United States Patent

[11] **3,547,038**

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[21] Appl. No. **769,503**
[22] Filed **Oct. 22, 1968**
[45] Patented **Dec. 15, 1970**
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[54] **RAILROAD TRACK CURVE RECORDING APPARATUS**
5 Claims, 14 Drawing Figs.

[52] **U.S. Cl.** **104/8**
[51] **Int. Cl.** **B61k 9/08**
[50] **Field of Search** 104/7, 7B, 8, 2;

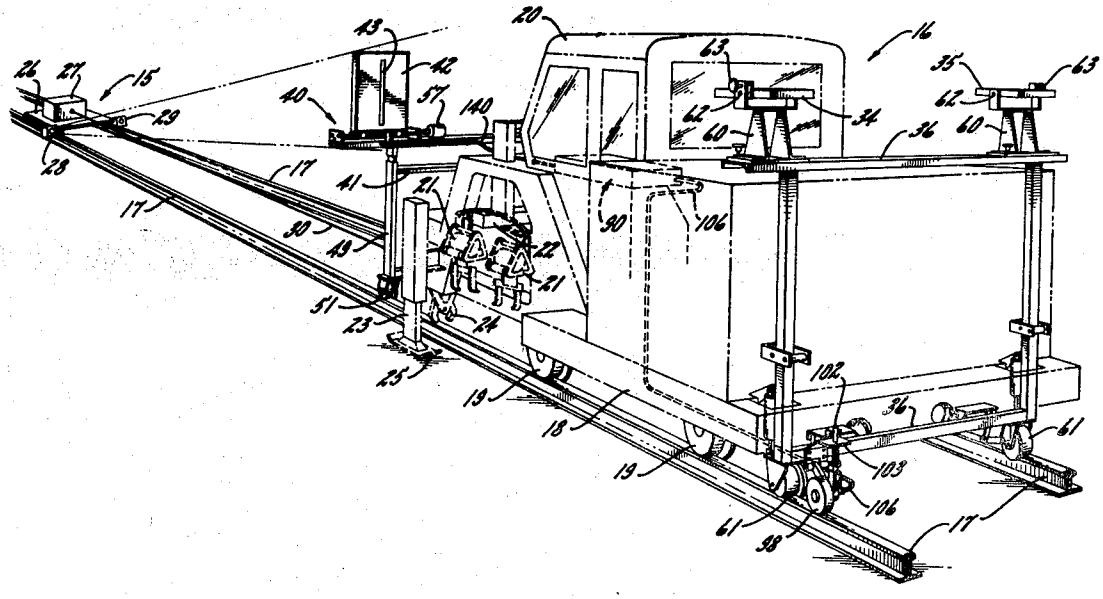
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ABSTRACT: Apparatus movable on railroad track for sensing and recording the ordinate distances of track curves and spirals from a moving reference chord. The recording medium is supplied in timed relation to movement of the apparatus on the track and the indicia recorded is proportional to the ordinate distances sensed. The sensing and recording apparatus may be installed on existing track aligning apparatus or it may be installed on its own independent movable carriages.



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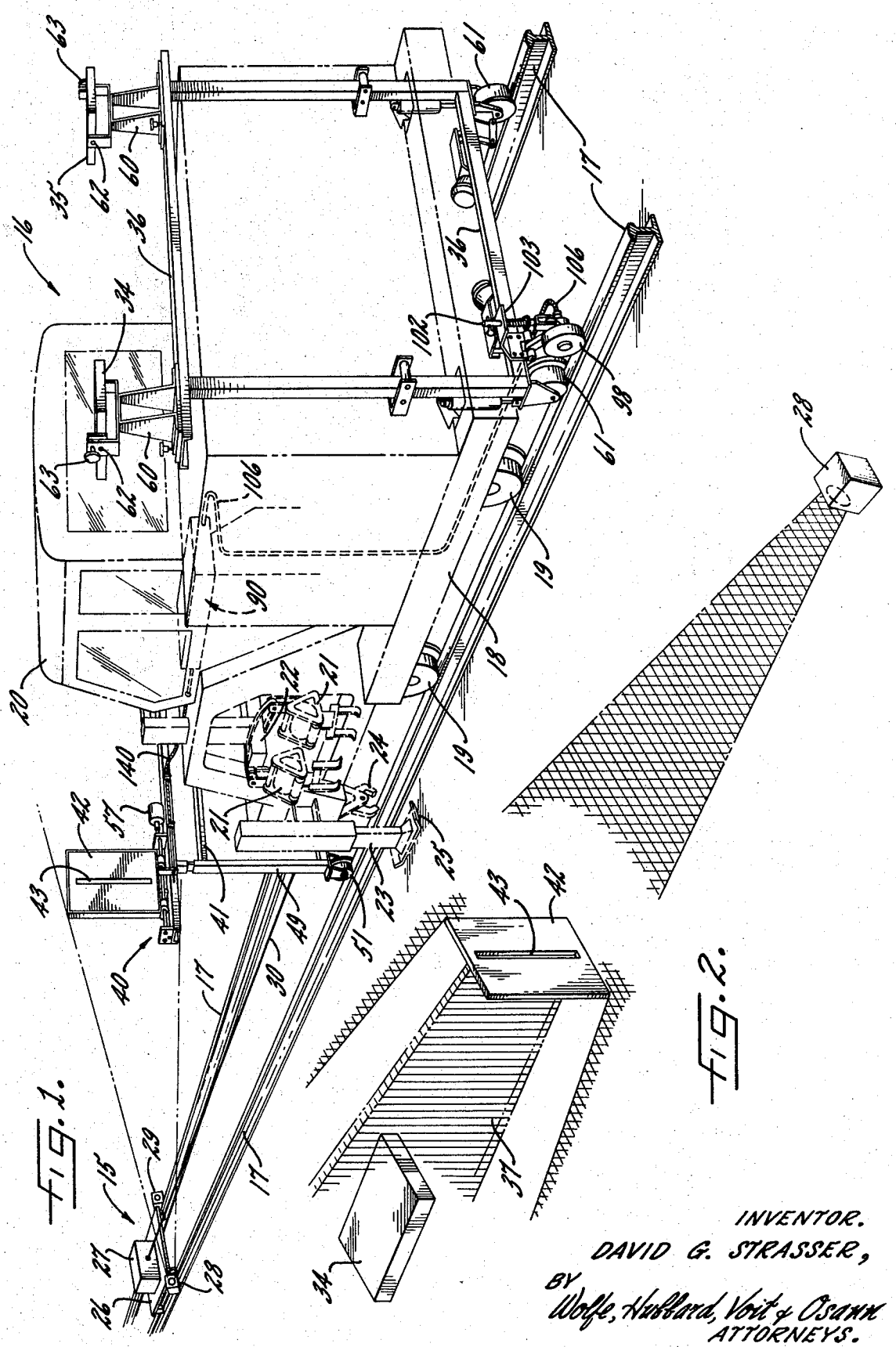


FIG. 1.

FIG. 2.

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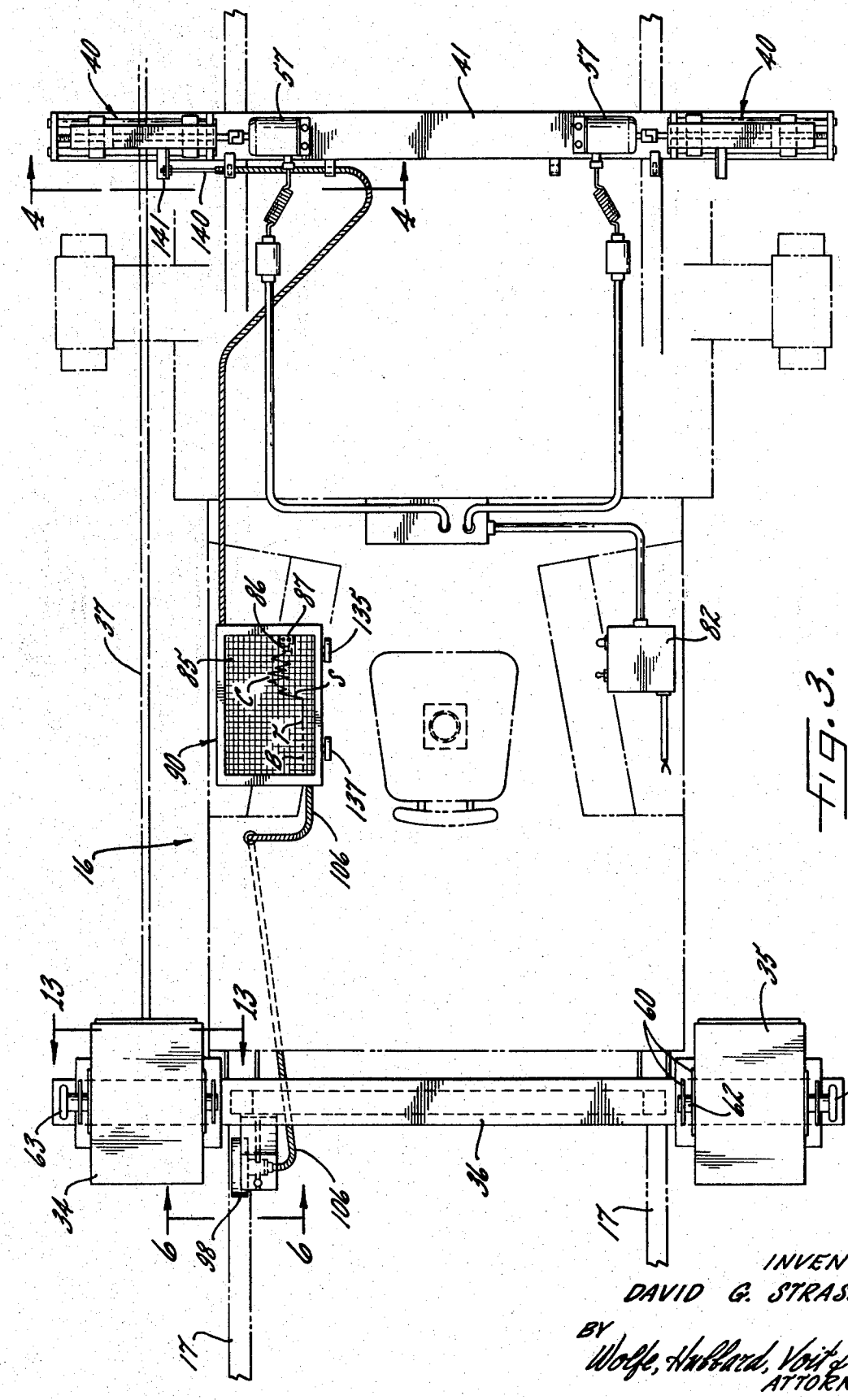


FIG. 3.

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Fig. 5.

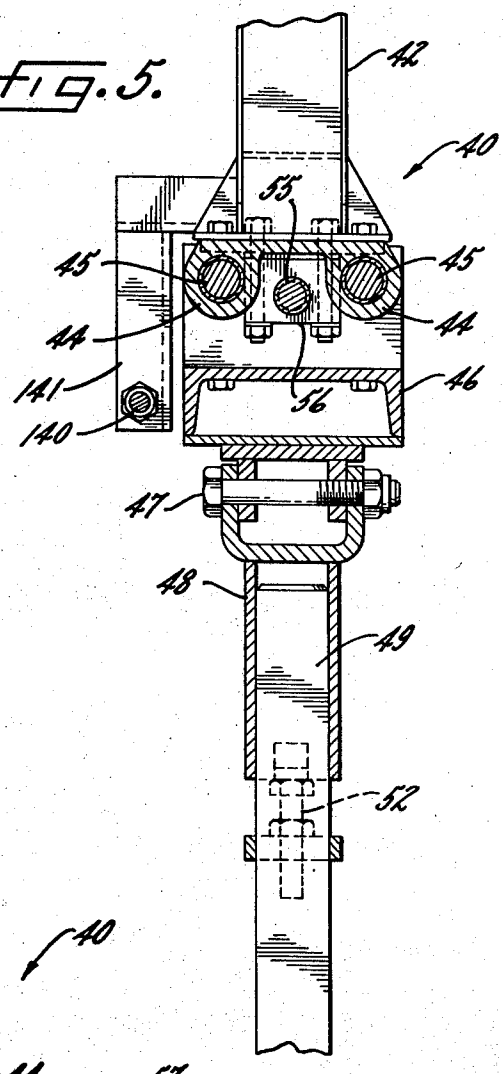
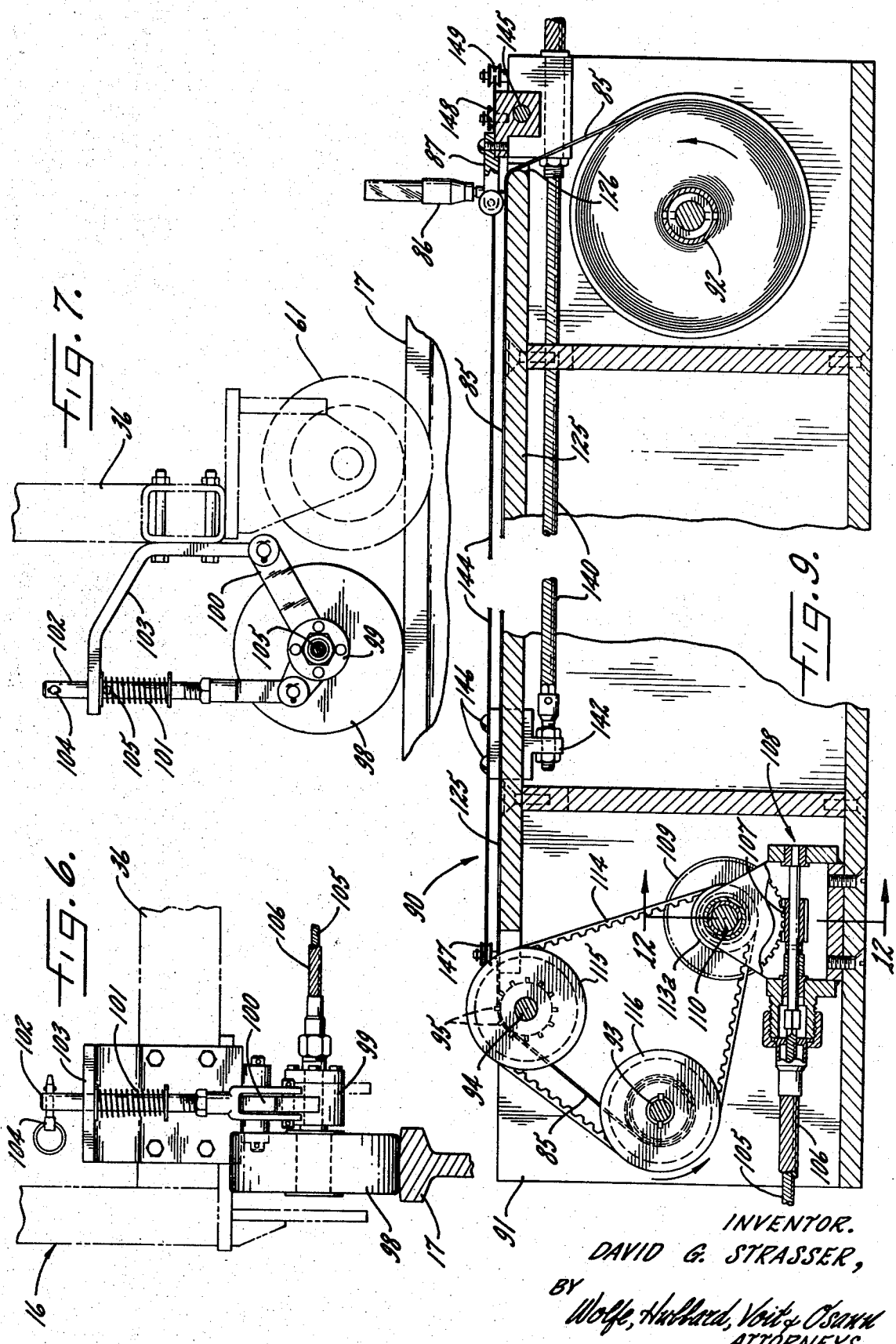


Fig. 4.

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FIG. 7.
FIG. 6.
FIG. 9.
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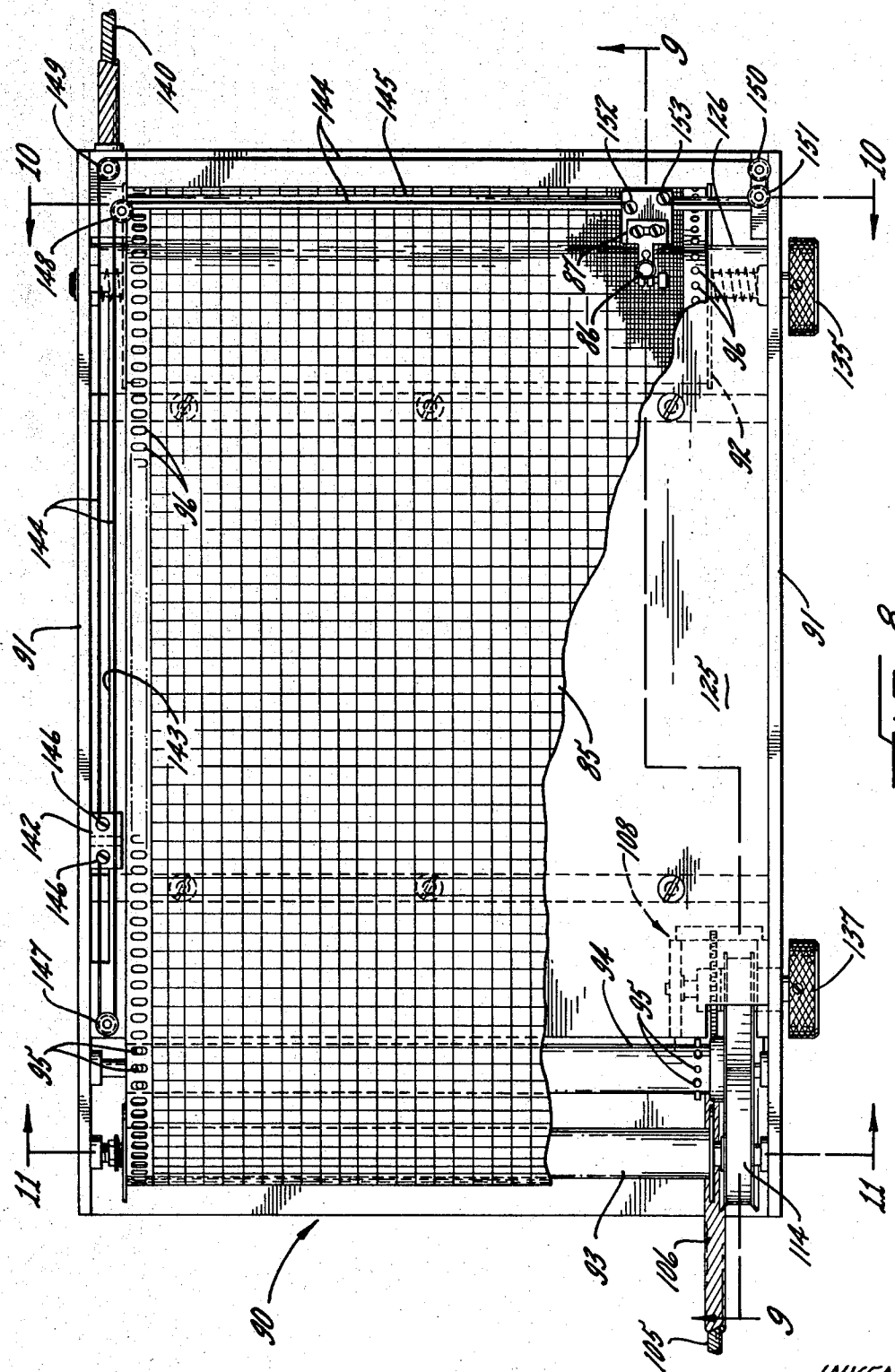


FIG. 8.

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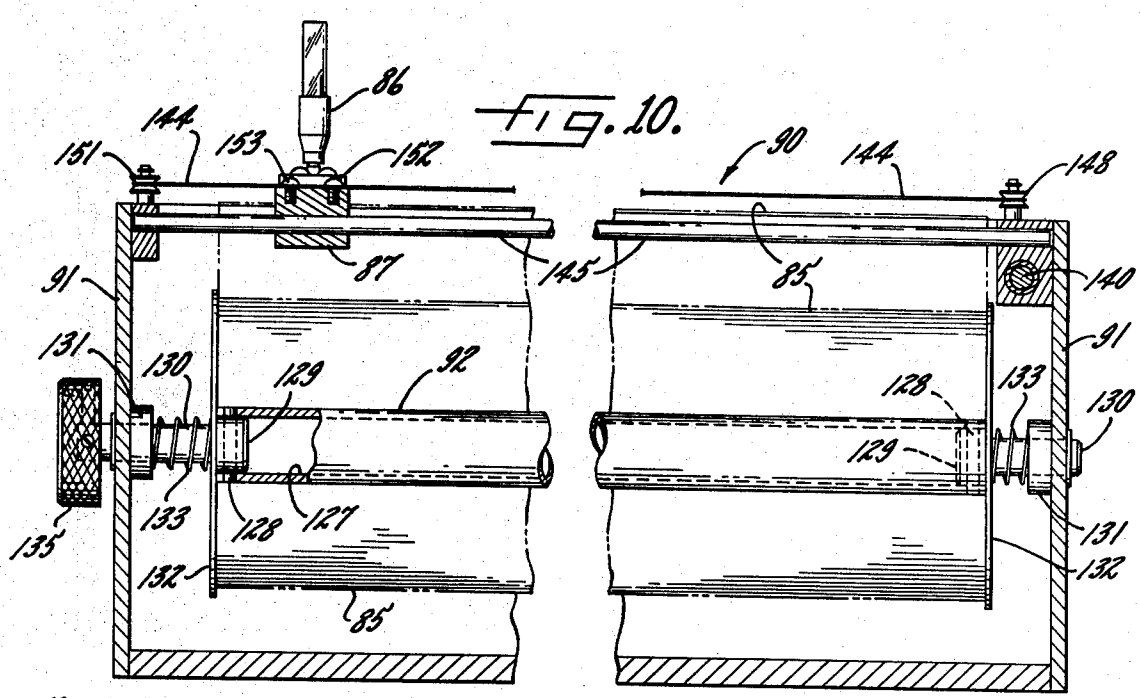


Fig. 10.

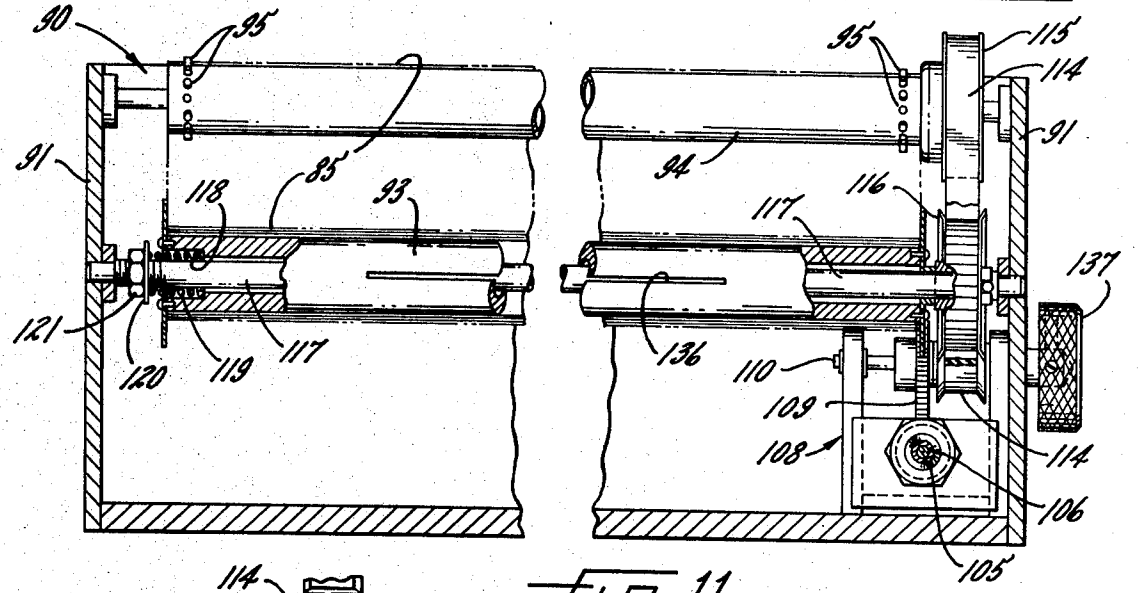


Fig. 11.

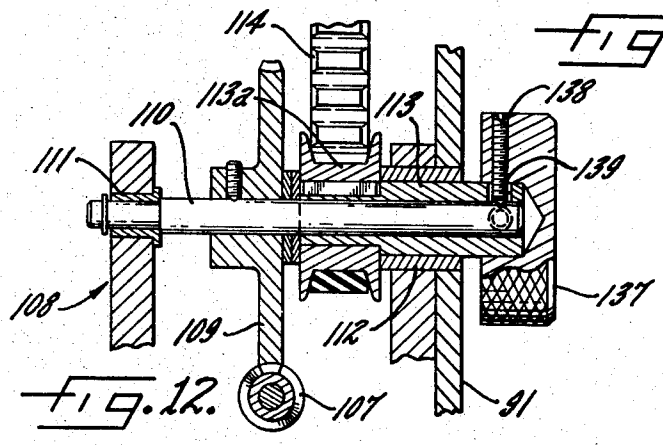


Fig. 12.

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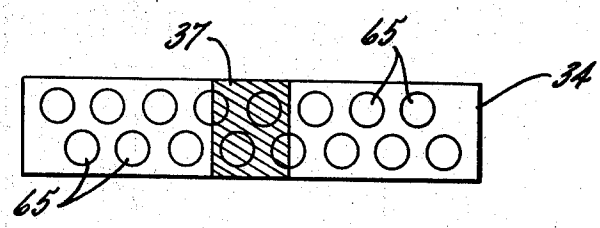


Fig. 13.

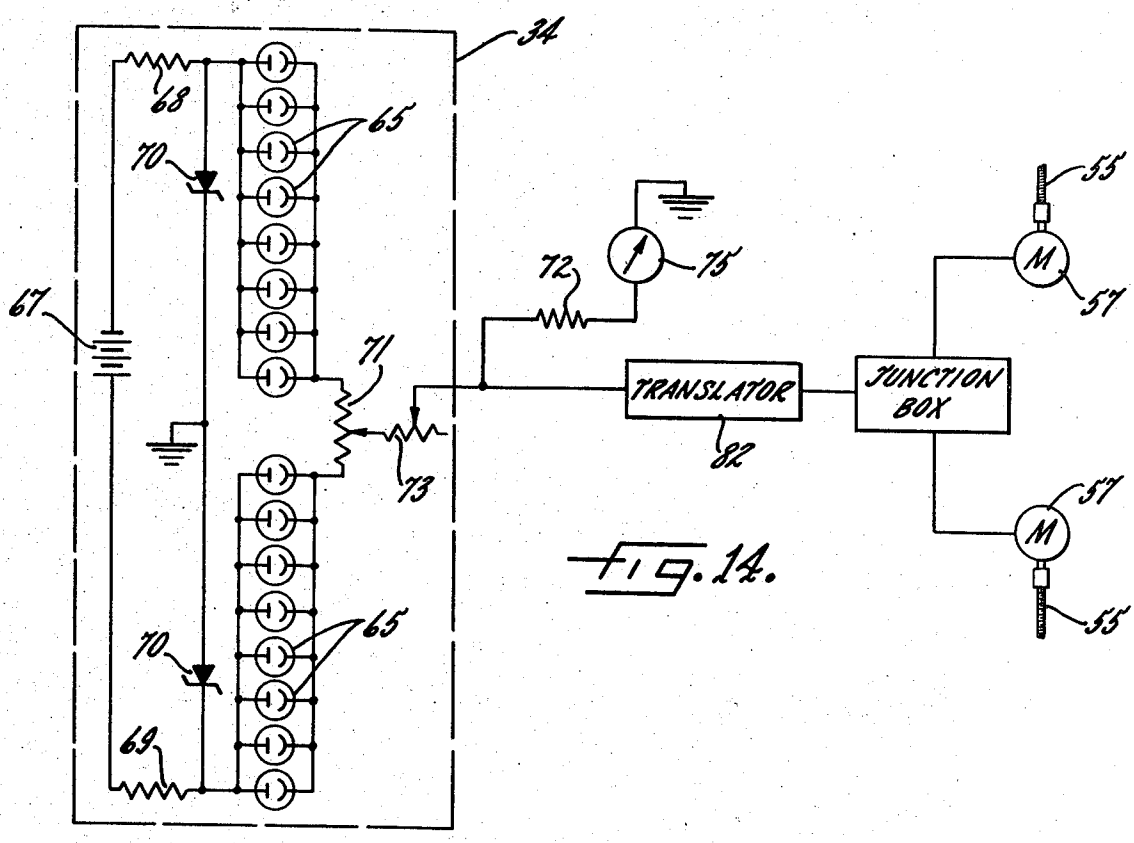


Fig. 14.

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RAILROAD TRACK CURVE RECORDING APPARATUS

This invention relates generally to railroad track maintenance apparatus and more particularly concerns apparatus for sensing and recording track curvature preliminary to corrective track alignment.

Railroad track aligning more commonly called "lining", is the side-to-side shifting of the track rails to produce straight (or tangent) track, and smooth curves of a desired arc. Recently, various forms of machines have been developed for automatically lining tangent track. These machines normally include provisions for establishing a straight reference line over and above one of the track rails, means for sensing lateral deviations of the track relative to the line and means for correctively shifting the track into proper alignment. While these automated machines have greatly increased the speed at which tangent track can be lined, they have not materially increased the speed at which track curves and the associated spirals leading into and out of the curves can be correctively shifted.

Prior to lining any curve it is necessary to first determine the existing track curvature and then compare it with the desired curvature. This initial step is referred to as "prelogging" and involves making an ordinate diagram of the existing curve. An ordinate is the perpendicular distance from a point located between the ends of a chord of predetermined length to one rail of the track, typically the outside rail of the curve. In the past, such ordinates have been obtained manually by two men holding the ends of a string to establish a chord across the track curve while a third man measures the distance from the chord to the reference rail. This method is more particularly disclosed in U.S. Pat. No. 1,127,204 where a particular chord length is employed to permit conversion of ordinate distance in inches directly into degree of curvature in degrees and minutes. More recently, the track lining equipment itself has been employed to prelog the track curves as described in U.S. Pat. No. 3,381,626. In either case the successive ordinate distances are noted and the existing curve is plotted on graph paper. The desired curve is then plotted, typically by superimposing it on the existing curve, and the ordinates necessary to establish the desired curve are noted. These latter ordinates are used to correctly align the curve.

It will be appreciated that whether the curve is prelogged manually with a string or with the aid of lining equipment, it is a time consuming operation to obtain the successive ordinates necessary to plot the existing curve. The former, as noted above, requires a three man team and the latter requires stopping the expensive lining equipment at each successive ordinate location and noting the ordinate distance before the equipment is moved ahead.

Accordingly, it is the primary aim of the present invention to provide apparatus for automatically prelogging and recording existing track curves preliminary a track lining operation. It is a more particular object to provide apparatus for continuously plotting the existing curve directly on graph paper as the apparatus travels on the track and around the curve.

A more specific object is to provide apparatus for automatically recording existing track curves wherein the recording medium is supplied in timed relation to movement of the apparatus around the curve and the indicia recorded are in direct proportion to the instantaneous ordinate distances.

It is a further object to provide an automatic curve recording apparatus of the above character which can be conveniently used with existing lining equipment to reduce the time required to prelog and plot existing curves or which can be installed on its own supporting carriages.

Other objects and advantages of the invention will become apparent to those skilled in the art upon reading the detailed description and upon reference to the drawings in which:

FIG. 1 is a perspective view of the track curve recording apparatus of the present invention installed for use with a track liner;

FIG. 2 is a simplified schematic view of a light source, mask and sensor employed to establish a reference chord;

FIG. 3 is an enlarged plan view of the liner shown in FIG. 1 with the elements of the present invention shown in solid lines;

FIG. 4 is an enlarged fragmentary section taken substantially along line 4–4 in FIG. 3;

FIG. 5 is a still further enlarged fragmentary section taken substantially along line 5–5 in FIG. 4;

FIG. 6 is an enlarged fragmentary section taken substantially along line 6–6 in FIG. 3;

FIG. 7 is a partial side elevation of the apparatus shown in FIG. 6;

FIG. 8 is a plan view, with portions broken away, of the recording device;

FIGS. 9—11, respectively, are fragmentary sections of the recorder taken substantially along the lines 9–9, 10–10 and 11–11 in FIG. 8;

FIG. 12 is an enlarged fragmentary section taken substantially along line 12–12 in FIG. 9;

FIG. 13 is a schematic illustration of the preferred form of light sensor employed with the recorder of the present invention; and

FIG. 14 is a schematic circuit diagram for the recording apparatus.

Turning now to the drawings, there is shown in FIG. 1*a* light carriage 15 and a self-propelled track maintenance machine 16, operating on rails 17 of a length of railroad track and with which the curve recording apparatus of the present invention is associated. It should be understood that the machine 16 can take many different forms and for that reason it is illustrated here with broken lines. While the main requirement of the machine 16, with respect to the present invention, is that it be a self-propelled on track vehicle, the one illustrated is a production type tamper generally similar to the one illustrated and described in U.S. Pat. No. 3,381,626 to which reference may be made for additional structural and operational details. For the sake of clarity of illustration the light carriage 15 and the machine 16 illustrated here have been modified to function only as a track liner, rather than as a combination track surfacer and liner of the type disclosed in the above-mentioned patent.

Generally, the machine 16 includes a frame 18 supported on flanged track wheels 19 and carrying an operator's cab 20 and a plurality of tamping units 21 mounted on vertically movable crossheads 22, only one of which is shown. The tamping machine also carries rail jacks 23 and rail clamps 24 of which only the left-hand set is illustrated. The clamps 24 are adapted to grip the rails and the jacks 23 include feet 25 which can be planted solidly in the ballast outboard of the rail ties to permit the track to be both raised and shifted from side to side as described in the patent noted above.

The light carriage 15 is also arranged for movement on the rails 17 either independently of or together with the tamper 16. The carriage includes a frame 26 supporting a power plant 27 which both propels the carriage 15 and energized lights 28 and 29 disposed on either side of the frame 26 near the rails 17. Preferably, the power plant 27 has a forward and reverse clutch in the carriage propelling a driving train that can be remotely controlled either by a cord or line 30 extended from the tamper 16 or by a signal actuated relay which permits a small radio transmitter to remotely control movements of the carriage 15. In the present instance the cord 30 is useful to keep a relatively constant spacing between the tamper and the carriage, as for example in prelogging curves as will be described below.

To "read" or sense the lights 28, 29 on the carriage 15, the tamper 16 carries a pair of sensors 34 and 35 mounted on a common frame 36 that is adapted to ride on the rails 17 independently of the tamper 16. The lights and sensors can take many different forms without departing from the present invention, but as illustrated the lights 28, 29 are each conventional "sealed beam" units of the type employed as automobile headlights and the sensors are capable of generating an electrical output signal when struck by a light pattern, unless the pattern falls in a predetermined null position on the sen-

sor. In the preferred construction and as schematically indicated in FIG. 2, the pattern utilized is a single band of light 37 falling across the narrow dimensions of the rectangular receiving face of the horizontally disposed sensor. The center of the long dimension of each of the sensor faces is the null position.

Cooperating with the lights on the carriage and the sensors 34, 35 are mask sets 40, only the left-hand set being illustrated in FIG. 1, carried on the tamper 16 on a common frame 41 which rides independently of the tamper on the track rails 17. It will be seen that each of the mask sets 40 includes an opaque plate 42 having side portions defining a vertically disposed slot 43. As shown in FIGS. 4 and 5, collars 44 are secured to the bottoms of the plates 42 and are mounted on parallel rods 45 fixed on the top of a cross rail 46. The cross rail is tiltably secured at each end by a bolt 47 to a fitting 48 which is slidably mounted on top of a side post 49 forming part of the frame 41. The frame 41 carries flanged wheels 51 which ride on the track rails. A screw 52 serves as an adjustable abutment stop for the fitting 48 and, since the opposite side mounting of the cross rail is identical, it can be seen that adjusting the screws 52 at each side of the frame 41 permits vertical adjustment and cross leveling of the rail 46, and hence of the mask sets 40, to their proper working positions.

In keeping with the present invention, the mask plates 42 are mounted for controlled lateral movement of the frame 41. In the preferred embodiment, the collars 44 are slidably fitted on the rods 45, and screws 55 rotatably mounted on the cross rail 46 parallel to the rods 45, are fitted respectively through nuts 56 secured to the plates 42. The screws 55 are coupled to small reversible electric motors 57 which, when energized, rotate the screws so as to drive the nuts 56 and hence the mask plates 42 along the rods 45 in either direction depending upon the direction of rotation of each motor 57.

The light sensors 34, 35 are mounted in brackets 60 anchored to the upper corners of the frame which is supported by flanged track engaging wheels 61. For initial aiming the sensors are mounted on trunnions 62 rotatably held in the brackets 60. Locking screws 63 mounted in the brackets can be loosened to permit pivoting and aiming of the sensors 34, 35 and, when tightened, the screws hold the sensors in adjusted position.

The reason for having two lights 28, 29, two sensors 34, 35 and two mask sets 40 is to permit using either rail 17 as the reference rail for determining track alignment. Generally, in lining track curves, the outer and superelevated rail is normally the lining rail. Since the track may curve either to the left or the right it is desirable to be able to switch reference rails with a minimum of difficulty. In the drawings, it has been assumed that the left rail in FIG. 1 is the reference rail.

In carrying out the invention the sensors include a plurality of closely arrayed photoelectric cells 65 coupled in electrically balanced circuits (see also FIG. 14). In the preferred construction, the cells 65 are disposed in two adjacent lines, with the cells being staggered so that a light pattern across the narrow dimension of the sensor overlaps several cells (see FIG. 13). Shifting movement of the light band along the length of the cell array thus energizes the same total number of cells, but different cells are illuminated depending upon the light band position.

The preferred electrically balanced circuit couples the cells on each side of the sensor center or null position in parallel groups, and the two groups of cells in series (see FIG. 14). A DC voltage source 67 is connected across the cells 65 through load resistors 68 and 69. A pair of oppositely poled Zener diodes 70 connected to ground and at each end of the cell array establishes fixed plus and minus voltages at the opposite ends of the cell array. In use, all of the cells 65 receive some ambient light reflected by the sensor surroundings. However, since the cells receive equal amounts of light, their resistances in the circuit are equal and the voltage drop is uniform across the cell array. A variable resistor 71 is interposed in the series connection between the cells on opposite sides of the null position so that the cell circuit can be exactly balanced to impose a 0 voltage on a ground connected signal resistor 72 when the cells are uniformly illuminated.

When a light band from one of the lights 28, 29 passes through the slot 43 in one of the mask sets 40 and strikes the sensor photocells 65, the resistance of the illuminated photocells changes. The preferred cells are of the photo resistance type, and thus, if the light band strikes only cells to the left of the center, for example, the resistance of the positive side of the balancing resistor 71 will greatly increase, causing a negative, with respect to ground, voltage signal to be imposed across the signal resistor 72. As the light band moves to the right, some of the cells on the other side of the null position will be illuminated and fewer of the cells to the left of the null position will remain illuminated. Therefore, the negative voltage signal becomes less, until an equal number of cells on each side of the null position receive light. At that time, the circuit is again in balance and the output signal is zero. If the light band continues to move to the right, a positive voltage signal is imposed on the signal resistor 72. Preferably, the magnitude of the output signal from the sensor is controlled by a variable resistor 73. Also the preferred circuit also includes a meter 75 positioned in the operator's cab 20 and connected to visually indicate the output signal from the sensor.

It will, of course, be understood that both of the sensors 34, 35 are constructed as described above although only one is illustrated in detail. Normally only one of the sensors, the one over the reference rail, is operated at a time.

The voltage signal created by the operating sensor is fed to a translator 82 which controls the mask motors 57. The translator energizes the motors 57 in one direction or the other depending on the polarity of the signal received from the sensor. If the light band strikes more of the photocells to the left of the null position than to the right the appropriate motor 57 is energized to shift its associated mask set 40 to the right until the light passing through the slot 43 of the mask plate is caused to strike the null position.

In accordance with the present invention, the machine 16 is equipped with apparatus for automatically recording the existing track curvature as the tamper 16 and its associated light carriage 15 travel in unison over a section of curved track. The operation of the recording apparatus is to simultaneously prelog and plot the ordinates of existing track curvature. As previously noted an ordinate is the distance measured from a point between the ends of a chord of predetermined length, which spans a portion of curved track, to the reference rail. For convenience we will continue to assume the left-hand rail is the reference rail.

With the light carriage 15 coupled to the tamping machine 16 by the line 30, the light 28 on the carriage and the sensor 34 on the tamper define the ends of a moving reference chord. Under control of the sensor 34 the left-hand mask set 40 is moved laterally by the motor 57 until light passing through the slot 43 falls on the null portion of the sensor. The lateral distance from the slot to the left-hand rail 17 is the ordinate dimension to be recorded.

Further in keeping with the invention, the recording apparatus includes means for supplying a recording medium in timed relation to movement of the machine 16 on the track and means for automatically recording the instantaneous ordinate distances on this medium as the machine travels around a section of curved track. In the illustrated embodiment the recording medium is a web of graph paper 85 on which the instantaneous ordinate distances are automatically plotted by a marking pen 86 mounted on a movable recording head 87. It will be appreciated, however, that other types of recording media and devices could also be employed in practicing the invention.

To supply the graph paper 85 a recording unit 90 is located in the cab 20 of the tamper 16. As shown in FIGS. 8—11, the recording unit 90 includes a frame 91 which journals the ends of a supply roll 92, a takeup roll 93 and a drive roll 94. The drive roll is provided at each end with a plurality of radially

projecting teeth 95 which engage spaced apertures 96 along the edges of the graph paper 85.

For timing the movement of the graph paper 85 in relation to movement of the tamper 16, a small drive wheel 98 is journalled in a bearing 99 mounted on a link 100 which is pivoted to the rear of the tamper and normally biased by a spring 101 to hold the wheel in engagement with one rail 17 of the track (see FIGS. 6 and 7). To disengage the wheel from the track rod a rod 102 about which the spring 101 is wound may be raised with respect to its bracket 103 and secured by inserting a pin 104 through an aperture 105 to hold the wheel above the rail.

Connected to the wheel 98 is a flexible drive shaft 105 which is enclosed in a protective sheath 106. The other end of the drive shaft is connected to a worm gear 107 journalled in a gear box 108 within the recording unit 90 (see FIG. 9). The worm 107 drives a gear 109 pinned on a shaft 110 which is also journalled in the gear box 108 by bushings 111, 112, with a sleeve 113 concentrically mounted on the shaft 110 and extending through the bushing 112. Keyed on the sleeve 113 is a toothed pulley 113*a* which drives a belt 114 which drives both the drive roll 94 and the takeup roll 93 through respective pulleys 115 and 116.

In the preferred embodiment the graph paper 85 is printed along its abscissa with one major and ten minor divisions per inch. Also the diameter of the drive wheel 98 and the gear ratio of the drive train are such that the graph paper is supplied at the rate of 1 inch for every 100 ft. of travel of the machine 16 on the track. Since conventional track rails are 39 ft. long, this means that each minor division on the graph paper is essentially one-fourth rail length; two minor divisions one-half rail length; etc.

Since the effective diameter of the takeup roll 93 increases as more graph paper 85 is wound on it, a slip drive connection is provided between the pulley 116 and the takeup roll 93. As shown in FIG. 11, the takeup roll 93 is concentrically mounted about a shaft 117 journalled in the frame and on which the pulley 116 is pinned. The remote end of the takeup roll 93 is relieved at 118 to receive a spring 119 surrounding the shaft 117 and abutting a washer 120 and stop nut 121. By adjusting the nut 121, the degree of slip between the shaft 117 and the takeup roll 93 and thus the tension of the graph paper 85 on the takeup roll may be controlled.

For support the graph paper between the supply roll 92 and the drive roll 94, a flat marking surface 125 is mounted on the frame 91 near the top of the recording unit 90. As seen in FIG. 9, the edge of the marking surface closest to the supply roll is rounded at 126 and serves to guide the graph paper 85 from the supply roll to the upper face of the marking surface.

To facilitate insertion and removal of a roll of graph paper 85 on the supply roll 92, provision is made for releasably mounting the ends of the roll. In the illustrated embodiment, the supply roll 92 has a hollow bore 127 and each end is notched to receive the ends of a cross pin 128 inserted through a collar 129 dimensioned to fit within the bore 127. Each collar is mounted on the end of a short shaft 130 journalled in a bearing 131 secured to the frame 91 of the recording unit. Outboard of the collars 129 each shaft carries an end plate 132 and a compression spring 133, which normally biases the end plates 132 against the ends of the roll of graph paper and the collars 129 within the bore 127 of the supply roll. Desirably one of the shafts 130 projects through the frame 91 of the recorder and is fitted with a knob 135. By pulling the knob 135, the collar 129 on its associated shaft 130 is held away from the end of the supply roll which can them be inserted on or removed from the other mounting collar 129. Also, by turning the knob 135 in one direction, graph paper 85 can be initially fed from the supply roll 92 over the marking surface 125 and onto the drive roll 94 and into a slot 136 in the takeup roll 93. Turning the knob 135 in the other direction, of course, winds the graph paper back on the supply roll 92, but only after the takeup roll 93 and the drive roll 94 have been disengaged from the drive gear 109 as explained below.

As shown in FIG. 12, the drive pulley 113*a* is coupled to the drive gear 109 by the shaft 110 and the sleeve 113 which is journalled in the bushing 112. The sleeve 113 projects out of the frame 91 and carries a knob 137 held on the sleeve by a set screw 138 which projects into a radial hole 139 in the sleeve. When fully inserted, the set screw 138 also engages the shaft 110 and causes the sleeve 113 to rotate with the shaft. By partially withdrawing the set screw 138 the sleeve is released from the shaft 110 disconnecting the drive pulley 113*a* from the drive gear 109. The knob 137 can then be turned manually to initially wind the graph paper 85 on the takeup roll 93 or to permit rewinding the graph paper on the supply roll 92 by turning knob 135.

In further keeping with the present invention, the recording head 87 and marking pen 86 are moved across the graph paper 85 incident to movements of the operative mask set 40. To this end, a flexible slide cable 140 is secured at one end to a bracket 141 attached to the mask plate 42 (see FIG. 4) and at the other end to a slide 142 mounted on a track 143 in the recording unit 90 (see FIGS. 8 and 9). The slide 142, in turn, is coupled by a direction changing cable 144 to the recording head which is slidably mounted on a rod 145 secured to the frame 91 of the recorder 90. As shown in FIGS. 8—10, one end of the cable 144 is secured to the slide 142 by a screw 146 and passes first over a direction reversing guide pulley 147 journalled on the frame 91 and then over a direction changing pulley 148 journalled on the frame in alignment with the recording head 87. The other end of the cable 144 is secured to the slide 142 by another screw 146 and passes first over a direction changing pulley 149 and then a pair of direction reversing pulleys 150, 151 journalled on the frame 91. Between pulleys 148 and 151 the cable 144 is secured to the recording head 87 by screws 152, 153.

As the plate 42 of the operative mask set 40 moves laterally in response to operation of its motor 57 under control of the sensor 34, the slide cable 140 moves the slide 142 on its track 143 longitudinally of the recorder 90. This movement of the slide 142, in turn, causes lateral movement of the recording head 87 across the graph paper 85 through movement of the direction changing cable 144. During the movement of the recording head 87 the marking pen 86 records the corresponding movements of the mask plate 42 on the graph paper 85 as instantaneous ordinate of track curvature. In this manner a curved section of track is automatically prelogged and plotted on the graph paper 85 as the machine 16 travels around the curve.

An example of such an ordinate plot is shown on the recorder 90 in FIG. 3. It will be understood, of course, that in prelogging a curve, the light carriage 15 and machine 16 are initially situated on tangent track several rail lengths ahead of the spiral leading into the track curve. Thus, the reference line established by the light beam is initially parallel to the tangent track and the initial plot of instantaneous ordinates appear as a straight line T coinciding with the abscissa or base line B on the graph paper 85.

As the light carriage 15 moves onto the track spiral leading into the curve, a moving reference chord is established between the light 28 and the sensor 34, and the operative mask set 40 shifts under operation of the sensor and the motor 57 to keep the light passing through its slot 43 centered on the null band of the sensor. This portion of the ordinate plot is indicated at S on the graph paper of FIG. 3 and ideally would appear as a straight line of constant slope whose progressively increasing height indicates increases in curvature of the track spiral. Assuming the track curve is of constant radius, following the entry spiral, the ordinate plot next recorded would ideally appear again as a straight line above the base line B on the graph paper. However, since the rails of the existing curve may have shifted the plotted ordinates of curvature may be irregular as indicated at C on the graph paper 85, somewhat exaggerated in FIG. 3 for illustrative purposes. It will be understood that the plot of the exit spiral (not illustrated) would appear as a downward sloping line which would be followed by a substantially straight line again indicating tangent track at the exit side of the curve.

Once the track curve and its associated spirals have been prelogged and plotted with the automatic recording apparatus of the present invention it is a simple matter to correctively adjust the track to the desired degree of curvature. First the ordinates of the desired curve and its associated spirals are superimposed on the ordinate plot of the existing curve. All that is required for this is to draw straight lines of the desired ordinates through the irregular spirals and curved track plots recorded on the graph paper **85**.

As previously indicated, the recording apparatus of the present invention is illustrated in connection with a production type tamper and track aligning machine. After the existing curve is recorded and the corrected ordinates plotted, the machine **16** and light carriage **15** are returned to their initial positions on th the tangent track leading into the curve which has been plotted. As the machine travels over the curved track the second time, the operator shifts the operative mask set **40** to a position which corresponds to the corrected ordinate and the sensor **34** which is now coupled in an operating circuit such as described in U.S. Pat. No. 3,381,626 automatically shifts the track to the desired position, i.e. one that causes the light beam passing through the mask slot to fall on the null band of the sensor. Operation of the lining machine **16** continues with the operator periodically making the necessary mask adjustments as indicated by the previously corrected plot of track curvature. In the present instance the mask adjustments may be conveniently made at every one-fourth rail length since as previously noted the graph paper has been subdivided into approximately these divisions.

It has already been noted that the recording apparatus of the present invention need not be installed on a production tamper and track aligning machine. Rather, in some instances it may be desirable to install the recording apparatus on its own self-propelled carriage having sensors and adjustable mask sets as described here but without rail clamps, jacks or tamping heads. This would permit prelogging and plotting the ordinates of existing track curvature with relatively expensive equipment and without interrupting the operation of a production type tamper to plot the curve. Other modifications and embodiments of the present invention will doubtlessly also occur to those skilled in the art and, accordingly, it is not intended to limit the present invention to the embodiment illustrated, but rather to cover such alternatives and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

I claim:

1. Apparatus for automatically plotting a railroad track curve and its associated spirals without moving the track, comprising, in combination:

means including spaced apart front and rear carriages traveling on said track and around said curve and spirals for establishing a moving reference chord of predetermined length by projecting a light beam along said track between respective reference points on said front and rear carriages;

detecting means including a sensor having a null section located between laterally spaced elements responsive to said light beam and a laterally movable mask having a substantially vertically disposed slot therein located intermediate the ends of said moving chord for detecting instantaneous ordinate distances from said chord to one rail of said track;

an actuator energized by said laterally spaced elements responsive to light from said beam passing through said slot and impinging on said elements to laterally move said mask into a position where light from said beam passing through said slot impinges on said null section of said sensor;

means including a wheel engageable with one rail of said track for supplying a recording medium in timed relation to movement of said carriages on said track, said recording medium having a base line indicating tangent track; and

means including an element coupled to said mask and movable therewith for applying indicia on said medium relative to said base line and proportional to said instantaneous ordinate distances as said apparatus travels around said track curve and spirals.

2. Apparatus as defined in claim **1** wherein said recording medium is graph paper supplied from a supply roll to a takeup roll by a drive roll at a speed proportional to movement of said apparatus on said track and including a clutch for disengaging said drive roll from said drive wheel and means for manually and advancing said graph paper.

3. Apparatus as defined in claim **1** wherein said detecting means includes an indicating element having a reference point laterally moveable into alignment with said reference chord.

4. Apparatus as defined in claim **3** wherein said reference point in said indicating element is laterally moveable relative to a point fixed relative to the lateral location of one of said track rails.

5. Apparatus as defined in claim **4** wherein said indicating element is coupled to said recording means for successively recording the distance between said fixed point and said reference point as said instantaneous ordinate distances.