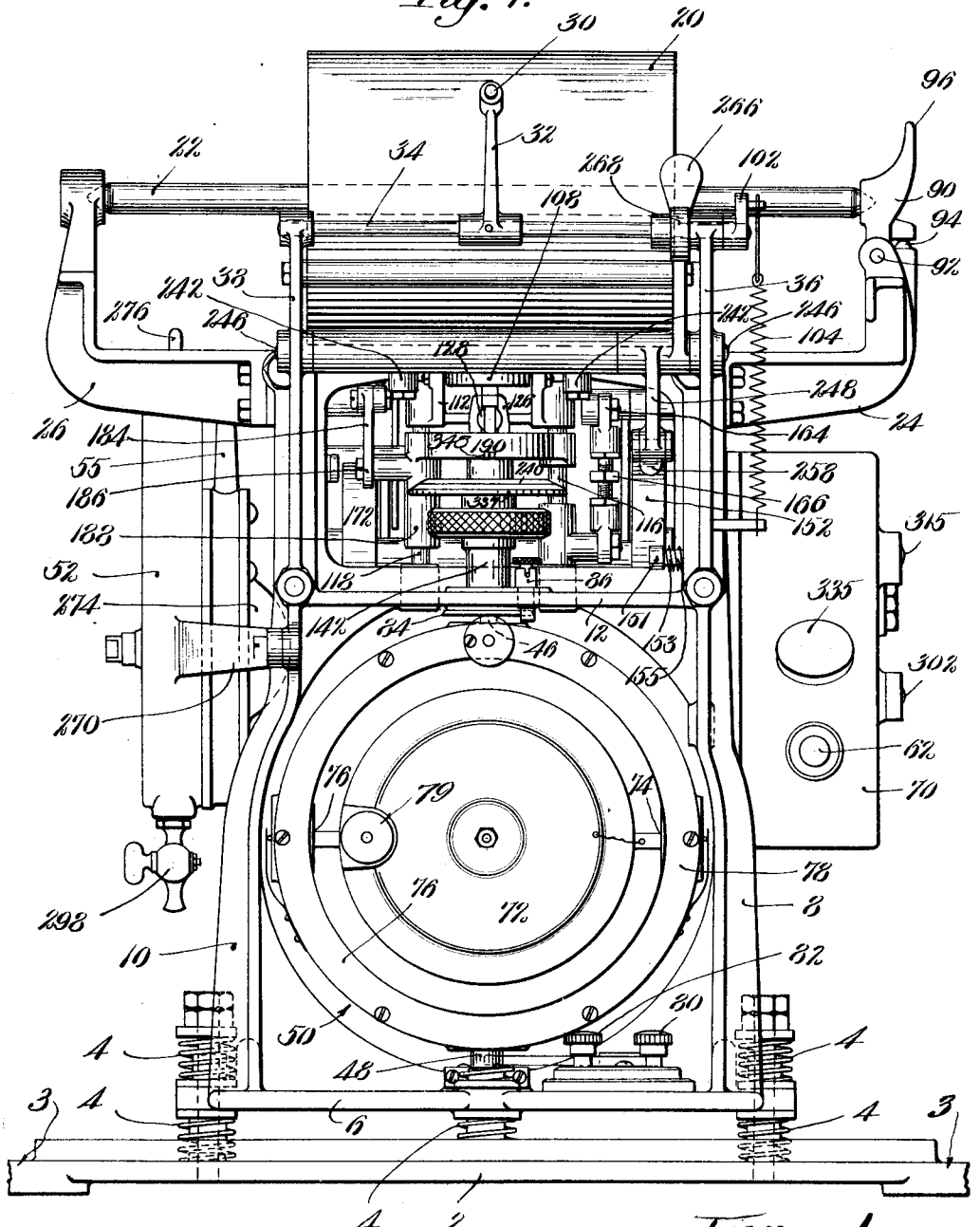
Sept. 10, 1929. E. E. WINKLEY 1,727,460

ODOGRAPH

Filed June 27, 1924 9 Sheets-Sheet 1

Fig. 1.



Inventor

Erastus E. Winkley

by Warren G. Ogden atty.

Sept. 10, 1929. E. E. WINKLEY 1,727,460

ODOGRAPH

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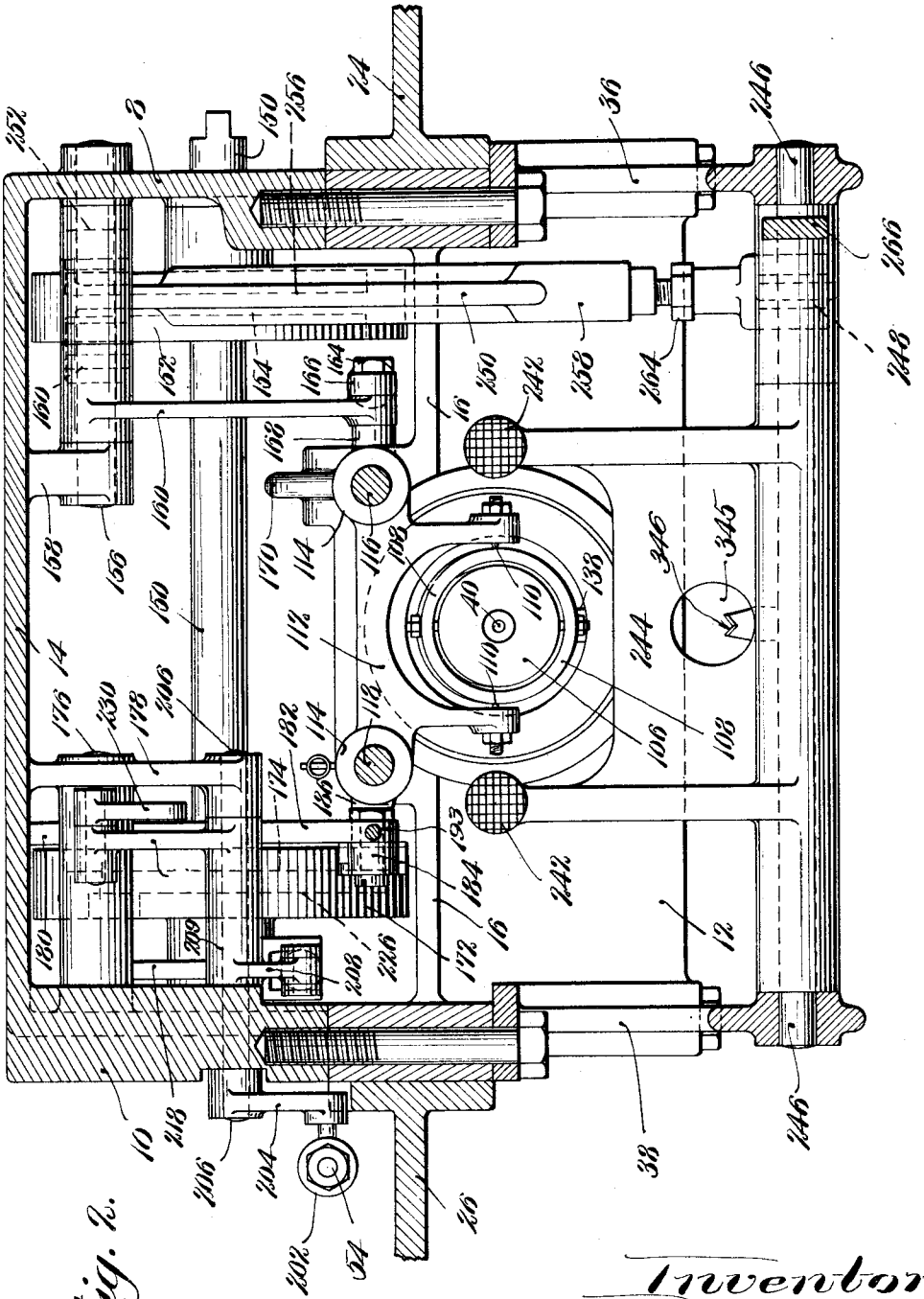


Fig. 2.

Inventor:
Erastus E. Winkley
by Warren G. Ogden
atty.

Sept. 10, 1929. E. E. WINKLEY 1,727,460

ODOGRAPH

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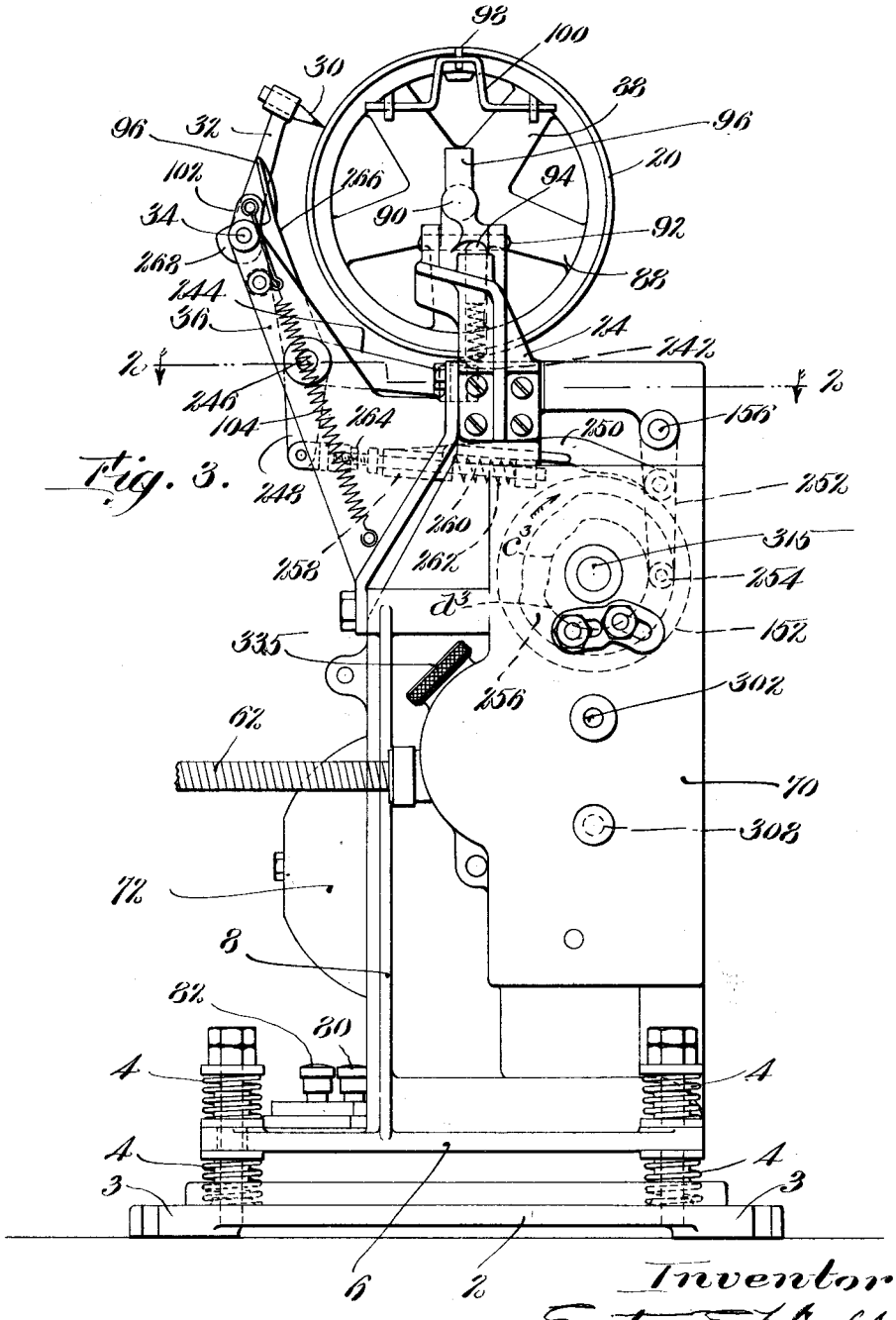


Fig. 3.

Inventor
Erastus E. Winkley
by Warren G. Ogden atty

Sept. 10, 1929. E. E. WINKLEY 1,727,460

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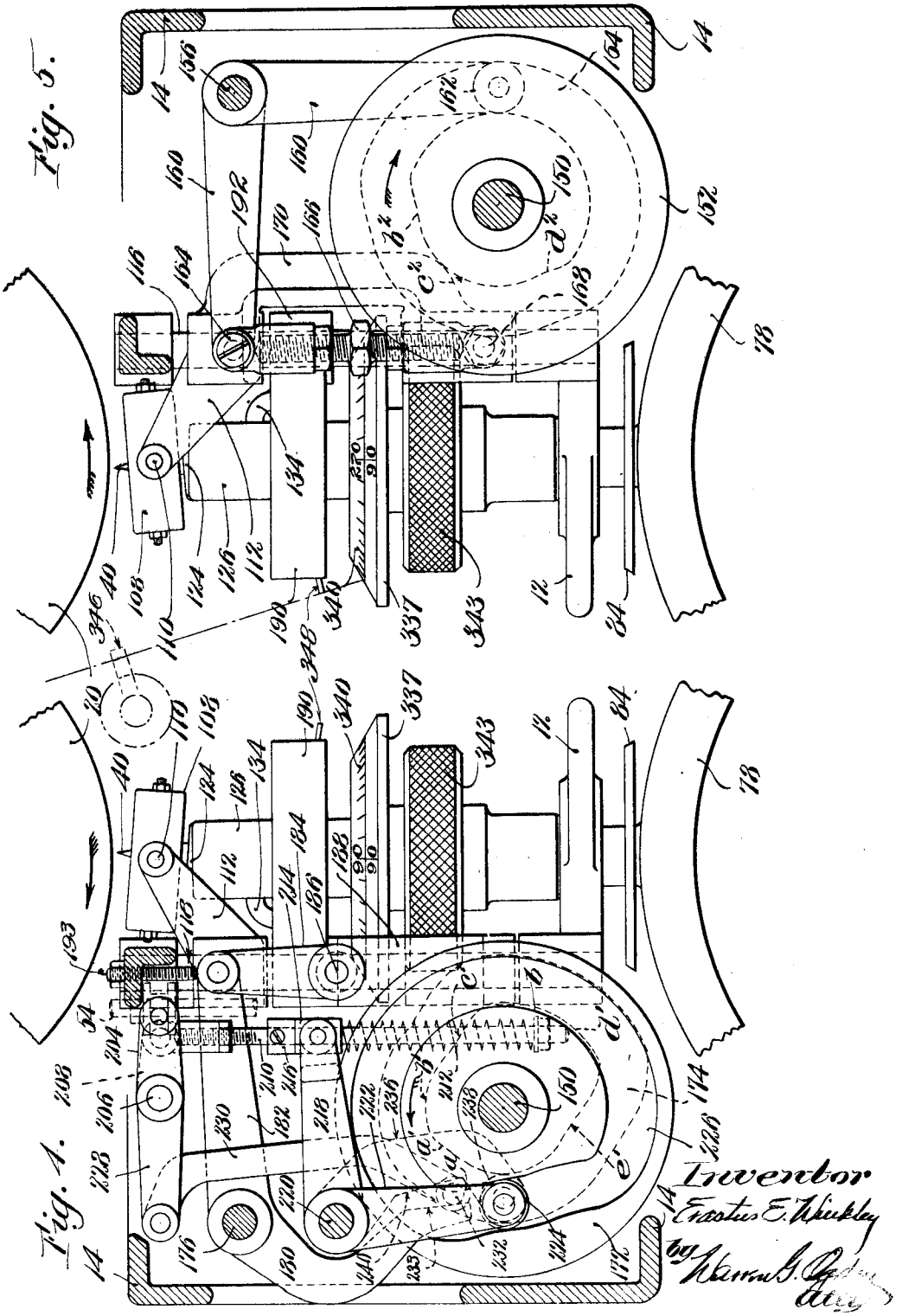


Fig. 5.

Fig. 4.

Inventor
Erastus E. Winkley
by Thomas G. Orton
Atty

Sept. 10, 1929. E. E. WINKLEY 1,727,460

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Fig. 17.

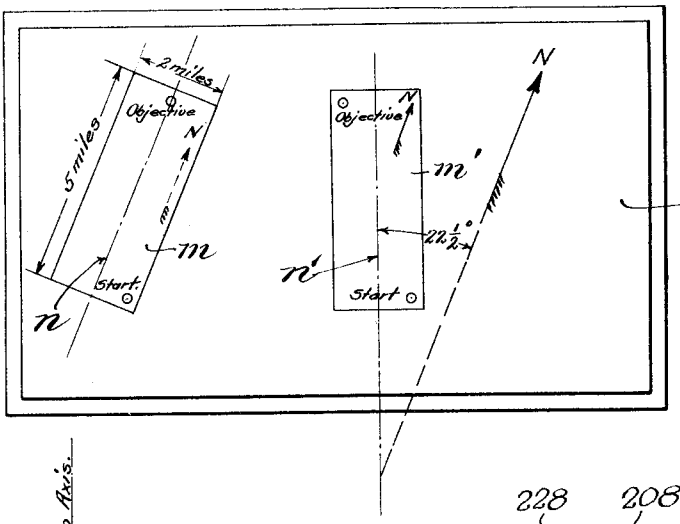
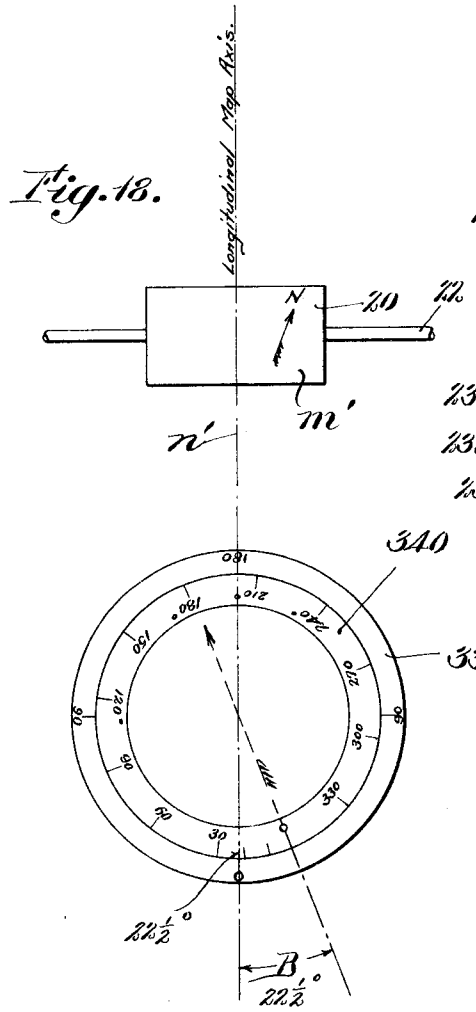


Fig. 18.



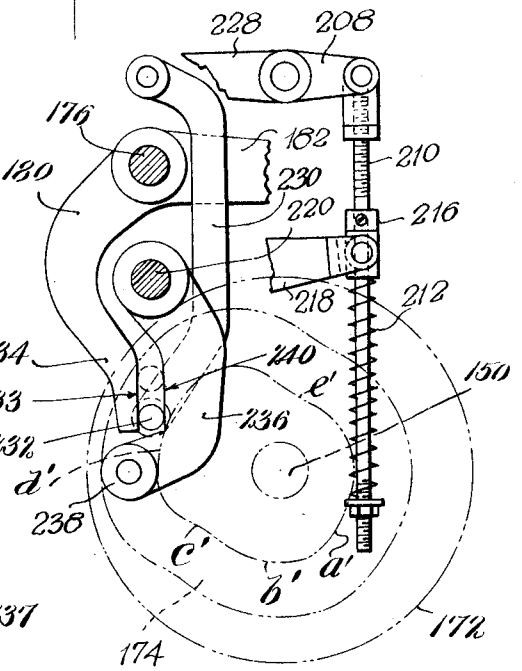


Fig. 4a

Inventor:
Eustus E. Winkley
by Warren G. Ogden
atty.

Sept. 10, 1929. E. E. WINKLEY 1,727,460

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Fig. 7.

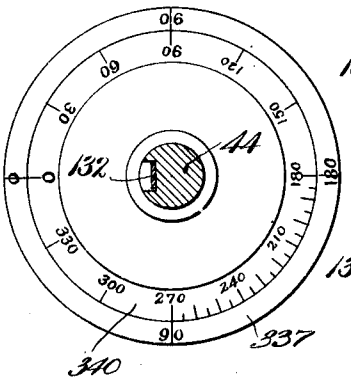


Fig. 8.

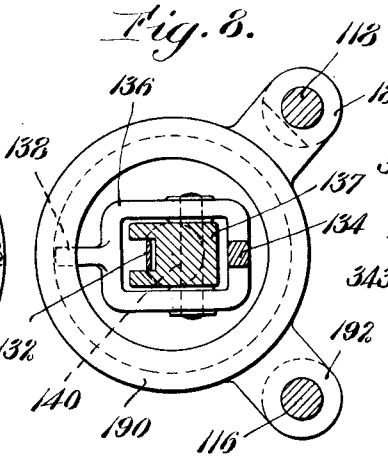
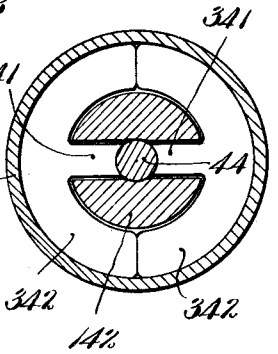


Fig. 9.



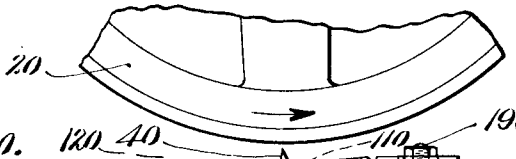
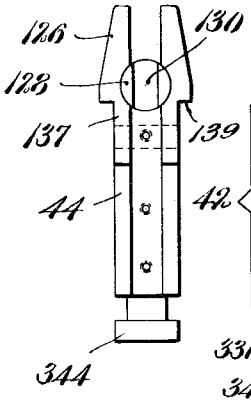


Fig. 10.



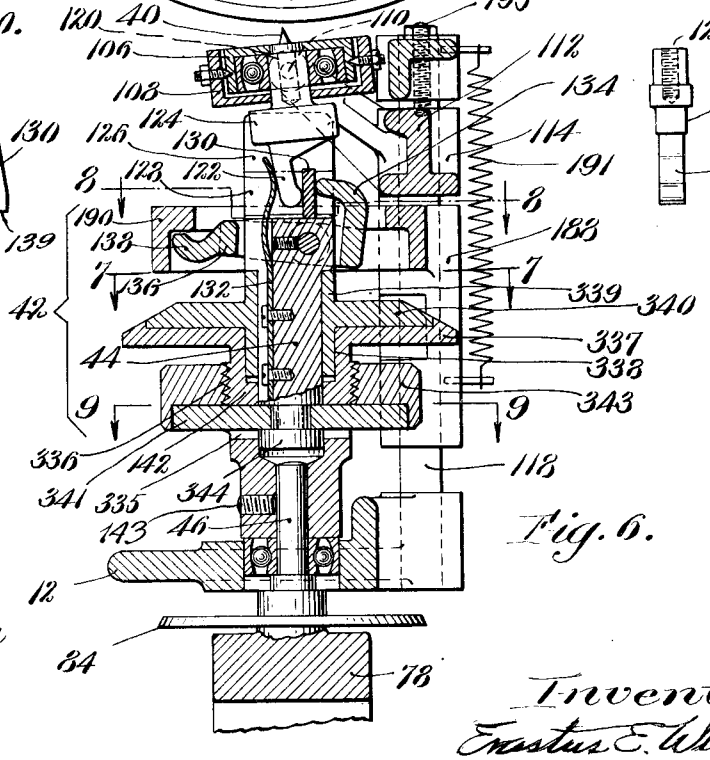


Fig. 11.

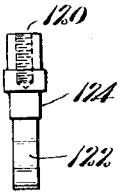
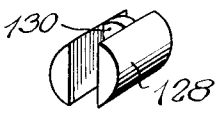


Fig. 6.

Fig. 10a



Inventor
Erastus E. Winkley
by Thurman G. Ogden
Atty.

Sept. 10, 1929. E. E. WINKLEY 1,727,460

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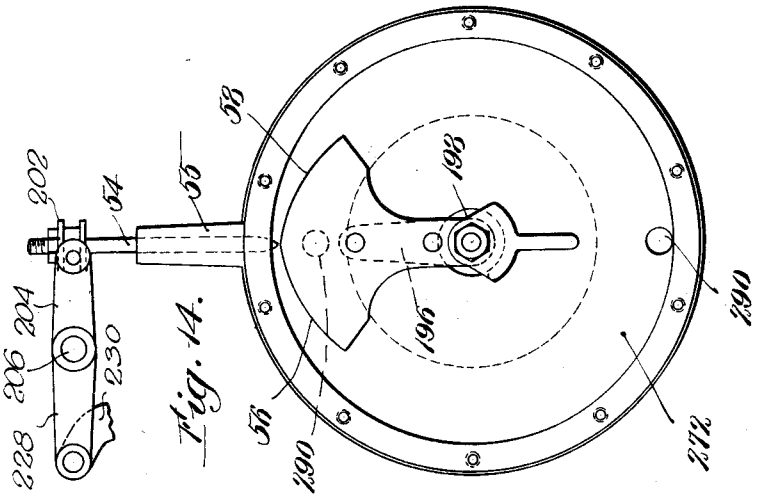


Fig. 14.

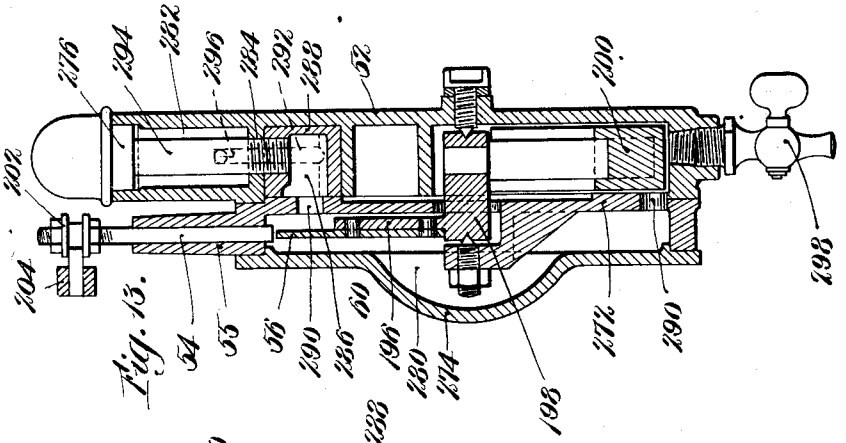


Fig. 13.

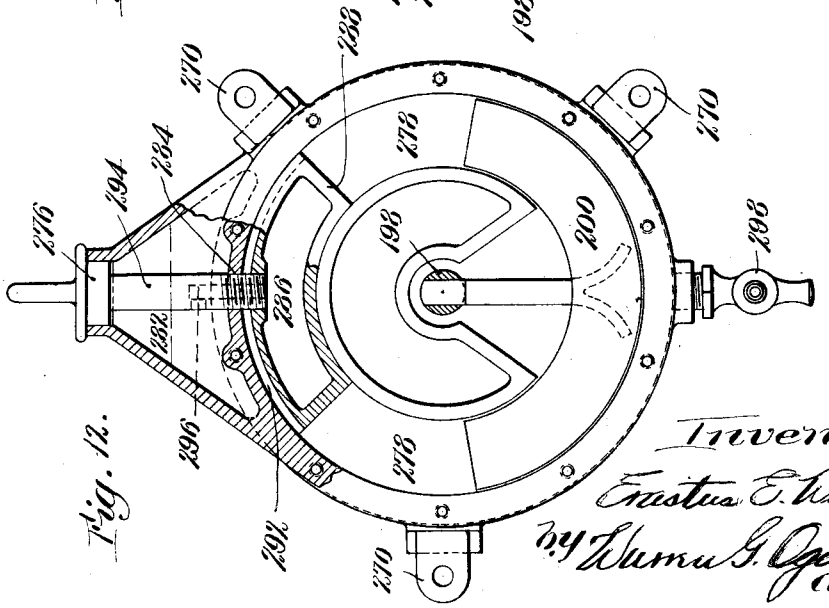


Fig. 12.

Inventor
Erastus E. Winkley
By Warren G. Ogden
Atty.

Sept. 10, 1929. E. E. WINKLEY 1,727,460

ODOGRAPH

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Fig. 15.

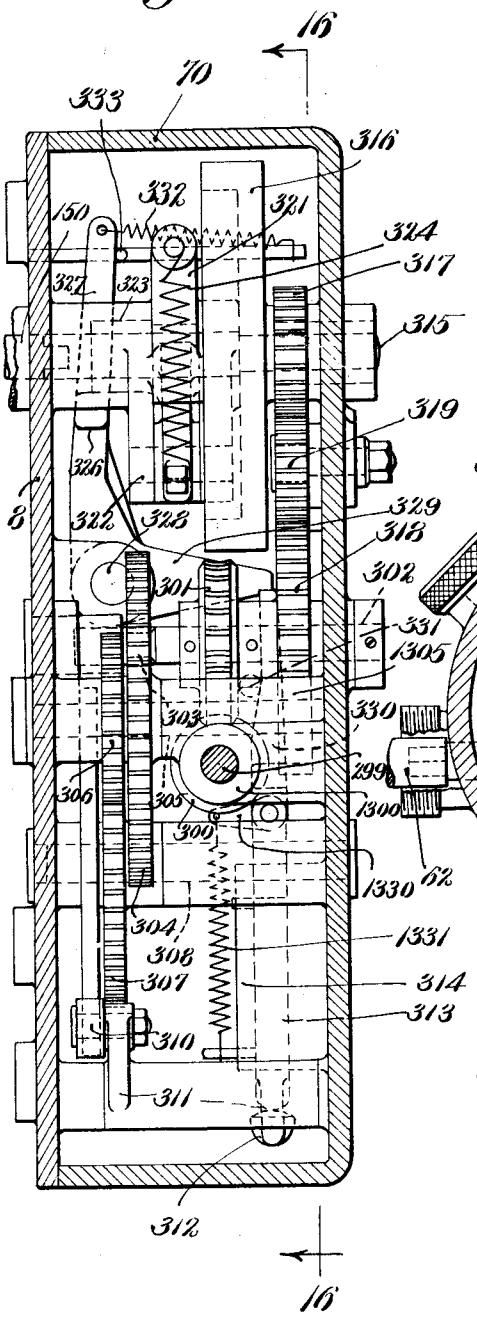
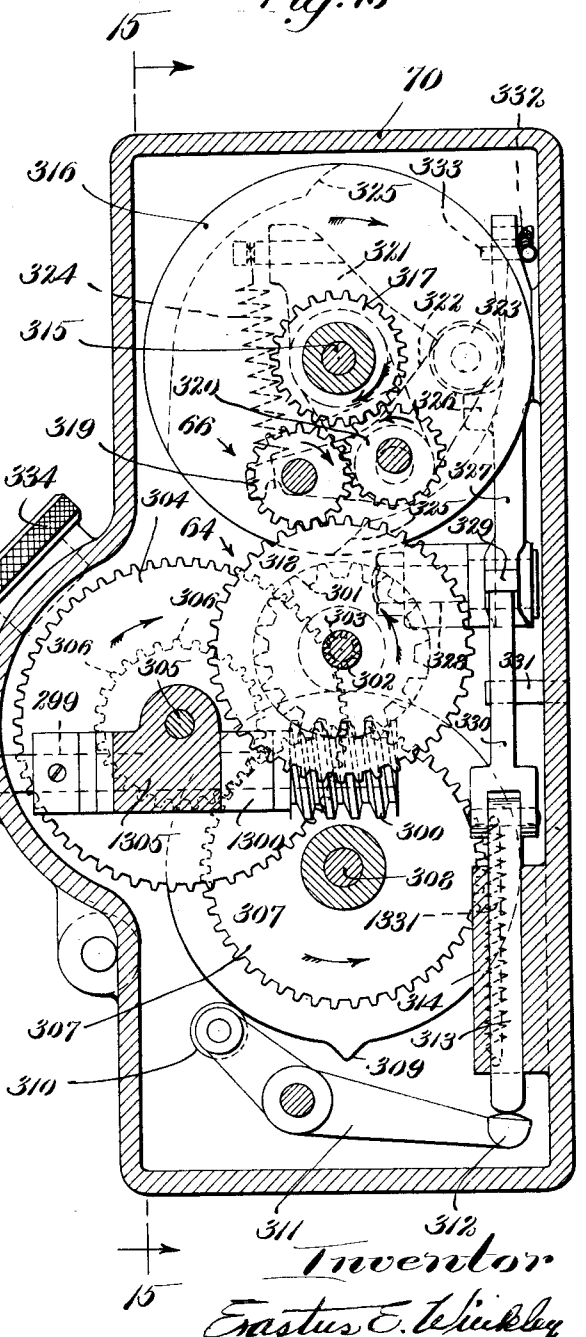


Fig. 16



Inventor

Eastus E. Winkley

by Warren G. Ogden

Atty.

Sept. 10, 1929. E. E. WINKLEY 1,727,460

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Fig. 19.

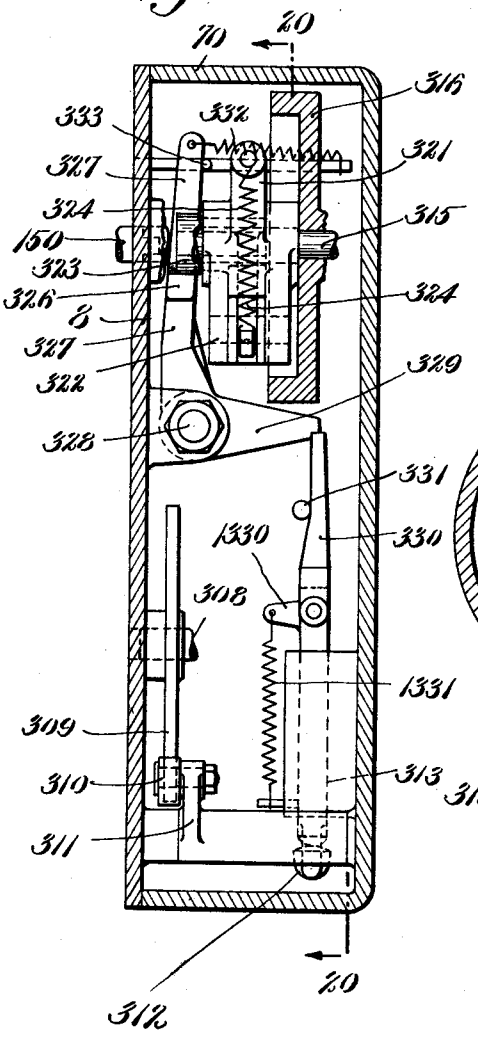
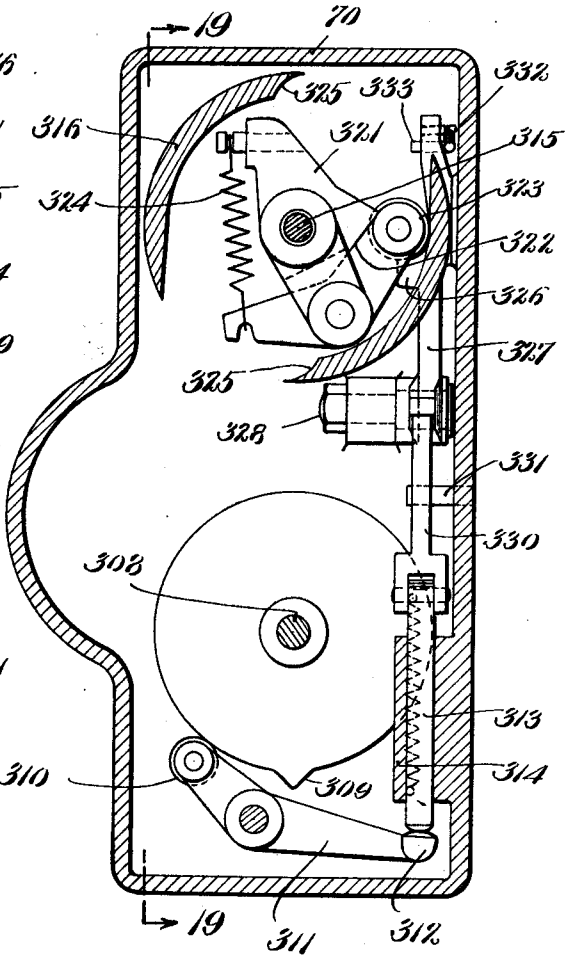


Fig. 20.



Inventor.
Everstus E. Winkley
by Herron G. Ogden
atty.

Patented Sept. 10, 1929. 1,727,460

UNITED STATES PATENT OFFICE.

ERASTUS E. WINKLEY, OF LYNN, MASSACHUSETTS.

ODOGRAPH.

Application filed June 27, 1924. Serial No. 722,673.

This invention relates to an instrument for recording, in true form and proportionate scale, the path traveled by any vehicle in which it may be installed. Because the instrument in its preferred form draws or marks the path on a record sheet, it has been named an "odograph", from the Greek "odo", the way or path, and "graph", to draw or mark.

While the instrument is susceptible of various uses, both on land and sea, it is particularly useful in plotting the paths of land vehicles which, of necessity, are forced to travel off of highways and roads and at times in darkness, for example the tanks employed for offense in military operations. For brevity of description, and without limitation on the scope of its uses, the odograph will hereinafter be described as performing its functions in an Army tank.

In time of war all roads leading to the front are heavily congested and if, in preparing for an offensive, or in bringing up reinforcements, tanks going to the front were permitted to use the roads, their slow movement would cause serious blocks and, by thus adding to the many difficulties to be overcome in any event, might cause a failure of the plans of the commander and jeopardize the lives of many troops. Accordingly it has been the custom for tanks to proceed toward the front across country, at night when near the front, finding their objective as best they may by inquiry and other available means. Some times a road will be crossed during such travel, but since the troops that may be moving on that road generally do not know where the road leads or, if they do, what part of the road they are on, much time is lost by the tank commander in locating his position before he can proceed. Oftentimes the objective is not located and when daylight comes the commander may find his tank within the enemy's lines.

Furthermore, with the development of radio communication, it is possible for the tank commander to keep his superior officer, at the rear, informed of his location, if he can determine such location himself. It is highly important after an offensive for headquarters to know, with certainty, what point the tanks have reached so that supporting troops for consolidating the position won may quickly be sent forward. It is well known that in the early days of the use of tanks in the World War hard won positions had to be abandoned because the commanders of the supporting troops could not bring themselves to believe that the tanks had actually reached the point which the message insisted had been reached. Serious and costly mistakes of this sort would have been eliminated if the tanks had been equipped with some mechanism or device, in which headquarters had confidence, for correctly determining their exact position on the terrain over which they were sent.

One object of the present invention is to provide an instrument for installation in all moving vehicles where it may be useful, that may be used, in conjunction with a map of the terrain being traversed or chart of the sea being sailed, to indicate or show at all times during the operation of the instrument the location of the vehicle on the map or chart, provided that the starting point and a directional base line are first correctly determined. The employment of such an instrument in any movable land vehicle, or ship, will enable the position of such vehicle to be indicated so that its location and direction of travel can be known and registered even though travelling in a smoke-screen, fog or darkness.

A further object of the invention is to provide an instrument which upon installation in a moving vehicle will, on driving the vehicle over a plot of country, reproduce a map of the course travelled, which may be completed by indicating thereon contours and other details of the terrain. Such a use of the instrument is valuable, for example, in making surveys or in plotting routes for travellers by motor car or otherwise.

Accordingly the invention is featured by a map carrier (it being understood that a blank sheet of paper is included in the term "map") having a scriber or style cooperating therewith for recording the location of

the vehicle on the map; means for causing a relative movement between the scriber and map in accordance with the travel of the vehicle; means which keeps a timed speed relation between the vehicle and the feed and preferably allows the feed to be operative only at predetermined intervals; means which governs the length of feed, and consequently the scribing on the map, according to whether the vehicle is travelling on level ground or on a gradient; and means which acts to maintain a base line direction relative to which the feed takes place and thus correctly records the path of travel on the map.

In the preferred form of the invention the scriber, for registering the location of the vehicle on the map, is fixed and the map is mounted on a drum which may be moved relatively to the scriber under the combined guidance and control of (1) a gyroscope which maintains the base line direction, (2) gear mechanism which keeps the timed speed relation between the rate of speed of the vehicle and the periodic movements of a feed-point which operates to move the drum a predetermined distance, i. e. one travel-unit, at each cycle or feed, and (3) an inclinometer which governs the length of feed to the extent that the delineation by the scriber on the map is in correct linear, or horizontal, distances regardless of the hills and valleys that may be traversed by the vehicle in travelling the route recorded.

To the accomplishment of these objects and such others as may hereinafter appear, as will readily be recognized by those skilled in the art from the following description, the invention comprises features and combinations of parts hereinafter described and then particularly pointed out in the appended claims.

The preferred form of the invention is illustrated in the accompanying drawings in which:

Figure 1 is a view, in front elevation, of the entire instrument;

Fig. 2 is a sectional plan view, on the line 2—2 of Fig. 3 with the casings at the two ends of the frame omitted;

Fig. 3 is a view, in side elevation, of the right-hand, or gear box end, of the instrument showing the map-drum brake-mechanism in dotted lines;

Fig. 4 is a detail view, in side elevation, of the cams and related mechanism at the left-hand end of the instrument for operating the feed-point under control of the inclinometer;

Fig. 4ª is a detail illustrating the relation of certain parts of the feed controlling mechanism at the end of a feed stroke;

Fig. 5 is a view, in side elevation, of the cam and related mechanism at the right-hand end of the instrument for imparting vertical movement of the feed-point;

Fig. 6 is a detail view, in vertical section, of the feed-point and its supporting members showing also the connection to the gyroscope;

Figs. 7, 8 and 9 are sections, in plan, taken on the lines 7—7, 8—8 and 9—9 of Fig. 6, respectively, illustrating the construction of the feed-point supporting and operating devices on those planes;

Figs. 10 and 11 illustrate details of the construction of the feed-point support;

Fig. 10ª is a view, in perspective, of the slide block a movement of which actuates the sticker point to feed the map;

Fig. 12 is a view, in side elevation, of the pendulum chamber of the inclinometer shown partly in section to illustrate interior details;

Fig. 13 is a view, in vertical section, of the inclinometer;

Fig. 14 is a view, in elevation, of the feeler cam chamber of the inclinometer with the outside cover plate removed;

Fig. 15 is a view of the mechanism within the gear box at the right-hand end of the instrument, the parts being shown as they appear on the vertical plane 15—15 of Fig. 16;

Fig. 16 is a view, in side elevation, of the mechanism shown in Fig. 15 taken on a line 16—16 of said figure;

Fig. 17 indicates a large map of country over which military operations are being conducted and the manner of obtaining the smaller map showing the particular sector to be used on the drum of the odograph and containing the starting point and objective to be reached;

Fig. 18 is a diagrammatic plan development of the map-drum having a map in place thereon, and the dial for synchronizing the direction of the path of the feed-point with the variation of north on the map from the gyroscopic base line which is illustrated as true north. In this figure the direction of the path of movement of the feed-point, in its calibrated position, is shown by an arrow, formed by dashes, on the movable scale;

Fig. 19 is a view, in elevation and partly in section, looking into the end of the gear box on the plane of line 19—19 of Fig. 20, and illustrating the intermittent mechanism controlling the feed; and

Fig. 20 is a view, in elevation, of the mechanism shown in Fig. 19, taken on the line 20—20 of Fig. 19.

In the embodiment of the invention illustrated in the drawings the instrument is yieldingly mounted by a three-point suspension on a base plate 2, as clearly illustrated in Figs. 1 and 3, the plurality of springs 4 acting to absorb the shock incidental to travel and more particularly when the instrument is installed in an Army tank. The following explanation of the invention will be confined to a use of the instrument in an Army tank, but it should distinctly be un-

derstood that such mode of presenting the invention is for convenience only, and is in no manner a limitation upon the scope of the invention which, as heretofore stated, may successfully be used in other environments and for various purposes.

The different elements of the instrument are supported on a generally U-shaped frame comprising a base 6, normally held parallel to the base plate 2 by the springs 4, and right and left sides 8 and 10. The sides are connected, substantially midway their height, by a horizontal cross-web 12, and further braced by two vertical skeleton cross-webs one, 14, at the rear and another, 16, arranged centrally.

Before describing the various mechanisms in detail the principal elements of the instrument and their relation to each other, will be described briefly. A map-drum 20 is supported above the frame for free rotational and sliding movement on a shaft 22 the ends of which are held between two upright wing-brackets 24 and 26 extending laterally from the side plates 8 and 10 respectively (Figs. 1 and 3). A scriber 30, which may be a pencil, is carried by a pring-pressed holder 32 supported on a transverse shaft 34 in front of and parallel to the map-drum axis, the ends of which are journaled in two head-brackets 36 and 38 (Figs. 1 and 3) extending forwardly and upwardly from the side plates 8 and 10 respectively being bolted thereto, as best shown by Fig. 3. Thus a rotary, a sliding, or a combined rotary and sliding movement of the drum 20 on its shaft 22 will cause the scriber to mark a path on the map that is parallel, perdendicular or oblique, respectively, to the map-axis i. e. a central circumferential line the plane of which is normal to the axis of the map-drum.

Beneath the map-drum 20, and in the vertical plane of its axis, is the feed-point 40 (Figs. 2 and 6) which periodically engages the map on the drum and moves the drum in such a manner as to cause the scriber 30 to make such a mark on the map, in direction and extent, as will always correctly locate the position of the tank on the terrain being traversed. The feed-point is always advanced to a predetermined position but the angle of its path of movement relative to the map-axis, hereinbefore defined, may be varied for a purpose later to be explained. Whatever said relative direction of the feed may be, its fixed relation to the compass-bearing is maintained, regardless of variations in the direction of travel of the tank. This is accomplished by mounting the feed-point 40 on a supporting structure, indicated generally by 42 in Fig. 6, comprising an angularly adjustable vertical shaft 44 (Fig. 10) seated in a lower bushing that is bored axially to receive and hold the upper precession-ring pintle 46 of a gyroscope 50. The upper pintle 46 is journaled in the cross-web 12 (Fig. 6) and the opposite lower pintle 48 is similarly journaled in the frame base 6, thus supporting the steering element in the lower part of the frame between the side plates 8 and 10. The base is provided with a ledge 3 (Figs. 1 and 3) for securing in place a casing (not shown) having a sight window that may be opened to place a map or remove it from the drum 20.

The instrument preferably is so mounted that it stands vertically, as shown in Figs. 1 and 3, since a vertical position makes inspection of the map more simple, but those skilled in the art will recognize that the instrument is so designed that it may be adjusted for effective and perfect operation in positions other than vertical. The scriber 32 is fixed centrally on its shaft 34, and, therefore, remains in the fore and aft vertical plane passing through the axes of the precession-ring pintles. The feed-point 40 as will presently appear, while mounted directly below the scriber may have its path of movement in said fore and aft plane or at any angle to it, according to the relation of the direction in which the tank is travelling to the constant direction of said path as maintained by the steering element, The gyroscope 50 is of a type permitting the axis of its rotor to be turned at any angle to the true north that may be found convenient or desirable and this position will then be maintained while the rotor is in operation. This is important, in the use of the odograph within a tank, because of the difficulty of obtaining outside sights by which the rotor shaft may be laid true north and south. Means is provided on the feed-point shaft 44 for calibrating the initial heading of the tank to the angle of the rotor shaft, whatever it may be.

All distances on the map are linear, or horizontal distances and hence, for a correct record of the path of travel, the ratio of the rate of feed to the scale of the map must be rectified when the tank is travelling up-hill or down-hill, the feed step being increasingly shortened as the obliquity of the gradient increases. Accordingly the feed mechanism is controlled by an inclinometer 60 (Figs. 12–14) contained within a casing 52 secured to the left-hand side frame 10 (see Fig. 1) and comprising a movable feeler 54, the upper end of which is connected to mechanism for controlling rectifications of the length of the feed step, and the lower end of which, at times, engages a pendulum controlled inclinometer cam having two surfaces 56 and 58 for up-hill and down-hill rectifications respectively.

The length of each periodic feed step of the feed-point 40 must be regulated to accord with the scale of the map upon the drum 20. Power to drive the feed mecha-

nism of the odograph may conveniently be taken from the transmission gear and transmitted through a flexible shaft 62 (Fig. 3) to the feed-cam shaft. Conveniently, although not necessarily, a train of reduction gearing is used, indicated generally by 64 (Figs. 15 and 16), which connects with mechanism 66 for driving the cam shaft from either a right or left drive from the transmission, all of which is enclosed within a gear box 70 secured to the right hand side frame 8 (see Fig. 1).

Having thus indicated generally the principal parts of the instrument and the manner in which they co-operate to cause the scriber to mark the path traversed by the vehicle, in which the instrument is installed, on a map bound on the map-drum, a detailed description of the various mechanisms will now be given.

The preferred type of gyroscope for use in the odograph is one that is perfectly balanced and provided with three degrees of freedom. It comprises a rotor, preferably electrically driven, mounted for rotation within the casing 72 which is journaled at 74 and 76 for horizontal oscillation within the periphery of the outer housing or precession-ring 78. The precession-ring, in the present instance, is vertically sustained by suitable, self-aligning bearings disposed at substantially right angles to the casing journals. The housing 78 is provided with an adjustable weight 79 (Fig. 1) to balance the whole element against precessing as the result of varying rotational forces of the earth at different latitudes.

It is obvious to those skilled in the art that since a properly balanced gyroscope maintains its position in azimuth as the result of certain actions and reactions, it is within the scope of the invention to employ any other means that would indicate a fixed or base line, by responding to similar or even different forces such as vibrations of heat, light, or electricity in its various manifestations. In its broader aspects the invention may be defined as the combination of certain forces, which will be called the "directional constant," with mechanism designed to produce in commercial form a reasonably correct record of a route or course travelled. From the foregoing it will be understood that the gyroscope is merely the preferred type of "directional constant" and that this term, and such terms as "steering gyroscope", and "steering element", are, in the present case, synonymous and broadly inclusive.

Electrical current for driving the rotor of the steering gyroscope 50 enters and departs through the binding posts 80 and 82 (Figs. 1 and 3) respectively, the circuit through the gyroscope being in accordance with commercial practice and well known. Mounted on the upper pintle 46, between the precession or gyro-ring 78 and cross-web 12, is a disk 84 (Figs. 1 and 6), and extending downward through the web is a stud within a housing 86 having a knurled head and having its lower end slabbed off for engaging the edge of the disk 84. When the parts are so engaged the gyroscope is locked from movement. Disengagement is effected by lifting the stud against the force of a coiled spring within the housing and resting a radially projecting pin on top of the housing, in a well known manner for such friction locking devices. This lock is used to hold the gyroscope steady at times when the odograph is not in use, i. e. when the gyrorotor is not running.

Before explaining the construction and operation of the feed-point 40, the mounting of the map-drum and scriber will be described. The map-drum 20 comprises a hollow cylinder having interior spiders 88 (Fig. 3) which form bearings for the drum shaft 22, and the two wing-brackets 24 and 26 provide cone bearings which frictionally hold the shaft from rotation by reason of endwise pressure from a spring pressed bunter 90 on the bracket 24 (Figs. 1 and 3). The bunter is pivoted at 92 and a spring-pressed plunger 94, housed in the bracket, bears beneath a lug on the bunter and holds it in position for supporting the shaft. A finger-hold 96 permits the bunter to be withdrawn and the map-drum to be removed from the instrument. The map, after having been prepared as hereinafter described, is wound about the circumferential surface of the drum and its ends are clamped in an axial slot by means of a filling bar 98 which is firmly held in place by positioning the wire bails 100, pivotally mounted on the spiders 88, over end shoulders on the bar. The scriber-holder 32 is secured by a set-screw (Fig. 1) at the desired angle on the shaft 34 which is provided at one end with a crank arm 102. A tension spring 104 has its ends attached to a pin on the crank arm and a pin on the bracket 36, the arrangement being such that the scriber 30 is held yieldingly against the map on the drum 20 (see Fig. 3).

The feed-point 40 is mounted at the center of the inner ring 106 of a common gimbal-ring construction (see Fig. 6), the outer ring 108 being supported by bearings in the form of points 110 carried by a U-shaped frame 112 (Fig. 2) provided with rear bushings 114 slidable upon two upright posts 116 and 118 the ends of which are fixed in upper and lower sleeves at the rear edge of the cross-web 12. The feed-point holder 120 is of the form shown in Figs. 6 and 11 having a threaded socket to receive the point, a tail 122 and an intermediate, smooth-sided block 124. The purpose of threading the feed-point 40 into the socket formed for its recep-

tion in the head of the feed-point holder 120 is to permit an adjustment of the feed-point relative to its axis of oscillation on the bearings 110 of the gimbal-ring, and thus to vary the length of the feed-step to accord with any given conditions. The block is received within the forked, upper end 126 of the vertical shaft 44, and the tail depends in a vertical slot formed at the forward end of a horizontally movable, cylindrical feed-slide 128 seated in a bore at the lower end of the fork 126. The tail is pressed against the forward face of a partition 130 in said slot, by a flat spring 132 secured in an axial groove in the shaft 44, and bearing against the rear face of said partition is the vertical hook 134 of a feed arm for actuating the feed-point 40. The feed-arm is in the form of a yoke 136, encircling a squared portion 137 of the shaft 44 (see Fig. 8), which carries a forward, horizontal hook 138. A short horizontal pin 140 is secured by a set screw in the squared portion 137 and the yoke arms are journaled on its projecting ends for rocking movement thereon. In Fig. 6 the feed-point is shown in position to begin its advance and it will be observed that any movement of the feed hook 134 to the left is immediately effective to tip the gimbal-ring and effect the feed. For the present it will be understood that the position of the feed hook may be maintained by a pair of shoulders 139 on the shaft 44 against which the arms of the yoke 136 are held by the flat spring 132. Without going into the detail of the construction at this time, it will be understood that the shaft 44, while angularly adjustable as hereinafter explained, is in fixed vertical position by being clamped at its lower end within a central bore of the stand 142, forming the main supporting element of the feed-point supporting structure indicated generally by 42. The stand 142 is secured at its lower end to the upper gyro-ring pintle 46 by means of a set screw 143 (see Fig. 6).

The feed point 40 has a quadrangular four-motion path; first, up, while standing at an angle to the vertical as shown in Fig. 6; second, to the rear, about the gimbal-ring pivots as a center, until its axis is in vertical alignment with the vertical gyro-axis; third, down, and moving at this time in a path in extension of the vertical gyro-axis; and fourth, angularly forward, to its initial position as illustrated. It will be understood that it is within the scope of the invention to vary the quadrangular motion of the feed-point from that just described, for example the feed-point may advantageously enter the map while moving radially toward the drum and end its feed in an oblique position. Before describing the means for tipping the yoke 136 in a direction to advance the feed-point, the means will be described for raising the feed-point to pierce the map and then lowering it after the feed has been completed, since the construction of the feed-point support, just described, has a direct relation to this vertical travel of the feed-point. Journaled in the side plates, at the rear of the posts 116 and 118, is a transverse cam-shaft 150 which passes through the side plate 8 and projects into the gear box 70. The intermediate mechanism between the flexible driving shaft 62 and the cam shaft 150 will be described in detail later, it being of moment now only to know that the cam shaft is timed to impart a feed-step to the feed-point 40 at predetermined intervals in accordance with the ratio of the length of feed step to the scale of the map on the drum. At the right of the cam shaft (Figs. 2 and 5) is found a cam disk 152, having at its inner face a cam path 154 for raising and lowering the feed-point which will be called, for convenience the "lifting cam". A short shaft 156 is fixed at its ends, in the side plate 8 and an interior bearing 158, in position above and to the rear of the cam shaft. Journaled on the fixed shaft 156 is a bell-crank 160 having a vertical arm carrying a roll 162 engaged by the lifting cam and a horizontal arm pivoted at 164, by its forward end, to the upper end of an adjustable link 166, the lower end of which is, in turn, pivoted at 168 to the lower bearing sleeve of a yoke member 170 depending from the frame 112 which supports the gimbal-ring. The link 166 is provided with a turn-buckle by means of which the link may be made longer or shorter as may be required to compensate for the vertical position of the feed-point within the holder. The lower bearing sleeve of the yoke 170 slides on the post 116 (see Fig. 2). The lifting cam raises and lowers the frame 112 on the upright posts and consequently the gimbal-ring and its feed-point 40. The block 124 of the feed-point holder slides, at such times, within the forked end 126 of shaft 44 (Fig. 6) and the partition 130 of feed-slide 128 is so proportioned that contact of the tail 122 therewith is never lost.

The feed stroke of the feed point 40 may conveniently be fixed at about one thirty-second of an inch, this equalling, on the usual scale of war maps, a unit of measure of fifty-five feet linear distance on the map. The unit of measure is, obviously, a matter of choice. The means by which the gimbal-ring is tipped about its bearings 110 in the frame 112 to swing the feed-point through one thirty-second of an inch arc will now be described. Any movement to the left, in Fig. 6, of the feed hook 134 will cause the feed-point holder to tilt within the fork 126, and when the pressure is relieved the spring 132 will return the feed-point to its starting point i. e. to the position illustrated

in Figs. 4 and 6. The hook 134 is actuated to make a feed stroke by tilting the feed arm 136 on its pivot 140 through pressure on the forward hook 138. To this end the cam shaft is provided with a cam disk 172 adjacent the side plate 10 (see Fig. 2), having at its inner face a cam path 174 which will be called, for convenience, the "feed cam". A short shaft 176 is fixed at its ends in the side plate 10 and an interior bearing 178 (Fig. 2), in position above and to the rear of the cam shaft. Journaled on the fixed shaft 176 is a bell-crank having a vertical arm 180 and a horizontal arm 182 (Fig. 4). Pivoted to the forward end of the arm 182 is a link 184 which depends and is pivoted also at 186 to a long sleeve 188 mounted to slide on the vertical post 118. This sleeve 188 is also shown in Figs. 6 and 8 and it carries an annulus 190 having a cross-section (see Fig. 6) which provides a shelf or shoulder above the forward hook 138 of the feed arm 136 so that on depressing the ring 190 the feed hook 134 is moved in a direction to effect a feed stroke of the feed-point 40. The purpose of making this actuator in the form of a ring will appear later. The ring 190 is steadied in its vertical movement by having a bearing formed by a sleeve 192, on the vertical post 116. The ring 190 is held in a position of clearance above the forward hook 138 of the feed arm (see Fig. 6) by a coiled spring 191 connected at one end to the upper cross beam which supports the vertical posts and at its other to the long bearing-sleeve 188. The amount of this clearance is determined by a stop screw 193, threaded through said cross beam, against the lower end of which the lever 182 is held by the spring 191. The importance of maintaining this clearance will appear later.

The feed cam 174 is so designed that if the vertical arm 180 of the bell-crank were provided with a roll to be engaged by the cam, the actuator ring 190 would periodically be depressed after each upward movement of the feed-point 40 due to the operation of the lifting cam 154, and the full throw of the cam would be transmitted to the feed-point after it had engaged the map. Since distances on the map are horizontal or linear distances it is requisite, in order to preserve the true relation of the path marked on the map to the actual position of the tank on the terrain traversed, to shorten the feed step when the tank is travelling up-hill or down-hill, the length being proportionately reduced according to the degree of the grade. Mechanism is therefore provided, co-operating with the bell-crank arm 180, to impart to it a slight movement, prior to the engagement of the map by the feed-point, proportionate to the degree that the odograph is tilted from the vertical when the floor of the tank in which the odograph is installed assumes an oblique position due to traversing a gradient. This advances the starting position of the feed-point to a varying degree, but does not alter the point at which each stroke finishes. Such compensating mechanism will now be described.

The control of the length of the feed-step, just referred to, is exercised by the inclinometer 60 (Figs. 12, 13 and 14). An important member of the inclinometer is the double cam surface 56—58 which is secured to a support 196 rising from a shaft 198 suitably journaled on delicate bearing points in the inclinometer casing 52. Depending from the shaft is a pendulum weight 200. Since the shaft 198 is a transverse shaft, parallel to the drum shaft 22 and cam-shaft 150, the pendulum weight acts to retain the double cam 56—58 vertical no matter what the fore-and-aft obliquity of the tank may be. The feeler 54 is housed in a vertical sleeve 55 through which it is moved to bear on the surface of the inclinometer cam (see Figs. 13 and 14). An adjustable spool 202, threaded on its upper end, is engaged by a horizontal pin projecting from the free end of a crank arm 204 fixed on the outer end of a horizontal rock-shaft 206 journaled in the side frame 10 and the interior bracket 178 (see Fig. 2). A second crank arm 208 is fixed on the rock-shaft, from the end of which depends a housing which receives the upper threaded end of a rod 210 (Fig. 4). This rod is provided with a fixed washer at its lower end for supporting a coiled spring 212 which, in turn, supports a sleeve 214 loose on the rod. Above the sleeve the rod 210 carries a fixed collar 216 forming an abutment for the sleeve 214. The sleeve is carried by the forked forward end of the horizontal arm 218 of a bell-crank pivoted on a shaft 220 (Fig. 4), below the shaft 176 and similarly mounted. The vertical arm 222 of the bell-crank carries a roll 224 at its lower end which is engaged by a cam path 226 formed in the outer face of the cam disk 172. The vertical position of the collar 216 is such that this cam path, through the connections just described, normally maintains the feeler 54 in a position of clearance relative to the center of the inclinometer cam 56—58 at all times. This cam will be termed, for convenience, the "feeler cam." If the tank is travelling on level ground the feeler will be in central position, as shown by Fig. 14, and the downward movement of the bell-crank arm 218 will merely cause the feeler to engage the cam and then compress the spring 212, but if the tank is tilted, fore-and-aft, then the first part of the throw of the feeler cam will act to lower the feeler until it contacts with one or the other of the cam surfaces 56 or 58 which is then beneath it. Such a movement of the

feeler carries the crank arm 208 downward with the following result.

Extending rearwardly from the hub 209, of the crank arm 208, is a lever arm 228 to the rear end of which is pivoted a depending link 230 having a roll 232 at its lower end which lies in front of a plane surface 233 at the forward side of a shoe 234 which forms the terminal portion of the vertical bell-crank arm 180. Thus as the lever 228 is raised, by a lowering of the feeler 54, the roll 232 rides up the shoe 234, and vice versa. Pivoted on the shaft 220 is a depending lever 236 (see Figs. 4 and 4a) having a roll 238 at its lower end which is engaged by the feed cam 174. This lever 236 lies in the vertical plane of the bell-crank arm 180 and is provided with a plane surface 240 opposite the shoe 234. When the feed cam throws the lever 236 to the left, Fig. 4, it transmits its movement in varying degree to the bell-crank arm 180 through the interposed roll 232 whatever may be the vertical position of this roll on the shoe 234 due to the elevation or depression of the inclinometer feeler 54.

A brake is employed to hold the map-drum from movement during the time that it is not under control of the feed-point 40 and this brake mechanism will be explained before detailing the movements of the mechanisms just described in making a feed-step. The brake comprises two shoes 242 (Figs. 1 and 2) at the ends of arms extending rearwardly from a brake frame 244 carried by a sleeve fixed on a transverse shaft 246 that is journaled in the forward brackets 36 and 38 somewhat below the scriber shaft 34. The shaft 246 carries a second sleeve, at its right-hand end, from which depends an arm 248 pivotally connected to the forward end of a yielding link 250, the rear end of which is pivotally connected to a cam lever 252 between its fulcrum pin 156 in the frame and its cam roll 254 at its lower end (see Fig. 3). The roll 254 is engaged by a cam path 256 formed in the outer surface of the cam disk 152. The brake cam 256 is designed to periodically draw the link 250 to the rear and, by thus rocking the shaft 246 in a counter-clockwise direction, raise the brake shoes 242 into contact with the map on the drum 20. The yielding link 250 is of common construction as clearly illustrated in Fig. 3. After the brake shoes have been seated any excess throw of the cam is taken up by the sleeve 258 sliding rearwardly on the rod 260 and compressing the spring 262 coiled thereon. The spring is confined in place by a nut 264 on the rear end of rod 260 having a flat side bearing on the under face of the link 250. The length of the link, to vary the brake pressure, may be adjusted by any usual connection for this purpose, shown at 264.

A hand lever 266 extends upwardly from the sleeve from which the arm 248 depends, and by pressing this lever inward the brake may be held released during adjustment of the map-drum on its shaft. The act of withdrawing the scriber 30 automatically releases the brake, and holds it released until the scriber is returned to its operating position, due to the provision of a cam 268, fixed on the scriber shaft just in front of the hand lever 266, which engages said lever and moves it clockwise when the scriber holder 32 is moved counter-clockwise. This automatic release of the brake is employed when it is desired to remove the map-drum from the instrument.

Having explained the mechanisms for imparting to the feed-point its four-motion travel and for holding the map drum in position during the periods between each feed stroke, the sequence of operation of these parts will now be described during the advance of the map through one feed-step.

It will be assumed that the feed-point 40 is in its lower position, disengaged from the map, and at the beginning of its feed stroke, as illustrated in Figs. 4, 5 and 6. Rotation of the cam shaft 150 in the direction of the arrows, from the position shown in these figures, will first cause the feeler cam 226 to move the cam roll 224 to the left, in Fig. 4, by reason of the engagement therewith of the cam-rise *a* shown just above the roll 224 in that figure. This turns the bell-crank arm 218 in a clockwise direction and, assuming that the tank is travelling on level ground with the feeler 54 at mid-point above its cam 56—58, the downward movement imparted to the arm 208 will close this feeler clearance, the coiled spring 212 absorbing the excess of cam throw in this position of the feeler or in any other position due to fore and aft tip of the tank. No movement of consequence being imparted to the arm 208, consequently the arm 228 and depending link 230 remain in substantially the positions shown in Fig. 4, with the roll 232 still at the lower end of the shoe 234. While the feeler cam is rotating through the angle just described the feed cam 174 also is being rotated and after the feeler clearance has been closed the slight cam-rise a^1 becomes effective to move the cam roll 238 to the left, in Fig. 4, and impart a slight movement in a clockwise direction to the bell-crank arm 180 by pressure thereon through the roll 232. The purpose of this is to close down all clearance and looseness through the parts, particularly between the parts 138 and 190 (Fig. 6) when all back-lash to the feed-point is taken up. It is thus apparent that absolute accuracy of every feed step is secured. The subsequent travel of the roll 224 in the feeler cam, after passing cam rise *a*, is through a dwell *b* of

sufficient length to maintain the outward position now assumed by the roll 232 during the following operations.

After the clearances have been closed there is a short dwell b^1 on the feed cam and while the roll 238 is traversing this sector the roll 162 of the lifting cam 154 has reached the cam fall b^2 which moves this roll to the left, in Fig. 5, throws the bell-crank lever arm 160 upward and thus raises the gimbal-ring frame 112 which causes the feed-point 40 to enter the map on the drum 20. The release of the brake shoes 242 by a fall of cam 256 immediately follows. The cam rise c^1 of the feed cam is now traversed by the roll 238 thus continuing the movement of the lever arm 236 to the left, in Fig. 4, and through movement of the bell-crank 180—182 depresses the feed arm actuator-ring 190 which, it will be remembered, is now in contact with the feed arm hook 138. During this time the feed-point is held in the map by a dwell c^2 of the lifting cam 154. The depression of the actuator-ring 190 turns the forward end of the feed arm 136 downward and causes its feed hook 134 to move to the left, in Fig. 6, which forces the slide 128 to the left and consequently tilts the feed-point holder toward the rear within the forked end 126 of the shaft 44 and rotates the map drum in the direction of the arrow shown on the drum in Fig. 6. At the completion of the feed stroke the lifting cam roll encounters the cam rise d^2 which moves the cam roll 162 to the right, in Fig. 5, and effects a disengagement of the feed-point from the map. The feed cam roll 238 is simultaneously travelling the dwell d^1 of its cam, but upon the feed-point becoming disengaged the roll 238 encounters a cam fall e^1 which causes the roll to return to its position as shown in Fig. 4, the bell-crank 180—182 being rotated in a counter-clockwise direction at this time. The spring 191 causes the bell-crank arm 180 to follow the movement of the lever 236 to the left and finally lifts the actuator ring 190 clear of the feed hook 138. Almost simultaneously with this last operation the cam fall in feeler cam 226 restores the feeler mechanism to a position of clearance relative to the inclinometer cam. This constitutes one cam cycle.

The brake cam 256 is so designed that before the feed-point 40 is withdrawn from the map by the rise d^2 of the lifting cam 154 on completion of the feed stroke, its roll 254 is moved to the right in Fig. 3, which causes the brake shoes to rise and yieldingly engage the map to hold the drum from movement until it is again under control of the feed-point. During the brief period that the feed-point is operating, the brake shoes are held in inoperative position by a short dwell c^3 of the brake cam 256, but during the greater part of the cycle the brake is on by reason of the travel of cam roll 254 through the long dwell d^3.

If the tank is travelling on a grade, for example up-hill, then the entire instrument will be tilted backward relative to the inclinometer cam, and the feeler 54 will be brought to a position above the curved portion 56 of the cam. Consequently when the cam rise a of the feeler cam 226 engages the roll 238 the downward movement of the bell-crank arm 218 will continue to lower the feeler until it engages, or feels, the portion of the cam 56 just below it, and after such engagement has been effected the excess throw of the cam will be absorbed by the coil spring 212 as before. This downward movement of the feeler 54 causes a similar downward movement of the crank arm 208 and a consequent upward movement of the link 230. The roll 232 is, therefore, caused to travel up the shoe 234, the amount of such movement being dependent upon the inclination of the tank, i. e. the degree, or per cent of the grade up which the tank is travelling.

It will be observed, see Fig. 4, that the plane surface 240 of the cam lever 236 extends at an angle to the opposed plane surface 233 of the shoe 234 before the feed stroke is started. The diameter of the roll 232 is less than the distance between these two surfaces at the lower ends thereof, therefore, as the roll is drawn upward on the shoe 234 under control of the inclinometer it fits more and more snugly into the intervening space, but never exactly. Since the throw of the cam rise a^1 of the feed cam 174 is constant the resulting effect of this construction is to cause the vertical bell-crank arm 180 to be moved further and further to the left, in Fig. 4, during the time of closing the clearances, dependent upon the vertical position of the roll 232 between the surfaces 233 and 240. In any position of the roll 232 the first portion of the throw from the cam rise a^1 is ineffective to move the bell crank arm 180 because this portion of the cam rise merely closes the clearance between the surfaces 233 and 240. The complete throw will close all clearances to the feed-point as hereinbefore referred to. As the roll 232 is raised on the shoe 234 this clearance between the surfaces 233 and 240 becomes less and less and the cam rise a^1 becomes increasingly effective to move the bell-crank arm 180. The obliquity of the angle at which the plane surface 240 lies with relation to the surface of the shoe 234 is so proportioned, with relation to the upward movement imparted to the roll 232 by variations in the position of the feeler 54 as it feels different portions of its cam 56—58, that this preliminary movement of the bell-crank arm 180 shortens the feed stroke in the exact percentage required for delineating on the map an air-line distance

when the actual travel or rolling contact on the ground is a greater distance. With this construction the shortening of the feed stroke is always by altering its starting point, and the timing is such that the feed-point is turned through the small angle required to effect this compensation before the lifting cam 154 operates to cause an engagement of the feed point with the map. The completion, or finish point, of the stroke of the feed-point is always the same; Fig. 4ª illustrates the position of the parts at the completion of a feed stroke. It will be observed that, due to the different centers about which the levers 180 and 236 move, the two surfaces 233 and 240 are parallel when the cam roll 238 enters the dwell d^2 of the feed cam and, therefore, each feed stroke, no matter what its length has been, ends at the same point with the roll 232 confined between the two levers.

Returning now to the inclinometer 60, its casing 52 is provided with lugs 270 by which it is removably secured to the side frame 10, the loose pin and spool connection 202—204 being so made for this purpose. The casing 52 may be opened from its inner side. This opening is closed by an inner plate 272 (Figs. 13 and 14) which has formed thereon the feeler housing 55 and one bearing of the pendulum fulcrum 198. Outside the plate 272 is the cover plate 274, the whole being secured together by a peripheral series of screws, as shown, forming fluid tight joints. In order to damp the oscillations of the pendulum, although still allowing action of reasonable alacrity when the casing is tilted, the casing is filled with a fluid which should be noncongealing, for example kerosene. The fluid is introduced through an opening at the top of the casing, a closure 276 being first removed. The fluid fills the pendulum chamber 278, the feeler cam chamber 280 and the expansion chamber 282 to the level shown by the dash line. In filling, the fluid is poured through a filling port 284, which is opened when the cap 276 is removed, into a chamber 286 within a casting 288 seated in the upper sector of the pendulum chamber, and then fills all the open spaces within the casing by flowing through the ports 290 in the inner plate 272. At the upper side of the casting 288 a groove 292 is cut that forms a bleeder passage for the escape of air during the filling operation. When the cap 276 is replaced, after filling, the stem 294 thereof screws into the filling port 284 and closes communication between the bleeder passage and the expansion chamber 282. The stem is provided with a central port 296 forming a communicating passage between the pendulum and expansion chambers. The pendulum weight 200 is of slightly less cross-sectional area than that of its chamber 278 thus providing by-passes for the fluid to flow from one side to the other of the weight whenever a tilting of the odograph requires such exchange. As the liquid escapes by the sides of the pendulum to the opposite chamber, the action of the pendulum is damped not only by the restricted area through which the liquid escapes but also by the skin friction of the liquid travelling past the pendulum, thereby producing great sensitiveness to the steady pull of gravity and great resistance to all forces tending to set up oscillations. A cock 298 is tapped into the casing at its lowest point to facilitate drawing off the contained fluid when necessary.

A well known peculiarity of balanced gyroscopes is that a change in their position is effected more easily by a steady, sustained pressure than by a sharp, quick blow, in fact the latter is substantially ineffective to alter the gyroscope's position. An important feature of the present invention resides in unfailingly maintaining the gyroscope in its set position since otherwise the fundamental base line direction, to which the compass bearings and selected direction of feed are referred, would be lost, and the scriber would trace an untrue course on the map. In order to prevent a sustained drag on the gyroscope from the operation of the feed-point the cam shaft 150 is operated intermittently, driving quickly through one revolution and then remaining at rest until the tank has traveled substantially the whole of the unit distance to be measured and marked on the map at each feed-step of the feed-point. In this way the resistance offered by the successive feeds is transmitted to the gyroscope as a succession of sharp blows and any tendency of the feed to alter the original base-line direction is thus overcome. The mechanism for accomplishing this, although not essential, is mounted within the gear box 70 and will now be explained.

The flexible drive 62 couples into a fore-and-aft shaft 299, journaled in a sleeve 1300, and provided with a worm 300 at its rear end (Figs. 15 and 16) which drives the reduction gearing 64. This gearing comprises a worm-wheel 301 on a cross shaft 302 journaled in a bearing carried by the outer casing wall; a small pinion 303 on the inner end of shaft 302; a large gear 304 on a stub shaft 305 journaled in a bearing 1305 which extends between the gear box walls and supports the sleeve 1300, meshing with the pinion 303; a smaller gear 306 outside the gear 304; and a large gear 307 carried on a lower cross shaft 308 journaled in the two gear box walls, meshing with the gear 306. The shaft 308 also carries a disk provided with a tappet cam 309 (Fig. 20) which periodically (as herein designed ninety-six times for each mile traveled by the tank) engages and depresses

a roll 310 at the forward end of a centrally pivoted lever 311 the rear end of which provides a bunter 312 for engaging and lifting a rod 313 guided vertically in a housing 314 on the rear wall of the gear box.

Before describing the effect of lifting the rod 313, it will be explained that the cam shaft 150 is coupled to a shaft 315 (Figs. 19 and 20) in axial alignment therewith, and journaled in a bearing at the upper end of the gear box 70. This shaft 315 carries a sleeve on which is mounted the loose member 316 of a one revolution clutch and a connected gear 317 (Fig. 16) which may mesh directly with a gear 318 on the worm-wheel shaft 302, thus constantly rotating the clutch member 316 while the tank is moving. For convenience in driving from either a right or a left transmission two intermediate gears 319 and 320 are adjustably mounted on the outer casing wall (see Figs. 3 and 16) in such manner that the gear 320 may be disconnected at will and the gear 319 enmeshed with both gears 317 and 318. The fast member of the clutch is keyed to the shaft 315 and comprises a frame 321 (Figs. 19 and 20) having a lever 322 pivoted thereon which carries a roll 323 at one end. The roll 323 is normally held by a spring 324 in position to be engaged by one or the other of two coupling shoulders 325 in which event the shaft 315 is driven, but when the roll engages a shelf 326 on the vertical arm 327 of a bell-crank pivoted at 328 on the casing (see Fig. 19) it is held inside the path of movement of the coupling shoulders 325 and rotation of the shaft 315 ceases.

Returning now to the bunter rod 313, its upward movement lifts the horizontal arm 329 of the bell-crank pivoted at 328 thus tipping the vertical arm 327 to the left, in Fig. 19, and permitting the spring 324 to throw the roll 323 into the path of the rotating coupling shoulders. The bell-crank is immediately restored to its position shown in Fig. 19 by reason of the upper pivotally connected end 330 of the bunter rod being cammed off the bell-crank by a fixed pin 331 and the tension of a coiled spring 332 which draws the vertical arm forward against a stop 333. The roll 323 engages the upper end of the arm 327 after one revolution of the shaft and is cammed thereby into position to seat against the shelf 326, stopping rotation of the shaft 315. To prevent rebound, due to inertia of the parts, the cam shaft 150 is driven against the continual pressure of a friction brake 151 (Fig. 1) pivoted on a pin 153 and held in contact with the peripheral surface of cam disk 152 by a suitably connected torsion spring 155.

It will be observed from the relative positions of the parts in Figs. 16 and 20 that a complete revolution of shaft 315 takes place during the travel of the tappet cam 309 through a very small arc so that the mechanism insures a quick, periodic feed stroke by the feed-point 40, the cam shaft 150 being idle during substantially all of the linear travel of the tank that is transcribed on the map by the scriber 30 when the drum finally is moved by the feed-point.

The gear casing 70 is provided with a filling opening 334 through which oil is introduced to maintain the gearing in an oil bath, the level of the oil being just below the shaft 299 which couples to the flexible drive 62. The pivoted end 330 of the bunter has a horizontal arm 1330 (Fig. 19) normally held in the position shown by a spring 1331 and this spring lowers the bunter and restores the part 330 to a position beneath the bell-crank for successive upward movements to throw in the cam shaft clutch.

The map drum 20, as the illustrated odograph is designed, mounts a small map representing a terrain about two miles in width by five miles in length on the usual scale of war maps. This map, having an area of ten square miles which is deemed sufficient by army strategists for the field of operation, may be obtained by removing or tracing a small map of this approximate area from a larger war map. Examples of how this is done will now be explained.

Referring to Fig. 17 it is preferable, for reasons which presently will appear, to remove or trace from the large map M a portion m which while including the starting point and objective, lies with its longitudinal axis n parallel to "north" on the map M. If the starting point and objective are so located relatively to each other that this relation of the map axis and "north" cannot be obtained, as for example in the case of the small map m^1, then the angle by which the map axis n^1 deviates from "north" on the map M must be measured and compensated for when such a small map as m^1 is mounted on the map drum.

It is obvious if map m is wound evenly on the map drum, the dial 340 is set to zero as in Figs. 6 and 7, and the tank is then pointed true north, that so long as the tank travels north the path of the feed-point will be in a north and south plane and the scriber will mark a path parallel to the map axis at each feed step, as is correct. The odograph may be located in any position but always with the map drum shaft lying crosswise of the tank. Should the direction of advance be altered to north-east then the instrument turns with the tank about the gyroscope which maintains its fixed north and south base-line direction. The next feed step of the feed-point, which still is held in its north and south plane through control by the gyroscope, will not only ro-

tate the map drum but will simultaneously slide it to the left, in Fig. 1, causing the scriber to mark the resultant of these two components, i. e. a path that is north-east relative to the map axis. Should the course of the tank be due west then the feed-point would move in a plane east on the map, merely sliding the drum on its shaft and the scriber would mark a westerly course.

And so on for every travel unit covered by the tank the scriber marks a path on the map, in the true direction of advance, and proportionate in extent to the horizontal distance travelled by the tank between each periodic feed step of the feed-point. The tank commander is thus enabled to tell, at any instant, exactly his position in the advance toward his objective and be guided accordingly.

If a small map similar to m^1 is wound on the drum with the odograph in the same position in the tank as just described for mounting the small map m, then on sighting the tank true north there will be a deviation of "north" on the map from true north. In Fig. 17 this is shown, by way of example, as 22½°. With the dial 340 again set to zero as before, the scriber would mark a path north-north-west when the tank was in reality travelling north. Under such a condition the deviation of "north" on the map from true north, or any other base-line direction that may be selected, must be compensated for. This may be accomplished by rotating the shaft 44, which supports the feed-point, in such a direction as to set the plane in which the feed-point moves at the same angle to the gyro-rotor shaft that "north" on the map varies from true north remembering, however, that since the path marked by the scriber extends in the opposite direction to the advance of the feed-point, the angle through which the feed-point is turned, when rotating the shaft 44 from right to left, in Fig 7, must be the difference between the angle of deviation and 360°. When rotating the shaft 44 from left to right then it is turned through the angle of deviation only. The means through which the direction in which the feed-point moves may be varied from the base-line direction as determined by the gyroscope, i. e. a variation from the set-up as shown by the drawings, will now be explained.

Referring to Fig. 6 the stand 142 which supports the shaft 44 is provided with a cross-slot 335, with external threads 336 just above it, and with a circular flange 337 at its upper end. The stand is also bored axially to receive the shaft 44, this bore forming an enlargement 338 just above the gyro-pintle 46 and also being counter-bored at its upper end to receive a sleeve 339 fast on the shaft 44 which has a flange 340 overlying and nesting within the flange 337. The lower end of shaft 44 has a circular groove that is embraced by the inwardly projecting tongues 341 (Fig. 9) of two semi-circular plates 342 located beneath a lock-nut 343 received on the threads 336. The lower face of the lock-nut is recessed, as illustrated, to protect these two plates and hold their tongues 341 above a head 344 formed by the groove. With this construction, when the lock-nut 343 is screwed down the tongues 341 bear on the shaft head 344 and hold the shaft from rotation within the stand 142 by bringing the two flanges 337 and 340 into close frictional contact. On loosening the lock-nut the pressure is relieved and the shaft 44 may be rotated freely within the stand, at the same time turning its flange 340 angularly relative to the fixed flange 337 beneath it. These two flanges are beveled at their edges and are marked with graduations indicating degrees (Fig. 7).

It will be understood then, that in order to vary the angle of the plane in which the feed-point moves, i. e. shift the feed-point holder 130 angularly from its location as shown in Figs. 6 and 7, it is merely necessary to loosen the lock-nut 343 and then turn the shaft 44 the desired number of degrees, after which, by tightening the lock-nut, the feed-point will be securely held in its new plane of travel.

The advantage of providing a circular feed arm actuator 190 will now be apparent, since in this form it is effective to depress the feed yoke 136 for any angular position to which the feed-point holder may be adjusted. Furthermore the circular form of the feed arm actuator permits it to turn about the feed-point holder and gyroscope, whenever the tank changes its direction of advance, and yet continually maintain its operative relation to the feed arm hook 138. The importance of the clearance between the actuator and feed arm will now be understood since without this clearance the continual turning of the instrument past and in contact with the feed arm hook 138 would exert a drag on the gyroscope that would eventually affect its predetermined base-line direction and destroy its value as a directional constant. It is highly important that precessing of the gyroscope be prevented.

In adjusting the feed-point to compensate for the condition hereinbefore mentioned when the small map m^1 (Fig. 17) is wound on the drum, the flange 340 would be rotated from left to right, in Fig. 7, until 22½° as marked on said flange registers with zero on the flange 337. A sight hole 345 (Fig. 2) is provided in the brake frame 244 which enables the operator to see the forward portions of the two flanges from above. Within the sight hole is a V-shaped sight 346 and interposed between the sight and zero on dial 337, conveniently projecting forwardly from the

ring 190, is a setting pointer 348 (Figs. 4 and 5) which is used to insure accurate calibration. When so adjusted every advance of the drum will cause the scriber to mark on the map in the true direction of advance with relation to "north" on the map. Now if the course of the tank is changed from north to north-north-west the map drum swings with it from right to left in Fig. 18, through an arc of 22½° which brings the vertical plane of the longitudinal map axis into coincidence with the vertical plane of the feed-point path. Thus on all feed strokes taken by the feed-point, while this course is held by the tank, the map drum merely rotates and the path marked by the scriber is always parallel to the longitudinal map axis, or north-west on the map, as is correct.

Sometimes the vehicle is in such a location, or other conditions are interposed, that prevent an initial facing of the vehicle to true north. Then the variation to be compensated for is complicated by a third factor, that is, the angle of deviation of the vehicle facing from the true north, but the same principles apply and compensation is effected for this, or any other analogous condition, by an adjustment of the feed-point path to the proper angle. It will be understood, of course, that it is not essential to have the gyro-rotor shaft lie north and south since the gyroscope will act as a directional constant whatever its setting.

It will be understood from the foregoing that, when using the illustrated embodiment of the invention, there are two factors that must be accurately determined before the vehicle is started on its journey, in order to cause the scriber correctly to mark the path travelled. These two factors are (1) a knowledge of the direction in which the vehicle is facing and (2) the angle to true north of the plane in which the longitudinal map axis lies, or more broadly, the plane of a right section through the cylindrical map drum. A knowledge of these two factors permits an exact determination of the directional base-line that is to control the path of the feed-point, this path being held to its base-line direction by the gyroscope. The instrument having been adjusted to these two factors then the scriber is registered on the map with the exact position of the vehicle on the earth's surface. This position would be the "starting point" indicated on Fig. 17 and ordinarily would be known by land-marks at that point.

In an open vehicle it is a simple matter to determine the directional base-line by sighting the gyro-rotor shaft on true north, and then such calibration may be made as is requisite to adjust the initial directional movement of the feed-point to "north" as indicated on the map of the terrain to be traversed. Other ways of determining a base-line direction have already been explained. The vehicle may then proceed on its journey, the feed-point making a preselected number of feed-strokes per mile, one at the end of each travel unit corresponding to that number of strokes in a mile of advance, as illustrated, and the scriber will faithfully reproduce the path traversed by making a continuous series of short lines on the map, proportionate in length to the scale of the map due to the design of the feed cam, and in the true direction of advance of the vehicle as indicated by "north" on the map.

Whenever the vehicle encounters hills or hollows the length of the feed stroke is shortened, before the feed-point engages the map, by advancing the start of the feed-point proportionately to the per cent of the grade in accordance with the control of the feed exercised by the inclinometer. Thus, if the inclination either up or down is 10 per cent, then a mile actual travel, i. e. rolling contact, would be but .98 of a mile direct or on the map and the portion of the inclinometer cam felt by the feeler would cause a 2 per cent shortening of the feed stroke. Either the feed-point or the brake has control of the map drum at all times while the vehicle is travelling. Thus the position of the scriber on the map at the end of each feed stroke will be maintained, and the exact position of the vehicle on the earth's surface at any moment will be recorded.

In the illustrated embodiment of the invention the scriber 30 and the feed-point 40 are located at a considerable angular distance from each other on the circumferential surface of the map drum. This is the preferable arrangement because the scriber makes its record of the course at the upper part of the drum where its progress may be watched by the observer. With this construction of the instrument the feed-point is simultaneously making a record of the course traveled at the under part of the drum by reason of its periodic piercings of the map and the intermediate map movements. This record is not in proper position relative to the topography of the map but it affords the advantage of an unalterable record of the course traveled that can always be referred to if the fugitive record made by the scriber becomes erased in part. It is within the scope of the invention to employ the feed-point as the only record making element by shifting the map angularly on the drum to bring the starting point to the feed-point position at the time the journey is commenced.

Nothing herein contained is to be interpreted as limiting the invention in the scope of its application to use in connection with the particular machine, or the particular mode of operation, or both, selected for pur-

poses of illustration and explanation. While the particulars of construction herein set forth are well suited to one mechanical form of the invention, it is not limited to these details of construction nor to the conjoint use of all its features, nor is it to be understood that these particulars are essential since they may be variously modified within the skill of the artisan without departing from the true scope of the actual invention, characterizing features of which are set forth in the following claims by the intentional use of generic terms and expressions inclusive of various modifications.

What is claimed as new, is:—

1. A course recording instrument having, in combination, a map carrier adapted to support a map, a scriber engaging the map, a step-by-step feeding device for moving the map relative to the scriber, and a directional constant for maintaining a predetermined compass bearing for the direction of said map feeding device irrespective of the direction in which the instrument as a whole may face.

2. Apparatus for recording the course of a moving vehicle on a map having, in combination, a single means engaging the map for moving the map in synchronism with the advance of the vehicle and for marking the course of the vehicle on the map, and a directional constant controlling said means and maintaining a fixed direction for the movement thereof regardless of changes in position of the map relative thereto due to changes in the course of the moving vehicle.

3. A course recording instrument for moving vehicles having, in combination, a map carrier, a four-motion feed-point for successively engaging and moving the map on its carrier proportionately to the advance of the vehicle through a predetermined unit of travel, and a steering gyroscope controlling said feed-point and maintaining a constant compass bearing for the direction of movement thereof when engaged with the map regardless of changes in the compass bearing of the instrument as a whole due to variations in course of the vehicle.

4. A course recording instrument for moving vehicles having, in combination, a map carrier adapted to support a map, a scriber for marking a course on the map, feeding means mounted to oscillate around a universal center, means for causing said map carrier to be moved relative to the scriber by the oscillations of said feeding means, and means for controlling said oscillations in direction and extent in a manner to cause the scriber to mark on the map the true course of the moving vehicle.

5. In a course recording instrument for moving vehicles of the type in which a map is moved relative to a scriber in steps proportionate to the length of a pre-selected travel unit of the vehicle, map feeding means oscillating around a universal center, and operating means therefor to cause a map engaging and feeding movement for each travel unit traversed by the vehicle.

6. In a course recording instrument for moving vehicles, a map carriage mounted for universal, parallel freedom of movement, a single unit feed mechanism for said carriage about which the carriage may move bodily between feeds, and means controlling the operation of said feed mechanism and the periodic presentation of the map carriage thereto providing for a movement of the carriage in all directions within the limits of its freedom of movement by said unit feed mechanism.

7. A course recording instrument having, in combination, a movable map carrier adapted to support a map, a step-by-step feed mechanism settable to vary the angularity of its path of movement in relation to the compass marking of the map, and means to maintain its path of movement in any set position.

8. A course recording instrument having, in combination, a movable map carrier adapted to support a map, a four-motion map feeding device, means for advancing and withdrawing said device, means for varying the direction of the path of feed relative to the compass marking of the map, and means to maintain the plane of said path in the plane of movement of said first named means whatever may be the direction of said path.

9. A course recording instrument having, in combination, a movable map carrier adapted to support a map, a four-motion map feeding device, means for advancing and withdrawing said device, means for varying the direction of the path of feed relative to the compass marking of the map, and a gimbal-ring in which said device is mounted.

10. A course recording instrument having, in combination, a movable map carrier adapted to support a map, a four-motion map feeding device, means for advancing and withdrawing said device, means for varying the direction of the path of feed relative to the compass marking of the map, and a gimbal-ring supported by said first-named means in which said device is mounted and through which it is connected to said second named means.

11. A course recording instrument of the type in which a map on a movable carriage is moved by a feeding device in direction and extent to accord with the course of the moving vehicle in which the instrument is installed, said device comprising a sticker-point, and operating means therefor to cause it periodically to engage the map, advance it, and then withdraw and return to its starting point.

12. A course recording instrument of the

type in which a map on a movable carriage is moved by a feeding device in direction and extent to accord with the course of the moving vehicle in which the instrument is installed, said device comprising a support having a sticker-point mounted for oscillatory movement thereon, means to move the support toward and from the map to cause an engagement and disengagement of the sticker-point therewith, means to oscillate the sticker-point while so engaged to advance the map through a feed step, and means to vary the length of said feed step by raising and lowering the sticker-point relative to its axis of oscillation on the support.

13. A course recording instrument for moving vehicles having, in combination, a fixed scriber for marking the course, a map movable relative to said scriber to receive its marking, means for advancing the map past said scriber comprising a four-motion sticker-point, and means to vary the length of the feed step of said sticker-point

14. In a course recording instrument for moving vehicles, a map carriage adapted to hold a map of the terrain to be traversed, and means controlled by the advance of the vehicle for feeding said map carriage in direction and extent to maintain a record on the map of the position of the vehicle, said feeding means being constructed to make an unalterable record of the course traversed.

15. In a course recording instrument for moving vehicles, a map carriage adapted to hold a map of the terrain to be traversed, and means controlled by the advance of the vehicle for feeding said map in direction and extent to maintain a record on the map of the position of the vehicle, said means comprising a sticker-point which is periodically forced into the map and then actuated to move the map a predetermined distance before withdrawal whereby said piercings produce an unalterable record of the course traversed.

16. An instrument for recording the course of a moving vehicle having, in combination, a movable map carriage adapted to hold a map, a feed device movable into and out of engagement with the map, a brake device movable in like manner, and means controlling the operation of said feed device and brake device to hold the map carriage under positive control of one or the other at all times.

17. An instrument for recording the course of a moving vehicle having, in combination, a movable map carriage adapted to hold a map, a four-motion feed device having a feed-point movable into and out of engagement with the map, a brake movable in like manner, and operating means to effect a feed of the map while the brake is disengaged, and to cause the brake to assume control of the map carriage during the periods that the feed point is disengaged.

18. An instrument for recording the course of a moving vehicle having, in combination, a movable map carriage adapted to hold a map, a four-motion feed device having a feed-point movable into and out of engagement with the map, a brake movable in like manner, and operating means for the feed device and brake relatively timed to hold the brake against the map while the feed device is passing through the inactive part of its cycle and until the feed point engages the map, to then release the brake and maintain such brake position until the feed step is completed when the brake is again actuated to engage the map, and to then withdraw the feed point for return to its starting point.

19. A route recording instrument comprising a movable carriage for supporting within a moving vehicle a map embracing the route to be travelled by said vehicle, and map feeding means controlled by the advance of the vehicle and operating to engage the map intermittently and advance the map at each operation a distance proportionate to the length of a predetermined constant travel-unit of said vehicle.

20. A route recording instrument comprising a movable carriage for supporting within a moving vehicle a map embracing the route to be travelled by said vehicle, map feeding means operating to engage the map intermittently and adapted to advance the map by successive feed movements through equal distances proportionate to the length of a predetermined constant travel-unit of said vehicle, and means controlled by the advance of the vehicle to cause said feeding means to act once during the time consumed by the vehicle in traversing a single travel-unit.

21. A route recording instrument comprising a movable carriage for supporting within a moving vehicle a map embracing the route to be travelled by said vehicle, map feeding means adapted to advance the map by successive feed movements through equal distances proportionate to the length of a predetermined constant travel-unit of said vehicle, and means controlled by the advance of the vehicle to cause said feeding means to act once during the time consumed by the vehicle in traversing a single travel-unit said means being constructed and arranged to cause said feeding means to initiate and complete its feed movement in a small fraction of said time.

22. A route recording instrument having, in combination, intermittently operated map feeding mechanism, including a reciprocating feed point, and means for insuring that said feed mechanism is rigid before any feed takes place.

23. A route recording instrument having, in combination, map feeding mechanism

comprising a sticker-point movable into and out of the map at the beginning and end of each feed movement, and means for closing all clearances throughout the operating mechanism for said sticker point previous to initiating any feed.

24. Apparatus for recording the course of a moving vehicle on a map having, in combination, a steering gyroscope, a map feeding device movable in a single predetermined direction relative to the base line determined by said gyroscope, operating means for said feeding device mounted for angular movement about said unit comprising the gyroscope and feeding device as the course of the vehicle deviates from the base line direction, a map carrier mounted to partake of said angular movement, and means for tracing the course on the map determined by the feed thereof.

25. Apparatus for recording the course of a moving vehicle on a map having, in combination, step-by-step map feeding mechanism having a constant normal feed step of preselected length proportional to horizontal distances on the map as related to linear travel of the vehicle through like distances, and means acting automatically to shorten the feed step whenever said proportion is varied by a decrease of the horizontal distance relative to the linear travel of said vehicle during a feed step.

26. Apparatus for recording the course of a moving vehicle on a map having, in combination, step-by-step map feeding mechanism having a constant normal feed step of preselected length proportional to horizontal distances on the map as related to linear travel of the vehicle through like distances, and means acting automatically to proportionately vary the length of the feed steps as said proportion varies due to travel of the vehicle over rolling ground.

27. In an instrument for recording on a map the route of a moving vehicle over rolling terrain in terms of horizontal distances on the map, an inclinometer comprising a damped pendulum and a periodically-cooperating feeler, the position of register of said feeler being determined by the relative angle of said pendulum to the feeler, and mechanism under control of said feeler for feeding the map as the vehicle advances.

28. In an instrument for recording on a map the route of a moving vehicle over rolling terrain in terms of horizontal distances on the map, an inclinometer comprising a pendulum and a cam mounted thereon to swing therewith, a feeler periodically brought into engagement with said cam as it swings past the feeler, means for feeding the map as the vehicle advances, and mechanism for regulating the operation of the feeding means controlled by the position of the feeler as determined by said inclinometer cam.

29. In an instrument for recording on a map the route of a moving vehicle over rolling terrain in terms of horizontal distances on the map, means for feeding the map as the vehicle advances, and an inclinometer operating to regulate the operation of said feed mechanism in accordance with variations in linear travel from air-line distances comprising a liquid-damped pendulum in a chamber of greater cross-section than the pendulum whereby reverse surging of the liquid increases damping and a feeler for transmitting the relative position of the pendulum to the feed mechanism train.

30. In an instrument for recording on a map the route of a moving vehicle over rolling terrain in terms of horizontal distances on the map, means operating periodically for feeding the map in steps as the vehicle advances through successive travel-units of predetermined constant length, an inclinometer including a pendulum for recording fore and aft tips of the vehicle, and means connecting said inclinometer and the feed mechanism and adjustable to regulate the length of the feed steps in accordance with said tip.

31. In an instrument for recording on a map the route of a moving vehicle, step-by-step feed mechanism for successively advancing the map distances proportionate to a predetermined constant travel unit of the vehicle, and mechanism operating to cause said feed mechanism to remain inactive until the vehicle approaches the end of its traverse of said travel unit.

32. In an instrument for recording on a map the route of a moving vehicle, a step-by-step feed mechanism for advancing the map controlled by a cam shaft, and means for rotating said cam shaft through a single cycle intermittently at equal intervals of travel.

33. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, a feed mechanism for advancing the map, a steering gyroscope for maintaining a constant base line direction for said feed, and means to vary at will the direction of feed controlled by said gyroscope.

34. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, feed mechanism for advancing the map, a steering gyroscope for automatically maintaining a constant base line direction for said feed, means to vary at will the direction of feed controlled by said gyroscope, and common means for operating the feed in any set position.

35. Apparatus for recording the course of

a moving vehicle on a map having, in combination, a steering gyroscope having its precession-ring pintles journaled in the frame; a bushing secured to one pintle; a feed-point holder, supporting a movably mounted feed-point for engaging and advancing the map, secured to said bushing and hence movable angularly with the gyroscope; a feed-point actuator supported by said holder and maintaining said feed point normally in its initial feed position; and means mounted independently of said holder for operating said actuator whatever its angular position may be.

36. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, and a feed-mechanism for advancing the map including a connected steering gyroscope for automatically maintaining a base line direction for the feed, said connection being settable whereby the selected base line direction may be achieved by varying the setting of the gyroscope or of the feed relative thereto.

37. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, a feed mechanism for advancing the map, a steering gyroscope for automatically maintaining a constant base line direction for said feed, means settable at will to vary said base line direction, and means for accurately setting the direction of said feed to a known compass bearing.

38. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, a feed mechanism for advancing the map, a steering gyroscope for maintaining a constant base line direction for said feed, means permitting a rotation of the feed relative to the gyroscope to vary said base line direction including a graduated dial mounted for rotation with the feed, and sighting means for accurately setting the dial to a known compass bearing.

39. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, a feed-point mounted in a gimbal ring for engaging and advancing said map, a holder supporting said gimbal ring for movement toward and from the map and permitting said feed-point to oscillate on said holder and within its gimbal ring, means connected to said gimbal ring and supported independently of the holder for moving said feed-point into and out of engagement with the map, and other independently supported means for oscillating said feed-point while engaged with the map.

40. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, a feed-point mounted in a gimbal ring for engaging and advancing said map, a holder supporting said gimbal ring for movement toward and from the map and permitting said feed-point to oscillate on said holder and within its gimbal ring, means connected to said gimbal ring and supported independently of the holder for moving said feed-point into and out of engagement with the map, other independently supported means for oscillating said feed-point while engaged with the map, and a directional constant for controlling the feed and maintaining a fixed direction thereof.

41. In an instrument for recording on a map the course of a moving vehicle, a four-motion feed-point for engaging and advancing the map, unidirectional means for moving the feed-point into and out of engagement with the map, means for varying the direction of feed of said feed-point relative to the compass marking on the map, and a gimbal ring for supporting said feed-point within the control of said unidirectional means.

42. In an instrument for recording on a map the course of a moving vehicle, a four-motion feed-point for engaging and advancing the map, said advance being effected through an oscillation of the feed-point by depression of a suitably connected laterally projecting lever, means for rotating said feed point and its operating lever to vary the direction of feed relative to the compass marking on the map, and an annular actuator for said lever whereby control of the lever is retained in any angular position thereof.

43. In an instrument for recording on a map the course of a moving vehicle, a feed-point movable to engage the map, oscillate while so engaged to feed the map, and then withdraw, means for varying the direction relative to the compass marking on the map in which said oscillation takes place, a unidirectional actuator for advancing and withdrawing the feed-point, a second actuator for causing the feed-point to oscillate, and means for mounting the feed-point to permit said adjustment for change of direction to be made relative to said two actuators but without relinquishing their control of the feed-point.

44. In an instrument for recording on a map the course of a moving vehicle, a feed member for engaging the map, and means to operate said member comprising an actuating train including two levers constructed and arranged to present opposed faces that are oblique to each other in the initial angular position of the levers and are parallel in another angular position, a spacing member interposed between said two faces, a cam moving one lever and consequently said other lever by reason of the interposed spacer

until said two faces are parallel, and means connected to said other lever for transmitting its movement to said feed member.

45. In an instrument for recording on a map the course of a moving vehicle, a feed member for engaging the map, and means to operate said member invariably to the same finish point comprising a short and a long lever pivotally mounted to present opposed faces to each other at their free ends, said faces being oblique to each other at the commencement of the feed, but adapted to reach a parallel position on angular movement thereof, means to move one of said levers and to cause the other to move with it until said position of face parallelism is reached, and means to transmit said movement to the feed member.

46. In an instrument for recording on a map the route of a moving vehicle over rolling terrain in terms of air-line distances on the map, a four-motion feed-point, means to move said feed-point into and out of engagement with the map, means to oscillate said feed-point while engaged with the map, and means to decrease the effective length of said oscillation when the vehicle is travelling on a gradient.

47. In an instrument for recording on a map the route of a moving vehicle over rolling terrain in terms of air-line distances on the map, a four-motion feed-point, means to move said feed-point into and out of engagement with the map, means to oscillate said fed-point while engaged with the map, and means automatically operative when the vehicle is travelling on a gradient for rendering the first part of said oscillation ineffective to feed the map.

48. In an instrument for recording on a map the route of a moving vehicle over rolling terrain in terms of air-line distances on the map, a four-motion feed-point, means to move said feed-point into and out of engagement with the map, means to oscillate said feed-point while engaged with the map, and means automatically operative when the vehicle is travelling on a gradient to proportionately decrease the effective length of said oscillation according to the degree of the gradient.

49. An instrument adapted to be mounted in a fixed position within a moving vehicle and record the course thereof on a map having, in combination, a movable map carrier, a balanced gyroscope mounted in the frame and set to a known position about which the map carrier turns as the vehicle changes its direction of movement, and a feed-point adapted periodically to engage the map and then move said carrier to feed the map, the direction of movement of said feed-point being fixed under control of said gyroscope.

50. An instrument adapted to be mounted in a fixed position within a moving vehicle and record the course thereof on a map having, in combination, a balanced gyroscope mounted in the frame set to maintain a known base line direction, an oscillating feed-point controlled by said gyroscope to maintain its oscillations in a fixed relation to the direction of said base line, a map carrier mounted in the frame and movable about said gyroscope as the vehicle changes its direction of movement, and operating means for said feed-point causing it to engage the map and oscillate while so engaged.

51. An instrument adapted to be mounted in a fixed position within a moving vehicle and record the course thereof on a map having, in combination, a balanced gyroscope mounted in the frame set to maintain a known base line direction, an oscillating feed-point controlled by said gyroscope to maintain its oscillations in a fixed relation to the direction of said base line, a map carrier mounted in the frame and movable about said gyroscope as the vehicle changes its direction of movement, an operating lever for the feed-point extending in the plane of the feed-point oscillation, intermittently operated actuating means therefor carried by the frame and constructed to engage said lever in any position of the map carrier relative to the gyroscope, and means for moving said feed-point toward and from the map before and after said map is moved by the oscillation of the feed-point.

52. An instrument adapted to be mounted in a fixed position within a moving vehicle and record the course thereof on a map having, in combination, a balanced gyroscope mounted in the frame set to maintain a known base line direction, an oscillating feed-point controlled by said gyroscope to maintain its oscillations in a fixed relation to the direction of said base line, a map carrier mounted in the frame and movable about said gyroscope as the vehicle changes its direction of movement, an operating lever for the feed-point lying in the plane of its oscillation, an annulus supported in the frame overlying said lever but held in a position of clearance to permit free turning movement with the map carrier, means for advancing and retracting said feed-point to engage and disengage the map, and means for depressing said annulus to cause an oscillation of the feed-point while engaged with the map.

53. A route recording instrument comprising means for movably supporting a map embracing the route to be travelled by a moving vehicle in which the instrument is installed, and mechanism for controlling the position of the map on the instrument including a device for periodically engaging the map and changing its position relative thereto to accord with the actual travel of the vehicle, constructed and operating to

pierce the surface of the map whereby to hold the map under positive control during said map moving operation.

54. A route recording instrument comprising means for movably supporting a map embracing the route to be travelled by a moving vehicle in which the instrument is installed, and mechanism for controlling the position of the map on the instrument including a device for intermittently engaging the map and securing a positive control thereof, means to actuate said device while so engaged to move the map in direction and extent proportionate to the advance of the vehicle, and means for positively engaging the map during the periods that the said device is disengaged therefrom to hold the map from displacement and maintain its new position until again under control of said device.

55. In an instrument of the character described, a movable map, a scriber for marking a route on the map mounted for displacement from the map at the will of the operator, means for holding the map in a fixed position when not in motion, and means for releasing said map holding means whenever said scriber is displaced from its operative position.

56. In an instrument of the character described, a movable map, a scriber for marking a route on the map mounted for displacement from the map at the will of the operator, means for holding the map in a fixed position when not in motion, and an actuator operated by a displacement of the scriber for simultaneously releasing the map holding means.

57. In an instrument of the type described, a map carrier for supporting a map, a scriber for marking a route on the map, mounted for displacement from the map at the will of the operator, and means for intermittently moving the map relatively to the scriber, a brake for engaging and holding the map from movement, a cam movable to release said brake, and means controlled by a displacement of said scriber for actuating said cam.

58. In an instrument of the character described, a movable map, a scriber for marking a course record on the map, a brake for holding the map from movement at times, means acting normally to hold said scriber and said brake in contact with the map but permitting withdrawal by the operator, and means for automatically releasing the brake when the scriber is withdrawn and for replacing the brake when the scriber is replaced.

59. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, a feed mechanism for advancing the map, and a steering gyroscope for maintaining a constant base line direction for said feed.

60. Apparatus for recording the course of a moving vehicle on a map having, in combination, a map carriage supporting a map, feed mechanism for advancing the map, and a steering gyroscope for automatically maintaining a constant base line direction for said feed.

61. A route recording instrument having, in combination, a step-by-step map feeding mechanism for feed steps of varying length, and means for automatically determining the point for initiating each new feed step, regardless of its length, relative to the point of termination of the previous feed step.

62. In a course recording instrument for moving vehicles, means for supporting a map while permitting freedom of movement thereof, and means, including a feeding device which periodically engages the map and records such engagement on the map, for controlling the direction and extent of map movement in accordance with the actual course of the moving vehicle constructed and arranged to retain a continuous, positive control of the map while said feeding device is in operation.

ERASTUS E. WINKLEY.