

Sept. 16, 1941.

L. G. TOWNSEND

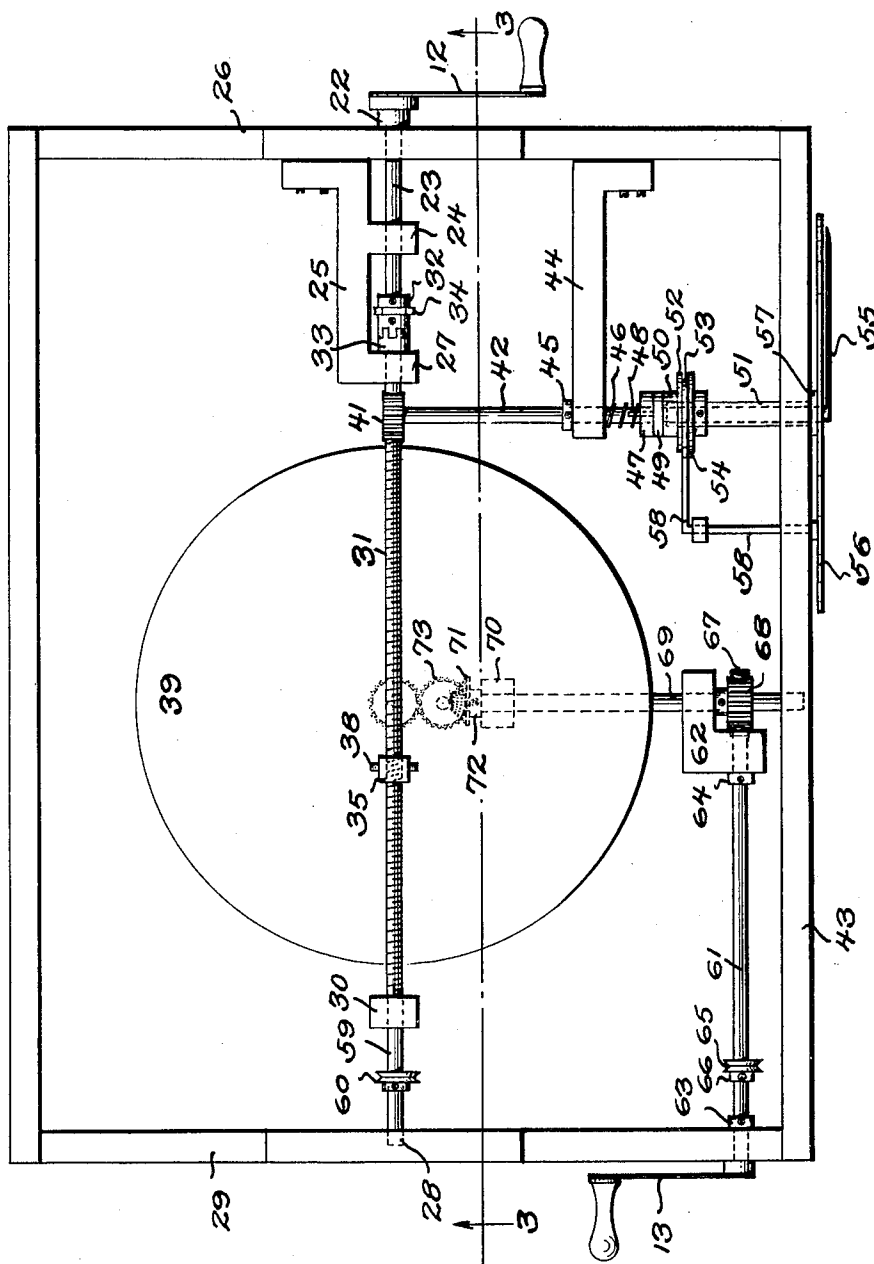
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APPARATUS FOR PLOTTING LINE GRAPHS

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7 Sheets-Sheet 2

Fig. 2.



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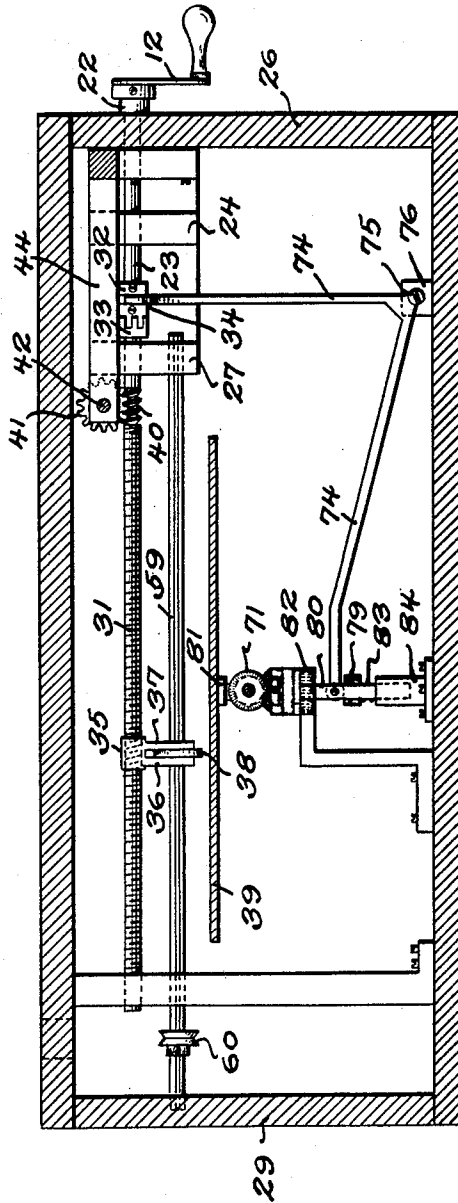
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Fig. 3.



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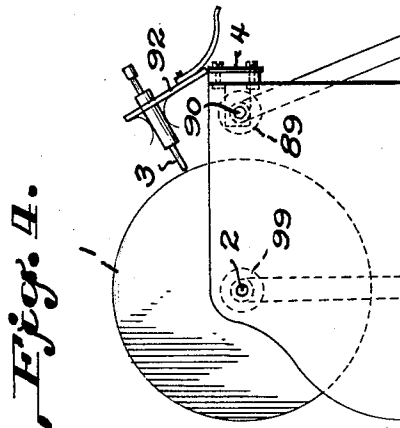
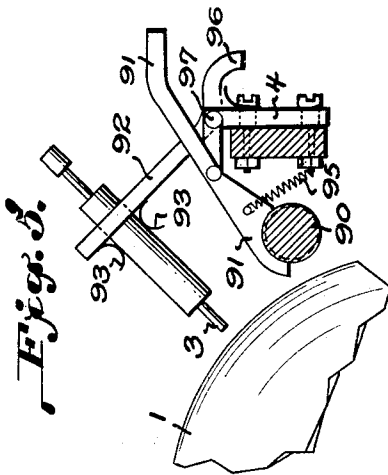
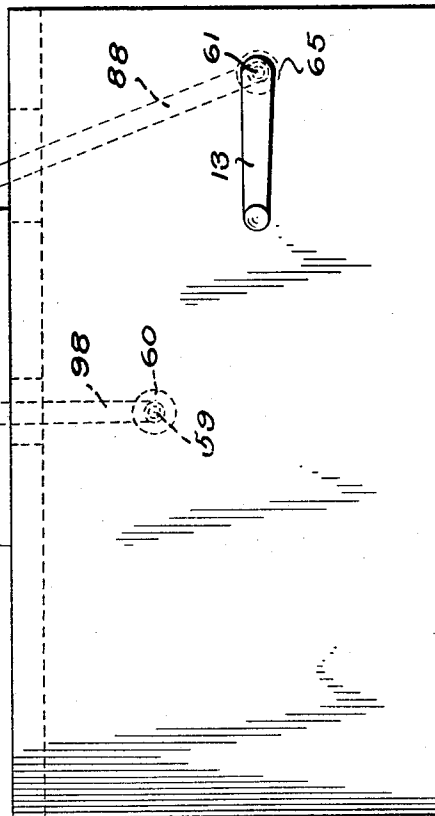
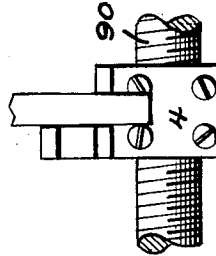


Fig. 6.



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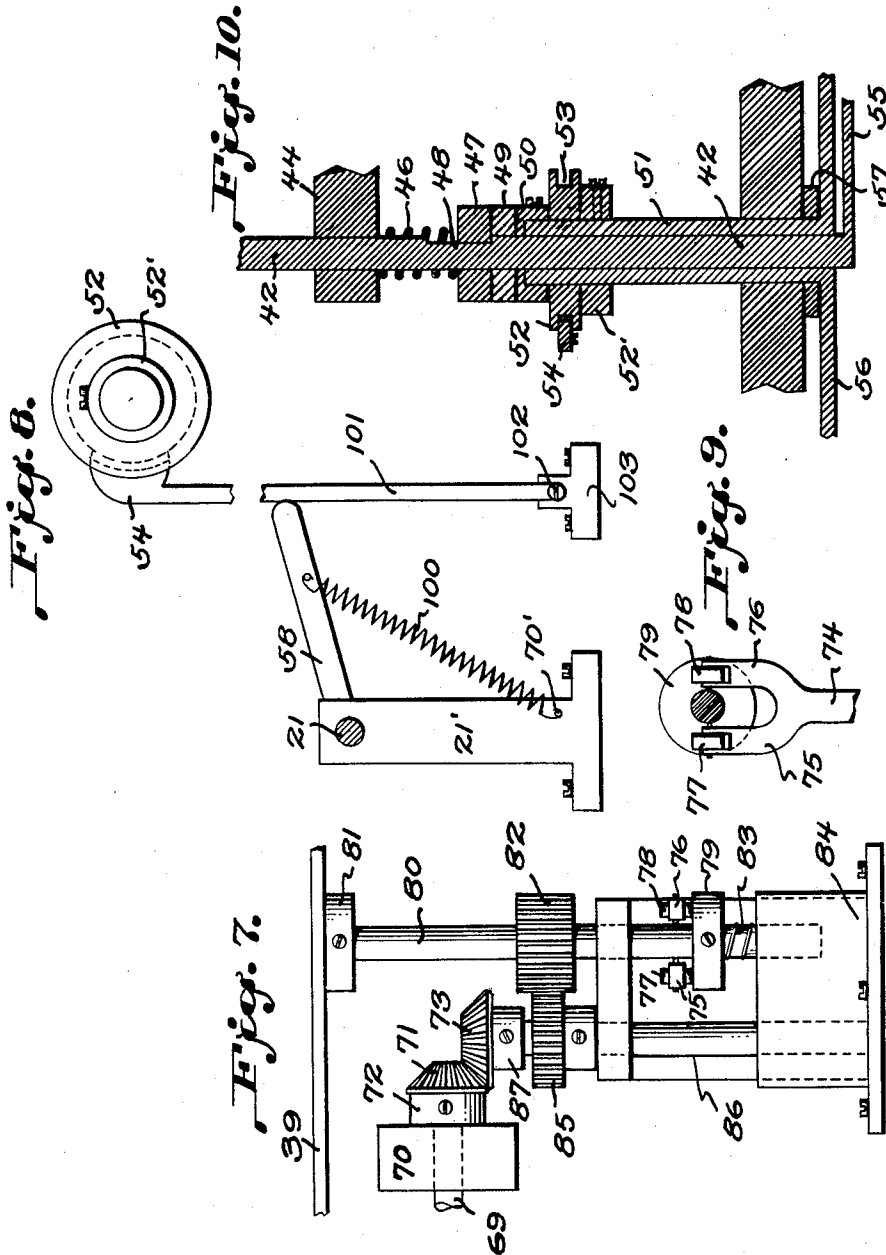
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7 Sheets-Sheet 5



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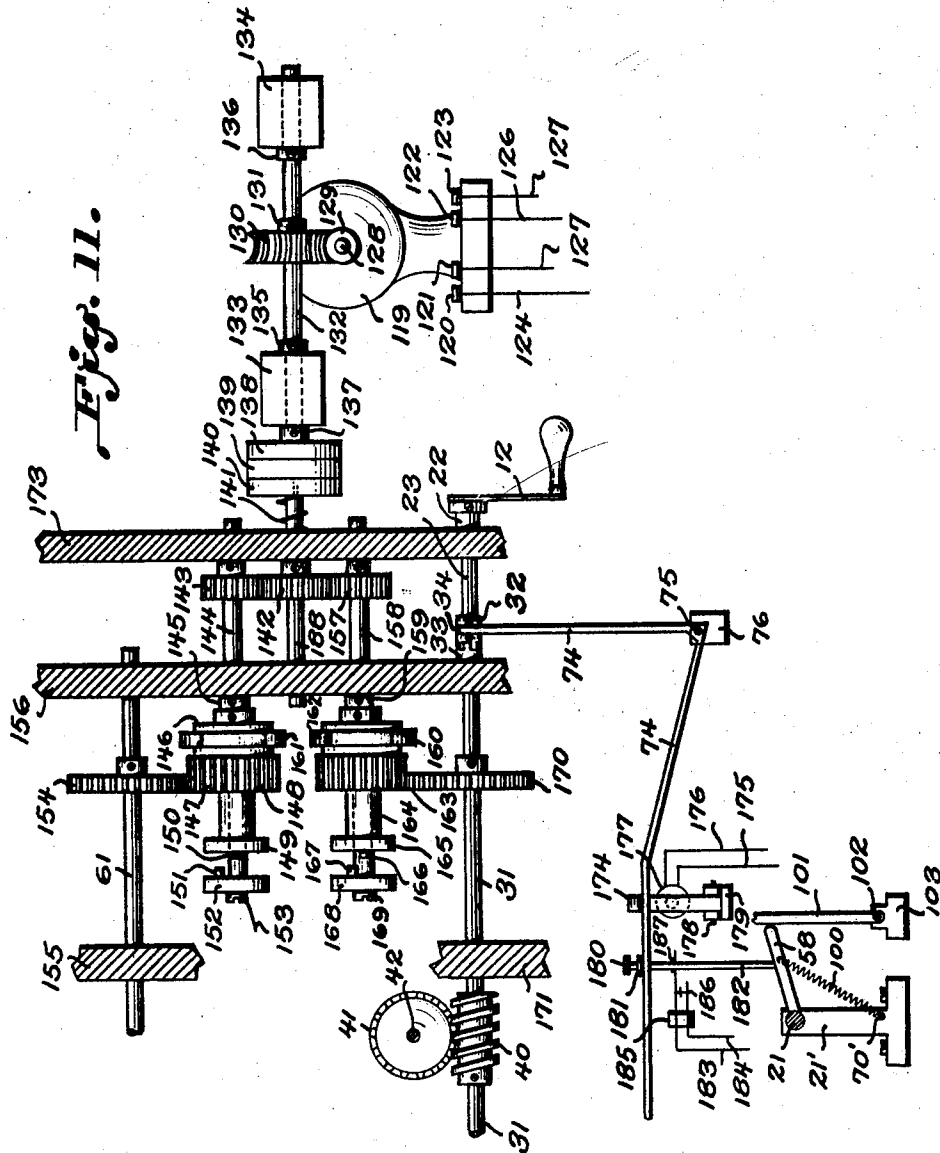
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APPARATUS FOR PLOTTING LINE GRAPHS

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7 Sheets-Sheet 6



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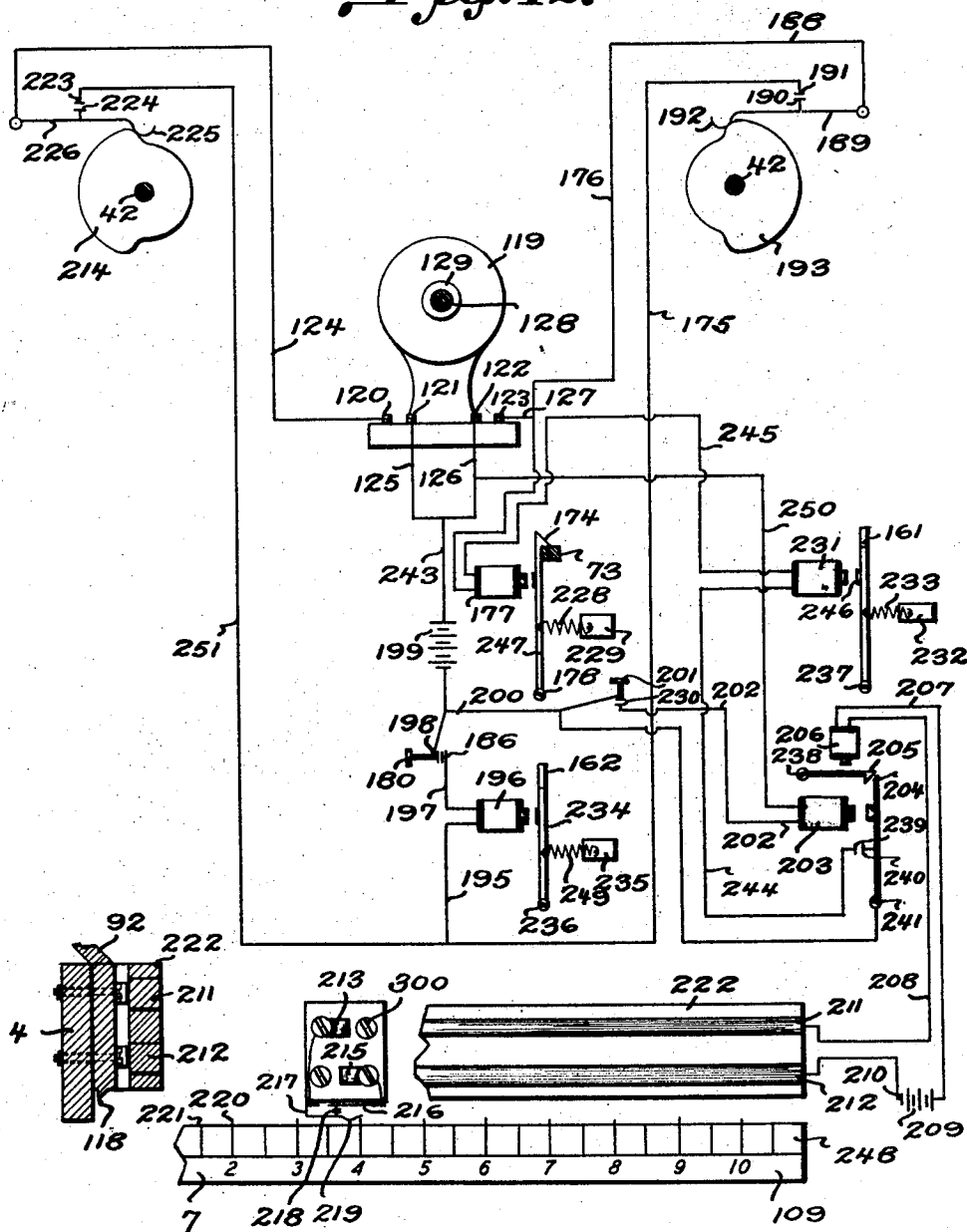
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7 Sheets-Sheet 7

Fig. 12.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR PLOTTING LINE GRAPHS

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Application July 15, 1940, Serial No. 345,666

6 Claims. (Cl. 33—18)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the Act of April 30, 1928, (Ch. 460, 45 Stat. L. 467).

This invention relates to improvements in apparatus for plotting line graphs in the form of a resultant of ordinate and abscissa factors.

Statistical practice necessitates large numbers of graphs to be drawn by laboriously plotting the same by draftsmen on finely ruled graph paper, this calling for a high degree of skill, neatness and accuracy. Such graph paper when photo-statically reproduced also reproduces the undesired finely ruled grid lines.

An object of this invention is to provide a machine which will automatically, and directly from the data sheet, accomplish the drafting and ruling of a line graph with a high degree of speed and accuracy and without the undesired finely ruled grid lines.

With the foregoing and other objects in view, the invention resides in the combination of parts and in the details of construction set forth in the following specification and appended claims, certain embodiments thereof being illustrated in the accompanying drawings, in which:

Figure 1 is a view in front elevation of the device, showing the relative positions of the ordinate and abscissa cranks and scales, the graph paper carrying cylinder and a line graph described on the paper.

Figure 2 is a top plan view of the device, with the cylinder assembly removed, showing the interior mechanism for actuating the cylinder and the ordinate and abscissa scale and crank assemblies.

Figure 3 is a view in section taken along line 3—3 of Figure 2.

Figure 4 is a view in end elevation of the device, showing the graph cylinder and pen assembly and the driving connections therefor in dotted lines.

Figure 5 is an enlarged view in detail, similar to Figure 4, of the pen assembly.

Figure 6 is an enlarged view in end elevation of the pen assembly and driving shaft.

Figure 7 is a detail enlarged view in front elevation of the friction disc and its lowering and raising mechanism.

Figure 8 is a detail enlarged view in front elevation of the release mechanism for the ordinate dial.

Figure 9 is an enlarged detail view of the friction disc release mechanism.

Figure 10 is a view in longitudinal section taken through the ordinate scale indicator assembly.

Figure 11 is a diagrammatical view partly in top plan and partly in section, of a part of the device as modified and adapted for electrification, showing the motor drive gear transmission and clutches.

Figure 12 is a circuit diagram of the electrical system for operating the device.

Referring more particularly to the drawings, there is shown a cylinder 1 rotatably mounted on a shaft 2 and provided with drawing paper removably carried thereon. A ruling pen 3 is supported in a holder 4 slidably mounted in slots 5 and 6 in a bar 6' carrying a removable scale 7. This permits the pen to be translated from end to end of the cylinder as it rotates and to describe a line graph, such as shown at 8, by means to be later described in detail.

As shown in Figure 1, there is provided an interchangeable dial scale composed of a debit half 9 and a credit half 10, separated by an ungraduated blank 11 therebetween.

The ordinate crank 12 is used in setting the ratio, or resultant of the rotation of the cylinder 1 and the linear movement of the pen 3 and the means for driving the two. The movement of the ordinate crank 12 is in two directions. When the crank is in its outward position it swings free of the machine and has no effect upon the operation of the device when rotated. When the crank is pushed inwardly, as shown in Figures 2 and 3, a rotation of the same will set up a ratio between the rotary movement of the cylinder and the linear movement of the pen. It is to be noted, however, that the pushing in and turning of the crank 12 does not effect a rotation of the cylinder or linear movement of the pen, but merely sets up a ratio of movement so that when the abscissa crank 13 is rotated there is effected a simultaneous rotation of the cylinder and linear movement of the pen.

When the ordinate crank 12 is rotated the indicator hand 14 on the dial 9, 10 and 11 is rotated to the left or right of the vertical indicator 15, depending upon the direction of rotation of the crank.

After the ordinate factor is thus set up by turning the crank 12 causing, for example, the indicator 14 to be moved to a "2" position on the debit scale 9, the abscissa crank 13 is rotated in such a direction that the pen 3 will be moved

laterally until the pointer 16 on the pen carriage 4 registers with the "1" on the scale 7. Due to the rotation of the cylinder and the linear movement of the pen there is thus formed on the graph paper, a graph 17 between the major grid lines 18 and 19 of the graph paper.

A reset key 20, mounted on a shaft 21, may be depressed to the right, and while in this position the ordinate crank may be rotated so as to bring the indicator 14 to a vertical position directly under the stationary indicator 15, causing the ordinate dial 9, 10, 11 to also rotate until the number on the dial to which the indicator 14 was previously set (namely "2") is directly below the stationary indicator 15. The next ordinate figure from the data sheet may now be plotted through the use of the ordinate crank 12 and thus continued until all of the data has been plotted and the graph completed.

Referring more particularly to Figure 2, the ordinate crank 12, with its collar 22 is mounted on a shaft 23 rotating in bearings 24 of the bracket 25 and bearings in the side wall 26. A movement of this crank rotates the threaded shaft 31 rotating in bearings 27 of the bracket 25, bearings 28 in the wall 29, and bearings 30.

Mounted on shafts 23 and 31 is a clutch assembly including clutch collars 32 and 33 and a clutch fork 34, the teeth of the two collars meshing in driving relationship when the ordinate crank is pushed in, as shown in Figures 2 and 3.

An internally threaded nut 35 is mounted on the threaded shaft 31 and is provided with forks 36 and 37 supporting friction wheel 38. As shaft 31 is rotated by the ordinate crank 12 the nut 35 and wheel 38 are moved to the left or right according to the direction of rotation of the crank. The clutch fork 34 is moved to the left upon the initial lateral movement of the crank 12 and this results in the lowering of the friction disc 39 out of contact with the friction wheel 38.

The threaded shaft 31 also has special threads 40 meshing with and driving a toothed wheel 41 mounted on a shaft 42 rotating in suitable bearings in the wall 43 and in the support bracket 44. Shaft 42 is provided with a collar 45 abutting the support 44. Surrounding shaft 42 is a compression coil spring 46 bearing against the support 44 and collar 47 which latter is longitudinally slidable on shaft 42 and keyed thereto in a keyway 48. The collar 47 is urged by spring 46 against a leather washer 49 and collar 50 on the shaft 42. Upon rotation of the shaft 42, and through friction between the leather washer 49 and the collars 47 and 50 the latter collar 50 tends to rotate a hollow shaft 51. A brake drum 52, having a groove 53 and brake shoe 54 with a collar 52', prevents turning of the hollow shaft 51 by reason of greater friction existing between the brake shoe 54 and the bottom of the groove 53 in the brake drum 52. An indicator hand 55 is fixedly mounted on shaft 42 and rotates therewith. A dial indicator 56 is fixedly mounted on the hollow shaft 51 and spaced from the wall 43 by a collar 57. Shaft 42 is free to rotate within the hollow shaft 51 except when the friction assembly 47-54 is effective. Upon release of the brake shoe 54, caused by a partial rotation of shaft 58, the brake drum 52 is free to follow the rotation of shaft 42 by reason of the friction clutch members 47, 49 and 50 under the action of the spring 46.

Mounted on a shaft 31 is a pulley 60 and also the friction wheel 38 which rotates with the shaft but is splined so as to be linearly moved

thereon. The abscissa crank 13 is mounted upon a shaft 61, rotating in a bearing in wall 29 and in a bearing in a bracket 62. The shaft 61 is provided with positioning collars 63 and 64 and also a pulley 65 and positioning collar 66. A worm gear 67, mounted on shaft 61 drives a worm wheel 68 mounted on a shaft 69 rotating in a bearing in the wall 43 and a bracket 70. The shaft 69 carries a bevel gear 71, positioned by a collar 72, this gear meshing with a bevel gear 73, to bring about a rotation of the friction disc 39, by means to be later described in detail.

When the ordinate crank 12 is pushed in, the forked end of the member 74 (Figure 3) is moved to the right about its pivot 75 in the bracket 76. The left end of the member 74 has forks 75 and 76 (Fig. 9) provided with rollers 77 and 78 which rest upon a collar 79 when the machine is in normal position. Upon moving the ordinate crank 12 to the left, the collar 79 is depressed and the friction disc 39 lowered out of contact with the friction wheel 38. Referring to Figure 7, the collar 79 is mounted on a shaft 80 which carries the friction disc 39 fastened by the positioning collar 81. Shaft 80 carries a pinion gear 82 and is lowered against the action of a coil spring 83 extending between collar 79 and bearing member 84. Pinion gear 82 is sufficiently wide to remain in mesh with pinion gear 85 during this limited raising and lowering operation. Pinion gear 85 is mounted on a shaft 86 which rotates in a bearing in support 84. Bevel gear 73 is positioned by collar 87 on shaft 86 and meshes with bevel gear 71. Referring to Figures 3 and 7, upon the release of the ordinate crank 12, the spring 83 expands and forces rollers 75 and 76 on the forked end of member 74 in a clockwise direction, returning the crank 12 to its outward disengaged position.

Referring to Figure 4 there is shown a belt drive assembly between the base and the head of the machine. When the abscissa crank 13 is rotated, the pulley 65, mounted on the same shaft 61, is rotated and through the medium of the belt 88, rotates a pulley 89 which is fixedly secured to the shaft 90 which is provided with screw threads. Riding in these threads under the tension of spring 95 is a threaded half nut 91 which, upon rotation of shaft 90, positions the pen longitudinally along the cylinder 1. The pen 3 may be mounted in a holder 92 and removably held in place by spring clips 93. Provision may be made for raising and lowering the pen out of and into contact with the graph paper on the cylinder, by means of a handle 96 pivoted at 97 on the carriage 4. The member 91 is threaded to engage the threaded shaft 90 and provides a means of positioning the carriage 4 as desired independently of the rotation of the worm shaft 90 and retained in set position by spring 95. Thus, when the shaft 90 is rotated it carries the pen assembly longitudinally.

As the abscissa crank 13 is rotated a rotation of the shaft 90 is effected and the pen assembly is linearly translated. At the same time a rotary motion is applied to the friction disc 39. This rotates the friction wheel 38 in a relationship of motion dependent upon the distance of friction wheel 38 from the center of the friction disc 39. Friction wheel 38, being splined on shaft 59, causes the latter to rotate and this rotation is imparted to the cylinder 1 by means of the belt 98 around the pulley 60 on shaft 59 and pulley 99 on the cylinder shaft 2.

With the machine in normal position, that is, with the pen carriage indicator 16 set at zero position on the scale 7 indicating the abscissa factor; the graph paper positioned on the cylinder, the ordinate crank 12 may be rotated until the indicator 14, the reset key 20 and the ordinate scale 9, 10, 11 are in the position shown in Figure 1, the following is a typical operation of the device in the plotting of an analysis chart. The drawing paper may be ruled with major grid lines corresponding to the divisions of the machine scales as indicated in Figure 1. Since the ordinate scale is divided in half, the origin line of the graph paper appears in the center of the sheet, to be considered as zero, and the ordinate figures thus progress numerically from this origin line.

As for example, in computing scales, we assume the minimum amount of the chart shown to be a minus \$20.00 and the maximum a plus \$20.00, the operator mentally adds a cipher to each number appearing on the ordinate scale. Thus "1" becomes "10," "2" becomes "20," etc. Assuming the problem to involve the scale of \$20.00 worth of merchandise, the operator pushes in and rotates the ordinate crank 12 until the indicator 14 points to numeral "2" on the debit side 9 of the ordinate scale.

In order to cause ordinate crank 12 to function, it was first pushed in to the left to engage the clutch collars 32 and 33 and the fork on crank member 74 lowered the friction disc 39 against the action of spring 83 as previously explained. The ordinate crank 12 is now rotated which turns the shaft 31, causing nut 35 to position the friction wheel 38 at twice its diameter to the left of the center of the friction disc 39. The positioning of friction wheel 38 in relation to the friction disc 39 merely sets up a ratio of movement between the same. The rotation of shaft 31 meshing with the worm 40, rotates the worm wheel 41 on the shaft 42, which rotates the indicator hand 55, while the dial 56 on the shaft 42 remains stationary.

The abscissa crank 13 is now rotated and the worm 67, engaging with the worm wheel 68 on the shaft 69, causes the bevel gear 71 to rotate the bevel gear 73 on the shaft 86. Pinion gear 85 rotates the pinion gear 82 on the shaft 80, raising the friction disc 39 under the action of spring 83 as the ordinate crank 12 is released at the completion of the ordinate setting operation. The friction disc 39, being in contact with the friction wheel 38, causes it to rotate at a 2 to 1 ratio. Since the friction wheel 38 is mounted by means of a spline, or key-way, to shaft 59, the latter is thus rotated. As the pulley 60 on shaft 59 is rotated the belt 98 rotates the pulley 99 causing a rotation of the same shaft 2 that bears the graph cylinder 1. As the abscissa crank 13 is rotated, it also rotates the pulley 65 as well as pulley 89, through the belt 88. The pulley 89 being mounted on the worm shaft 90, a longitudinal movement is imparted to the carriage assembly 4. The carriage assembly 4 carries the inking pen 3 and moves the same in a longitudinal direction, in relation to the graph cylinder. Since the graph cylinder is also rotating and the pen is drawing a line, such a line represents the resultant of the movement of the rotation of the cylinder and the longitudinal movement of the pen assembly.

Upon the completion of this last operation, the reset key 20 is now depressed, causing a counter-clockwise movement of the lever 58 about its

pivot 21 in the bracket 21' and a resulting release of brake shoe 54 from contact with brake drum 52 against the action of spring 100 tending to hold crank 58 against the arm 101 pivoted at 102 to a base member 103, the arm 101 carrying the brake shoe 54. The ordinate crank 12 is now rotated in a direction opposite to that which was necessary to position the indicator hand 14 to the number "2" on the ordinate dial. The ordinate crank 12 is rotated until the indicator hand 14 is positioned under the fixed indicator 15 and, due to the release of braking shoe 54, the dial 56 follows the movement of this hand 14 until the figure "2" on the debit side of said dial, being positioned directly under the point of the indicator, is also positioned under the fixed indicator 15. The machine is now completely reset and ready for the next ordinate factor to be plotted.

Ordinate crank 12 is again pushed in and rotated until the indicator hand 14 has moved one division to the right of the indicator 15. Since the ordinate dial 9, 10, 11 has moved two divisions to the left, by reason of the last operation, the indicator hand 14 is now positioned over numeral "3" on the debit side 9, of the dial. The abscissa crank 13 is now rotated and an action, similar to that previously described, takes place. The next factor has been plotted on the graph and the reset key is now depressed, and the ordinate crank 12 is rotated until the hand 14 and the dial 9, 10, 11 move to a position where the indicator 15, the numeral "3," on the debit side of the dial, and the indicator hand 14 are all in line.

The next number to be plotted is a plus "10," and as this number is less than "30" the ordinate crank 12 is rotated in the opposite direction to move the indicator 14 to the "1" position, two divisions to the left of the indicator 15. This brings the friction wheel 38 to a position equal to its diameter to the left of its diameter to the left of the center of the friction disc 39.

As the abscissa crank 13 is turned, the next line of the graph changes its direction due to the change in direction of rotation of the friction wheel 38, and drops toward the origin line of the graph.

When the machine is again reset the debit "1" is positioned under the indicator 15 and under the hand 14. If the next factor to be plotted is a credit of minus "20" the hand 14 is moved by the ordinate crank 12 three spaces to the left of indicator 14, or to the credit "2" position. This positions the friction wheel 38 to the right of the center of the friction disc 39. As the ordinate crank 12 is rotated, the pen assembly is moved from the "3" to the "4" position of the abscissa scale, and the cylinder rotates so that the resulting line is drawn below the center, or origin line, of the graph paper to indicate a minus \$20.00.

From the sample operations disclosed above, it will be readily understood that any figures from the maximum to the minimum, first decided upon, may be plotted. Although even numbers have been chosen for the illustration, each division of the ordinate or the abscissa scale may be understood to be made up of as many smaller divisions as necessary. In other words, the elasticity of the device is dependent only upon the ability of the operator in estimating correctly division points between the major divisions of either scale.

As both the abscissa and the ordinate scales are removable and replaceable, it may be readily seen that other scales may replace those indicated

in the accompanying drawings. For instance, instead of the conventional credit and debit scale illustrated in Fig. 1, such ordinate scale may be substituted for a complete credit or debit scale having twice the capacity of the scale shown. In a similar manner, the abscissa scale may be replaced with a scale reading from "0" to "30," representing the 30 days in a month, from "0" to "7," representing the days of the week, or any other type of scale which satisfies the conditions of the graph being drawn. It will also be understood that the ordinate scale may be replaced by a logarithmic scale when necessary. A logarithmic scale may also replace the abscissa scale if it is found expedient to do so.

The drawing paper used on the graph cylinder may be either pre-printed with the major grid lines or such major grid lines may be actually drawn by means of the pen by properly setting up the machine. Should it prove desirable, all major grid lines, and other markings may be eliminated completely from the graph paper, since the operation of the machine does not depend upon any identification lines on the graph paper.

For rough or practice graphs, the pen may be substituted by an ordinary pencil and sample graphs made very quickly in this manner.

For purposes of simplicity, this invention has been described in its simplest elements. It will be understood, however, that other machines known to the art, may be connected either directly or indirectly, to this machine with results satisfactory to both. It will be further understood that such a machine as herein described, adapts itself very readily to the incorporation of a numerical key-board and motor drive, and that with such an adaptation, each of the several cycles of operation of the machine may follow each other logically, from the first depression of a key by the operator, to the final reset operation of the machine and the returning of the key, once more, to its normal position. Various other forms of friction clutches, etc., than those shown, may be used in this machine and it is intended that they shall fall within the scope of the claims in this disclosure.

In Fig. 11 is shown motor 119, which is capable of being reversed by control through leads 124, 125, 126 and 127. This motor is equipped with worm wheel 129, mounted on shaft 128. This worm wheel drives the gear 130, mounted on shaft 132, by collar 131. Shaft 132 is positioned between bearing members 133 and 134 by means of collars 135 and 136. Mounted on shaft 132 is a clutch plate 138, by means of collar 137. Clutch plate 138 contacts leather friction washer 139, which tends to impart motion to clutch plate 140, mounted on and integral with shaft 188. Pressure spring 141, mounted on shaft 188 exerts pressure between bearing member 173 and clutch plate 140. Also mounted upon shaft 188 is pinion gear 142. Pinion gear 142 simultaneously meshes with pinion gears 143 and 157. Pinion gear 143 is mounted upon shaft 144, operating in bearing members 173 and 156. Also mounted upon shaft 144 is sliding clutch member 146. Collars 145 secure this member to shaft 144. Pinion gear 147, and clutch member 146, with extension collar 148, and collar 149 bearing contact tooth 150, are all slidably mounted upon shaft 144.

Clutch fork 161 engages the slots in clutch member 146, and positions said member in a longitudinal direction. Integrally mounted upon shaft 144, by means of screw 153 is collar 152, 75

bearing contact tooth 151. When clutch fork 161 is moved to the left, it carries with it clutch member 146, collar extension 148, collar 149, and contact tooth 150, so that contact tooth 150 is intercepted by rotating contact tooth 151, which causes clutch assembly 150, 149, 148, 147 and 146 to revolve. Upon the rotation of pinion 147, such rotation is also imparted to pinion 154, mounted upon shaft 61. Shaft 61 is free to rotate in bearing members 156 and 155. In a similar manner, pinion 157, mounted upon shaft 158, rotates collar 168 with contact tooth 167, made integral with aforesaid shaft by screw 169. When clutch fork 162 is moved to the left it forces clutch member 160, mounted upon shaft 158, by means of collars 159, to carry with it pinion 163, collar extension 164, collar 165, bearing contact tooth 166. When contact tooth 166 and contact tooth 167 engage, motion is imparted to clutch assembly 166, 165, 164, 163, 160 and 159. Pinion gear 163 imparts its rotation to pinion gear 170, mounted upon shaft 31, which bears worm wheel 40, clutch members 32, 33, 34, collar 22 and crank 12. This shaft rotates in bearing members 171, 156 and 173. Worm wheel 40 mounted upon shaft 31, imparts a rotary motion to gear 41, mounted upon shaft 42. Clutch fork 34 is integral with crank 74, pivoted at pivoting point 75, which is fastened to anchoring member 76. Crank 74 is utilized for lowering friction disc, as explained completely in connection with description in Figures 1 to 10, inclusive.

When crank 12 is moved to the left the toothed members of a clutch 32 and 33 are engaged. This engagement makes it possible for a rotary movement of crank 12 to be transmitted to gear 170 and worm wheel 40. When crank 12 is moved to the left, it also results in a partial rotary movement of crank 74, about pivot 75. The left hand extension of crank 74 forces back latch 174 until it latches. At this point the extension of crank 74 is latched in a downward position by latch 174, which pivots at point 178, of base member 179. Electromagnet 177, upon being energized through leads 175 and 176, withdraws latch 174, thus allowing crank extension member 74 to assume its normal position. Control button 180 mounted upon pin 182 serves to reset the machine by carrying with it, when depressed, stud 181, mounted upon pin 182, and contact 187, mounted in insulating block 185, in conjunction with other contact members 186. Contact members 186 and 187 are supplied with current through leads 183 and 184. Crank 58, pivoting in base member 21', at pivoting point 21, is depressed simultaneously, and as a consequence of depression of reset button 180. When crank 21 is depressed it tends to move crank member 101 to the right as crank member 101 is pivoted at pivoting point 102 of base member 103. Tension spring 100, fastened to base member 21' at stud 70, and also at its upper end, to crank 58, serves to keep aforesaid crank 58 in contact with crank 101. The tension of spring 100 is less than the tension of the retracting spring operating on member 101.

In Fig. 12 is shown reversible motor 119, equipped with clockwise direction binding posts 122 and 123, and counter-clockwise binding posts 120 and 121.

Cams 214 and 193 are mounted upon shaft 42 integrally, and serve to close contacts 190 and 191 and contacts 223 and 224, according to their

positioning. Batteries 199 and 209 serve as a source of current supply.

Electromagnet 177 serves to attract armature 247 to a position so that latch 174 unlatches crank extension member 74 (shown in elevation in Figs. 11 and 3). Tension spring 228 serves to return latch armature 247 to a latched position when released by magnet 177. Tension spring 228 is held by anchor member 229 to the bed of the machine. Latch armature 247 is pivoted at pivoting point 178. The release and retention of crank extension member 174 serves to raise or lower friction disc shown more clearly in Figures 2 and 3.

Electromagnet 231 serves to attract clutch armature 246 to an engaged position. Clutch fork 161 is shown in top view of Fig. 11. Tension spring 233, anchored to frame 232, serves to return clutch armature to its normal position when magnet 231 is not energized. Clutch armature 246 is pivoted at pivoting point 237.

Electromagnet 196 serves to attract clutch armature 234 to a position so that clutch fork 162 (shown in top view in Fig. 11) engages clutch in an operating position. Clutch armature 234 is returned to its normal position by tension spring 249, which is anchored to base member 235. Clutch armature 234 is pivoted at pivoting point 236.

Electromagnet 203, when energized, attracts relay armature 204 to a position where it is latched by member 205, pivoted at 238. When relay armature 204 is in latched position, contacts 239 and 240 are closed. Relay armature 204 is pivoted at pivoting point 241.

Electromagnet 206, when energized, serves to attract armature 205, pivoting at pivot point 238, and thus releases relay armature 204 so that said relay armature may return to its unlatched position.

Abscissa scale 1 is equipped with a slotted bar 248, which permits the insertion of tabulating stop members familiar to the art. These tabulating stop members are shown in 220, of Fig. 12. When these tabulating stop members are inserted in one way, they are flush with top of slotted bar 248. When they are inserted another way, they protrude a trifle above the bar, or just enough to intercept and close the slide contact 219, and the electrical contacts 218. These contacts are connected to leads 216 and 217, respectively, which lead to contact springs 213 and 215. The contact springs 213 and 215 are supported on the carriage assembly, shown in Fig. 12, and slidably contact metal bars 211 and 212. Metal bars 211 and 212 are insulated from one another and mounted in support bar 222, Fig. 12. It will be apparent that, when a tabulating stop 220 is raised that it will result in the closing of contacts 216. The closing of these contacts completes the circuit from the battery 209, through the electromagnet 206, through the leads 207 and 208, and bars 211 and 212, the sliding contact members 213 and 215, the leads 216 and 217, and the contacts 218.

In operation, the motor 119 is not in motion at the start. Ordinate crank 12 is moved to the left, or engaged position, and thus lowers friction disc 39 from contact with friction wheel 38 as described above. The extension of crank member 74 is held in the latched position by means of latch 174. Ordinate crank 12 is now rotated until the desired number is beneath the indicating hand of the ordinate dial. This rotation results in the positioning of cams 193 and 214 to either

the right or the left, depending upon the direction of rotation of ordinate crank 12. We will suppose that crank 12 has been rotated to the right, or in a clockwise direction. Cam 193 will now have raised, with its high point, sliding member 192 of contact arm 189, and thus closed contacts 190 and 191. Cam 214, having its high point on the other side has not raised contact arm 226 to a position where contacts 223 and 224 are closed. The results of the closing of contacts 190 and 191 will be described more completely when the reset circuit is taken into consideration.

With the carriage assembly positioned at the left, or starting position of the graph paper, starting button 201, Fig. 12, is now depressed. Current from the battery 199 flows through lead 200, key 201, lower key contact 230, lead 202, electromagnet 203, lead 250, lead 243, and back to battery 199.

When magnet 203 was energized, contacts 239 and 240 were closed, thus establishing a circuit from battery 199 through lead 200 to contact 240 and contact 239 to lead 244 and through magnet 231 and lead 245 through magnet 177, to lead 127 and into motor 119, through binding post 123. Current now flows through motor 119, urging it in a clockwise rotation, because of the return of current through terminal 122 and lead 126, to lead 243 and back to battery 199.

When magnet 231 was energized it attracted the armature clutch arm 246 to an operating position. The engagement of the parts of the clutch assembly, as described hereinbefore, results in the movement of shaft 61, Fig. 11. Shaft 61 is directly connected with the abscissa crank as shown and described hereinbefore. The movement of this shaft results in the movement of the carriage assembly in a longitudinal direction, to the right.

The energizing of magnet 177 results in the unlatching of crank extension member 74, Fig. 11, and thereby allows the friction disc 39 to contact friction wheel 38.

As the carriage assembly 300 (Fig. 12) moves to the right, contacts 218 are open. Carriage assembly 300 moves to the right until a tabulating stop member 220, in a raised position, closes contacts 218 because of contact between tabulating stop member 220 and sliding shoe 219. Current is now allowed to flow from battery 209, through lead 210, to contact bar 212, to contact slide spring 215, to contact 216, contact 217, slide contact spring 213, contact bar 211, lead 208, to magnet 206. Through magnet 206 to lead 207, and return to battery 209.

When magnet 206 is energized, it attracts armature latch arm 205 and thus releases armature contact arm 204 from its latched position. When armature contact arm 204 is released, it breaks contacts 239 and 240, thus releasing clutch assembly, 32-33, and stopping the carriage assembly from further advance.

When magnet 177 is de-energized, it releases latch arm 247 to a position to engage crank extension arm 74 at the beginning of the next cycle of operation.

When contacts 239 and 240 are broken, by the above action, the motor 119 is stopped from its rotation in a clockwise direction because of current stoppage through leads 126 and 127, as a result of the breaking of these contacts.

By the above different sequence of action, the desired line is now plotted and drawn upon the

in the paper. The next action to be described is the reset function.

When the reset key 180 is depressed, current flowing from battery 199 passes through contacts 198 and 186, lead 197, magnet 196, lead 195, lead 175, contacts 190 and 191, lead 188, lead 127, through motor in a clockwise direction of rotation, lead 126, lead 243, and back to battery 199.

Magnet 196, being energized, attracts armature clutch member 234 to the left so that shaft 31, Fig. 11, is rotated. Worm wheel 40, meshing with pinion 41, causes said pinion to rotate, and also turn shaft 42, bearing cams 193 and 214. Cam 193 rotates until slide contact shoe 192 drops into low position of cam 193, thus breaking contact between contacts 190 and 191 and stopping the motor. Magnet 196 is, at the same time, de-energized, returning the clutch assembly to its normal, unlatched position.

By means of the above sequence of actions, the ordinate indicator 14 is returned to a vertical position although the dial is left in its last position because of the braking action caused by the depressing of the reset key pin 182, Fig. 11, on brake assembly 100, 101, 102, 21 and 21'. Such assembly being shown in greater detail in Figs. 3 and 7. Coincidentally with the depression of the reset key extension 181, Fig. 11, contacts and depresses crank extension arm 74, and thus lowers friction disc 39 from contact with friction wheel 38, as hereinbefore explained.

If the crank 12 had been rotated in a counterclockwise direction, cam 214 would have been positioned so that its high point would have closed the circuit between contacts 223 and 224, while cam 193 would have left contacts 190 and 191 separated, or in an open position because of the contact shoe 192 being positioned on the low face of cam 193. With cam 214 in this position, current now flows from battery 199 through lead to contacts 198 and 186, through said contacts to lead 197, through magnet 196, lead 195, lead 251, contacts 223 and 224, lead 124, to motor binding post 120, through motor 119 in a counterclockwise rotary direction, from motor binding post 121, lead 125, lead 175 and back to battery return circuit 199. The motor would, in this way, revolve to the left and thus position the ordinate dial indicator hand to a vertical position, from a position to the left of said vertical position.

I claim:

1. In a device of the character described including a record bearing assembly and an inscribing assembly, means for establishing the relationship between two factors, said means including driving and driven rotatable members, said driving member being adjustable into and out of engagement with said driven member and said driven member being adjustable so as to vary the ratio of rotation between said driving and driven members, said driving member being adjustable so as to be disengaged from said driven member while said driven member is being positioned to alter the ratio of rotation between said driving and driven members, and said driving member being adjustable to reengage said driven member after said ratio of rotation has been established, and means for registering such relationship, through the simultaneous movements of said record bearing and inscribing assemblies, in the form of a plotted line graph.

2. In a device of the character described including a record bearing assembly and an inscribing assembly, means for establishing the re-

lationship between two factors, said means including driving and driven rotatable members, said driving member being adjustable into and out of engagement with said driven member and said driven member being adjustable so as to vary the ratio of rotation between said driving and driven members, said driving member being adjustable so as to be disengaged from said driven member while said driven member is being positioned to alter the ratio of rotation between said driving and driven members, and said driving member being adjustable to reengage said driven member after said ratio of rotation has been established, and means for registering such relationship, through the simultaneous movements of said record bearing and inscribing assemblies, in the form of a plotted line graph, said driven member being mounted on a rotatable screw threaded shaft, a single crank having a shaft and clutch device for releasably coupling said shaft with said screw threaded shaft whereby, when said clutch device is effective, a rotation of said crank effects an adjustment with relation to the center of rotation of said driving member, said driving member being connected, by means of a pivoted member, to said shaft of said crank whereby a longitudinal movement of the latter, so as to engage said clutch device, effects driving engagement between said driving and driven members.

3. In a device of the character described including a record bearing assembly and an inscribing assembly, means for establishing the relationship between two factors, and means for indicating the same, said means comprising a fixed indicator, a movable dial and pointer, clutch means for effecting dependent and independent associations of movements of said dial and pointer, the independent movement of said pointer indicating, with respect to said dial, the relationship between said two factors, the dependent movement of said pointer and dial, in relation to said fixed indicator, indicating the setting of the device for the next plotting operation, and means for registering such relationship, through the simultaneous movements of said record bearing and inscribing assemblies, in the form of a plotted line graph.

4. In a device of the character described including a record bearing assembly and an inscribing assembly, means for establishing the relationship between two factors, said means including driving and driven rotatable members, said driving member being adjustable into and out of engagement with said driven member and said driven member being adjustable so as to vary the ratio of rotation between said driving and driven members, and means for registering such relationship, through the simultaneous movements of said record bearing and inscribing assemblies, in the form of a plotted line graph, a single means for effecting the simultaneous movement of said record bearing and inscribing assemblies, said inscribing assembly being driven directly by said means and said record bearing assembly being driven through and controlled by the operation of said adjustable driven member when positioned to effect said ratio of rotation.

5. In a device of the character described including a record bearing assembly and an inscribing assembly, means for establishing the relationship between two factors, said means including driving and driven rotatable members, said driving member being adjustable into and out of

engagement with said driven member and said driven member being adjustable so as to vary the ratio of rotation between said driving and driven members, and means for registering such relationship, through the simultaneous movements of said record bearing and inscribing assemblies, in the form of a plotted line graph, a single means for effecting the simultaneous movement of said record bearing and inscribing assemblies, said inscribing assembly being driven directly by said means and said record bearing assembly being driven through and controlled by the operation of said adjustable driven member when positioned to effect said ratio of rotation, said inscribing assembly having an inscriber and carrying an indicator and movably mounted on a fixed scale.

6. In a device of the character described including a record bearing assembly and an inscribing assembly, means for establishing the relationship between two factors, and means for indicating the same, said means comprising a fixed indicator, a movable dial and pointer, clutch

means for effecting dependent and independent associations of movements of said dial and pointer, the independent movement of said pointer indicating, with respect to said dial, the relationship between said two factors, the dependent movement of said pointer and dial, in relation to said fixed indicator, indicating the setting of the device for the next plotting operation, and means for registering such relationship, through the simultaneous movements of said record bearing and inscribing assemblies, in the form of a plotted line graph, means for electrically and automatically effecting said setting, said means comprising a source of electric power and an electric circuit and a pair of rotatably mounted staggered contact cams, one of which controls the latching and unlatching of said clutch means and the other of which controls the relative movement of said dial and pointer to set position, said electrical circuit including a manually operable key for opening and closing said circuit.

LEONARD G. TOWNSEND.