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APPARATUS FOR THE CONTINUOUSLY PROGRESSING LATERAL ALIGNMENT OF A CURVED TRACK SECTION

Filed Aug. 5, 1963 3 Sheets-Sheet 1

FIG-1

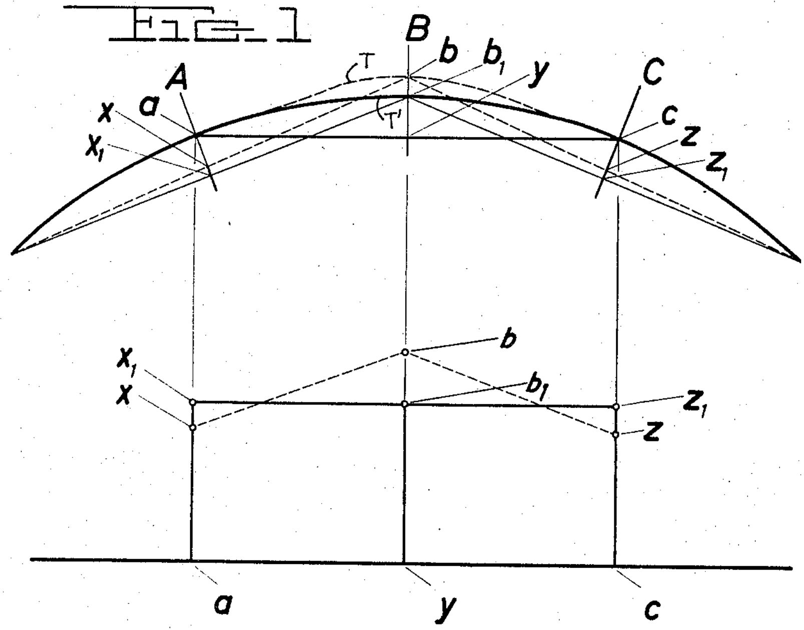

FIG-2

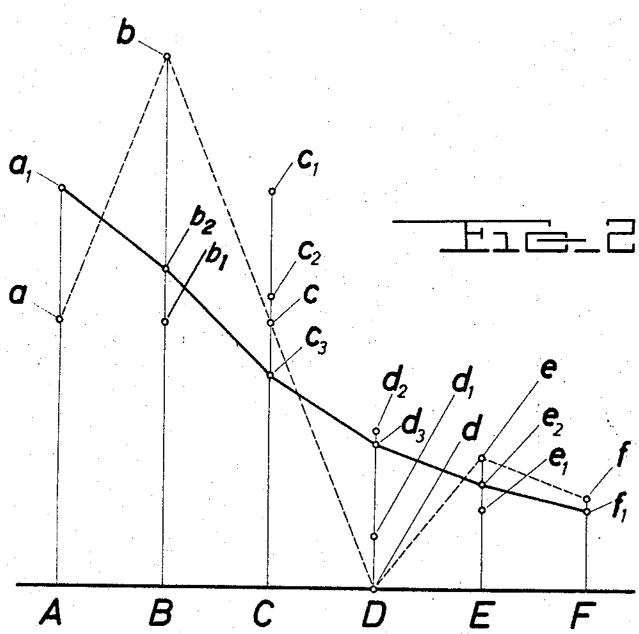

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FIG. 3

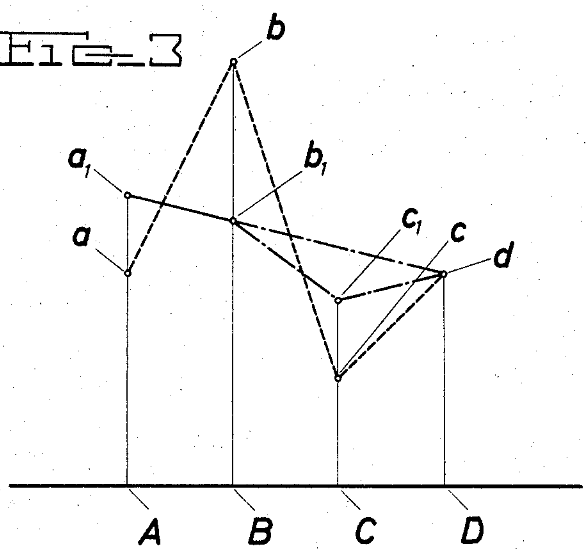

FIG. 4

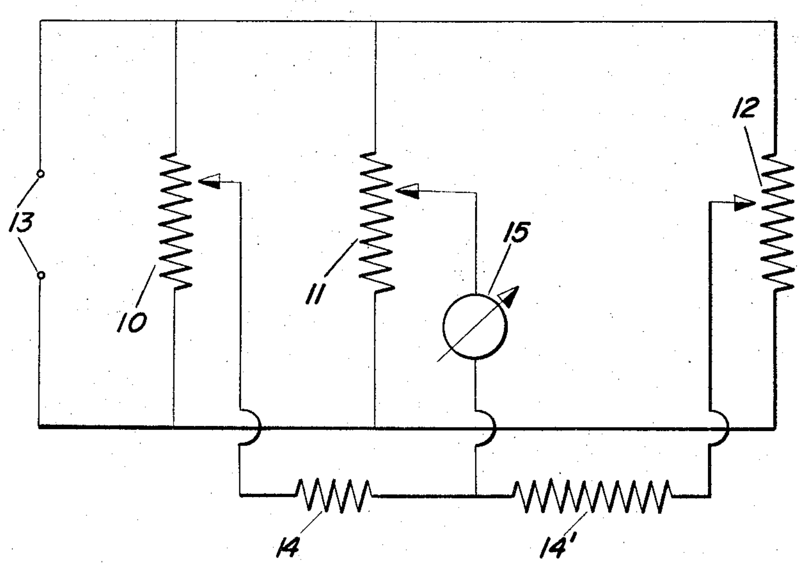

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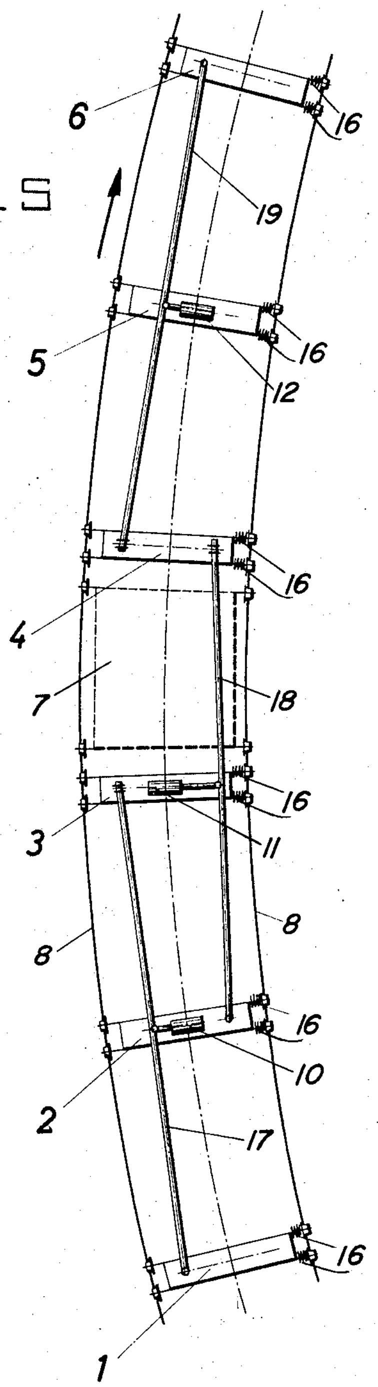
FIG. 5



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APPARATUS FOR THE CONTINUOUSLY PROGRESSING LATERAL ALIGNMENT OF A CURVED TRACK SECTION

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3 Claims. (Cl. 33—1)

The present invention relates to improvements in lateral track alignment.

Various methods have been proposed to straighten out ill aligned curved track sections, which require first the determination of the actual position of the track and the movement of the track into the desired position on the basis of these measurements. However, various disadvantages have been encountered in at least some phases or under some conditions of applying conventional track aligning methods.

It is the primary object of this invention to overcome such disadvantages and to provide a system with which continuously progressing alignment work may be effected along any given track section. This system makes it possible to move the track at any point and, as work proceeds continuously from point to point along the track, a continuous mean value of all ordinates of a curved track section over long distances may be obtained to obtain a smooth track.

According to the invention, this is accomplished by continuously "sensing" the curvature of the track and then laterally moving a track point rearwardly of the "sensed" track point and forwardly of a previously aligned track point into a desired alignment with the forward and rear points. This is done continuously and progressively along the track section and without first measuring its actual position.

In the method of the present invention, chords are arranged between a series of equidistant points of a curved track section and the middle ordinates over the chords are drawn on the track section, the arrangement being such that the middle ordinates of chords between odd-numbered points of the series intersect the track section at the even-numbered points of the series, and vice versa. The track section is then shifted laterally at each point of the series in sequence until the adjusted length of the middle ordinate intersecting the track section at the point of shifting assumes a value which is a linear function of the ordinate lengths prior to shifting at a point of the series behind the point of shifting, at the point of shifting, and at a point of the series ahead of the point of shifting. Preferably, the ordinate through the point immediately behind the point of shifting and the ordinate through the second point of the series ahead of the point of shifting are employed as references from which the magnitude of the shifting movement is determined.

A useful apparatus for carrying out this method comprises a mobile track aligning machine mounted for movement along the track section and a plurality of cars coupled forwardly and rearwardly to the machine for movement along the track section with the machine. Rigid chordal elements extend between alternate ones of the cars and each chord element bridges one of the cars between alternate cars. Means pivotally connect the ends of the chordal elements to the alternate cars. The distance between adjacent cars is half the length of the chordal elements and the chordal elements are of equal length. Means is mounted on the cars between the alternate cars and midway between the chordal element ends for measuring the ordinate of the respective chordal element.

In a preferred embodiment, the ordinate measuring

means comprises an electrical control circuit, rectilinear potentiometers connected in the circuits and arranged midway between the chordal element ends, and elements connected to the chordal elements and mounted for slidable cooperation with respective ones of the potentiometers, the slidable elements and potentiometers extending perpendicularly in respect of the chordal elements.

Desirably, an indicator means is connected in the electric control circuit and is set to show when the ordinates measured by the potentiometers are of the desired length.

The above and other features of this invention will be more fully understood by reference to the following detailed description of certain specific embodiments thereof, taken in conjunction with the accompanying drawing wherein

FIGS. 1 to 3 graphically illustrate geometric principles underlying the present invention;

FIG. 4 shows an electrical control system for use with the invention; and

FIG. 5 schematically illustrates apparatus useful for carrying out track alignment in accordance with this invention.

FIG. 1 illustrates an arcuate track section which is to be re-positioned at point B so that the actual track position indicated by broken line T be changed to the desired track position indicated by full line T'. A portion of chord AC underlying the arcuate track section is shown to define a middle ordinate b–y with track point B. Naturally, when the track point B is moved inwardly, the length of the ordinate is accordingly changed, and the lengths of the ordinates drawn from the end points A and C on chords terminating at B and having each a length equal to AC are changed by half the amount of change of the ordinate length b–y but in the opposite sense, i.e. as the ordinate length b–y decreases, the length of the ordinates of track points A and C increases by half the amount of the decrease. Thus, as shown in FIG. 1, the length of ordinates b–y is decreased by the distance b–b_1, i.e. the distance moving the track point B inwardly, while the ordinates a–x and c–z at track points A and C, respectively, are thereby lengthened by the distances x–x_1, and z–z_1, respectively.

The lengths of the track point ordinates, with their changes due to the alignment of track point B in relation to track points A and C, are shown on a larger scale at the bottom of FIG. 1, in which the ultimate ordinates ax_2, yb_1, and cz_1 are of equal length as in a perfectly aligned circular aligned track section.

FIG. 2 shows the lengths of the ordinates of successive track points reached when the track is moved laterally at C after alignment at B, and afterwards at D, and so on at succeeding track points ahead of the previously moved track point in the manner described with reference to point B in FIG. 1.

Thus, when track point B is moved inwardly by the distance b–b_1, track point A is moved outwardly by half that distance, as shown at a–a_1, b–b_1 being equal to $2(a–a_1)$. The ordinate at track point C is changed in the identical manner, as shown at c–c_1 which also is half of b–b_1. Now, when this forward point C is laterally moved inwardly from c_1 to c_2, the track point B, which is backwardly of point C, changes its ordinate in the same manner as point A changed its ordinate in relation to point B, i.e. it is lengthened by half the distance the ordinate of point C was shortened, so that the track moves there from b_1 to b_2. In the same manner, track point D forwardly of point C assumes the ordinate d–d_1, i.e. it increases by half the distance the ordinate at C was decreased. When the ordinate at track point D is now lengthened to d_2, the ordinate at backward point C is shortened by half the distance from c_2 to c_3 while the ordinate at forward point E is equally shortened by distance $e-e_1$. Finally, when track point E is moved laterally outwardly from e_1 to e_2, the ordinate length at D is shortened by distance d_2-d_3 and the ordinate length at forward point F is equally shortened by the same distance $f-f_1$.

Thus, where the alignment of the succeeding track points A, B, C, D, E, and F is shown by the ragged broken line leading through actual track points *a, b, c, d, e* and *f*, a much smoother full line is shown to lead through aligned track points a_1, b_2, c_3, d_3, e_2 and f_1 after adjustment of the track point ordinates in the indicated manner. The straightness of the adjusted track depends on the leveling of the curve sections a_1-b_2, b_2-c_3, c_3-d_3, d_3-e_2, e_2-f_1, etc.

The lateral alignment of the track at each succeeding forward point in the above-described manner must be effected according to a simple rule and the distance, by which each point is laterally moved, is controlled according to the actual position of the arcuate track section to be aligned or straightened out.

The graph of FIG. 3 illustrates a preferred embodiment of our method in which the magnitude of the lateral displacement of a point B of the track section is determined by establishing chords AC, BD, CE, EF, etc. on the track section, and drawing middle ordinates from the chords on the curve representing the track section at A, B, C, D, etc. in a manner obvious from FIG. 1. The displacement of point B in an unadjusted part of the track section is determined as a linear function of the actual unadjusted lengths of the ordinates drawn on point A in a correct or previously adjusted track section, on point B, and on point D ahead of point D in a track section subsequently to be adjusted. A simple rule permits the displacement of point B to be determined.

This rule is mathematically determined by the equation

$$4b_1=2a+b+d$$

wherein b_1 is the adjusted ordinate at track point B, a is the actual ordinate at track point A, b is the actual ordinate at track point B and d is the actual ordinate at the most forward point D of the track section to be aligned.

A further improvement in the track alignment according to this invention may be obtained when the procedure is reversed at the end of the track arc, i.e. if the same alignment method is used again at the end of the forward movement in the opposite direction. At the end of such a double alignment of a curved or arcuate track section, the alignment is at an optimum. In most practical instances, however, a single forward pass over the track section to be aligned will suffice to obtain the desired track alignment and it will not be necessary to pass backwardly over such a section to obtain the optimum accuracy.

When, as shown in FIG. 3, the track has been laterally moved at A and B so that a_1, b_1 and d, which are the end points of the respective ordinates at A, B and D, respectively, lie in a straight line, the track points at A and B are aligned with the track point at D, which serves as the target in relation to which the track section is to be aligned.

The above-described alignment method may be readily carried out with an electrical control apparatus schematically shown in FIG. 4. The electrical control circuit consists of a suitable source of current **13**, such as a 12-volt storage battery, feeding power to the three rectilinear potentiometers **10**, **11** and **12** connected in parallel to the current source by suitable electrical conductors. Potentiometers **10**, **11** and **12** are respectively mounted at track points A, B, and D, graphically shown in FIG. 3. For instance, the potentiometers may have a resistance of 100 ohm and deliver an electrical parameter corresponding to the respective ordinates at those points. Resistance **14** is connected in shunt between potentiometers **10** and **11**, and resistance **14'** is connected in shunt between potentiometers **11** and **12**. If the resistance **14'** is twice as strong as resistance **14**, the potentiometer circuit will be balanced by the resistances when the electrical parameter measuring the ordinate at B, i.e. at potentiometer **11**, has reached about one third of the slope between the electrical parameters measuring the ordinates at track points A and D, i.e. at potentiometers **10** and **12**, respectively.

An electrical parameter indicator dial **15** is mounted in the line between resistance **14'** and potentiometer **11**. When the indicator needle points to zero, track point B is in the desired position. When the needle deviates from zero, it indicates the direction in which the ordinate of point B must be changed, i.e. the track must be moved there, to attain circuit balance. As soon as movement of point B balances the circuit, the needle will point to zero and lateral alignment of the track at this point is discontinued.

This re-alignment of the track section may proceed continuously from point to point, as described hereinabove, the same procedure being followed at each succeeding point, as the alignment proceeds along the track.

A suitable apparatus for such continuous track alignment is illustrated in FIG. 5, making use of the electrical control circuit of FIG. 4. The illustrated apparatus comprises a conventional mobile track aligning machine **7** mounted on wheels for movement along rails **8** and **9** of the track section to be aligned. In a manner well known per se, the track aligning machine is provided at its forward and rear ends with suitable rail clamps and means for laterally moving the clamped rails to the left or right, as may be desired. Such track aligning machines are quite conventional and since their structure forms no part of the present invention, the machine has been indicated on the drawing merely by a box in broken lines so as to simplify the illustration and not to obscure the novel parts of the apparatus. The alignment apparatus of this invention is characterized by a plurality of measuring cars coupled to the front and the rear of the track aligning machine. In the illustrated embodiment, six such cars or wagons are shown, cars **1**, **2** and **3** being coupled to the rear of machine **7** while cars **4**, **5** and **6** are coupled to its front. Adjacent cars are coupled to each other and cars **3** and **4** adjacent to machine **7** are coupled to the latter. To make it possible to adjust the distance of the cars from the machine, at least one of the cars **3**, **4** is adjustably coupled to the machine, i.e. by a telescoping rod, so that the cars may be moved closer to, or farther from, the centrally arranged track aligning machine **7**.

Each car runs on the rails on four wheels and is forced into contact with one of the rails by suitably arranged resilient means, the illustrated means being constituted by compression springs **16** pressing each car into contact with rail **8**. To avoid confusion, the electrical conductors of the control circuit are not shown in FIG. 5 which only illustrates the potentiometers of the control circuit mounted on respective ones of the measuring cars. Potentiometer **10** is mounted on car **2** corresponding to track point A in the graph of FIG. 3, potentiometer **11** is mounted on car **3** corresponding to track point B and potentiometer **12** is mounted on car **5** corresponding to track point D.

The measuring cars are equidistant from each other along the track arc which is to be aligned and rigid chordal elements of equal lengths extend between alternate cars. The illustrated chordal elements are rigid rods and, as shown, rod **17** extends from car **1** to car **3**, bridging car **2** with its potentiometer **10**, rod **18** extends from car **2** to car **4**, bridging car **3** with its potentiometer **11**, as well as track aligning machine **7**, and rod **19** extends from car **4** to car **6**, bridging car **5** with its potentiometer **12**. The ends of the chordal rods **17**, **18** and **19** are pivotally mounted on the respective cars and one end of each rod is also longitudinally slidably mounted in a suitable bearing so as to permit for minor changes in the distances between the cars to which the respective rod is attached. Thus, if there is a slight change in the distance between cars **1** and **3**, for instance, the end of rod **17** will slide in its bearing on car **3** to allow for such relative movement between the cars along the track. The respective potentiometers are centered in respect of the ends of the chordal rods so that the ordinates of the curved rail **8** may be measured there in reference to the chords. Suitable slidable elements, such as pistons, are mounted at the center points of the chordal rods and cooperate with the potentiometers to produce an electrical parameter corresponding to the respective ordinate.

This apparatus operates as follows while it proceeds continuously in the direction of the arrow indicated in FIG. 5:

As the mobile track aligning machine **7** moves along the track and every time it enters a track arc, such as illustrated, or an ill aligned track section, the measuring cars are pressed into contact with rail **8** by spring **16** and the slidable elements cooperating with the potentiometers on cars **2**, **3** and **5**, but rigidly connected to the chordal rods, are correspondingly moved a distance accurately corresponding to the ordinates at these track points in reference to the respective chordal rods.

The indicator dial **15** of the electrical control circuit, of which the potentiometers are a part (see FIG. 4), is mounted on the track aligning machine **7** so that it may readily be read by an operator riding thereon. The position of the indicator needle will show the direction in which the track must be laterally shifted at car **11**, which is directly adjacent the rear rail clamps of the machine and all the operator has to do is to actuate the track shifting mechanism until the indicator needle points to zero.

As will be evident, the alignment may be effected at any desired point of the track without change in position of an adjacent track point which may have been previously aligned.

The minimum distances between alignment points may best be ascertained by practical experience. If accuracy of alignment requires a double pass, i.e., reversal of the alignment direction after a track section has been laterally aligned in one longitudinal direction, the apparatus will have to be adjusted for the backward pass over the aligned section. For this purpose, potentiometers **10** and **12** are reversed in the circuit and potentiometer **11** is moved from car **3** to car **4** but remains in the same position in the circuit. The rigid chordal rod **18** is moved to extend between cars **3** and **5** and, during the backward pass, the apparatus reads the movement of the track at car **4**, instead of car **3**.

While the invention has been described in connection with certain preferred embodiments, it will be clearly understood that many structural modifications and variations may occur to the skilled in the art without departing from the spirit and scope of this invention, as defined in the appended claims.

What we claim is:

1. An apparatus for the continuously progressing lateral alignment of a curved track section, comprising a mobile track aligning machine mounted for movement along the track section, a plurality of cars coupled forwardly and rearwardly to the machine for movement along the track section with the machine, rigid chordal elements extending between alternate ones of said cars, each chord element bridging one of said cars between the alternate cars, means for pivotally connecting the ends of the chordal elements to said alternate cars, the distance between adjacent ones of said cars being half the length of said chordal elements and said chordal elements being of equal length, and means mounted on said cars between the alternate cars and midway between the chordal element ends for measuring the ordinate of the respective chordal element.

2. The apparatus of claim **1**, wherein said means for measuring the ordinates comprises an electrical control circuit, rectilinear potentiometers connected in said circuit and arranged midway between the chordal element ends, and elements connected to said chordal elements and mounted for slidable cooperation with respective ones of said potentiometers, the slidable elements and potentiometers extending perpendicularly in respect of the chordal elements.

3. The apparatus of claim **2**, further comprising an indicator means connected in said electrical control circuit, said indicator means being set to show when the ordinates measured by the potentiometers are of the desired length.

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