation of the solenoid 880, the pawl 891 will ride in the ratchet tooth 905, thus enabling the pawl 892 to engage the ratchet wheel 828. Such a disposition is shown in FIG. 21.

In FIG. 21, the pawl 891 engages the ratchet tooth 905, permitting the pawl 892 to engage the ratchet 828, as is shown in FIG. 21. Subsequent to the engagement of the pawl 891 with the ratchet 828 shown in FIG. 20, the solenoid 880 has again been actuated. The pawl assembly 890 is thus moved clockwise, and the pawl 891 forces the clockwise movement of the ratchet 836. When the solenoid 880 is deactuated, the pawl assembly 880 moves counterclockwise and the pawls 891 and 892 engage the ratchets 828 and 836. Actuation of the solenoid 880 then causes the pawls 891 and 892 to move both ratchets 828 and 836 clockwise, so as to advance both dials 826, 835. The deactuation of the solenoid 880 causes the pawl 891 to engage a tooth 907 in the ratchet 836. This tooth 907 is of a short depth, and thus the pawl 892 is unable to engage the hundreds ratchet 828. In order to maintain the ratchets 828 and 836 and thus the hundreds dial 826 and tens dial 835 in the positions set by pawl assembly 889, a dual stop pawl assembly 910 is utilized. The dual stop pawl assembly 910 includes a pair of stop pawls 911, only one of which is shown in FIG. 21. Each of the stop pawls 911 engages one of the ratchets 828, 836. The stop pawls 911 are mounted on an axle 912, and are contacted by a torsion bias spring 913, which is operable to urge the pawls 911 against the ratchets 828, 836. The bias spring 913 is held in position by an end plate 914. Thus, the ratchets 828, 836 are free to move in a clockwise direction in response to such urging by the pawl assembly 890, but are prevented from moving in a counterclockwise manner by the engagement of the pawls 911 with the teeth of the respective ratchets 828, 836. Each time the sole-

noid 880 is actuated the tens dial ratchet 836 moves the tens dial 835 to display the next succeeding number on the dial. However, the hundreds dial 826 is only moved at such time as a deeper tooth 905 occurs in the tens dial ratchet 836. These teeth are spaced so as to occur at every one hundredth tooth, and thus a counting function is provided, whereby the hundreds dial is moved to indicate the next one hundred number once for each hundred actuations of the solenoid.

FIGURE 22 is a sectional side elevation of an automatic record length control assembly 950. The automatic record length control assembly 950 is utilized to automatically control the length of recording material which is run off during the recording of an event. The length of material to be run off is preselected by turning a pointer knob 951 to the appropriate length, indicated on a control panel 62, which is positioned in the front of the oscillograph (see FIG. 1). The pointer knob 951 is attached to a shaft 953 which extends through an aperture 954 in the control panel 952. Mounted on the shaft 953, by means of a mounting pin 955, which engages a slot 963 therein, (not shown, see FIG. 25) is a disk-shaped rotatable contact mounting plate 956, having a first contact 957 and a second contact 958 extending therethrough. The contact mounting plate 956 is disposed between a circuit interrupter board 960 and circuit input and output board 961. The circuit interrupter board 960 has an especially configured electrically conductive ring 962 extending therearound, as is more clearly shown in FIG. 25. The first and second contacts 957 and 958 are in contact with the ring. A portion of the ring 962 is omitted, so that when the first electrical contact 957 reaches this point, electrical circuit continuity does not exist between the first and second contacts 957 and 958 through the ring 962.

The electrical circuit input and output board 961 has an electrically conductive input ring 965 and an electrically conductive output ring 966 concentrically disposed thereon. The shaft 953 extends through the board 961 and is separated therefrom by a bearing 969. An electrical input circuit 970 for the electrically conductive input ring 965 is shown. The input and output board 961 has a bolt 975 extending therethrough so as to threadably engage a standoff tube 976. A second bolt 977 holds on the opposite end of the standoff tube 976 to a portion 978 of the oscillograph frame.

The automatic length control assembly 950 includes a central body portion 980, through which a passage 981 extends. A pair of electrical leads 982 are disposed within the passage 981, and connect to two terminals 983, 984 of the solenoid 985, which is wound on a bobbin 886. The shaft 953 is free to rotate in the passage 981. A clutch assembly 990, which consists of a first clutch portion 991, and a second clutch portion 992, encloses the central body 980 and the solenoid 985. Bolts 993 (only one of which is shown in FIG. 22) attach the circuit interrupter board 960 to the second clutch portion 992, so as to fix the two in position with respect to each other. A spacer washer 994 and a snap ring 995 are disposed on either side of a standoff plate 996, and the spacer washer 994, snap ring 995, and standoff plate 996 are positioned between the solenoid 985 and the second clutch portion 992. An arcuate spring washer 998 is disposed between the first clutch portion 991 and the solenoid 985, so as to force the solenoid 985 against the spacer washer 994, and urge the first clutch portion 991 away from the second clutch portion 992. The first clutch portion 991 is attached to a circular gear 1000 by means of a pin 1001 extending through passages 1002 and 1003, respectively, thereof. The pin 1001 also extends into an aperture 1004 in a cam 1005, so that both the first clutch portion 991 and cam 1005 are moved when the circular gear 1000 rotates. A worm gear 1006 engages the circular gear 1000 so that the gear 1000 is rotated by rotation of the worm gear 1006. The worm gear 1006 is mounted on an exten-

sion of the metering roller 70 so that the amount of rotation of the circular gear 1000 is directly proportional to the length of recording material utilized without regard to the rate of transport of the recording material.

A snap action switch 1010 is contacted by the cam 1005, so as to close the switch 1010 periodically. Since the amount of rotation of the cam 1005 is directly proportional to the length of recording material utilized, the switch 1010 will close at predetermined increments of recording material length. The snap action switch 1010 is utilized to flash the flash lamp 840 in the event numbering assembly 800, so as to periodically print the equipment identification number on the record.

When the automatic record length control is to be utilized, the leads 982 are connected in parallel to an equipment operating switch by an automatic record length control switch 1013, so that the solenoid 985 is energized when the operating switch is closed. The electrical input connection 970 is connected in series with the operating switch so that electrical circuit conductivity through the contacts 957 and 958 must exist in order to have oscillographic operation. Such conductivity exists at all times except when the first contact 957 is positioned in the interrupter slot 963 in the interrupter circuit board 960.

A coil spring 1015 is connected to the second clutch portion 992 by a lug 1016, so as to normally urge the second clutch portion 992 to rotate in a clockwise direction. A stop cam 1017 is positioned in a slot in the second clutch portion so as to ride against the standoff tube 976 to limit the amount of clockwise rotation of the second clutch portion 992.

FIGURE 23 is an elevation of the circuit input and output board 961. The outer contact portion 965 and inner contact portion 966 are shown in dotted lines, since they are on the reverse side of the board 961 from that shown in FIG. 23. An electrical circuit outlet lead 1020 extends between the inner ring 966 and an output circuit connecting aperture 1021. The outlet lead 1020 is utilized to connect the electrical output circuit to the ring 966 so as to complete circuit continuity between the inner and outer rings 956 and 966 through the contacts 957, 958 and interrupter board conductive ring. An aperture 1022 is utilized for the electrical input circuit connector 970. The bolt 975, referred to in FIG. 22, extends through an aperture 1023, and bolts (not shown) extend through passages 1024 and 1025 to hold the assembly together.

The contact mounting plate 956 is shown in elevation in FIG. 24, as is the standoff tube 976. A cam surface 1030 on the contact mounting plate 957 limits the rotary movement of the contact plate 956. A slot 1031, previously referred to, contains the mounting pin 955 utilized to fix the rotary position of the shaft 953 with respect to the contact mounting plate 956.

In FIG. 25, an elevation of the circuit interrupter board 960 is shown. The slot 963 is shown in the normal disposition assumed under the urging of the coil spring 1015. Dotted lines 957A and 958A illustrate the zero position of the contacts 957 and 958 with respect to the slot 963. Dotted lines 957B and 958B illustrate the offset position of the contacts 957 and 958 when a predetermined length recording material is to be run off. The angular displacement of the contacts 957B and 958B with respect to the ring 963 is proportional to the length of recording material run off, as will subsequently become apparent.

The dotted line 963B illustrates the position of the slot 963 upon the conclusion of the run off of recording material. When the solenoid 985 is energized, the first clutch portion 991 is attracted thereto, and makes contact with the second clutch portion 992. This frictional contact transmits the rotary imparted to the first clutch portion 991 by rotation of the worm gear 1006 through the circular gear 1000 to the second clutch portion 992. Thus, the slot 963 is driven to the point of which continuity between the electrical input circuit connector 970 and electrical output circuit connector 1021 is interrupted by the

slot 963. Since this circuit is connected in series with the oscillograph operating circuit, interruption of this circuit terminates the run off of recording material, as well as the oscillograph recording operation. Certain of the power and cooling circuits are connected to a power switch 1025 and remain actuated, only the actual oscillograph drive circuits being deactuated by the automatic recording length material assembly 950. In order to prevent the reactivation of the circuits upon the return of the slot 963 to its zero position, a solenoid is included in the circuit, and is deactuated by the interruption of electrical continuity between contacts 957 and 958. The solenoid is actuated upon the closing of the automatic record length control switch, which is of the momentary close type.

FIGURE 26 is a side elevation of a modular oscillograph according to the invention. An electrical power supply module 1050, which is of conventional construction and is designed as appropriate for the particular oscillographic operations to be performed, is connected to the oscillograph frame. An electrical power and control cable 1052 extends from the electrical power module 1050 and has branches 1052A, 1052B, 1052C, 1052D, and 1052E, which are connected to the various modules and control circuits on the front panel assembly. Visible in FIG. 26 is the event numbering assembly 800 and the terminal board 815, thereof.

Also visible in FIG. 26 is the drive module 99. The transmission output shaft 152 is connected to a coupling 1055 (see FIG. 3) to which a main drive gear assembly 1060 is connected. The main drive gear assembly 1060 includes a tooth gear 1061 which engages a tooth gear 1062 attached to a take-up roller transfer pulley 1063. A drive belt 1064 extends between the transfer pulley 1063 and a take-up roller drive pulley 1065. The drive pulley 1063 is attached to a magnetic clutch (not shown) which abuts the magnetic clutch 539 (see FIG. 13) of the take-up roller 531. The main drive gear assembly 1060 includes a metering roller drive transfer pulley 1066 which engages a belt 1067. The belt 1067 passes on one side about an idler roller 1068 and engages a metering roller drive pulley 1069 which is attached to the metering roller axle 576 (see FIG. 13). Also driven from the take-up roller drive transfer pulley 1063 is the trace interrupter assembly 340 (see FIG. 7) by means of a flexible rotary shaft 1070, which rotates a wheel around which the drive belt 343 extends. The pulleys 1063, 1065, 1066 and 1069, and idler roller 1068 are held in position by a positioning plate 1072 through which the gear axles extend. The positioning plate 1072 is fixed to the side 1051 by a pair of bolts 1073.

As will be recalled with respect to FIG. 9, the light control shutters for the recording radiations were selectively controlled to give the appropriate intensity of light for recording. Intensity control knobs 1075 are connected by flexible connectors 1076 to cams 1077, which, when rotated by rotation by the flexible connectors 1076 in response to rotation of the intensity knobs 1075, transmit a linear displacement motion to the shutter actuating arms 425, so as to selectively increase or decrease the openings therebetween. It will be apparent that, as the speed of recording material transport increases, a greater intensity of light is required to maintain the same intensity of the recorded image. In order to automatically provide for compensation of light intensity in accordance with the speed of recording material transport, a flexible connector 1080 is connected to a linear cam member 1081, and is actuated by the depression of multiplier speed buttons 1085, 1086 or 1087 on the speed selection control 59, which select driving of the transmission 101 through clutches 160, 161 or 162, respectively, to increase or decrease the shutter openings as set by the intensity control knobs 1075.

FIGURE 27 is a schematic diagram of an embodiment of the power supply module 150 utilizable with the modular oscillograph of the present invention. The

power supply is conventional in design. A one hundred and fifteen volt A.C. input is applied to terminals A and B of a terminal board 1100. Leads 1101 and 1102 are connected between the primary 1103 of a power transformer 1104. The transformer 1104 has three secondary windings 1105, 1106 and 1107.

The secondary winding 1105 is connected to a conventional diode bridge rectifier circuit 1108, the output of which is applied to a conventional cascaded transistor voltage regulation circuit 1109. The regulated output is applied to terminals C and D of the terminal board 1100 by leads 1111 and 1112, for use in energizing the recording lamp. It will be noted that a lead 1113 is connected from one end of the secondary winding 1105 to a terminal E. Connected to a terminal F is a lead 1114, the other end of which is connected to the bridge circuit 1108. A recording lamp control switch 1115, shown by dotted lines, is located in the control panel 57, and is utilized to apply the recording lamp voltage to the recording lamp 306, by completing the bridge circuit through the switch 1115. The energization of the recording lamp circuit actuates a master relay 1120, through the contacts of which a twenty-eight volt potential, present at a terminal G, is applied to a terminal H, so as to energize a recording lamp "ON" indicator 1116. When de-energized, the twenty-eight volt potential at the terminal G is applied to a terminal I, and is utilized to energize a power supply "ON" indicator. A high voltage starting pulse is generated by the actuation of a pulse generating relay 1121, which closes the contacts thereof so as to apply a momentary high voltage pulse to a terminal P for application to the recording lamp.

The secondary winding 1106 and diode 1125 constitute a half-wave rectifier circuit, the five hundred volt output of which is applied to terminals J and K, to which is connected the lamp 840 of the record event numbering assembly 800. The secondary winding 1107 has a pair of diodes 1130 connected thereto so as to constitute a full-wave rectifier in conjunction with the center tap 1131 of the secondary winding 1107. This circuit produces a twenty-eight volt output which is connected to terminals L and M for application to the control circuit modules as an actuating potential.

The invention claimed is:

1. An optical component for an oscillograph wherein movable beams of illumination are relied upon to record variations of oscillograph input signals on a moving sheet of photosensitive material, the apparatus comprising a plurality of galvanometers, means adapted for supplying the input signals to the galvanometers, a source of continuous illumination, means for projecting illumination in opposite directions from the source onto the galvanometers, means for reflecting said illumination from the galvanometers along a first preselected path, an ordinate-forming plate adapted to pass illumination from the source therethrough only at preselected locations of the plate, and means for directing illuminations from the source along a second preselected path so as to fall on the ordinate-forming plate, the apparatus being adapted for disposition in an oscillograph relative to the photosensitive material so that illuminations following the first path and illuminations passing through the ordinate-forming plate are incident upon the photosensitive material.

2. Apparatus as described in claim 1 and including a flash lamp, means for flashing said lamp according to a selected frequency, and means for directing said lamp flashes along a third preselected and abscissa-forming path, the third path being incident upon the photosensitive material as a line disposed across the material.

3. An optical component for an oscillograph wherein movable beams of illumination are relied upon to record variations of oscillograph input signals on a moving sheet of photosensitive material, the apparatus comprising a

plurality of galvanometers, means adapted for supplying an input signal to each galvanometer, a source of continuous illumination, means for projecting illumination in opposite directions from the source onto the galvanometers, means for reflecting the illumination from the galvanometers along a first preselected path, an ordinate-forming plate adapted to pass illumination from the source therethrough only at preselected locations of the plate, means for directing illuminations from the source along a second preselected path so as to fall on the ordinate-forming plate, the apparatus being adapted for disposition in an oscillograph relative to the photosensitive material so that illuminations following the first path and illuminations passing through the ordinate-forming plate are incident upon the photosensitive material, and means in said apparatus operable at a preselected frequency for flashing on the photosensitive material a line of illumination across the sheet of photosensitive material disposed transverse to the direction of motion thereof.

4. An optical component for an oscillograph wherein a movable beam of illumination is relied upon to record variations of an oscillograph input signal on a moving sheet of photosensitive material, the apparatus comprising a galvanometer, means adapted for supplying the input signal to the galvanometer, a source of continuous illumination, means for projecting illumination from the source onto the galvanometer, means for reflecting the illumination from the galvanometer along a first preselected path, an ordinate-forming plate adapted to pass illumination from the source therethrough only at preselected locations of the plate, means for directing illuminations from the source along a second preselected path so as to fall on the ordinate-forming plate, a flash lamp, means for flashing the lamp according to a selected frequency, means for directing the lamp flash illumination along a third preselected path, the apparatus being adapted for disposition in an oscillograph relative to the photosensitive material so that illuminations following the first and third paths and illuminations passing through the ordinate-forming plate are incident upon the photosensitive material, and means for adjusting the third path relative to the first path so that illuminations following said paths are coincident upon the photosensitive material.

5. Apparatus according to claim 4 wherein the means for directing the lamp flash illumination along a third path is independent of the means for reflecting illumination along the first path.

6. Apparatus according to claim 4 including means for viewing from externally of the oscillograph the coincidence upon the photosensitive material of illuminations following the first and third paths.

7. An oscillograph comprising

- (a) an oscillograph frame,
- (b) a modular optical unit,
- (c) a modular transport unit adapted for moving a sheet of photosensitive material along a predetermined path,
- (d) a drive unit,
- (e) a source of electrical power,
- (f) a modular control circuit unit, and
- (g) means for releasably mounting the units to the frame and for releasably interconnecting the units and the source of electrical power so that

(1) operation of the oscillograph is controlled by actuation and deactuation of the control circuit unit,

(2) the optical unit and the transport unit are disposed for coaction one with the other for recording on the photosensitive material by means of light emanating from the optical unit, and

(3) the modular units are replaceable individually with respect to the remainder of the modular units and the power source to permit substituting

- tion of modular units of the same function type, one for another, within the oscillograph.
8. An oscillograph comprising
- (a) an oscillograph frame,
- (b) a modular optical unit including
- (1) a source of illumination,
 - (2) a galvanometer having a movable mirror,
 - (3) means for projecting a beam of light from the source of illumination to the mirror for reflection thereby and for directing the reflected beam exteriorly of the optical unit, and
 - (4) means for applying an electrical signal to the galvanometer,
- the reflected beam moving along a selected path as it issues from the optical unit,
- (c) a modular transport unit including means for moving a sheet of photosensitive material along a preselected path,
- (d) a drive unit,
- (e) a source of electrical power,
- (f) a modular control circuit unit, and
- (g) means for releasably mounting the units to the frame and for releasably interconnecting the units and the source of electrical power so that
- (1) operation of the oscillograph is controlled by actuation and deactuation of the control circuit unit,
 - (2) the optical unit is disposed adjacent the transport unit and the reflected beam is incident on the photosensitive material for recording on the photosensitive material a record of the condition of the signal, and
 - (3) the modular units are replaceable individually with respect to the remainder of the modular units and power source to permit substitution of modular units of the same function type, one for another, within the oscillograph.
9. An oscillograph comprising
- (a) an oscillograph frame,
- (b) a modular optical unit including
- (1) a source of illumination,
 - (2) a galvanometer having a movable mirror,
 - (3) means for projecting a beam of light from the source of illumination to the mirror for reflection thereby and for directing the reflected beam exteriorly of the optical unit, and

- (4) means for applying an electrical signal to the galvanometer,
- the reflected beam moving along a selected path as it issues from the optical unit,
- (c) a modular transport unit including means for moving a sheet of photosensitive material along a preselected path,
- (d) a drive unit,
- (e) a source of electrical power,
- (f) a modular control circuit unit, and
- (g) means for releasably mounting the units to the frame and for releasably interconnecting the units and the source of electrical power so that
- (1) operation of the oscillograph is controlled by actuation and deactuation of the control circuit unit,
 - (2) the optical unit is disposed adjacent the transport unit and the path along which the reflected beam moves is disposed transverse to the path of sheet movement and the beam is incident on the sheet for recording on the sheet a record of the condition of the signal, and
 - (3) the modular units are replaceable individually with respect to the remainder of the modular units and power source to permit substitution of modular units of the same function type, one for another, within the oscillograph.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,186,000

May 25, 196

Kauno E. Sihvonen et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 12, lines 74 and 75, for "881. An axle 886 is connected to the triangular plate plate 883 is axially centered with respect to the shaft" read -- plate 883 is axially centered with respect to the shaft 881. An axle 886 is connected to the triangular plate --.

Signed and sealed this 23rd day of November 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents