

[54] **MOVING PROJECTOR SYSTEM**

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[51] Int. Cl.² **E01B 27/17; E01B 29/16;**
E01B 33/00

[58] Field of Search 33/287; 104/7 R, 7 B, 8

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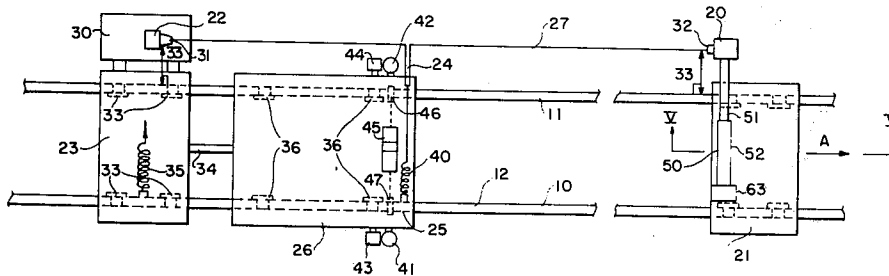
Assistant Examiner—Steven L. Stephan

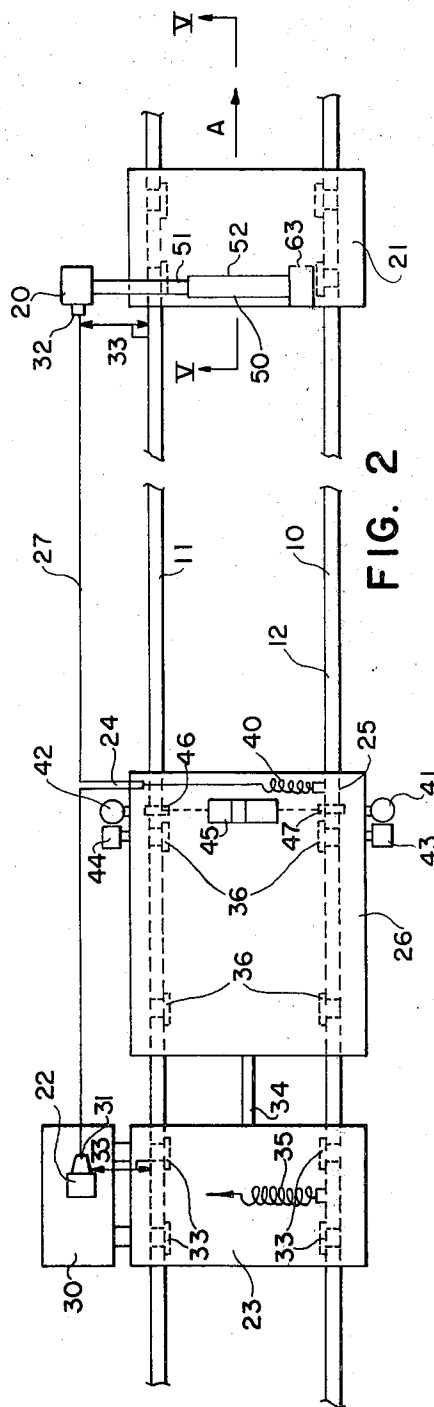
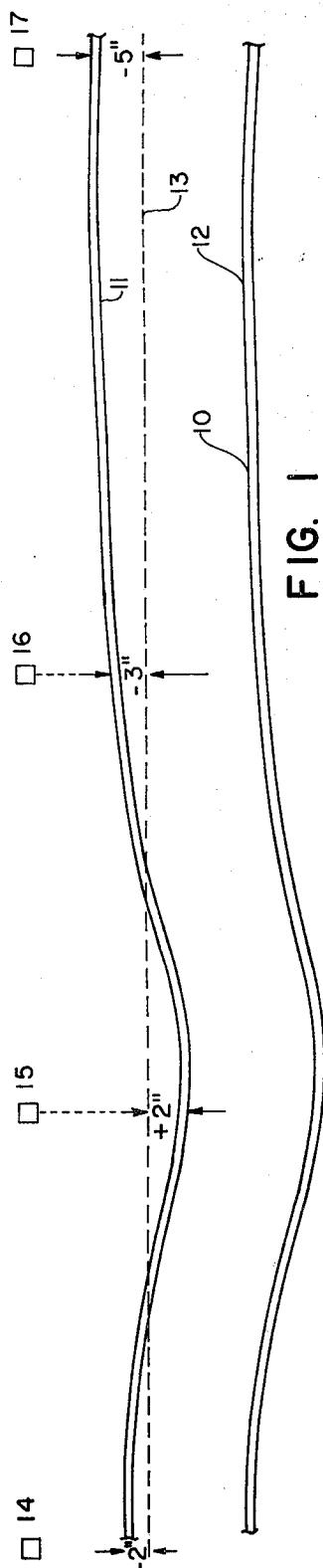
[57] **ABSTRACT**

A lining system and method for aligning a length of

railroad track extending between two locations, the amount of error in the alignment of the track at these locations having been determined. A reference beam projector is mounted on a car to travel over the track ahead of the track lining machine. A beam receiver is mounted on another car behind the machine on correctly aligned track. A shadowboard is mounted on the machine to indicate the position of the track being aligned to the receiver. A potentiometer having a linear resistance and a wiper is employed to interpolate the amount of error in the alignment of the track at the location of the projector. A voltage is applied to each end of the resistance, the amount of the voltage at each end corresponding to the error in alignment of the track at each of the two locations. The position of the wiper relative to the resistance corresponds to the distance travelled by the projector. The wiper is electrically connected to a differential amplifier which transmits a signal to an electric motor whenever the position of the projector relative to the optimum path for the track differs from a predetermined amount and then the electric motor adjusts the position of the projector accordingly.

11 Claims, 7 Drawing Figures





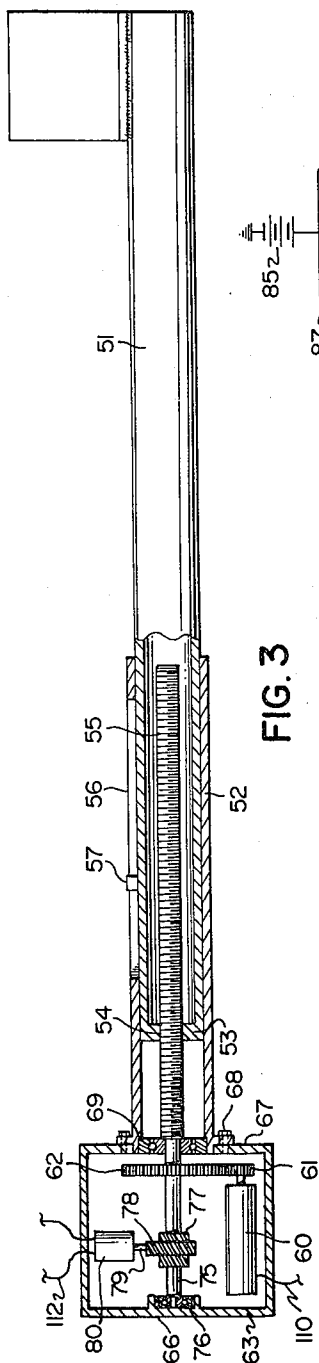


FIG. 3

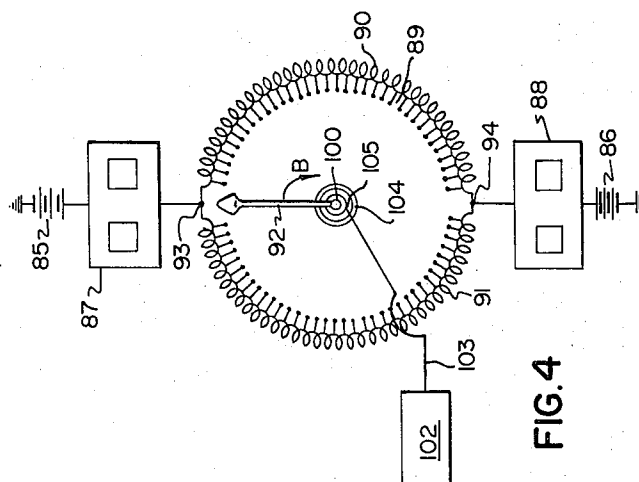
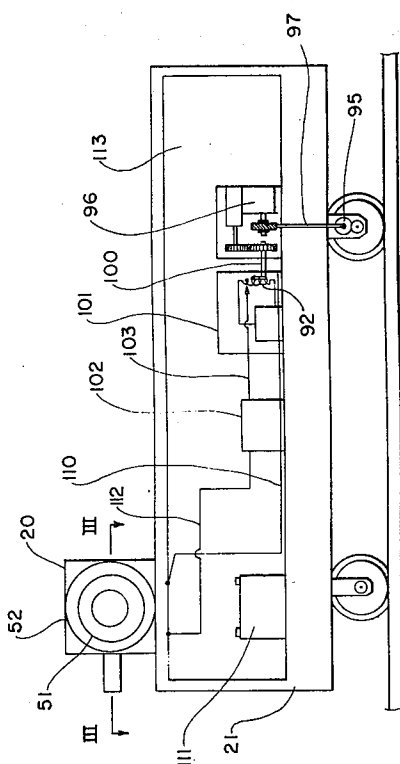


FIG. 4



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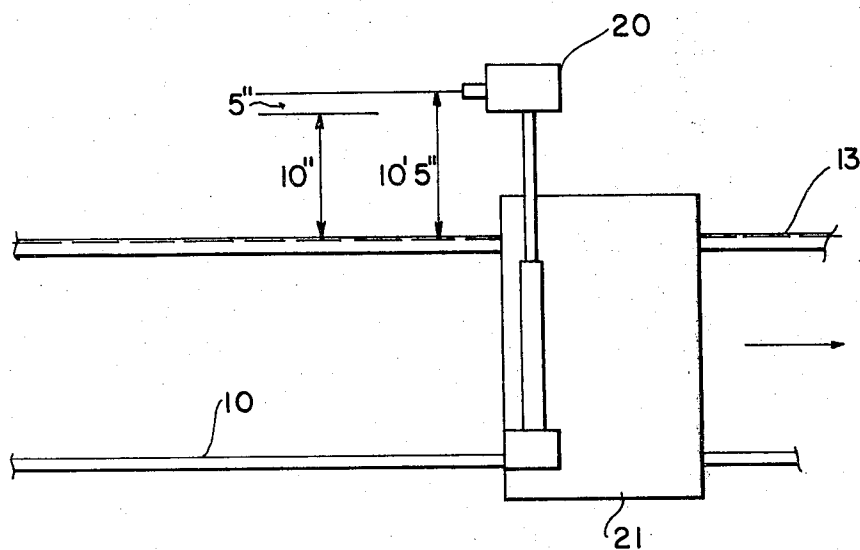


FIG. 6

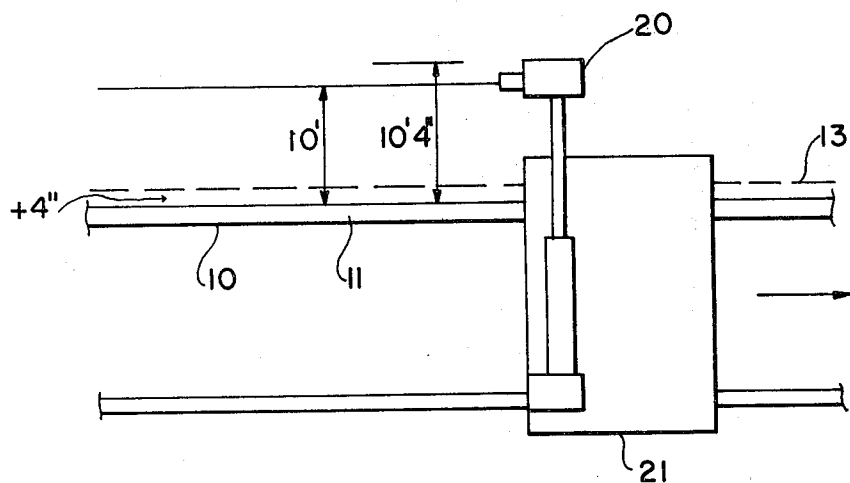


FIG. 7

MOVING PROJECTOR SYSTEM

This invention relates to a lining system for aligning a length of railroad track extending between two locations along a correct line, the amount of error in the alignment of the track having been determined beforehand. The present invention relates to a method of, as well as an apparatus for, aligning the length of railroad track.

BACKGROUND OF THE INVENTION

Certain railroads re-align railroad track using a method of lining known as "lining to stakes" or "stake lining". An example of a railroad employing this method is the Spanish railroad.

With this method of lining, the best or optimum path for the length or stretch of railroad to be re-aligned is determined and then this optimum path is physically located by means of stakes driven into the ground at regular intervals along the stretch of railroad track. The stakes are normally offset a certain distance from the optimum path so as not to interfere with the re-alignment of the track. The amount of error in the alignment of the track adjacent each stake is then relatively easy to determine by means of a measuring tape or other measuring device. The track may be out of alignment due to a shifting of the track, the roadbed or the ground beneath the roadbed.

Normally a foreman will precede the track lining machine, will carry out the above measuring step, and will record the amount of error in the alignment of the track at each stake. The amount of error is either recorded in a record book or marked on the track or ties. Subsequently the lining machine throws or moves the track to the left or right in accordance with the prerecorded data or mark on the track or ties.

The difficulty with the "stake lining" method in the past arises from the fact that it relies solely upon the offset distances obtained at stake locations. Information as to the ideal location for the track at any point between successive stakes is not readily available and therefore the ideal location at such a point must be guessed by the operator of the track lining machine. As a result, correct alignment of the track between the stakes is often not achieved and, when it is achieved, it is often due only to a high degree of operating skill on the part of the machine operator.

Track lining machines are known at the present time and at least one version of these machines employs a reference consisting of an infrared light beam and a shadowboard indicating the position of a piece of track to be aligned. The latter apparatus employs an infrared projector mounted on a satellite car which travels ahead of the track lining machine per se over uncorrected track and a receiver mounted on a trail car travelling behind the track lining machine per se over correctly aligned track. According to the position of the shadowboard relative to the reference beam which is indicated to the receiver, the receiver sends out a signal to the track lining machine to move the track either to the left or right.

However, the above-mentioned machine is only capable of lining the track with respect to the position of the satellite car on which the projector is mounted and the position of the trailing car on which the receiver is mounted. Thus the reference beam may not be parallel to, and indeed probably is not parallel to, the optimum path or correct line for the railroad track. The refer-

ence beam is not referenced to any such optimum path and the known apparatus provides no way of adjusting the reference beam so that it can be so referenced. Thus the known apparatus is not being used where the "stake lining" method is employed or is required.

Accordingly, it is an object of the present invention to provide a track lining system or apparatus employing a reference beam and a shadowboard which can be used in conjunction with the "stake lining" method.

A further object of the present invention is to provide a reference beam, for the shadowboard, having a position referenced with respect to the optimum or correct line for the railroad track to be aligned.

Another object of the system of the present invention is to provide a reference beam projector whose position with respect to the track is automatically adjusted during travel over the track according to the amount or interpolated error in the alignment of the track on which the projector is located, whereby the projector traces a path of movement generally parallel to the correct path for the track.

Another object of the present invention is to provide a method of aligning a length of railroad track according to the "stake lining" procedure and wherein a reference beam and a shadowboard indicating the position of the track to be aligned are employed.

SUMMARY OF THE INVENTION

Accordingly the apparatus of the invention consists of a lining system for aligning a length of railroad track extending between two locations along a correct line, the amounts of error relative to said correct line in the alignment of the track at said two locations having been determined, comprising a reference beam projector mounted on first support means for travel over track, a reference beam receiver mounted on said second support means for travel over track, a shadowboard mounted on further support means to indicate the position of a piece of track being aligned to said receiver, said shadowboard being located between said projector and said receiver along the intended line of projection of the reference beam, track aligning means for moving said piece of track in a direction indicated by said receiver, means for continually adjusting the location of said projector in the transverse direction of the track relative to the adjacent track on which said projector is located as said projector moves between said two locations, said adjusting means including first recording means for recording while said projector moves along the track between said two locations the amounts of error at each of said two locations and for indicating at a given moment in time the location of said projector along said length of railroad track and means for interpolating the error in alignment of the track at the location of the projector on the basis of the recorded amounts of error and the recorded location of said projector, the continual adjustment in the location of said projector depending directly on the amount of the interpolated error such that, when said projector travels over track yet to be aligned, said projector traces a path of movement generally parallel to said correct line, whereby in operation said projector is moved over track yet to be aligned and projects a reference beam to said receiver, the position of said piece of track is indicated to said receiver by the position of said shadowboard relative to said reference beam, said receiver indicates to said track aligning means the direction in which said track is to be moved in order that said track

is correctly aligned, and said track aligning means moves said track in said direction to correctly align said track.

Also the method of the invention consists of a method of aligning a length of railroad track extending between two locations so that said track follows a correct line, the amounts of error in the alignment of the track relative to said correct line at both of said two locations having been determined beforehand, comprising moving a reference beam projector along the track yet to be aligned and between said two locations, recording while said projector moves along the track between said two locations the amounts of error at each of said two locations and indicating at a given moment in time the distance travelled by said projector from one of said two locations on recording means, interpolating the error in alignment of the track at the location of the projector on the basis of the recorded amounts of error and the indicated location of the projector, continually adjusting the perpendicular horizontal distance of said projector from the track over which said projector is moving as said projector moves between said two locations, the amount of adjustment at any moment in time depending on said interpolated error, in order that said projector has a path of movement generally parallel to said correct line, projecting a reference beam from said projector to a suitable receiver positioned adjacent correctly aligned track, determining the correct position for a piece of track located between said projector and said receiver by the position of a shadowboard located along the line of projection of said reference beam relative to said reference beam, and moving said piece of track to said correct position.

A preferred embodiment of the apparatus and method of the present invention will now be described, by way of example only, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which illustrate the method of the present invention and a preferred embodiment of the system and apparatus of the present invention,

FIG. 1 is a plan view of a length of railroad to be realigned according to the "stake lining" method,

FIG. 2 is a schematic plan view of the lining system of the present invention illustrating the combination of reference beam projector, receiver, and intermediate shadowboard.

FIG. 3 is a detailed plan view, partially in section along the line III—III of FIG. 5 of the reference beam projector and the preferred means for adjusting its position relative to the track,

FIG. 4 is a schematic illustration of the potentiometer and related voltage control means for interpolating the amount of error in the alignment of the track,

FIG. 5 is a sectional side view along the line V—V of FIG. 2 of the projector and the car on which it is mounted, and

FIGS. 6 and 7 are schematic plan views of the projector and the car on which it is mounted illustrating the manner in which the projector is adjusted relative to the track.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

As stated above, the present lining system and method can be used in connection with the "stake lin-

ing" method for lining railroad tracks and FIG. 1 illustrates this method of lining. The railroad track to be aligned by the track lining machine is indicated by the numeral 10. For present purposes, only the left hand rail 11 of the track need be considered as the correct position of the right hand rail 12 can of course be determined quickly and easily once the correct position of the left hand rail 11 has been determined. It is assumed for present purposes that the track 10 is to be laid in a straight line but it is to be understood that the present invention is not limited to lining track in a straight line.

In the present case, the optimum path or correct line for the left hand rail 11 is represented by the dotted line 13. A suitable offset distance for the stakes is then selected in order that the stakes will not interfere with traffic moving over the rails or with the re-aligning machine. FIG. 1 shows four offset stakes extending along the left side of the left hand rail 11. The stakes 14 to 17 are driven into the ground, each at the same offset distance from the optimum path or correct line 13. Preferably the stakes are located equal distances apart but it is also possible to vary the distances between the stakes.

Once the stakes have been placed in the ground, a person such as a foreman measures the distances from each stake to the left hand rail 11. The error in the alignment of the track at each stake is then determined by simply subtracting the known offset distance for each stake from the measured distance and this error is recorded. Thus the error in the alignment of the track at each of the stakes 14 to 17 is respectively - 2 inches, + 2 inches, - 3 inches, and - 5 inches.

It will be noted that the amount of error between each of the stakes is constantly varying and, in general, is dependent upon the amount of recorded error at each end of the length of track which extends between successive stakes and the location of a particular point along the length of track with respect to the stake on either side of it. This becomes more true of course as the distance between successive stakes becomes smaller as there is then less chance for a peculiar variation in the alignment of the track. It is therefore desirable, at least when employing the apparatus and method of the present invention, to select the distance between successive stakes so that there is no peculiar variation (i.e. a material variation in the alignment of the track which cannot be taken into account by the interpolation process, described in greater detail hereinafter) between successive stakes.

FIG. 2 schematically illustrates the set-up and general overall structure of the lining system of the present invention moving over the railroad track 10. The lining system of the present invention employs a reference beam projector or transmitter 20 which is mounted on a first support means or car 21 for travel over the railroad track 10. A reference beam receiver 22 is mounted on second support means or car 23 for travel over the railroad track 10. A shadowboard 24 is mounted to indicate the position of a piece of track to be aligned to the receiver 22, the piece of track being generally represented by the numeral 25. Track aligning means are mounted on the car 26 for moving the piece of track 25 in a direction indicated by the receiver 22. The projector itself, the receiver 22, the support means 23, the shadowboard 24, and the track aligning means are, as stated above, known in industry at the present time and these parts may be constructed in the known manner.

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In operation, according to the known method, the car 21 carrying the reference beam projector 20 precedes the track aligning means by a suitable distance. The car 21, generally known as the satellite car, travels over track which has yet to be aligned and therefore, since the position of the projector with respect to the adjacent track is normally not adjusted in any way, in the known track lining system, the path of movement traced by the projector 20 is such that it is not parallel to the optimum path for the railroad track. Thus the reference beam 27 projected rearwardly from the projector 20 will not provide a reference line for the shadowboard 24 which is either parallel to or has any relationship whatever with the optimum path for the railroad track. Thus the railroad track 10 will not be aligned exactly along the optimum path and, if it is, the alignment will be merely a coincidence. Incidentally, the known projector 20 projects an infra-red light beam and such a beam can be used with the method and apparatus of the present invention. However, other forms of beams might of course be used for this purpose. For example, it might be possible to use a laser beam or a beam of radio waves.

As illustrated in FIG. 2, the receiver 22 is mounted on a platform 30 attached to the left side of the car 23 facing the direction indicated by the arrow A in which the cars 21 and 23 are moving, and is thus able to receive the reference beam 27. In the known track lining system, the reception point 31 of the receiver is located the same distance from the left hand track 11 (or the right hand track for that matter) as the projection point 32 is from the left hand rail 11. This distance is indicated by the numeral 33 and it is measured along a horizontal line perpendicular to the rail 11.

The car 23 is mounted on wheels 33 and is preferably towed by a tow bar 34 connected to the car 26 for the track aligning means. The car 23 is referenced to the track 10, in particular the right hand rail 12 by means of a spring roller 35. The operation and construction of the spring roller 35 is known per se in the industry and therefore the spring roller 35 has only been shown schematically in the drawings.

The car 26 carrying the track lining means is preferably selfpropelled and is mounted on wheels 36. Mounted to the front end of the car 26 on the left side thereof is the shadowboard 24. This shadowboard is referenced to one rail of the track 10, preferably the grade rail. In the drawings shown the grade rail is the right hand rail 12 but it could just as easily be the left hand rail 11. The shadowboard is referenced to the grade rail by means of a spring roller 40. Again the operation and structure of the spring roller 40 is known per se and therefore the spring roller is shown only schematically in the drawings. Any movement of the piece of track to be aligned 25 either to the left or to the right will result in a corresponding movement of the shadowboard 24. The position of the shadowboard relative to the reference beam 27 will determine how much of the reference beam 27 reaches the receiver 22. The receiver 22 is able to determine the position of the shadowboard 24, and thus the position of the piece of track 25 by the amount of the reference beam 27 received by it. For example, according to one embodiment of the shadowboard, if the shadowboard 24 completely cuts off the reference beam 27 so that no infra-red light is received by the receiver 22, the lack of light at the receiver will indicate to it that the center or null position of the shadowboard is located to the left of the refer-

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ence beam 27, looking in the direction of movement indicated by the arrow A. On the other hand, if the receiver 22 is receiving all of the light of the reference beam 27, this will indicate to the receiver that the center or null position of the shadowboard 24 is located to the right of the reference beam.

The track aligning means may be of the type comprising lifting jacks 41 and 42, tamping heads 43 and 44, and a track lining jack 45. Again, as each of these features are known in the art, they are shown only schematically in FIG. 2. Each lifting jack is disposed on one side of the car 26 at the front end thereof. These lifting jacks lift the front end of the car 26 sufficiently to permit the two rails of the piece of track 25 to be shifted either to the left or to the right by the track lining jack 45. The track lining jack 45 is disposed between the lifting jacks at the front of the car 26 and has two clamping arms 46 and 47 for clamping the two rails. As is shown in the art, the movement of the track lining jack 45 is under the control of the receiver 22.

In operation, the shadowboard is arranged so that it center or null position will be in line with reference beam 27 whenever the piece of track 25 to be aligned is in its proper position. Thus, when the track adjacent the shadowboard is not in its proper position, the center or null position of the shadowboard will either be to the left or to the right of the reference beam 27. Since the position of the shadowboard varies directly according to the position of the track 25, the receiver 22 will note the position of the shadowboard according to the amount of the light beam received by it and will then signal the lining jack to move the rails either to the left or to the right. Assuming the receiver signals the lining jack to move the rails to the left, the shadowboard 24 will be moved to the left as the lining jack moves the rails. When the center or null position of the shadowboard comes in line with the reference beam 27, the receiver will signal the track lining jack to cease movement. The track lining jack will then hold the piece of track 25 in the correctly aligned position until the lifting jacks 41 and 42 lower the car 26 onto the correctly aligned rails. Once the piece of track 25 has been secured in its proper position, the track lining car 26 will move forward in the direction A to the next piece of track to be aligned. The operation is then repeated again.

The track lining method and apparatus described above is, as stated, known at the present time. Because neither the projector 20 nor the receiver 22 can be referenced with respect to an optimum path or correct line for the railroad track, the known apparatus cannot be used to align the track so that it follows this optimum path.

However, with the lining system of the present invention, means are provided for adjusting the location of the projector 20 relative to the track 10 on which the projector is located. Moreover, this adjustment of the projector is carried out constantly as the projector travels over the track by the adjustment means. The adjustment means are indicated in generally in FIG. 2 by the numeral 50 and include the support means for the projector 20 which is shown in detail in FIG. 3 of the drawings.

The projector is mounted at the outer end of a horizontal first telescoping arm member 51. The other end of the first arm member 51 is slidably received in a second telescoping arm member 52. The second arm member 52 is rigidly connected to the first car 21 by

any suitable connecting means.

The bottom end of the first telescoping arm member 51 has an end member 53 having a hole 54 formed in the center thereof. Extending along the center axis of the second arm member 52 is a rotatable threaded shaft 55. This shaft 55 extends through the hole 54 in the first arm member and threadingly engages the threads formed about this hole. A slot 56 is formed in one side of the second arm member 52 and a small projection 57 on the first arm member 51 projects into this slot. It will be understood that the slot 56 extends parallel to the center axis of the two arm members and is just wide enough to permit the projection 57 to slide therein. The slot 56 and projection 57 prevent rotation of the arm member 51 in the arm member 52 while at the same time permitting the first arm member to slide in the longitudinal direction with respect to the second arm member. The shaft 55 is prevented from moving longitudinally in the second arm member 52 by suitable support means. It can be readily seen that rotation of the shaft 55 will cause the first arm member 51 to be moved either inwardly or outwardly depending on the direction of rotation of the shaft 55. The power cable, if any, for the projector 20 may be extended through the hollow interiors of the arm members (not shown) if desired or may simply extend out to the projector by some form of external support means which permit the outer end of the power cable to move with the projector.

Motor means in the form of an electric motor 60 are provided to move the first arm member 51 with respect to the second arm member 52. A shaft extends from one of the end of the motor and to this shaft a small gear 61 is rigidly attached. This small gear 61 drives a relatively large gear 62 which is rigidly connected to the shaft 55. The motor 60 and the gears 61 and 62 are enclosed in a housing 63. The housing 63 is formed with a rear wall 66 and a front wall 67. The inner end of the second telescoping arm member 52 is rigidly connected to the center of the front wall 67 by means of bolts 68. A hole is formed in the front wall 67 where the second arm member 52 is connected to the front wall. Inserted in this hole and in the inner end of the arm member 52 is bearing means 69 which surrounds the rotatable shaft 55 and supports this shaft. The innermost end 75 of the shaft 55 is located adjacent the rear wall 66 and is mounted in further bearing means 76. The bearing means 76 are rigidly supported by the rear wall 66.

Mounted approximately in the center of the housing 63 is a worm wheel 77 rigidly attached to the shaft 55. Located immediately above the wheel 77 is the worm 78 the threads of which engage the teeth of the wheel 77. The worm 78 is mounted on a shaft 79 which extends to a feed-back potentiometer 80 also enclosed in the housing 63. The operation and purpose of this feed-back potentiometer will be explained hereinafter.

The horizontal position of the projector 20 with respect to the track over which the car 21 is travelling is adjusted according to the amount of error in the alignment of the track at at least one of two locations and the location of the projector with respect to one of these two locations. Assume for the present, that the car 21 on which the projector is mounted is operating on the length of track between stakes 14 and 15 in FIG. 1. The amount of error in the alignment of the track at stake 14 and at stake 15 has already been determined as - 2 inches at stake 14 and + 2 inches at stake 15.

Also assume that the projector 20 is located half way between the two stakes 14 and 15. The position of the projector is then adjusted according to the two amounts of error, - 2 and + 2 inches, at the two stakes, each stake being located at one end of the length of track being aligned, and according to the known fact that the projector has travelled half way from the stake 14 to the stake 15. However, it should be noted that is is not necessary to use the amounts of errors at two stakes in determining the amount by which the projector is to be adjusted. For example, one might assume that the stake 14 is correctly aligned (for instance, where stake 14 is at the end or beginning of a railroad line) and then determine by the "stake lining" method the amount of error in the alignment of the track at stake 15. In such a case only one amount of error would be employed in the determination of the adjustments to be made to the projector as the projector travels from stake 14 to stake 15.

The apparatus and system of the present invention provides means for interpolating the amount of error in the alignment of the track at the location of the projector on the basis of the recorded amounts error at two locations, these locations being at the stakes located on both sides of the projector, and the location of the projector between the two stakes. In addition, means are provided for recording the amounts of error in the alignment of the track at these two locations and the distance of the projector from one or both of the two locations. The interpolated error is then calculated by the interpolating means on the basis of the recorded values. The interpolated error is then employed by the adjusting means for the projector in order to adjust the position of the projector so that it traces a path of movement generally parallel to the correct path for the length of track between the two locations (i.e. the two stakes).

One possible means for recording the amounts of error in the alignment of the track at the two stakes between which the projector is travelling is illustrated schematically in FIG. 4 wherein there is shown two positive and negative voltage sources 85 and 86 such as suitable batteries. The terminals of each of the positive and negative voltage sources are connected to control means comprising two control members 87 and 88, control member 87 being connected to source 85 and control 88 being connected to source 86. The control members can take the form of calibrated potentiometers or suitable rotary switches controlling resistor banks. Preferably the operation of the machine adjusts the control members to enter the two stake errors with the use of two dials or sets of buttons. The errors might also be entered by punched paper tape. Each of the control members is connected to one end of a potentiometer 89 having two resistance members 90 and 91. Each resistance member is in the form of a semi-circle and the two members are arranged to form a complete circle. The potentiometer 89 also has a movable take-off arm 92. The movable take-off arm is preferably in the form of a rotatable wiper, the outer end of which contacts one of the resistance members 90 or 91.

During operation of the projector, the control member 87 is adjusted so that the voltage applied at point 93 of the potentiometer corresponds to the error in alignment at the stake from which the projector is moving. Thus, for example, if the projector is moving along the track between stakes 14 and 15 in FIG. 1 and is presently located on the track adjacent stake 14, the volt-

age applied at point 93 will correspond to the minus two inches of error recorded at this stake. Thus, if a voltage-distance calibration factor is used wherein a voltage of +1 volt is equal to an alignment of plus +1 inch, the voltage applied to point 93 will be -2 volts. At the same time control member 88 is adjusted so that the voltage applied at point 94 corresponds to the error in alignment at the next stake along the track, in this case stake 15. Therefore, using the same calibration factor, a voltage of +2 volts is applied at point 94, the error in alignment at stake 15 being +2 inches. It should be noted at this time that the resistance members 90 and 91 are electrically isolated from one another and that therefore there is a differential voltage between points 93 and 94 around the resistance 90 of 4 volts.

As stated, the present invention provides means for recording the location of the projector between adjacent stakes along the track and these means are illustrated schematically in FIG. 5 of the drawings wherein a cross-sectional view of the first car 21 is shown. Connected to the front wheel assembly of the car 21 is a distance measuring device 95 capable of measuring the distance travelled by the car 21 over the track. Alternatively a separate distance measuring wheel which actually engages the track may be employed to measure the distance travelled. The distance measured is then transmitted to a distance recorder 96 by means of a mechanical or electrical connection 97. The distance measuring device 95, connection 97 and distance recorder 96 may be such as to operate in the same manner as the distance measuring device of an automobile. The distance recorder 96 may consist of a small motor, the speed of which varies directly with the speed of the car 21. This motor can be connected to operate various reducing gears which drive a small shaft 100. The shaft 100 is connected to rotate the take-off arm 92 in the direction indicated by the arrow B. The potentiometer 89, the control means and the two positive and negative voltage sources 85 and 86 can be contained in the housing 101 shown in FIG. 5. The take-off arm 92 is arranged on the shaft 100 so that its outer end can be returned to point 93 whenever the projector is adjacent a new stake. The gearing or motor of the distance recorder 96 is arranged so that the take-off arm 92 rotates from point 93 to point 94 as the projectors move from one stake to the next stake in the series.

It will be readily seen from the above description how the means for interpolating the error in the track at the location of the projector at any point in time are provided. It should first of all be pointed out that the potentiometer 89 can be a single-turn potentiometer which operates in the manner of a linear potentiometer. It should always be borne in mind however that other forms of positioning servos can be employed to move the arm member 51 and the projector thereon to the correct position. The take-off member 92 is electrically connected to a differential amplifier 102 by means of a transmission wire 103. An electrically conducting ring 104 can be securely mounted about a shaft extending from the take-off arm 92 opposite the shaft 100. The ring 104 is connected to the wire 103 and can be electrically connected with the shaft opposite shaft 100 by means of brush means 105. The brush means may either be mounted on the ring 104 or on the electrically conducting shaft. Shaft 100 is of course electrically insulated from the take-off arm 92 so that any sig-

nal coming through the take-off arm 92 is transmitted to the ring 104 and the connecting wire 103.

As the take-off arm rotates along the resistance 90 the voltage applied to the take-off arm through the resistance will be varied according to the amount of rotation of the arm. For example, a 45° rotation of the arm will result in a voltage at the arm of -1, assuming the voltage at point 93 to be -2 and the voltage at point 94 to be +2. When the car has travelled half way between the stakes 14 and 15, the take-off arm will have rotated 90°, or, in other words, half way between point 93 and point 94. After this 90° rotation, the voltage at the take-off arm will be zero. Whatever voltage is at the take-off arm will be recorded in the differential amplifier 102. Thus, an electrical signal is transmitted to the amplifier 102 which corresponds to the interpolated error in the alignment of the track at the position where the projector is presently located. It should be noted that the signal transmitted to the amplifier will not necessarily correspond to the actual amount of error in the alignment of the track since the interpolated error in alignment and actual error in alignment need not necessarily be equal to each other. If the distance between the stakes is relatively short, this interpolated error should be sufficiently close to the actual error in the alignment of the track for track lining purposes. Adjusting the position of the projector relative to the adjacent track using such an interpolated error results in the aligned track being positioned within a first order correction of the optimum path.

The amplifier 102 is capable of sending out an electrical signal to the electrical motor 60 through a connecting wire 110. The electric motor 60 will operate to rotate the shaft 55 to either in the clockwise direction or anticlockwise direction, depending on the signal received from the amplifier 102. If no signal at all is received from the amplifier, the motor 60 ceases operation so that the projector 20 is held in a single position.

In order to complete the means for adjusting the projector 20, it is desirable to have means for recording the existing position of the projector and in the embodiment shown such means are provided by the worm wheel 77, worm 78 and the feed-back potentiometer 80. The feed-back potentiometer 80 may be connected to its own positive and negative voltage source such as the battery 111 shown in FIG. 5. The potentiometer itself may be constructed in a manner similar to that of potentiometer 89 shown in FIG. 4 with one terminal of the battery 111 connected at one of its resistances and the other terminal of the battery connected to the other end. The wiper or take-off arm of the feed-back potentiometer can be connected to the shaft 79 using a suitable combination of reducing gears. The take-off arm of the feed-back potentiometer is electrically connected to the amplifier 102 by means of the wire 112. The voltage through the take-off arm will correspond to the present location of the projector with respect to the adjacent track. Assume that the projector is to be arranged so that it is ten feet taken in the horizontal direction from the track when the track is in the correctly aligned position. The feed-back potentiometer 80 would then be arranged so that the voltage reading through the wire 112 is zero when the projector is in fact 10 feet from the track. If then the projector is 10 feet 5 inches from the track as shown in FIG. 6 whereas in fact the projector should be 10 feet from the track because the track 10 is following the optimum path 13, the feed-back potentiometer will be calibrated so as to

emit a signal of +5 volts. The figure of +5 volts assumes the same calibration factor is being used as that stated above in connection with the potentiometer 89. As the potentiometer 89 will be providing an output signal at its take-off arm of zero volts, this voltage corresponding to a condition of correct alignment, the differential amplifier 102 will be recording a difference in voltage between the two potentiometers of -5 volts, the voltage of the potentiometer 80 being subtracted from that of the potentiometer 89. Because of the difference, the amplifier will send a negative electrical signal to the electric motor 60 indicating to the electric motor that the projector is to be moved inwardly. As the projector is moved inwardly the voltage output from the feed-back potentiometer 80 will be decreased from +5 volts to zero volts. When the voltage output of the feed-back potentiometer corresponds to the voltage output of potentiometer 89, the differential amplifier 102 will cease to emit a signal to the motor and the motor will cease to operate.

FIG. 7 illustrates the projector moving over a piece of track which is +4 inches out of alignment from the optimum path 13. The projector is located presently 10 feet from the left hand track 11, the position the projector is calibrated to be located at when the track is correctly aligned. By an error of alignment of "plus four inches" is meant an interpolated error as determined by the potentiometer 89. The potentiometer 89 then by indicating to the amplifier 102 a voltage of +4 volts and the feed-back potentiometer 90 will be indicating a voltage of zero volts to the differential amplifier because the projector is located 10 feet from the left hand track. As the two voltages at the differential amplifier differ by +4 volts when the voltage of the feed-back potentiometer is subtracted from the voltage of the potentiometer 89, the amplifier then sends out a positive electrical signal to the motor 60 so that the motor 60 will move the projector outwardly. Once the projector 20 has moved outwardly by 4 inches, the feed-back potentiometer 80 will have an output voltage of +4 volts, the same voltage as the potentiometer 89. As soon as the two voltage correspond, the amplifier will cease to send an electrical signal to the motor and the motor will cease operation again. This adjustment of the position of the projector 20 with respect to the track adjacent the projector is carried out constantly as the projector moves along the track so that the projector is maintained generally at the selected distance of ten feet from the optimum path 13 for the track. The projector thus traces a path of movement generally parallel to the optimum or correct path for the length of track being aligned. As the receiver 22, which is travelling over correctly aligned track, is also located ten feet from the correct path for the track, a reference beam between the projector and the receiver will be parallel to this optimum or correct path and will be located a known distance from this path along its entire length. The track lining means can thus employ a shadowboard to align the track by means of a beam referenced to the optimum or correct path.

The distance recorder 96, housing 101 and differential amplifier 102 can all be enclosed in a suitable enclosed space 113 as shown in FIG. 5 to protect them from damage and from adverse weather conditions.

Thus it is apparent that the lining system of the present invention provides an automatic means of providing a linear interpolation of lateral track error between stakes and positioning the projector in accordance with

this interpolation so that the projector is caused to follow a path that is generally parallel to the ideal track position.

What I claim as my invention is:

1. A lining system for aligning a length of railroad track extending between two locations along a correct line, the amount of error relative to said correct line in the alignment of the track at said two locations having been determined, comprising a reference beam projector mounted on first support means for travel over track, a reference beam receiver mounted on second support means for travel over track, a shadowboard mounted on further support means to indicate the position of a piece of track being aligned to said receiver, said shadowboard being located between said projector and said receiver along the intended line of projection of the reference beam, track aligning means for moving said piece of track in a direction indicated by said receiver, means for continually adjusting the location of said projector in the transverse direction of the track relative to the adjacent track on which said projector is located as said projector moves between said two locations according to said amount of error at each location and the existing location of said projector along the length of track, said adjusting means including first recording means for recording while said projector moves along the track between said two locations the amounts of error at each of said two locations and for indicating at a given moment in time the location of said projector along said length of railroad track, said first means for recording the amounts of error comprising two positive and negative voltage sources and voltage control means for controlling the amount of voltage from each source, each of said amounts corresponding to the amount of error at one of said two locations, said first means for indicating the location of said projector comprising a movable electrical take-off arm contacting a resistance member of a potentiometer and means for moving said take-off arm along said resistance a distance depending on the distance travelled by said projector from one of said two locations, and means for interpolating the error in alignment of the track at the location of the projector on the basis of the recorded amounts of error and the recorded location of said projector, wherein, when said projector travels over track yet to be aligned, said projector traces a path of movement generally parallel to said correct line, whereby in operation said projector is moved over track yet to be aligned and projects a reference beam to said receiver, the position of said piece of track is indicated to said receiver by the position of said shadowboard relative to said reference beam, said receiver indicates to said track aligning means the direction in which said track is to be moved in order that said track is correctly aligned, and said track aligning means moves said track in said direction to correctly align said track.

2. A lining system according to claim 1 wherein said amount of voltage is applied through said voltage control means to each end of said resistance from one of said two sources and said interpolating means includes said resistance.

3. A lining system according to claim 2 wherein said adjusting means further includes a motor operatively connected to adjust the position of said projector, a differential amplifier electrically connected to said take-off arm to receive a first signal therefrom, the voltage of said first signal corresponding to the interpolated

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error in alignment at the location of the projector, second recording means for recording the existing position of said projector relative to the adjacent track on which the projector is travelling and for creating a second signal having a voltage corresponding to said existing position, said amplifier being electrically connected to receive said second signal, whereby said amplifier emits a third signal which causes said motor to operate whenever there is a difference in the voltage of said first and second signal.

4. A lining system for correctly aligning a length of railroad track extending between two locations along a correct line, the amounts of error in the alignment of the track relative to said correct line at said two locations having been determined, comprising a first car, a reference beam projector mounted on said first car, a second car, a reference beam receiver mounted on said second car, a shadowboard mounted on support means to indicate the position of adjacent track by the extent of interference of said shadowboard with a beam directed from said projector to said receiver, track aligning means for moving said track in a direction indicated by said receiver, means for recording while said projector moves along the track between said two locations said amounts of error in the alignment of said track and for indicating at a given moment in time the distance of said projector from one of said two locations, interpolating means for forming an electrical signal, the size of said signal depending on said amounts of error and said distance, means for adjusting the position of said projector in the transverse direction of the track relative to the track over which said projector travels in response to said signal, whereby in operation said first car travels ahead of said track aligning means and shadowboard over track yet to be correctly aligned, said receiver travels behind said track aligning means and shadowboard over track in correct alignment, said projector is continuously moved by said adjusting means in response to said signal such that said projector travels along a path generally parallel to the correct path for said track, said projector projects a beam at said receiver, said shadowboard indicates to said receiver the position of the adjacent track, and said track aligning means moves said track in the direction indicated by said receiver such that said track is aligned along said correct path.

5. A lining system according to claim 4 wherein said interpolating means includes a potentiometer and said means for recording the amounts of error in the alignment of said track includes a positive and negative voltage source and a control mechanism for controlling the amount of voltage applied to said potentiometer by said voltage source whereby said amount of voltage is varied in proportion to said amounts of error.

6. A lining system according to claim 4 wherein said interpolating means includes a potentiometer and said recording means includes two positive and negative voltage sources and voltage control means for controlling the amount of voltage applied to said potentiometer by each of said voltage sources whereby the amount of voltage from each source is varied in proportion to the amount of error at one of said two locations.

7. A lining system according to claim 5 wherein said adjusting means includes an amplifier connected to receive the output signal of said potentiometer.

8. A lining system according to claim 6 wherein said potentiometer has a resistance and a movable take-off arm which contacts said resistance at a predetermined

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location along the length of said resistance and said indicating means moves said take-off arm to said predetermined location, said predetermined location depending on the distance of said projector from said one of said two locations.

9. A method of aligning a length of railroad track extending between two locations so that said track follows a correct line, the amounts of error in the alignment of the track relative to said correct line at both of said two locations having been determined beforehand, comprising moving a reference beam projector along the track yet to be aligned and between said two locations, recording while said projector moves along the track between said two locations the amounts of error at each of said two locations and indicating at a given moment in time the distance travelled by said projector from one of said two locations on recording means, interpolating the error in alignment of the track at the location of the projector on the basis on the recorded amounts of error and the indicated location of said projector, continually adjusting the perpendicular horizontal distance of said projector from the track over which said projector is moving as said projector moves between said two locations, the amount of adjustment at any moment in time depending on said interpolated error, in order that said projector has a path of movement generally parallel to said correct line, projecting a reference beam from said projector to a suitable receiver positioned adjacent correctly aligned track, determining the correct position for a piece of track located between said projector and said receiver by the position of a shadowboard located along the line of projection of said reference beam relative to said reference beam, and moving said piece of track to said correct position.

10. A method of aligning a length of railroad track extending between two locations so that said track follows a correct line, the amounts of error in the alignment of the track relative to said correct line at said two locations having been determined, comprising moving a reference beam projector along the track yet to be aligned between said two locations, recording while said projector moves along the track between said two locations the amount of error at each of said two locations and indicating at a given moment in time the distance travelled by said projector from one of said two locations on recording means, said recording means comprising two sources of positive and negative voltage and voltage control means for controlling the amount of voltage from each of said sources applied to a potentiometer having a resistance member, said amounts of error at each location being recorded by applying a corresponding voltage from each of said sources to said potentiometer, said distance travelled by said projector being indicated by a movable take-off member of said potentiometer which contacts said resistance, the position of said moving member with respect to said resistance corresponding to the distance travelled by said projector, interpolating the error in alignment of the track at the location of the projector on the basis of the recorded amounts of error and the indicated location of said projector, continually adjusting the perpendicular horizontal distance of said projector from the track over which said projector is moving as said projector moves between said two locations, the amount of adjustment at any moment in time depending on said interpolated error, in order that said projector has a path of movement generally parallel to said correct line, projecting a reference beam from said

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projector to a suitable receiver positioned adjacent correctly aligned track, determining the correct position for a piece of track located between said projector and said receiver by the position of a shadowboard located along the line of projection of said reference beam relative to said reference beam, and moving said piece of track to said correct position.

11. A lining system for aligning a length of railroad track extending between two locations along a correct line, the amounts of error relative to said correct line in the alignment of the track at said two locations having been determined, comprising a reference beam projector mounted on first support means for travel over track, a reference beam receiver mounted on second support means for travel over track, a shadowboard mounted on further support means to indicate the position of a piece of track being aligned to said receiver, said shadowboard being located between said projector and said receiver along the intended line of projection of the reference beam, track aligning means for moving said piece of track in a direction indicated by said receiver, means for continually adjusting the location of said projector in the transverse direction of the track relative to the adjacent track on which said projector is located as said projector moves between said two loca-

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tions, said adjusting means including first recording means for recording while said projector moves along the track between said two locations the amounts of error at each of said two locations and for indicating at a given moment in time the location of said projector along said length of railroad track and means for interpolating the error in alignment of the track at the location of the projector on the basis on the recorded amounts of error and the recorded location of said projector, the continual adjustment in the location of said projector depending directly on the amount of the interpolated error such that, when said projector travels over track yet to be aligned, said projector traces a path of movement generally parallel to said correct line, whereby in operation said projector is moved over track yet to be aligned and projects a reference beam to said receiver, the position of said piece of track is indicated to said receiver by the position of said shadowboard relative to said reference beam, said receiver indicates to said track aligning means the direction in which said track is to be moved in order that said track is correctly aligned, and said track aligning means moves said track in said direction to correctly align said track.

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