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Plasser et al.

[11] **3,828,440**

[45] **Aug. 13, 1974**

[54] **TRACK SURVEYING**

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[21] Appl. No.: **243,619**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 813,855, April 7, 1969, abandoned.

[30] **Foreign Application Priority Data**

Apr. 9, 1968 Austria 3508/68

[52] **U.S. Cl.** .... **33/144,** 33/1 Q, 33/287, 33/338, 104/8

[51] **Int. Cl.** **B61k 9/00,** B61k 9/08, E01b 29/00

[58] **Field of Search** .... 33/144, 146, 331, 287, 33/1 Q, 338; 104/8; 73/146

[56] **References Cited**

UNITED STATES PATENTS

610,848	9/1898	Livtschak	33/144
661,813	11/1900	Olekiewicz	33/144
1,110,894	9/1914	Cauthorn	33/146
2,672,694	3/1954	Bienfait	33/146
2,784,496	3/1957	Rousse	33/331
2,859,528	11/1958	Grossmann	33/144
2,974,607	3/1961	Talboys	33/287
3,056,209	10/1962	Oliver	73/146 X
3,141,419	7/1964	Clayborne	33/287
3,165,838	1/1965	Plasser	33/338
3,263,332	8/1966	Plasser	33/1 Q
3,334,592	8/1967	Plasser	104/8
3,345,746	10/1967	Plasser	33/1 Q
3,392,451	7/1968	Lombardo	33/144
3,481,183	12/1969	Swift	73/146
3,514,862	6/1970	Helgemeir	33/331
3,557,459	1/1971	Plasser	33/144
3,685,157	8/1972	Plasser	33/144

FOREIGN PATENTS OR APPLICATIONS

748,984	5/1956	Great Britain	33/146
748,985	5/1956	Great Britain	33/146

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[57] **ABSTRACT**

The track gage, camber or flexure, as well as the strength of the rail fastening may be measured with a surveying car with two surveying buggies or frames spaced from each other in the direction of track elongation and running on the track rails with the car. Each surveying frame has two axles having wheels running on the track rails. A respective undercarriage on which the car chassis is mounted is arranged between the two axles of a respective surveying frame. The surveying frames are preferably yielding and their axles and wheels indicate the relative position of the frames to each other and to the track.

11 Claims, 9 Drawing Figures

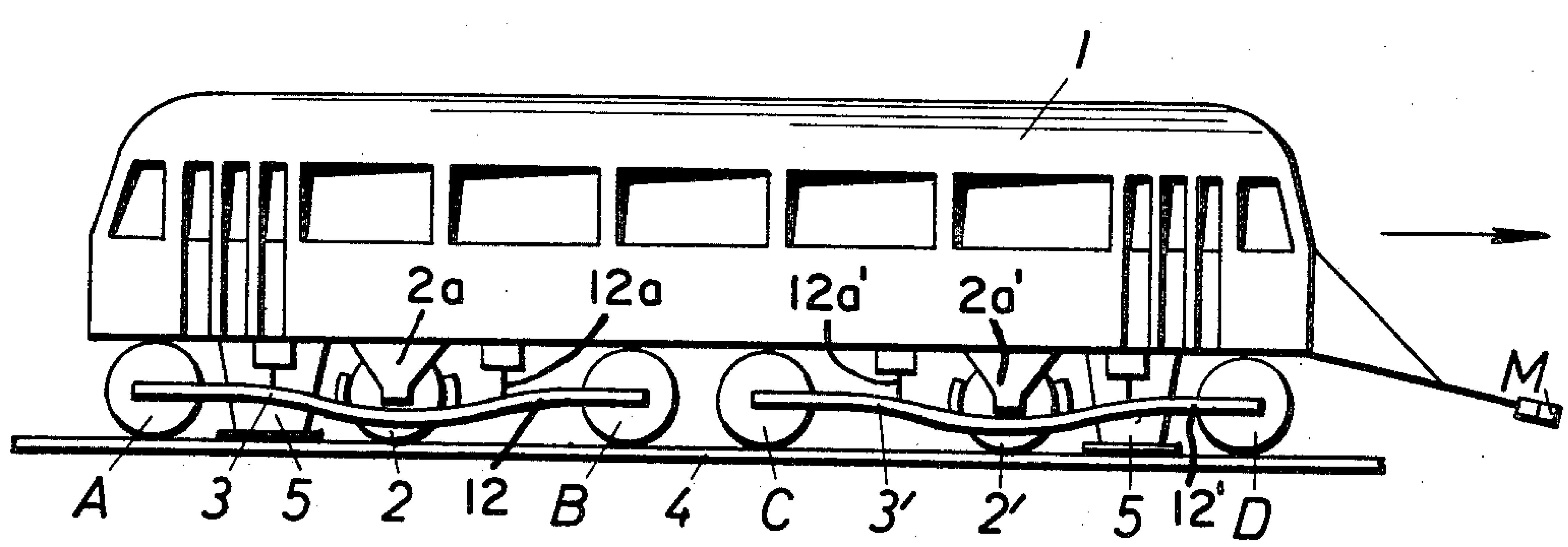

FIG. 1

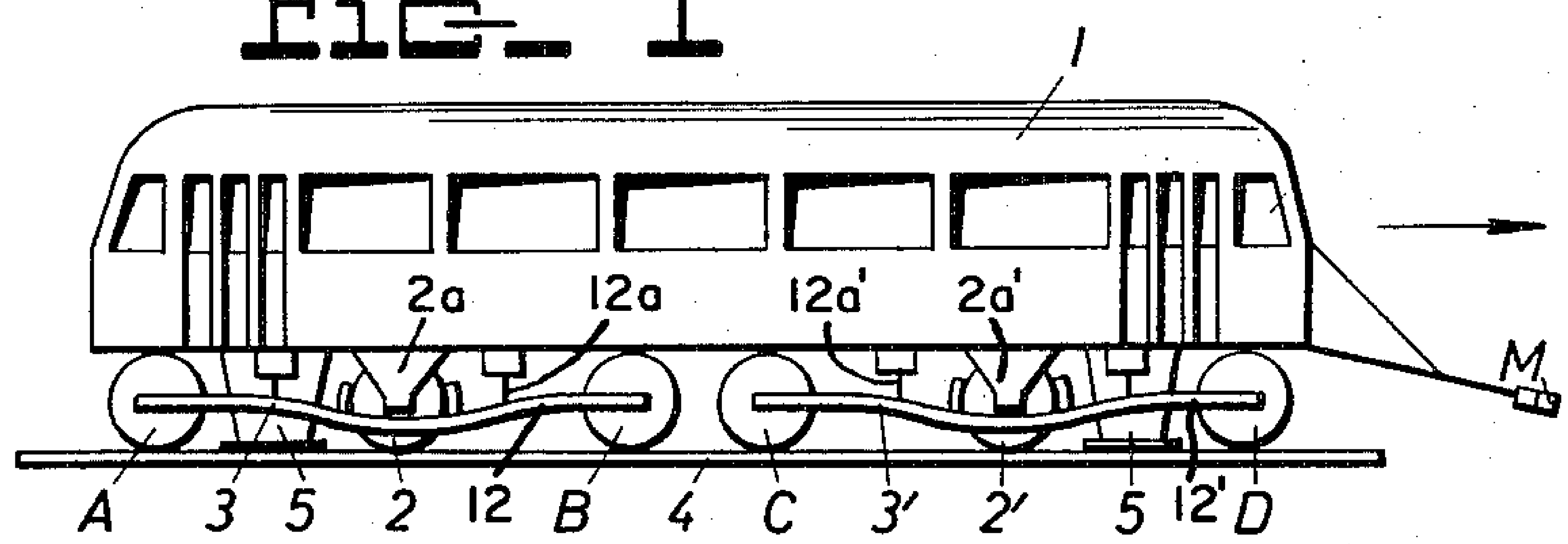

FIG. 2

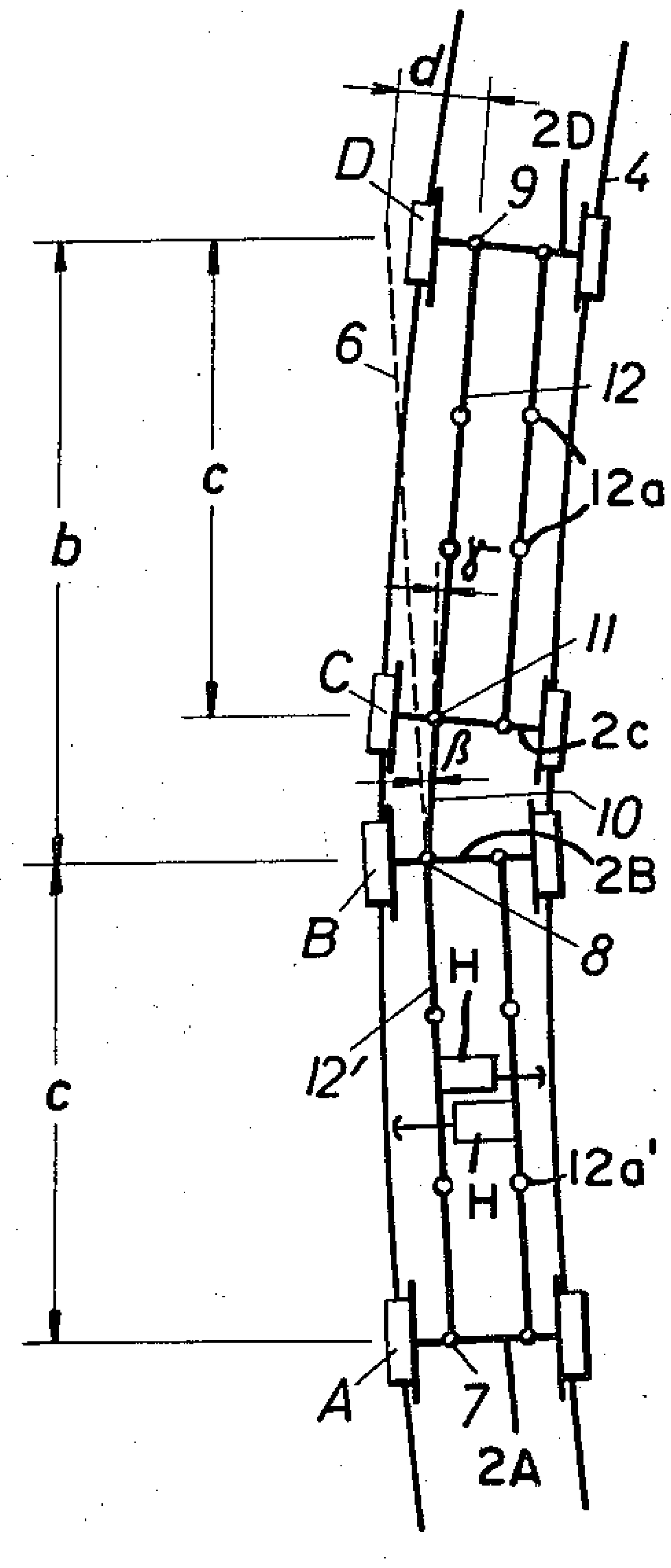

FIG. 4

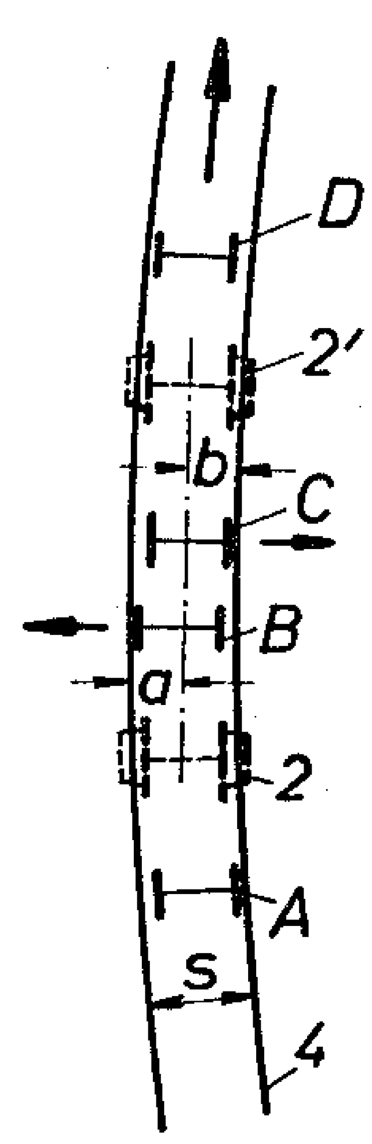

FIG. 3

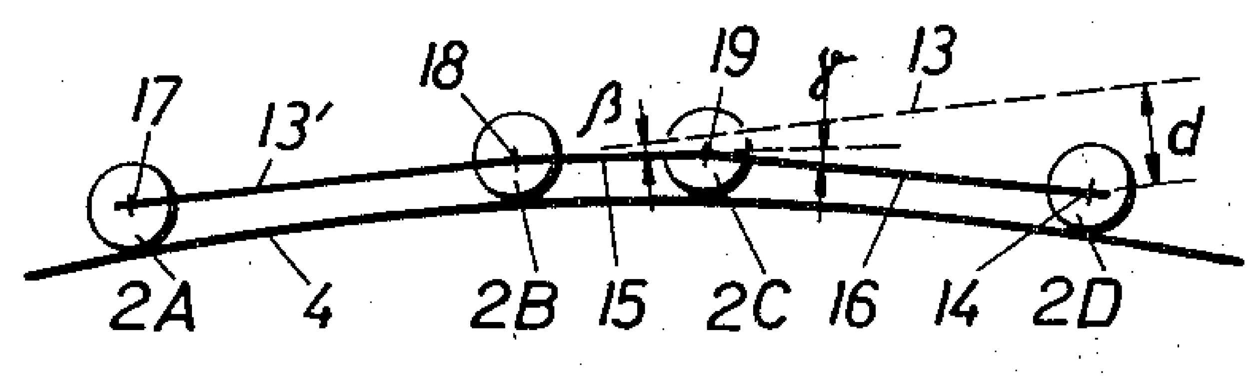

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FIG. 5

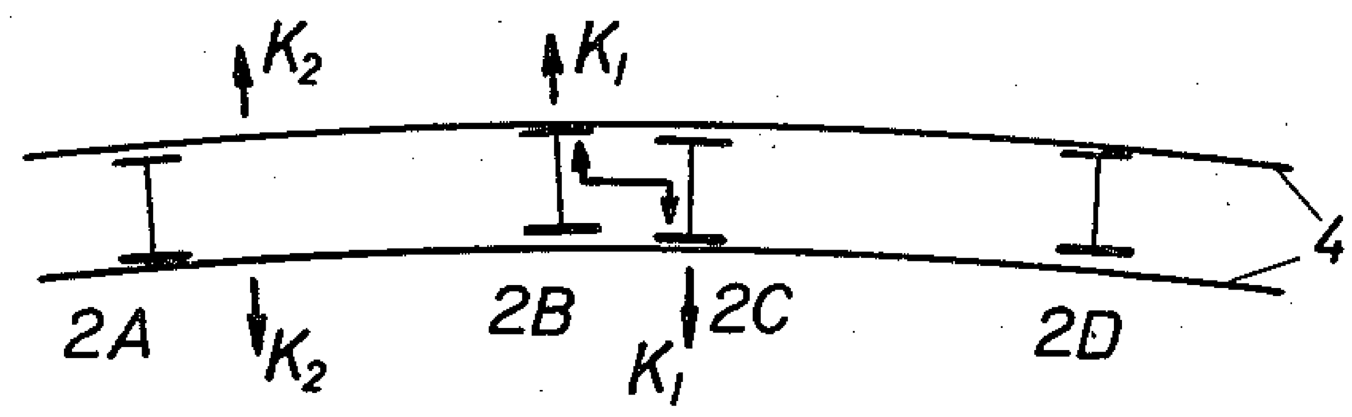


FIG. 6

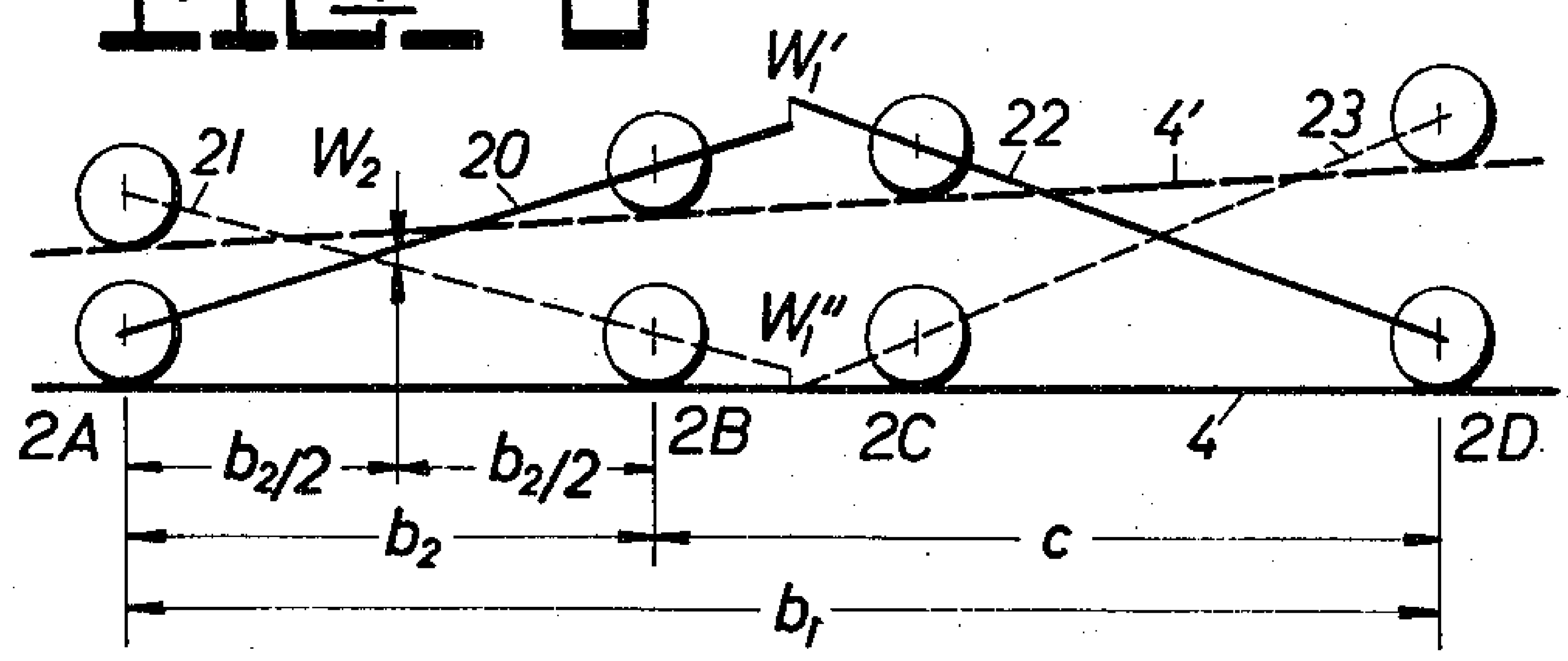


FIG. 7

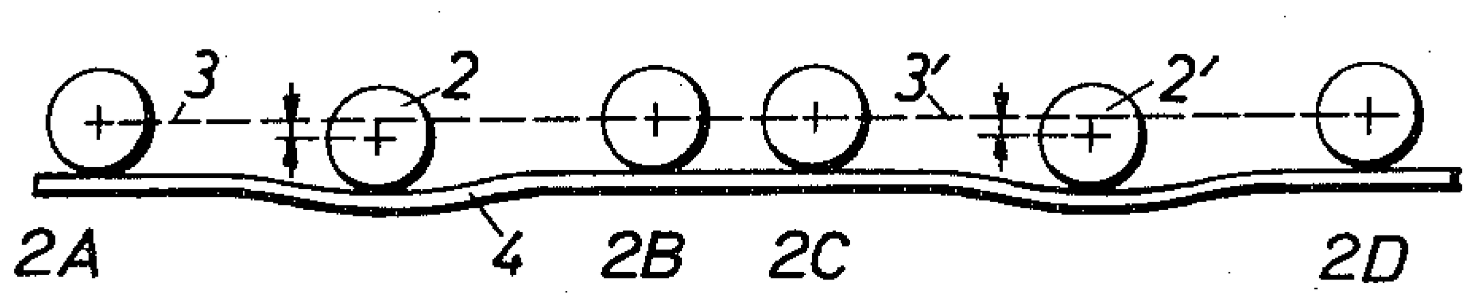


FIG. 8

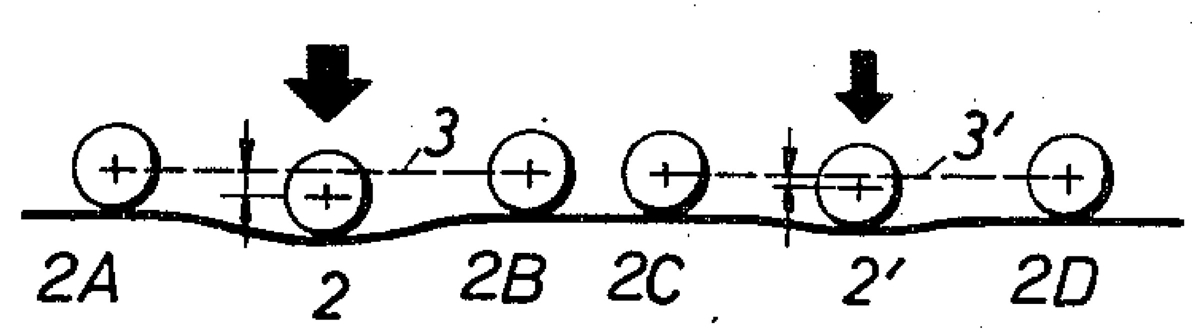
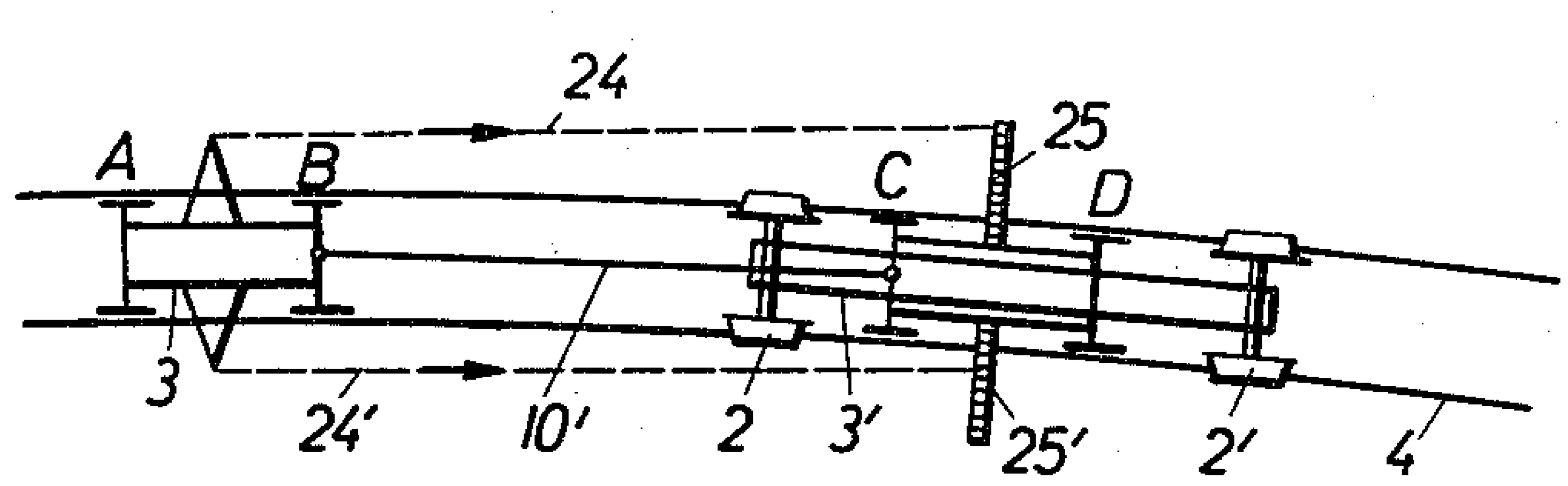


FIG. 9



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TRACK SURVEYING

This is a continuation-in-part of application Ser. No. 813,855, filed Apr. 7, 1969, now abandoned.

The present invention relates to track surveying, and to an improved railroad track surveying car which has two surveying bogies or frames mounted below, but independently movable in respect of, the chassis of the car and running on the track rails with the car.

Surveying frames of this type have the advantage that they can be used as reliable reference for measuring signals characteristic of a track condition without this reference being influenced to any substantial extent by the position and/or movements of the car chassis.

It is the primary object of this invention to provide a track surveying car of this general type which is not only adapted to perform an increased variety of surveying and measuring operations but also improves the accuracy of the signals derived therefrom to determine corresponding track conditions. This object is accomplished primarily by using only the surveying bogies as a reference for establishing the desired measurements or signals characteristic of a given track condition, without using the car chassis for this purpose.

It is another object of the invention to provide and use a minimal number of sturdy surveying elements capable of accurate and full engagement with the track rails for obtaining measurements or signals characteristic of a great variety of track conditions. This is accomplished by using the same surveying elements for multiple purposes so that a single apparatus can be used for an extraordinary variety of surveying operations making it possible to determine all important conditions of a track.

The above and other objects are accomplished in accordance with the invention by providing two such surveying buggies or frames spaced from each other in the direction of track elongation. Each surveying frame has two axles having wheels running on the track rails, the axles and wheels being arranged to indicate the positions of the surveying frames in relation to each other and in relation to the track rails. The chassis of the surveying car is mounted on undercarriages for movement on and along the track rails, and a respective undercarriage is arranged between the two axles of a respective surveying frame. Preferably, each surveying buggy is a yielding frame consisting of universally linked frame parts, and at least some of the wheels should be flanged, with the wheel treads running on the rails and the flanges capable of being pressed into contacting engagement with the rails.

The surveying buggies or frames are preferably relatively closely adjacent each other in the direction of track elongation and, as the following detailed description will show, their parts may be used directly to survey and measure practically all parameters characteristic of the condition of a track. The surveying frames are so mounted as to be practically independent of the position of the surveying car chassis although changes in its position and corresponding changes in the pressures exerted upon the track rails by the undercarriages of the car will have some influence upon the magnitudes of the measurements made by the surveying frames.

The yielding surveying frame, which keeps all its wheels in contacting engagement with the rails, assures that the geometrical measurements made by the surveying elements are made in reference thereto and not to the surveying car chassis. However, the latter may serve as a reference to obtain measurements of both surveying frames but, in this case, too, the measurements obtained by the surveying frames are related to each other. The accuracy and dependability of the measurements increase with the closeness of the two surveying frames to each other. Therefore, they are preferably mounted below the surveying car chassis immediately next to each other, with the undercarriages of the car being arranged between the two axes of respective ones of the surveying frames.

A small distance between the facing axles of the two surveying frames has the advantage that a position change between the two frames in relation to each other between the two facing axles may be very readily and accurately measured. This advantage is of particular importance when the surveying car is used to measure the track gage, as will be explained hereinafter.

Each surveying frame forms a reference for the measurements to be taken and, therefore, the distance between the axles of each surveying frame in the direction of track elongation should not be too small. Since, however, some measurements require close spacing of reference axles, it is preferred that the distance between the facing axles of the two surveying frames is considerably less in the direction of track elongation than the same distance between the axles of each surveying frame.

With the flanged wheels of the surveying frame pressed laterally into contacting engagement with a selected grade rail, the surveying frame will serve as an accurate reference with the grade rail.

According to one important feature of the invention, at least some of the axles of the surveying frames and/or the undercarriages of the surveying car are capable of applying a controlled and measureable lateral and/or vertical pressure upon the track rails. The resultant track changes may then be measured and evaluated to determine certain track conditions. Suitable measuring devices are provided to indicate the parameters obtained by the surveying elements, such as distances, angles or their functions, etc.

Finally, the measurements must be suitably evaluated, which requires recording and/or computing devices to which the measurements are fed in a manner well known in the art of automation so that the measured parameters will provide an accurate over-all picture of the track condition. Particularly in long track sections to be surveyed, the surveying car may be combined with an elongated reference system whose reference line is considerably longer than the surveying frames but of which system the surveying frames form a part. The reference line may be any beam of electromagnetic radiation or a tensioned wire, as is well known, but particular accuracy will be obtained by using a laser beam for this purpose since its direction may be most precisely controlled.

If the surveying cars are to be capable of considerable speeds, the spacing between the undercarriage must be relatively large and it will be useful to employ swivel trucks for this purpose, rather than fixed axles. If the surveying frames are also spaced far apart, one, for instance, being mounted on the car and the other one being spaced therefrom, it will be difficult to measure their changes of position in relation to each other directly. In such an arrangement, it will be advantageous to use a laser beam as a common reference extending from one to the other surveying frame.

Surveying equipment of this type may be advantageously used for a great variety of surveying and track measuring operations, as will become clear hereinafter.

The above and other objects advantages and features of the apparatus and method of the present invention will become more apparent from the following detailed description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawing wherein

FIG. **1** is a side view of an embodiment of a surveying car according to this invention;

FIG. **2** is a schematic top view of an apparatus for surveying a track curve;

FIG. **3** is a schematic side view of an apparatus useful in track leveling operations;

FIG. **4** is a schematic top view of an apparatus for measuring a track gage;

FIG. **5** is a schematic top view of a similar apparatus used to survey the condition of the ties and rail fastenings;

FIGS. **6** to **8** are schematic side views of apparatus respectively useful to survey the camber or superelevation of tracks, the flexure of the track rails, and the condition of the ballast bed; and

FIG. **9** is a schematic top view of an apparatus using laser beams for measuring the curvature or lateral position of a track.

As will be apparent from a consideration of the illustrated embodiments described hereinafter, a great variety of track surveying and measuring operations may be effected with a surveying car according to the invention.

The chassis **1** of the surveying car illustrated in FIG. **1** is mounted on undercarriages **2** and **2'** whose wheels move on track rails **4.** This may be a more or less conventional railroad car and each undercarriage may comprise a fixed axle or swivel truck. In the specific embodiment of FIG. **1,** the undercarriages are fixed axles mounted on brackets *2a* and *2a'* affixed to the underside of chassis **1.** The undercarriage axles are journaled in the brackets and carry the wheels of the undercarriages **2** and **2'.**

Two measuring or surveying buggies or frames **3** and **3'** are mounted below the chassis of the surveying car, each surveying buggy having two axles spaced from each other in the direction of track elongation and each undercarriage being arranged between the two axles of a measuring frame associated therewith. As shown, the measuring frame or surveying buggy **3** has axle **2A** and **2B** carrying flanged wheels A and B running on the track rails, and like frame **3'** has like axles **2C** and **2D** also carrying such flanged wheels C and D, frame **3** being associated with undercarriage **2** and frame **3'** being associated with undercarriage **2'.**

The undercarriages **2** and **2'** carry the load of the surveying car. They may be subjected to controlled loads of the same or different known magnitudes so that the pressure on the track rails at points **2** and **2'** may be readily determined. Similarly, controllable downward loads or pressures of known magnitudes may be applied from car **1** upon axles **2A, 2B, 2C,** and **2D** of the surveying buggies by hydraulic motors or springs, for instance. Additionally, these axles may be subjected to controllable lateral pressures so that they may exert corresponding pressures of measurable magnitude upon a selected track rail by means of the flanged wheels of the surveying buggies which engage the rail. Hydraulic motors, solenoids or any other suitable and conventional means may be used to apply the vertical and/or lateral pressures upon selected axles of the car and/or the surveying buggies.

The measuring frames or surveying buggies **3** and **3'** each consists of universally linked frame parts or rods so that the frames may readily conform to the rails' curvature and all four flanged wheels of each frame at all times engage the rails **4.** The frame linkage yields sufficiently so that the wheels at its four corners will follow each rail at a superelevated track curve section.

The wheels of the surveying buggies have a cylindrical tread running on the rails and a flange for engagement with the rail head of a selected rail, i.e., the grade rail, when the wheel is laterally pressed thereagainst. In this manner, the frame forms an accurate reference or datum line in cooperation with the grade rail which it firmly engages. Also, the controlled lateral pressure makes it possible to measure any form changes in the rail which has been subjected to such pressure.

In the specific embodiment of FIG. **2,** the frame of each surveying buggy consists of universally linked frame parts, the axles **2A, 2B** and **2C, 2D** of the respective buggies being linked to pairs of elongated rods **12** and **12',** respectively, by respective pairs of ball-and socket joints **7, 8** and **9, 11.** If desired, these axles may be telescoping tubes whose length is adjustable, for instance by hydraulic motor means. Each pair of elongated surveying frame rods **12** and **12'** is suspended from the surveying car, as shown in FIG. **1,** by pairs of pivotal mounting rods **12***a*, **12***a'* whose ends are linked, respectively, to rods **12, 12'** and to supports on the underside of chassis **1.** In this manner, the surveying frames are freely movable in a universal suspension on the car.

As shown in connection with surveying frame **3'** in FIG. **2** (the same arrangement being used on the other frame), its flanged wheels A and B may be pressed against a selected rail **4** by hydraulic motors H, each of the motors having its hydraulic cylinder affixed to a respective rod of the surveying buggy while its associated piston has a shoe for engagement with the selected grade rail. As hydraulic fluid is supplied, a measurable and controlled pressure is exerted upon the buggy axles in a selected direction so that the flanged wheels of the buggy will press against the selected rail. Hydraulic motor means for pressing flanged wheels against rails are shown, for instance, in U.S. Pat. No. 3,334,592, dated Aug. 8, 1967, and solenoid means for the same purpose are shown in U.S. Pat. No. 3,557,459, dated Jan. 26, 1971.

As shown in FIGS. **1** and **2,** the distance between the facing axles **2B** and **2C** of the two surveying buggies **3** and **3'** is considerably less, in the direction of track elongation, than the distance between the axles of each buggy, each of which forms a reference.

As indicated in FIG. **1,** the surveying car may also carry additional surveying devices, such as track gage measuring devices **5** and/or a microphone M at the front of the car (in the working direction of the car indicated by the horizontal arrow). The track rails or parts thereof may be subjected to vibrations producing sound waves received by the microphone, and the corresponding signals may be used to read certain conditions of the vibrating rails or their parts in a manner known per se.

Merely by way of examples, the above-described surveying car may be used to survey the following track conditions and to produce and record, if desired, signals characteristic of the surveyed or measured track conditions. In all operations, there is the advantage that the successive measuring or surveying points are closely spaced in the direction of track elongation so that any position change of adjacent points may be simply and directly measured as the car moves continuously along the track. It is, of course, within the scope of the present invention to make more complex and indirect measurements of survey points spaced farther apart if and when desired.

1. Surveying the curvature of a track curve:

As indicated in FIG. **2**, the two successive surveying buggies with their axles 2A, 2B and 2C, 2D are used to determine the curvature of a track section. For this purpose, straight rods **12** and **12'**, which could also be imaginary lines, are established on the respective surveying buggies between points **7**, **8** and **9**, **11**, respectively, which are ball-and-socket joints linking the rods to the buggy axles in the illustrated embodiment. The lines constituted by rods **12**, **12'** extend in the direction of track elongation and are in alignment parallel to the track rails in a straight track section. In a track curve, the line **12'** is extended by a rod or imaginary line **6** beyond point **8** on axle **2B** at least to axle **2D**. The lateral distance *d* between point **9** on axle **2D** and line **6** is measured either directly or, preferably, by measuring angles β and γ, or their functions. Angle β is enclosed between lines **6** of the one surveying buggy and a real or imaginary line **10** connecting point **8** with point **11** of the other surveying buggy. Angle γ is enclosed between lines **10** and **12**. The following formula is used to derive distance *d:*

$$d = b\tan\beta = c\tan\gamma$$

wherein *b* is the distance between two corresponding points of axles **2A** and **2C** or **2B** and **2D** of the two surveying buggies, and *c* is the known length of lines **12**, **12'**, i.e., the distance between the axles of each surveying buggy, which constitutes the reference or datum.

If *d* is known, the radius *R* of the track curve may be derived from the following formula:

$$R = b\ (b = c)/2d$$

The accuracy of this survey depends on the location of reference points **7**, **8**, **9** and **11** on the axles of the two surveying buggies at an equal distance from the axis of the track or the grade rail. In a track curve, the outer rail is always used as the grade rail.

2. Surveying the track grade:

In a manner similar to establishing the curvature of the track in a horizontal plane, the curvature of the track **4** in a vertical plane, i.e., its grade, may be measured with the two surveying buggies, as illustrated in FIG. **3**. **2**A real or imaginary fixed reference line **13'** between axles A and **2B** of one surveying buggy is extended by real or imaginary line **13** at least to the far axle **2D** of the other surveying buggy. The distance *d* of line **13** from reference point **14** of axle **2D** is measured in a manner corresponding to that described hereinabove. The parameter *d* may then be used in an analogous manner to determine the vertical curvature of the track, it again being preferred not to measure distance *d* directly but to establish its value by measuring the functions of angles β and γ between lines **13**, **15** and **16**. As in the previous embodiment, the reference points **14**, **17**, **18** and **19** on the respective surveying buggy axles are all at the same distance from the grade rail which, in a track curve, is the inner rail when it is desired to determine the track grade for leveling purposes.

3. Surveying the track gage:

As shown in FIG. **4**, the two most closely adjacent axles of the two surveying buggies, with their respective wheels B and C, are pressed against opposite rails of track **4**, i.e., in opposite transverse directions, until the flanges of the respective wheels on these axles contact and engage a respective one of the rails. The amount of the relative movement of wheels B and C transversely of the track establishes the track gage at the surveyed track point. Thus, the distances $a = b$ constitute the gage *S* of the track. The distances *a* and *b* are measured in relation to the chain-dotted center line of chassis in respect of which the axles are laterally movable. The surveying frames merely serve as a reference and their relative position in relation to track **4** is of no significance. As *a* increases, *b* becomes smaller, and vice versa, so that turning of the surveying frames has no significant influence on the magnitudes of *a* and *b* because the wheels B and C are close together in the direction of track elongation.

When measuring the track gage, the lateral pressure on the surveying frame axles must be controlled so that it does not deform the rails but merely presses the respective wheel flange into contacting engagement with its grade rail. However, if it is desired to determine how the track gage may change under lateral pressures exerted upon the rails by the wheels of regular train traffic, the lateral pressure upon axles B and C may be so chosen that it corresponds to that of the wheels of train passing over the track.

4. Determining the condition of the ties:

As shown in FIG. **5** and proceeding in a manner similar to that for surveying the track gage, the two closely adjacent axles **2B** and **2C** are pressed in opposite transverse directions against opposite rails of track **4** but with a force K_1 which is sufficiently large to deform the rails, i.e., to increase the track gage. It is preferred to produce two rail deformations of different magnitude at longitudinally spaced points, i.e. with a force K_2 at axle **2A** and a force K_1 at axles **2B**, **2C**, the two lateral forces differing, for instance, by 1,000 kg to determine the modulus of elasticity of the rails. This produces a survey of the quality of the rail fastening on the ties.

The forces K_1 and K_2 are preferably exerted upon the rails from the surveying car **1** by means of the surveying buggies but, if desired, the force K_2 may be exerted upon the track directly from car **1**. In any case, the modulus of form changes in the track may be determined by the ratio between the exerted force and the track form change produced thereby. If the same track is subjected to two forces of different magnitude and the resultant track form changes are measured, the influence upon these form changes of the same material, i.e., the track rails, can be eliminated from consideration so that there remains only the influence of the other track material, i.e., the ties, whose condition can thus be established. Such a tie survey is particularly conclusive when the difference in the magnitude of the applied lateral forces is large. Therefore, it will be useful to make the smaller of the two forces as small as possible.

5. Surveying camber of the rails and superelevation:

As shown in FIG. **6**, the same two surveying buggies with their axles 2A, 2B and 2C. 2D are used. In this operation, the distance between a pair of reference points on each rail **4, 4'** is measured, the position of these points being determined by that of the axles of the surveying buggies. As previously indicated, the frames of the surveying buggies are freely adaptable to any shape of track.

As indicated in FIG. **6**, the two rails are at a camber in relation to each other and the wheels on the surveying buggy axle run on these rails, the wheels being on different levels, due to the superelevation of the track section being surveyed. If the four wheels of each survey buggy are interconnected by real or imaginary diagonal lines **20, 21** and **22, 23,** respectively, and these diagonals are extended towards each other, the camber for base b_1 may be measured at the center line extending transversely of the track between the two adjacent axles **2B** and **2C** of the two surveying buggies. The camber for the base b_1 is constituted by the sum of the transverse distances w_1' and w_2'' between adjacent diagonals of the two surveying buggies. As is known, the camber for the base b_2 is established by measuring the distance w_2 between the two diagonals **20, 21** at the center of the surveying buggy midpoint between the axles 2A and 2B. The measurement w_2 constitutes the superelevation at the center which is approximated by the distance of the midpoints of the diagonals.

The magnitude of the superelevation of the track in a track curve is determined in a manner known per se as the sum of the measured grade differences between successive points of the two rails.

6. Surveying the flexure of the track rails:

Referring to FIG. **7**, if the axles **2C** and **2D** of one surveying frame are under the same load as the surveying car axle **2'**, the track rails **4** will show the same despression or flexure under each of these axles. However, if the undercarriage **2'** rests on a rail joint, the identical downward pressure on the ends of the two adjoining rail sections forming the joint will produce a stronger flexure when the ballast under the joint is poorly tamped because the rail ends act like the ends of a lever arm. Thus, the additional downward movement of the undercarriage **2'** in relation to the surveying frame **3'**, which is used as a reference, indicates the location of a rail joint as long as the loads on all axles remain the same. In the illustrated embodiment, the position of undercarriages **2** and **2'** is measured in reference to the surveying frames **3** and **3'** so that the position of the frame of car **1** is without influence on these measurements. Only the surveying frames serve as references.

7. Surveying the ballast bed condition:

FIG. **8** illustrates the use of the same arrangement for purposes of determining the condition of the ballast bed. If the downward pressures on the axles **2A, 2B, 2C** and **2D** of the surveying frames are equal while the load on car axle **2** exceeds that on car axle **2'** by a controlled amount, the difference between the downward movement of axle **2** and of axle **2'** can be readily established. The measured difference, which depends on the magnitude of the different loads, is a parameter indicating the compactness of the ballast bed.

If a track section is thus surveyed and an average parameter for the ballast condition is established, those skilled in the art of railroad bed maintenance will be in a position to determine whether it is necessary to tamp the surveyed track section.

Thus, if the difference in grade or horizontal level of at least one axle of car **1** is measured in relation to a reference point whose position is determined by one of the surveying frames and the track is subjected at the same track point or at different track points to downward pressures of different magnitude, the differences between the measured grade or level changes in the track can be compared to permit conclusions in respect of the condition of the ballast bed.

The above description gives an indication of the great variety of track survey operations which can be carried out with the surveying car of this invention, without in any way exhausting all possibilities. Thus, the car may be equipped with any number of additional devices for measuring track conditions and producing signals characteristic thereof, such additional devices being functionally associated with the surveying buggies, or operating independently thereof. For instance, the tension or stress of the track rails may be measured by using one or more flattened wheels on the surveying buggies and/or car axles. The flattened or otherwise noncircular portions of these wheels will subject the rails over which they run to rapidly succeeding impacts causing the rails to vibrate. The proper frequency of these vibrations may be measured by conventional sound analysis devices. If the frequency is high, the rail tension is high. If the vibration frequency is compared with that of a test piece having a desired tension, the magnitude of the track rail tension may be determined. For this purpose, an electroacoustical device, such as microphone M (FIG. **1**), may be used to measure the frequency.

Similarly, the proper positioning of the rail clamps, bolts or other rail fasteners may be determined. For this purpose, one measures the frequency of the sound resulting from the vibrations of the rails when they are slightly lifted. If the rail fastening is loose, i.e., the rail fastening means are poorly positioned, the sound is deeper.

It is also possible to survey the condition of the rails heads on which the wheel treads run with the surveying car of the invention. This is done best by direct measurement at the closely adjacent axles **2B** and **2C** of the surveying buggies, with considerable magnification. The seams at the rail joints need not be considered in this surveying operation.

Since meters for measuring the various above-indicated parameters are well known and any conventional measuring devices may be used within the scope of the present invention, those skilled in the art will choose suitable devices without requiring further descriptions thereof, which have been omitted to avoid prolixity. Since mechanical meters and/or recording devices may be subject to vibrations and corresponding inaccuracies, it may be useful to record and transmit mechanical parameters electrically or electronically. However, hydraulic meters may also be useful, particularly if it is desired to dampen the motion of the measuring device.

The measured parameters may be used to produce characteristic signals which may be fed to computers for evaluation of the results.

It is also possible to combine the surveying car of the present invention with a suitable reference system for determining and controlling the lateral alignment and/or level of the track. Such reference systems may make use of reference lines constituted by beams, wires, sighting lines and, for high precision, laser beams.

FIG. **9** illustrates an arrangement in which the position of one surveying frame A-B in relation to the other surveying frame C-D is determined by two laser beams **24, 24'**. The laser beams are directed from the one surveying frame to receivers **25, 25'** on the other surveying frame, each receiver consisting of a horizontally aligned series of optical eyes or photo-electric cells. The relative position of the two surveying frames will be shown by the cells activated by the laser beams. Since laser beams are precisely controllable and constitute sharply defined pencils of light, the positioning of the two surveying frames can thus be very precisely determined.

Other means may be used to indicate the position of the surveying frame, such means being well known in the track survey art. For instance, rotary potentiometers may be mounted on the surveying frames for this purpose, as fully disclosed in U.S. Pat. No. 3,463,095, dated Aug. 26, 1969.

In the illustrated embodiment, the two surveying frames are held at a fixed distance from each other by a coupling rod **10'**.

We claim:

1. A railroad track surveying car comprising a chassis mounted on undercarriages for movement on and along the track rails, two surveying frames spaced from each other in the direction of track elongation and running on the track rails with the car, each surveying frame having two axles having rail surveying wheels running on the track rails, a respective one of the undercarriages being arranged between the two axles of at least one of the surveying frames, and means connected to the axles and wheels of the surveying frames for indicating the position of the surveying frames relative to each other and relative to the track.

2. The surveying car of claim **1**, wherein each of the surveying frames comprises universally linked frame parts including the axles of the frame whereby all the wheels may be maintained in contact with the respective rails of the track at any camber of the track.

3. The surveying car of claim **1**, wherein the chassis is mounted on two undercarriages and each undercarriage is arranged between the two axles of a respective one of the surveying frames.

4. The surveying car of claim **1**, wherein the two surveying frames are adjacently mounted so that one of the axles of one of the frames is adjacent one of the axles of the other one of the frames, and the distance between the two adjacent axles of the frames is less than the distance between the axles of each frame, each frame forming a reference.

5. The surveying car of claim **1**, wherein at least some of the wheels of the surveying frames are flanged wheels, and comprising means for selectively pressing selected ones of the flanged wheels against a selected one of the track rails into engagement therewith, the selected rail and engaging wheels forming a reference.

6. The surveying car of claim **1**, further comprising means for establishing associated straight lines extending in the direction of the track, each of the straight lines extending between two points on each surveying frame, the associated lines enclosing angles therebetween.

7. The surveying car of claim **1**, further comprising a reference system including a reference line associated with the surveying frames.

8. A method of measuring the gage of a track, comprising the steps of placing on the track two surveying frames spaced from each other in the direction of track elongation, each surveying frame having two axles having flanged wheels running on the track rails, supporting the two surveying frames on a chassis mounted on undercarriages for movement on and along the track rails, the surveying frames being so supported on the chassis that one axle of one of the surveying frames is closely adjacent one of the axles of the other surveying frame, and an undercarriage is arranged between the two axles of one of the surveying frames, continuously moving the chassis with the surveying frames on the undercarriages in said direction, continuously laterally pressing respective wheels of the adjacent axles against the opposite rails in opposite transverse directions while the chassis is continuously moving, and measuring the extend of the lateral movements of the wheels transversely of the track to establish the track gage.

9. A method of measuring the camber of superelevation of a track, comprising the steps of placing on the track two surveying frames spaced from each other in the direction of track elongation, each surveying frame having two axles having wheels running on the track rails, the wheels of each surveying frame forming a quadrangle, supporting the two surveying frames on a chassis mounted on undercarriage for movement on and along the track rails, the surveying frames being so supported that one of the undercarriages is arranged between the two axles of one of the surveying frames, establishing diagonal lines between the wheels of each of said surveying frames, extending the diagonal lines to a vertical plane wherein respective ones of the diagonal lines of respective ones of the surveying frames intersect, and measuring the distance between the diagonal lines in the plane to establish the camber or superelevation.

10. A method of measuring the flexure of a track on a ballast bed, comprising the steps of placing on the track two surveying frames spaced from each other in the direction of track elongation, each surveying frame having two axles having wheels running on the track rails supporting the two surveying frame on a chassis mounted on undercarriages for movement on and along the track rails, the surveying frames being so supported that each of the undercarriages is arranged between the two axles of a respective one of the surveying frames, establishing a first surveying point determined by one of the surveying frames, and measuring the vertical position of a second surveying point determined by the other surveying frame in respect of to the first surveying point.

11. A method of measuring the strength of the rail fastening of track rails to their ties, comprising the steps of placing on the track two surveying frames spaced from each other in the direction of track elongation, each surveying frame having two axles having flanged wheels running on the track rails, supporting the two surveying frames on a chassis mounted on undercarriages for movement on and along the track rails, the surveying frames being so supported on the chassis that one axle of one of the surveying frames is closely adjacent one of the axles of the other surveying frame and one of the undercarriages is arranged between the two axles of one of the surveying frames, continuously moving the chassis with the surveying frames on the undercarriages in said direction, continuously laterally

pressing respective wheels of the adjacent axles against the opposite rails in opposite transverse directions while the chassis is continuously moving with a lateral pressing force exceeding a predetermined strength of the rail fastening to permit the fastening to become loose and the track rails to become laterally displaced under the pressing force, and measuring the extent of such lateral displacement of the track rails caused by the lateral pressing force thereagainst.

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