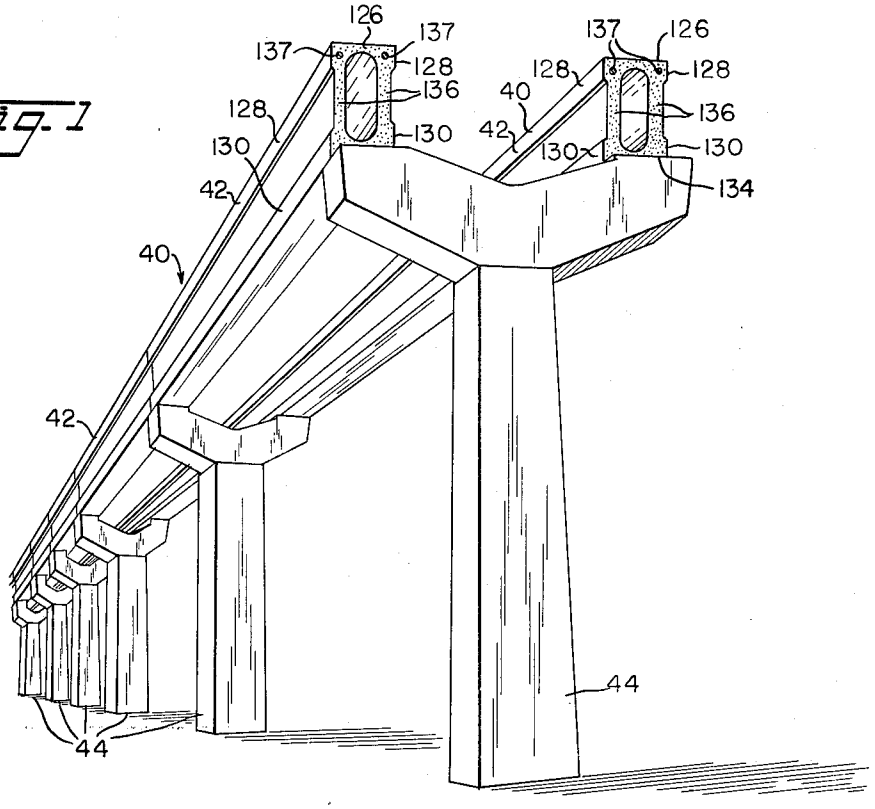
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RAILWAY SYSTEMS, MONOBEAM TYPE

Filed July 23, 1962 10 Sheets-Sheet 1

Fig. 1



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Fig. 2

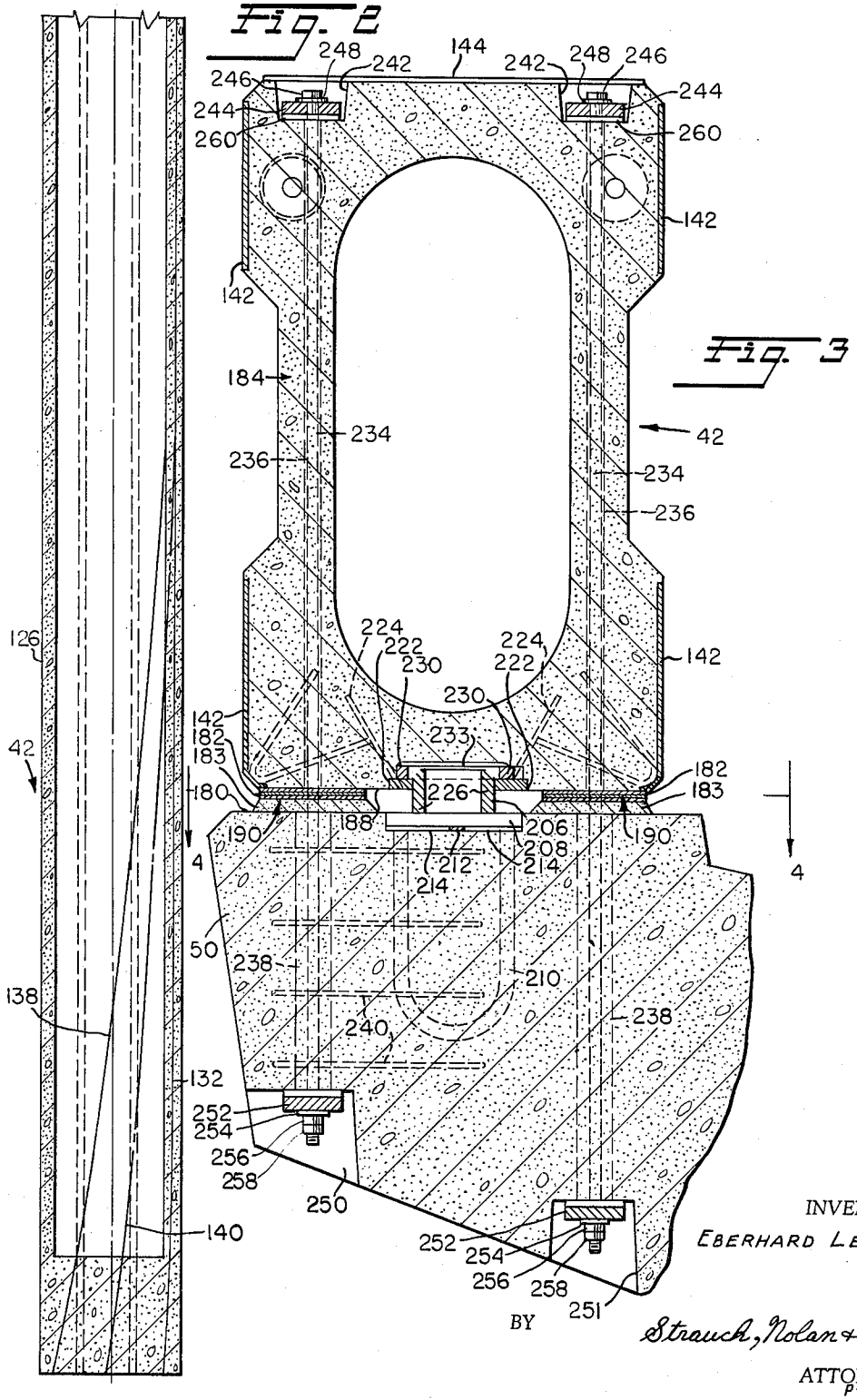


Fig. 3

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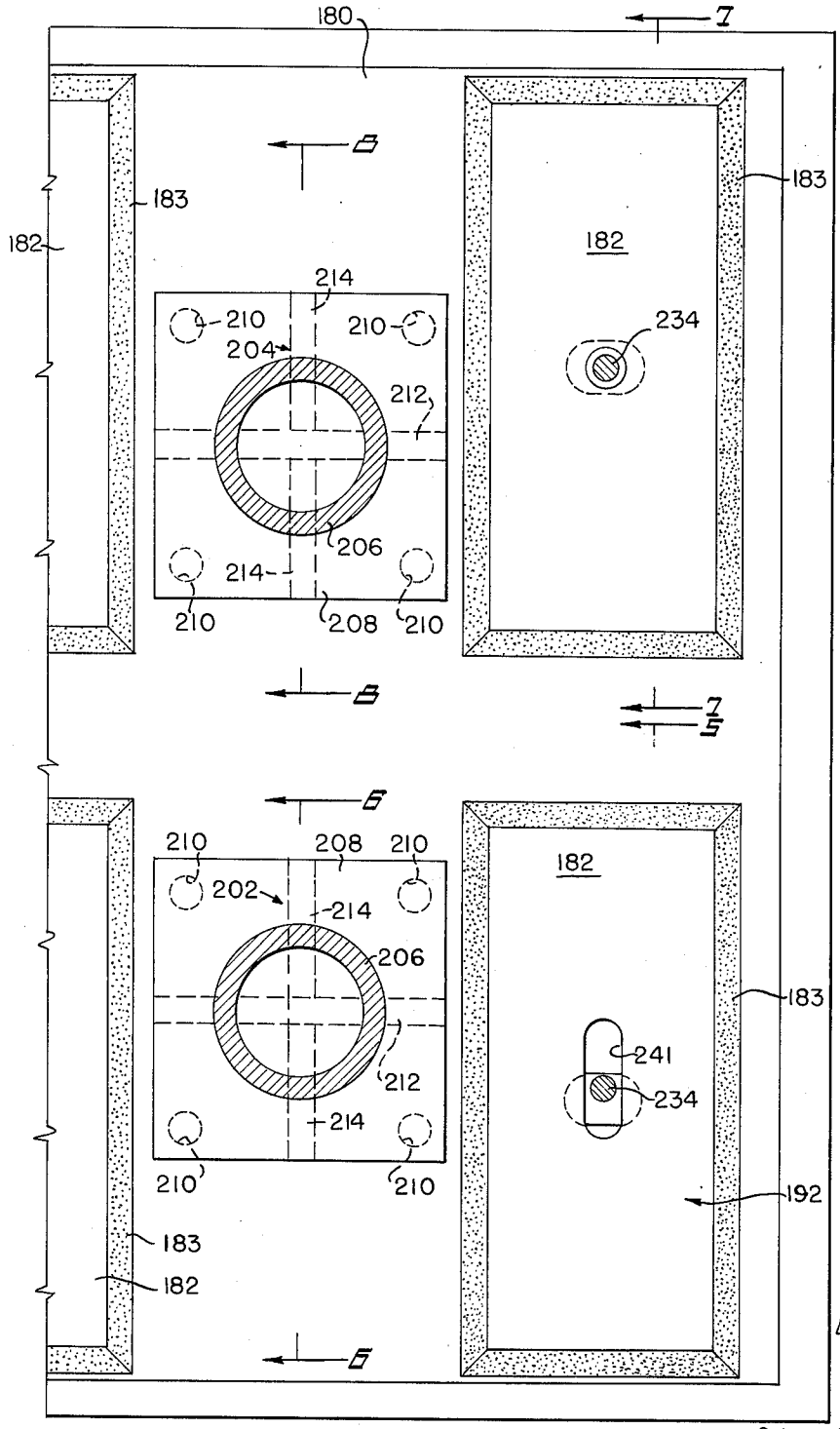


Fig. 4

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RAILWAY SYSTEMS, MONOBEAM TYPE

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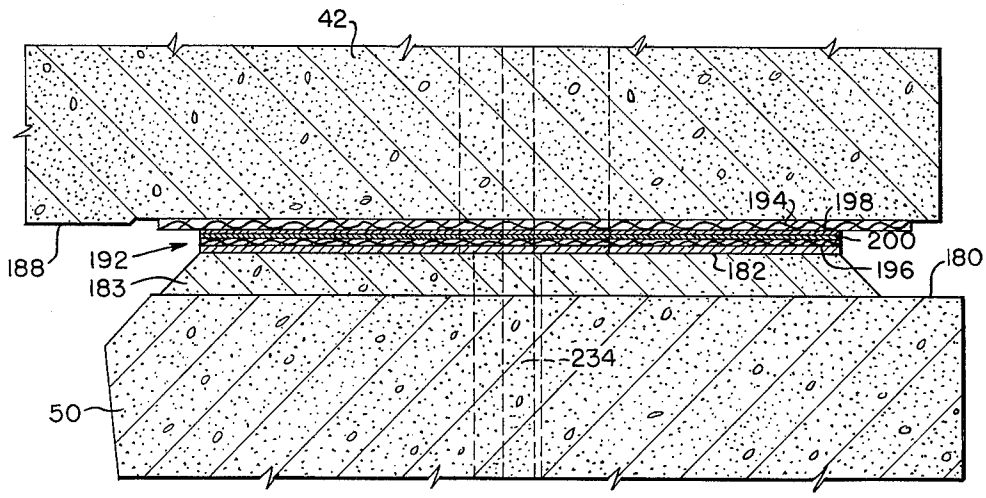


Fig. 5

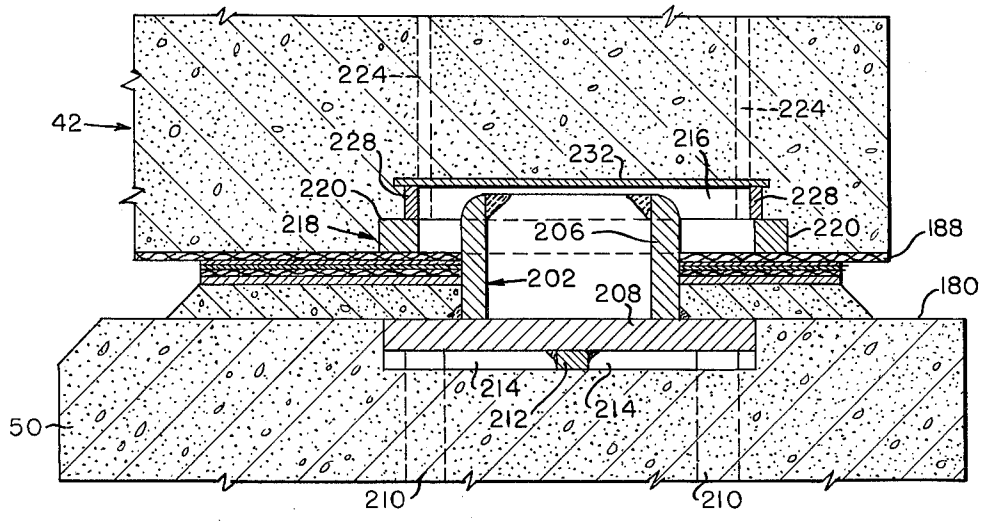


Fig. 6

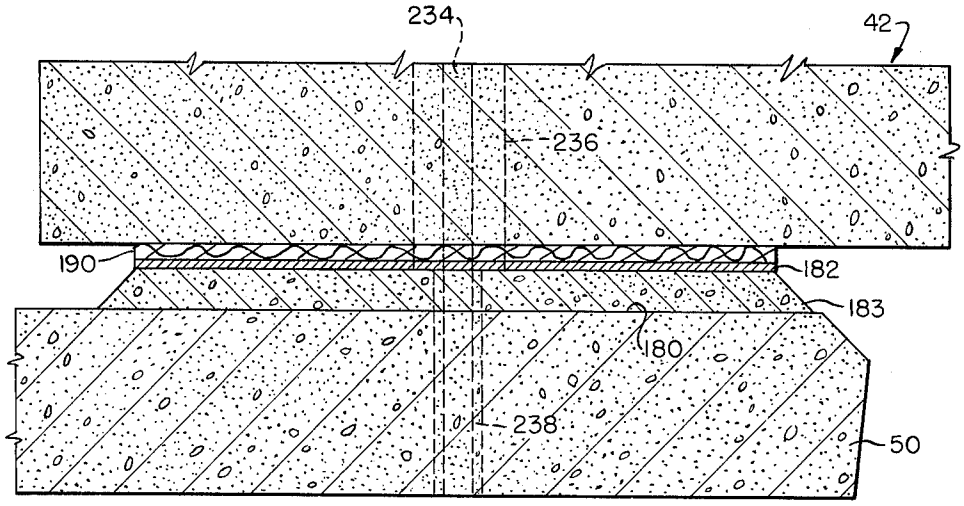
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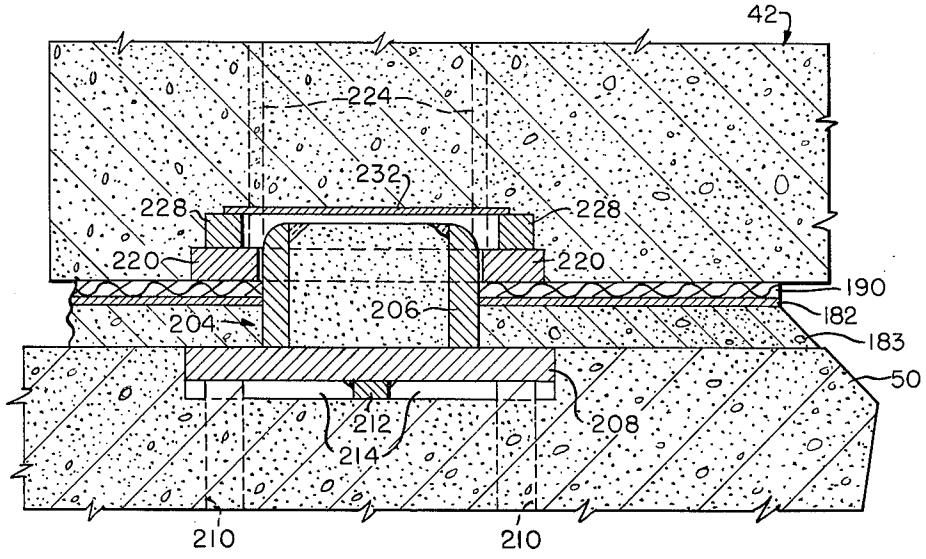
RAILWAY SYSTEMS, MONOBEAM TYPE

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FIXED

Fig. 7



FIXED

Fig. 8

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RAILWAY SYSTEMS, MONOBEAM TYPE

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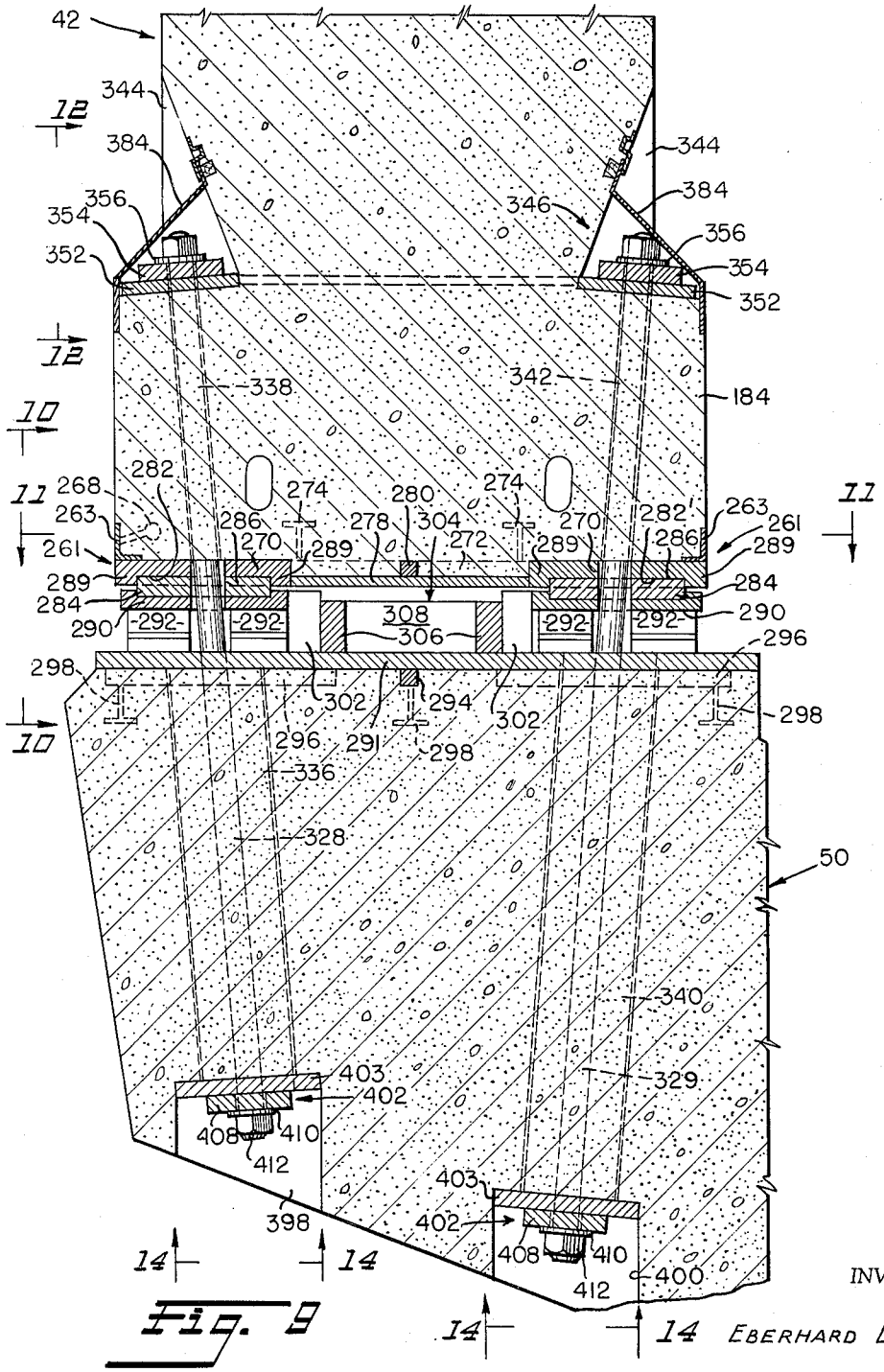


Fig. 9

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RAILWAY SYSTEMS, MONOBEAM TYPE

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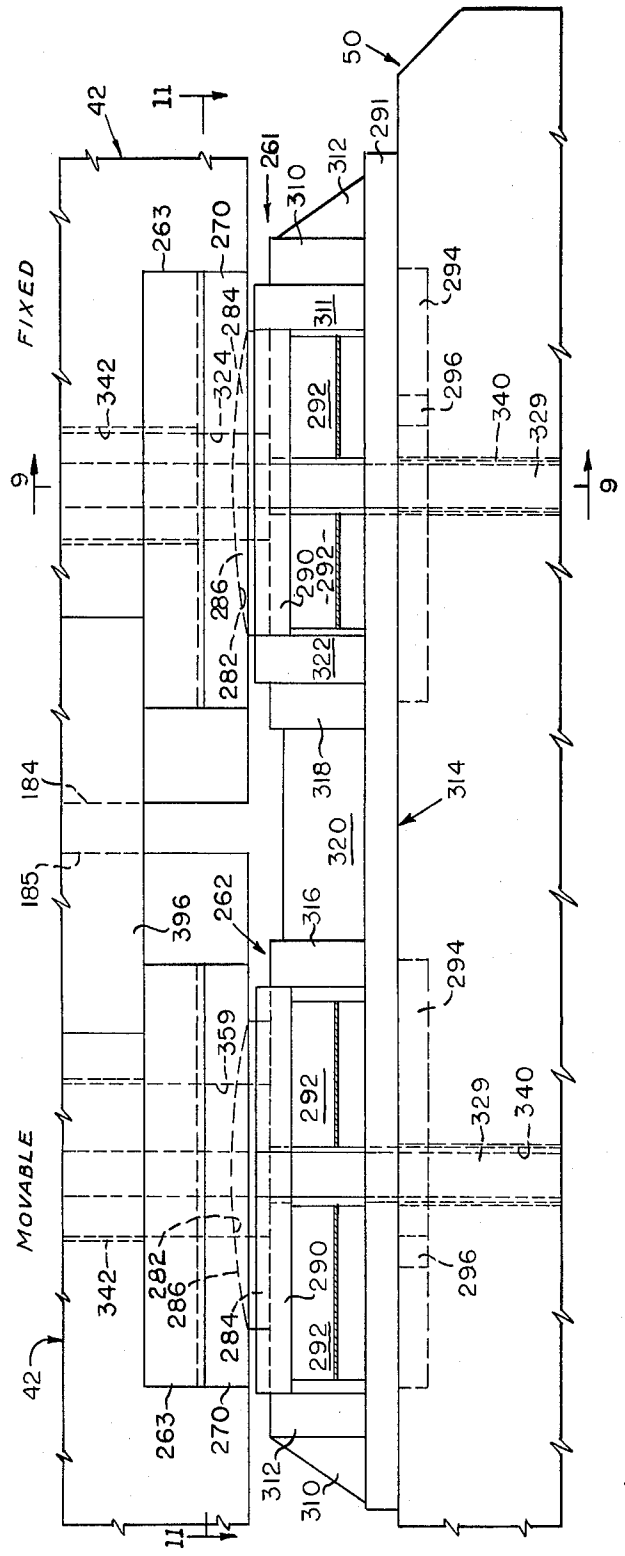


Fig. 10

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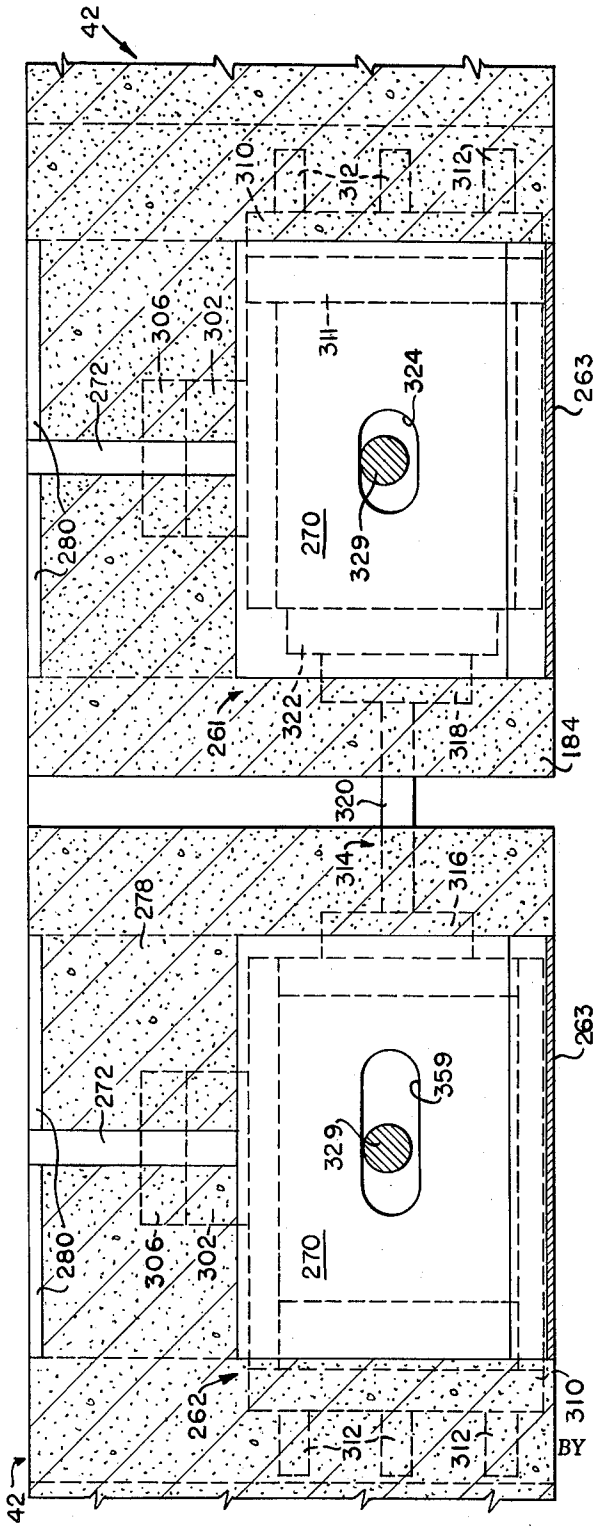


Fig. 11

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RAILWAY SYSTEMS, MONOBEAM TYPE

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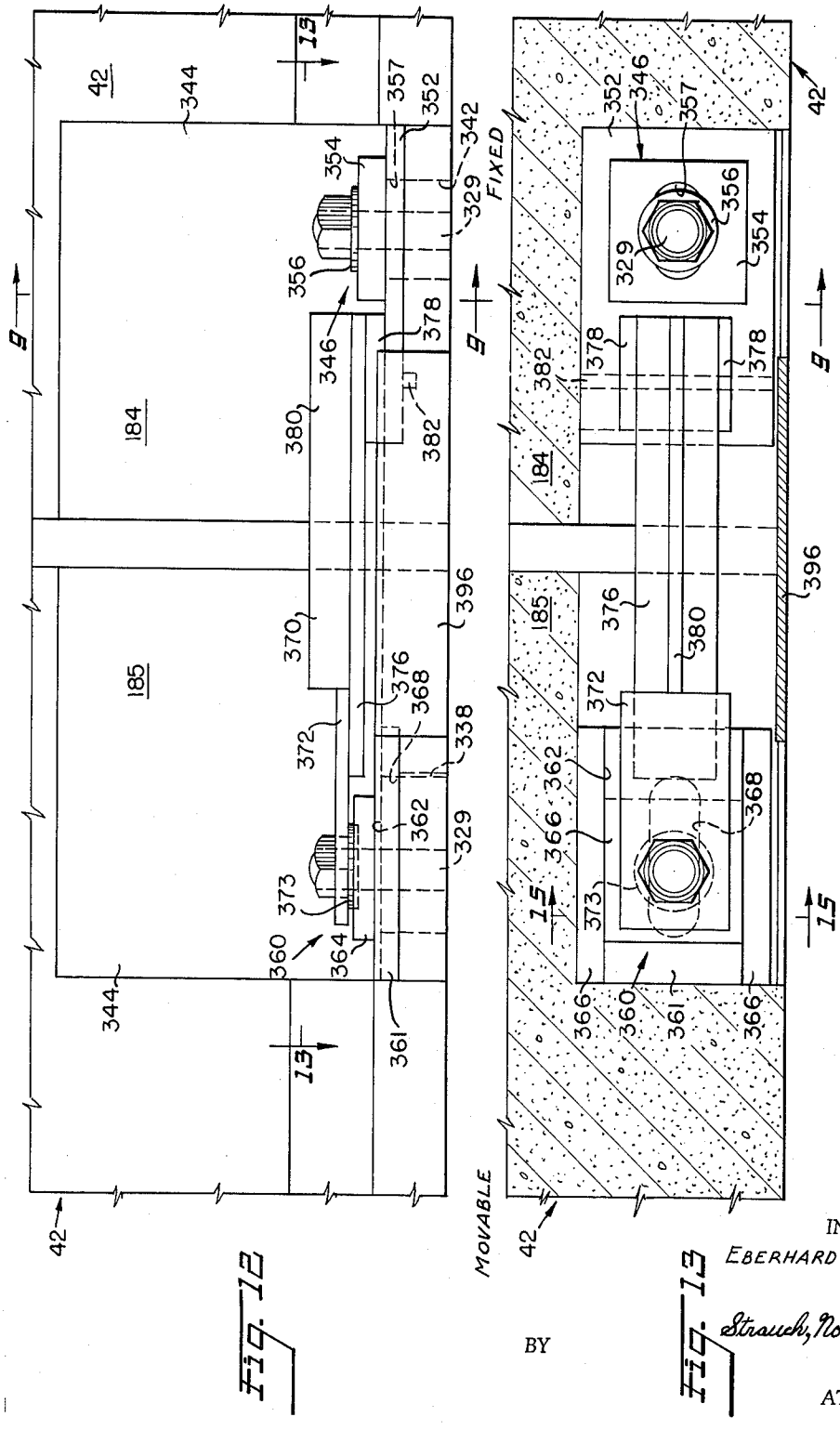


FIG. 12

FIG. 13

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RAILWAY SYSTEMS, MONOBEAM TYPE

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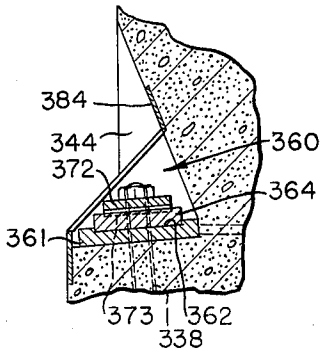


Fig. 15

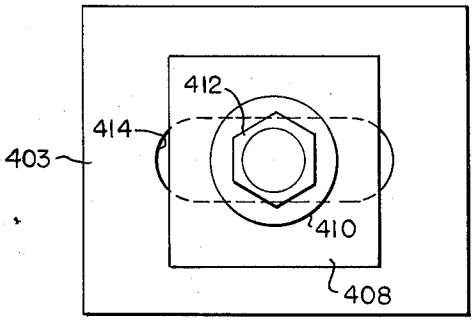


Fig. 14

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United States Patent Office 3,209,702 Patented Oct. 5, 1965

3,209,702

RAILWAY SYSTEMS, MONOBEAM TYPE

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Filed July 23, 1962, Ser. No. 211,549
22 Claims. (Cl. 104—120)

This invention relates to railway systems and, more specifically, to railway systems of the monobeam type.

Railway systems of the type to which the present invention relates consist, generally, of heavy, substantially rectangular, horizontally extending reinforced concrete beams supported twenty-five feet or more above the ground on reinforced concrete pylons. Such systems are intended to support and guide monorail passenger cars travelling at high speeds and monorail freight cars of substantial load-bearing capacity.

The monorail beam-supporting pylons employed in the monorail railway systems to which the present invention relates are graceful reinforced concrete structures extending twenty-five feet or more above ground level. These pylons are normally precast and subsequently erected on foundations previously installed along the right of way of the system.

One especially useful form of beam-supporting pylon has a substantially T-shaped configuration providing two oppositely extending beam-supporting arms at its upper end. These arms support two monorail track beams in spaced, side-by-side relationship, allowing trains to be simultaneously run in opposite directions without the necessity of providing independent systems.

Safe operation of a high speed monorail train is in part dependent upon accurate alignment of the monorail track. Even though care is exercised in aligning the beam-supporting pylons when they are erected on their foundations, it may still be necessary to align the monorail beams both vertically and horizontally when they are assembled on and before they are secured to the supporting pylons.

Accordingly, it is a primary object of the present invention to provide novel means for assembling monorail beams to beam-supporting pylons which permit the beam to be adjusted both horizontally and vertically relative to the column before it is secured in place.

In conjunction with the foregoing object it is a further object of the present invention to provide novel shear lug assemblies which may be fastened to the beam supporting pylons after the monorail beams have been aligned and which prevent lateral shifting of the beams after they are secured in place.

The reinforced concrete monorail beams to which the present invention relates may have a length of forty feet or more and may, therefore, expand and contract a significant amount.

A further object of the present invention, therefore, resides in the provision of novel means for assembling monorail beams to beam-supporting pylons which will accommodate expansion and contraction of the beams.

When large, downwardly acting forces are imposed on a monorail beam intermediate its ends, as by a passing monorail car, the central portion of the beam is flexed downwardly, resulting in rotational movement of the beam ends relative to their supporting pylons. This rotational movement is of sufficient magnitude that, if the beam ends were rigidly fixed to the supporting pylons, damage to the pylons, the beam, the beam-securing fasteners, or all of these components might result.

It is, therefore, a further object of the present invention to provide novel bearing assemblies positioned between the end portions of track beams and the structures on

which they are supported to accommodate flexure of the beams.

The reinforced concrete monorail beams may have a depth of five feet or more and may be supported on pylon arms having a depth ranging upwardly from twenty-five inches. These relatively large dimensions may vary significantly as the seasons change due to thermal expansion and contraction.

Consequently, it is a further object of this invention to provide novel means for securing monorail beams to beam-supporting pylons including structural fasteners of sufficient length that they will not be stressed beyond their elastic limits by expansion and contraction of the monorail beams and pylons.

Other objects and the novel features of the present invention will become fully apparent from the appended claims and the ensuing detailed description and discussion taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a perspective view of a monorail railway system constructed in accordance with the principles of the present invention;

FIGURE 2 is a side elevation, in section, of a reinforced concrete track beam, illustrating a typical arrangement of prestressed tendons which may be employed to reinforce the beam;

FIGURE 3 is an end view of a track beam and of a portion of the pylon on which it is supported and illustrates, partly in section, the novel fixed bearing assemblies interposed between the track beam and the supporting pylon and the novel structural fasteners employed to secure the beam to the pylon;

FIGURE 4 is a partial plan view of the fixed bearing assemblies together with novel expansion bearing assemblies provided to accommodate expansion and contraction of the track beam and novel shear lug assemblies provided to prevent lateral and, in some instances, longitudinal movement of the beam relative to the supporting pylon and is taken substantially along line **4—4** of FIGURE 3;

FIGURE 5 is a section of the expansion bearing assemblies taken substantially along line **5—5** of FIGURE 4;

FIGURE 6 is a section of the shear lug assembly employed in conjunction with the expansion bearing assemblies and is taken substantially along line **6—6** of FIGURE 4;

FIGURE 7 is a section of the fixed bearing assemblies taken substantially along line **7—7** of FIGURE 4;

FIGURE 8 is a section of the shear lug employed in conjunction with the fixed bearing assemblies and is taken substantially along line **8—8** of FIGURE 4;

FIGURE 9 is an end view of the lower portion of a track beam and that portion of the beam supporting pylon to which it is secured, and illustrates alternate bearing assemblies and structural fasteners for securing the beam to the pylon;

FIGURE 10 is a side view of the bearing assemblies looking in the direction of arrows **10—10** in FIGURE 9;

FIGURE 11 is a transverse section showing the bearing assemblies of FIGURES 9 and 10, and is taken substantially along line **11—11** of FIGURE 10;

FIGURE 12 is a side view of a portion of the monorail track beam looking in the direction of arrows **12—12** of FIGURE 9, illustrating the upper end of the structural fasteners securing the beam to its supporting pylon, the load distribution assemblies interposed between the structural fasteners and the beam for distributing stresses imposed on the fasteners to the beam, and the tie bar assemblies for preventing bending of the structural fasteners;

FIGURE 13 is a top plan view of the assemblies illustrated in FIGURE 12 looking in the direction of arrows **13—13** of FIGURE 12;

FIGURE 14 is a section of the assemblies employed at the movable ends of the beams, taken substantially along line **14**—**14** of FIGURE 13; and

FIGURE 15 is a view looking in the direction of arrows **14**—**14** of FIGURE 9 showing the lower end of one of the structural fasteners illustrating the load distribution assembly employed for distributing the stresses imposed on the fastener to the monorail beam-supporting pylon.

Referring now to the drawings, the novel railway system of the present invention comprises generally, a pair of elevated tracks **40**, each constructed from a plurality of track beams **42** assembled in end-to-end relationship, supported above the level of the surrounding terrain in side-by-side relationship on a plurality of vertical pylons **44** spaced along the right-of-way. Each of the pylons **44** comprises an elongated vertical column **48** and a beam-supporting structure at the upper end of the column including a pair of laterally extending arms **50**. Pylons **44** are preferably pre-cast concrete reinforced by a network of bars (not shown in FIGURE 1). The tops of the pylons are normally about twenty feet above the level of the surrounding terrain.

A typical pylon column **48** may have a maximum thickness and width of 4½ feet with these dimensions decreasing with elevation to provide a tapered configuration. The width of the track beam supporting structure may be on the order of 16 feet.

Pylons **44** rest on foundations (not shown in FIGURE 1) having their upper surfaces disposed on the order of 4 feet below the level of the surrounding terrain. These foundations are relatively massive pads of reinforced concrete having, in one physical embodiment, a length and width of 13 and 16 feet, respectively and a thickness of 3 feet. The details of the reinforcing bars incorporated in these foundations are not critical and will vary from installation to installation.

Referring now to FIGURES 1 and 2, the track beams **42** are elongated, hollow, reinforced concrete members having a substantially rectangular cross section. The ends of beam **42** may be solid, as shown in FIGURE 2 or may be open as illustrated in FIGURE 1, permitting the installation of electric cables and similar utilities interiorly of the beams. Beams **42** have a flat top running surface **126** for the load-supporting wheels of monorail cars which is roughened during the beam fabricating process with a brush finish, or otherwise. Flat, vertical side portions **128** and **130** adjacent the upper and lower edges, respectively, of the beam and on both sides thereof provide running surfaces for monorail car side guiding and stabilizing wheels. The pattern of reinforcing steel employed in beams **42** is not critical and will vary from installation to installation, but preferably includes straight tendons **132** in the bottom wall **134** of the beam and draped tendons **137** (see FIGURE 1) embedded in the side walls **136** of the beam in the area bounded by lines **138** and **140** (see FIGURE 2). Beams **42** are precast and both the draped and straight tendons are preferably emplaced and pretensioned and the beam cast around them.

Monorail beams **42** are typically on the order of 3 feet wide and 5 feet deep and may range in length from 40 to 90 feet. Side guide wheel running surfaces **128** and **130** typically have a width of 14 and 17 inches, respectively.

When monorail beams **42** are erected on supporting pylons **44**, a space or gap on the order of 1½ inches must be provided between the juxtaposed ends of adjoining beams to accommodate thermal expansion and contraction and to provide for manufacturing tolerances. In order to establish continuity of the top running surface **126** and the side running surfaces **128** and **130** over this gap, top finger plates (not shown) and side finger plates (not shown) are employed. These finger plates, the details of which form no part of the present invention, are disclosed in United States Patent No. 2,993,647 issued to K. Deller July 25, 1961, for "Track Constructions For Monobeam Type Railways."

The beam-supporting pylons **44** are so spaced that when the beams **42** are erected, the opposite ends of adjoining beams will be disposed above an upwardly directed bearing surface **180** (FIGURE 3) formed on the upper edge of the laterally extending, beam-supporting arms **50** of the pylon adjacent their outer ends. As was pointed out above, it is a requisite to safe high speed operation of a monorail train that the beams **42** over which the train travels be accurately aligned.

Leveling plates **182** and layers of grout **183** are employed to bring the end of each beam **42** to the proper elevation and to insure that the top running surface **126** of each beam is level or has a desired lateral or longitudinal inclination. Two leveling plates **182** are employed to support each beam end **184** and are symmetrically disposed about the vertical centerline of the beam. The leveling plates are adjusted to a vertical tolerance preferably not exceeding $\frac{1}{32}$ inch and are retained in their aligned position by grout layers **183** which are preferably conventional sand-cement grout and which are installed between the lower surfaces of the leveling plate and the bearing surface **180** of the beam-supporting pylon arm **50**.

The beams **42**, which may vary in length from 40 to 90 feet, expand and contract to a significant extent as their temperature varies. Consequently, one end of each beam **42** is rigidly fixed to the supporting arm **50** of pylon **44** (see FIGURE 3 and the appropriately labelled portion of FIGURE 4) and the other end of the beam is mounted on the next adjacent pylon for limited longitudinal movement to accommodate expansion and contraction of the beam (see FIGURE 4). A pair of bearing pads **190**, which are on the order of ½ inch thick and which are fabricated from a resilient material such as rubber, are disposed between leveling plates **182** and the bottom edge **188** of the fixed end of the beam.

When substantial vertical loads are imposed on the beam **42** intermediate its ends by a passing train, the central portion of the beam tends to move or flex downwardly with a consequent rotational movement of the beam ends **184** relative to the leveling plates **182** on which they are supported. The resilient fabric bearing pads **190** accommodate this relative rotational movement, preventing damage to the beam ends and the structural member on which it is mounted. The contact surfaces between the bearing surface **180** of pylon arm **50**, grout **183** and leveling plate **182**, leveling plate **182** and bearing pad **190**, and bearing pad **190** and the bottom edge **188** of beam **42** are preferably coated with a suitable epoxy resin bonding agent to prevent relative movement of the contacting members.

As shown in FIGURES 4 and 5, the opposite end of each of the beams **42** is mounted for limited longitudinal movement relative to the supporting pylon arm **50** by a pair of bearing pad assemblies **192**. Each of the bearing pad assemblies **192**, as is best shown in FIGURE 5, consists of a pair of fabric pads **194** and **196** (which are preferably of the same material as bearing pads **190** and accommodate relative rotational movement of the beam ends in the same manner as the latter), to the adjacent surfaces of which are secured metallic (preferably stainless steel) plates **198** and **200**. As beam **42** expands and contracts under the influence of varying temperatures plate **198** slides on plate **200**, accommodating the expansion and contraction of the beam. Pad **194** is bonded to the bottom edge **188** of beam **42** and to metal plate **198** with a suitable epoxy resin. Fabric pad **196** is bonded in a similar manner to metal plate **200** and leveling plate **182**. And, as has been described above, the grout **183**, employed to align beam **42**, is similarly bonded to leveling plate **182** and to the bearing surface **180** of pylon arm **50**.

Although it is necessary to allow limited longitudinal movement of one end of each of the beams **42** it is, at the same time, necessary to prevent lateral shifting of both

the fixed and movable ends of the beam ends to insure safe operation of high speed monorail trains over the tracks **40**. For this purpose the novel shear lugs illustrated in FIGURES 4, 6, and 8 are employed. Shear lugs **202** (FIGURE 6) are employed at the longitudinally movable ends of the monorail **42** and the shear lugs **204** (see FIGURE 8) are used at the fixed ends of the beams **42**.

Referring first to FIGURES 4 and 6, each of the shear lugs **202** consists of a cylindrical member **206** attached at its lower end, preferably by welding, to a bearing plate **208** embedded in and flush with the bearing surface **180** of pylon arm **50**. Bearing plate **208** is retained in pylon arm **50** by U-shaped reinforcing bars **210** welded to the bottom edges of plate and extending downwardly into the pylon arm. As a further precaution against shifting of the bearing plate relative to the pylon arm **50** in which it is mounted, shear lugs **212** and **214**, disposed at right angles to each other, are welded to the bottom of plate **208** and embedded in the pylon arm.

Shear lug member **206** extends upwardly into a pocket **216** formed in the lower edge **188** of beam **42**. Disposed in pocket **216** flush with the bottom edge **188** of beam **42** is a rectangular metallic frame **218** fabricated from a pair of end bars **220** and a pair of side bars **222**. The frame **218** is firmly retained in beam **42** by reinforcing rods **224**, only two of which are shown (see FIGURES 3 and 6). The side bars **222** of the frame **218** are so spaced that their inner surfaces **226** are about $\frac{1}{32}$ inch from the opposite exterior surface portions of shear lug member **206**. The end bars **220**, on the other hand, are spaced sufficiently far apart to permit sufficient movement of the shear lug to accommodate expansion and contraction of the beam.

Welded to the upper edges of bars **220** and **222**, respectively, are bars **228** and **230** to which, in turn, is welded a plate **232** defining the inner end of pocket **216**.

After beams **42** are erected on pylon arms **50** and aligned, shear lug members **206** are welded to the bearing plates **208** to maintain the beam ends **184** in alignment and their hollow interiors are filled with grout. After the beams **42** are in place, the portions of pockets **216** surrounding shear lug members **206** are preferably filled with Igas or an equivalent material.

Shear lugs **204** are substantially identical to shear lugs **202** and like reference characters have, therefore, been employed to designate like elements. The only substantial distinction between shear lugs **202** and **204** is that, in the latter, the end bars **220** of the frame **218** embedded in the lower portion of beam **42** and defining the pocket **216** into which the cylindrical shear lug member **206** extends are so spaced as to provide only about a $\frac{1}{32}$ inch clearance between the bars **220** and cylindrical member **206** to preclude longitudinal movement of the beam ends with which the shear lugs **204** are associated.

Referring now to FIGURES 3 and 4, after the beam **42** is erected on its supporting pylon arms **50** and shear lug members **206** are welded to bearing plates **208**, each of the monorail beam ends **184** is secured to the supporting pylon arm by a pair of high strength rods **234** symmetrically disposed relative to the vertical centerline of beam **42**. The rods **234** extend through elliptically-sectioned tubes **236** embedded in beam **42** (which are preferably filled with grout after the bolts are installed) and elliptically-sectioned tubes **238** embedded in pylon arm **50**. Tubes **236** and **238** are oriented with their major axes at right angles to the longitudinal axis of beam **42**, permitting the beam end **184** to be shifted in the final alignment process without making it difficult to subsequently insert rods **234**. Embedded tubes **238** may be secured in place with U-shaped reinforcing bars **240**, only a few of which are shown. Longitudinally extending slots **241** formed in the leveling plates **182** of expansion bearing assemblies and vertically aligned slots of the same configuration (see FIGURE 5) in fabric pads **194** and **196** and in slide plates **198** and **200** accommodate expansion and contraction of beam **42**, preventing changes in beam length from imposing bending stresses on rods **234**.

The upper ends of rods **234** are disposed in notches **242** formed in the top running surface **126** of beam **42**. Rectangular load distribution plates **244**, separated from the nuts **246** threaded onto rods **234** by washers **248**, distribute the stresses imposed on the rods over substantial areas of the beam ends **184**. The top running surface finger plates **144** cover the upwardly opening recesses **242** which are preferably filled with Igas after rods **234** are installed and tightened.

Rods **234** terminate, at their lower ends, in recesses **250** and **251** formed in the lower edge of the pylon arms **50**. Load distribution plates **252**, similar to the plates **244** described above, are disposed over the lower ends of rods **234** to distribute tensile stresses imposed on the bolts over substantial areas of the pylon arm **50**. Threaded on the lower end of each rod **234** is a washer **254**, a nut **256**, and a lock nut **258**. The nuts **256** are tightened to impose a tension load of about 20 kilograms on the rods **234**.

Fabric pads **260** and **262** are disposed between load distribution plates **244** and the inner ends of recesses **242** and between load distribution bars **252** and the inner ends of recesses **250** and **251** to accommodate expansion of the pylon arm and the beam end and minor relative movement between these members.

Because of their long length, bolts **234** are able to absorb high stresses without exceeding their elastic limit.

After rods **234** have been pretensioned, several trial runs at moderate speed are made over the track **40**, following which rods **234** are checked and retensioned if necessary. Recesses **250** and **251** are then closed with wooden plugs (not illustrated) and finished with an epoxy resin and sanded to match the surrounding concrete of the pylon support arm **50**.

FIGURE 9 illustrates an alternate arrangement for assembling beams **42** to the supporting arms **50** of pylons **44**. As in the mounting arrangement described above, one end of each beam **42** (which may be hollow as shown, or solid) is longitudinally fixed to a pylon support arm **50** and the opposite end is mounted for limited longitudinal movement on the supporting arm **50** of the adjacent pylon to accommodate expansion and contraction. Thus, each pylon arm supports the fixed end of one beam and the movable end of the adjacent beam. FIGURE 9 illustrates the arrangement employed at the fixed ends of the beams. The fixed and movable beam ends are indicated by appropriate legends in FIGURES 10 and 11.

Two fixed bearing assemblies **261** support the fixed end **184** of the beam and two expansion bearing assemblies **262** support the movable beam end **185**. The bearing assemblies at each end of the beam are symmetrically disposed relative to the vertical centerline of the beam. In the ensuing description detailed reference to the fixed bearing assemblies **261** will be made. The expansion bearing assemblies **262** are identical with certain exceptions which will be pointed out hereinafter.

Embedded in lower corners of the fixed end beam **42** are angles **263** retained in place by reinforcing bars **268**, only one of which is shown. Fastened to the bottom of beam **42** are a pair of upper bearing supports **270** connected by a laterally extending shear lug **272**. Bearing supports **270** may be welded to angles **263** to retain them in place. Shear lug **272** is fixed to beam **42** by a pair of reinforcing members **274** welded to the shear lug.

Welded to bearing supports **270** is a laterally extending plate **278** also welded to shear lug **272** and to shear lugs **280** embedded in the beam end. Extending into recesses providing concave bearing support surfaces **282** in upper bearing supports **270** are a pair of elongated, longitudinally extending, preferably bronze, bearings **284** having convex upper surfaces **286**.

As stated above, a passing train imparts a substantial vertical load on the monorail beam **42** intermediate its ends, tending to bend or flex the central portion of the beam downwardly and to rotate the beam ends relative to the pylon support arms **50**. This rotational movement which would otherwise impose high stresses on the edges of the pylon support arms is accommodated by the mating surfaces of bearings **284** and supports **270** which have the same degree of curvature to provide maximum weight distribution and to facilitate free sliding movement of the bearing surfaces. These cooperating arcuate bearing surfaces are formed on a circle having its center substantially at the lower ends of the bolts securing the beam ends to pylon supporting arm **50**. As a result, little, if any, stress will be imposed on these bolts by the rotation of the beam end and the consequent sliding movement of the bearings relative to the upper supports. Depending side walls **289** of upper bearing supports **270** (see FIGURE 9) prevent lateral movement of the bearings **284**.

Bearings **284** are received in recesses formed in supports **290** (see FIGURES 9 and 10) spaced from a bearing plate **291** by rectangular shims **292** which are of appropriate thickness to dispose the top running surface of beam **42** at the proper elevation.

Shifting of bearing plate **291** relative to pylon support arm **50** is prevented by longitudinally extending shear lugs **294** and a pair of laterally extending shear lugs **296** welded to the bottom of the plate and embedded in pylon support arm **50**. Shear lugs **294** and **296** are positioned by bar assemblies **298**.

Lateral movement of the beam end relative to pylon support arm **50** is prevented by a pair of shims **302** which bear against supports **290** and against shear lug assembly **304** which includes a pair of longitudinally extending bars **306** welded to the bearing plate **291** and separated by one or more transversely extending stiffener bars **308** welded to the bars **306** and to the bearing plate. After final adjustment of beam **42**, shims **302** are welded to bearing plate **291**.

Longitudinal movement of the fixed beam end **184** is limited in one direction (see FIGURE 10) by vertical plates **310** welded to plate **291** and by shims **302** disposed between plates **310** and supports **290** and engaging bearings **284**. A plurality of triangular support fillets **312** are welded to the plates **310** and to bearing support plate **291**.

Longitudinal movement of the bearings **284** and supports **290** (and, therefore, the beam end **184**) in the opposite direction is prevented by the stiffener assemblies (only one of which is shown) indicated generally at **314** which are prevented from shifting to the left as viewed in FIGURE 10 by the supports **290** of expansion bearing assemblies **262** and the plates **310** of those assemblies. Each stiffener assembly **314** consists of a pair of plates **316** and **318** separated by a longitudinally extending stiffener plate **320**. Plate **318** is separated from lower bearing support **290** of bearing assembly **261** by shims **322** to facilitate alignment of the juxtaposed ends of adjacent beams **42**.

Slightly elongated slots **324** are formed in the upper walls of the upper bearing supports **270** to permit alignment of the fixed beam end **184** without hindering the subsequent insertion of bolts **328** and **329**, but to prevent substantial longitudinal movement of the fixed beam end once it has been aligned and secured in place. The slight elongation of the slot, however, permits limited movement of support **270** on bearing **284** in response to flexure of the central portion of the beam without stressing bolts **328** and **329**.

Referring now to FIGURE 9, the bolt **328** securing fixed beam end **184** to pylon support arm **50** extends through elliptical aligned tubes **336** and **338** embedded in the pylon support arm and the beam end, respectively. The elliptical section of these tubes permits lateral alignment of the fixed beam end **184** on the pylon support arm without hindering the subsequent insertion of bolt **328**. Bolt **329** is disposed in similar tubes **340** and **342**, embedded in the pylon support arm and beam end, respectively, on the opposite side of the beam from bolts **328**. Bolts **328** and **329** are symmetrically disposed relative to the vertical centerline of the monorail beam **42** for maximum resistance to tipping of the beam.

The upper ends of bolts **328** and **329** extend into notches **344** formed in the sides of beam **42**. Bolts **328** and **329** are separated from the beam by load distribution assemblies **346** which consist of a lower load distribution plate **352** supported on the beam, an upper load distribution plate **354** supported on the lower plate **352**, and a washer **356** disposed between the upper load distribution plate and the head of the bolt **328** or **329** as the case may be. Slightly elongated slots **357** (see FIGURE 13) are formed in the plates **354** and **352** in alignment with the upper ends of the tubes **338** and **342**, respectively, to permit alignment of the fixed ends **184** of the monorail beams.

The movable ends **185** of beams **42** are mounted in the same manner as the fixed beam ends **184** except that the shims **311** and **322** are omitted and elongated slots **359** (see FIGURE 11) are formed in the upper bearing supports **270**. Omission of shims **311** and **322** permits sliding movement of bearings **284** on fixed supports **290** to accommodate expansion and contraction of the beam. The elongated slots **359** insure that this movement will not impose bending stresses on bolts **328** and **329**.

The movable ends of beams **42** are secured to the pylon support arm **50** by structural fasteners identical to the structural fasteners **328** and **329**. The upper ends of fasteners **328** and **329** terminate in notches **344**. At this end of the beams **42**, however, different load distribution assemblies **360** are employed. The assembly **360** associated with bolt **329** is illustrated in FIGURES 12, 13 and 15. An identical assembly is employed with bolt **328**.

The assembly **360** includes a plate **361** supported on beam **42** and having a longitudinally extending recess **362** slidably supporting a bronze plate **364** which is restrained from lateral movement by the recess walls. A longitudinally elongated slot **368** formed in load distribution plate **361** accommodate expansion and contraction of the movable beam end **358** without imposing bending stresses on the bolts **328** and **329**.

The upper ends of the bolts **328** and **329** associated with the movable beam ends are tied to the fixed beam ends to maintain those bolts vertical and thus avoid excessive bolt stress when the beam ends shift due to expansion or contraction.

Tie assemblies **370** are provided for this purpose, each assembly comprising a tie bar **372** surrounding the bolt **328** or **329** at the movable end of the beam and separated from the head of the bolt by a circular washer **373**. Welded or otherwise secured to tie bar **372** is a tie plate **376** which extends substantially to the upper end of the bolt **329** at the fixed end of the adjacent beam. The end of tie plate **376** at the fixed end of the beam is secured to lower load distribution plate **352** by a plate **378** welded to the tie plate **376** and to the plate **352**. A stiffener plate **380** is also welded to the tie plate **376**. The tie bar assembly **370** is anchored to the fixed beam end by a transversely extending shear lug **382** welded to the lower surface of the lower load distribution plate **352** embedded in the beam.

Cover plates **384** (see FIGURES 9 and 15) may be installed over the upper ends of bolts **328** and **329** and the load distribution assemblies **346** and **360** at both the fixed and movable ends of the beams. Finger plates **396**, similar to the finger plates **142** described above, bridge the gap between adjoining beams **42** (see FIGURE 13).

With reference now to FIGURES 9 and 14, the lower ends of bolts **328** and **329** securing both the fixed and movable beam ends to pylon support arm **50** are disposed

in notches 398 and 400, respectively, formed in the lower surface of pylon support arm. Identical load distribution assemblies 402 are employed at the lower ends of bolts 328 and 329 to distribute the loads imposed on them over a substantial area of plyon support arm 50. Each of the load distribution assemblies 402 includes metal plates 403 and 408. Nuts 412 are tightened until bolts 328 and 329 are pretensioned to approximately 85 kilograms.

As is best shown in FIGURE 14, laterally elongated slots 414, having substantially the same cross-sectional configuration as the tubes 336 and 340 embedded in pylon support arm 50, are formed in load distribution plates 403 to permit lateral alignment of the beams 42.

After the monorail beams 42 are erected, several train runs at moderate speeds are made over the tracks 40. Structural fasteners 328 and 329 are then checked and, if necessary, retightened to the proper tension.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. A monorail track construction, comprising:
(a) a plurality of spaced apart beam-supporting pylons, each of said pylons having at least one beam-supporting portion with an upwardly directed beam-supporting surface;
(b) a plurality of monorail beams disposed in end-to-end relationship above said pylons with the opposite ends of adjacent beams over the supporting surface of each pylon's beam-supporting portion;
(c) first means securing one end of each of said beams to the beam-supporting portions of one of said pylons, said first means fixing said beam against movement relative to said pylons; and
(d) second means securing the other end of each of said beams to a beam-supporting portion of a second pylon adjacent that to which said one end is fixed including at least one bearing plate assembly transverse of said beam having first and second substantially horizontal relatively slidable members fixed, respectively, to said other beam end and to the beam-supporting portion of said second pylon to enable limited movement of said beam relative to said second pylon and thereby provide for expansion and contraction of said beam, and resilient fabric bearing means independent of and interposed between the vertically spaced surface of at least one of said first and second members and the track component to which said member is fixed including means enabling limited rocking movement of said other beam end relative to said second pylon to accommodate vertical flexure of said beam intermediate its ends.

2. A monorail track construction, comprising:
(a) a plurality of spaced apart beam-supporting pylons, each of said pylons having at least one beam-supporting portion with an upwardly directed beam-supporting surface;
(b) a plurality of monorail beams disposed in end-to-end relationship above said pylons with the opposite ends of adjacent beams over the supporting surface of each pylon's beam-supporting portion;
(c) first means securing one end of each of said beams to a beam-supporting portion of one of said pylons, said first means fixing said beams against movement relative to said pylons;
(d) second means securing the other end of each of said beams to a beam-supporting portion of a pylon adjacent that to which said one end is fixed including means enabling limited rocking movement of said other beam end relative to said second pylon to accommodate vertical flexure of said beam intermediate its ends; and
(e) a pair of shear lugs independent of said first and second beam end securing means fixed to each of said beam-supporting portions and extending upwardly from the supporting surface of each beam-supporting portion into each of the beam ends above said beam-supporting portion to prevent lateral movement of said beam ends.

3. The monorail track construction as defined in claim 1, wherein said first beam and end securing means includes means enabling limited rocking movement of said one beam end relative to said one pylon to accommodate vertical flexure of said beam intermediate its ends.

4. In a monorail track construction:
(a) a beam-supporting pylon having a laterally extending beam-supporting arm with an upwardly directed bearing surface on the upper edge thereof;
(b) a monorail beam above said pylon with one end thereof over said bearing surface;
(c) bearing means between said beam-supporting arm and said one beam end, said bearing means including a pair of smooth-surfaced metallic slide plates permitting relative sliding movement between said one beam end and said pylon and a pair of fabric pads on opposite sides of said slide plates to enable limited rocking movement between said beam end and the beam-supporting portion of the pylon and thereby accommodate vertical flexure of the beam intermediate its ends; and
(d) means securing said one beam end to said plyon including a plurality of high strength structural fasteners extending through said one beam end and said supporting arm.

5. In a monorail track construction:
(a) a beam-supporting pylon having a laterally extending beam-supporting arm with an upwardly directed bearing surface on the upper edge thereof;
(b) a monorail beam above said pylon with one end thereof over said bearing surface;
(c) bearing means between said beam-supporting arm and said one beam end including a single fabric pad bonded to the bottom of said one beam end, a bearing plate bonded to said pad, a layer of grout between said bearing plate and said bearing surface, a bonding agent between said bearing plate and said grout and between said grout and said bearing surface; and
(d) means securing said one beam end to said pylon including a plurality of high strength structural fasteners extending through said one beam end and said supporting arm.

6. In a monorail track construction:
(a) a beam-supporting pylon having a laterally extending beam-supporting arm with an upwardly directed bearing surface on the upper edge thereof;
(b) a monorail beam above said plyon with one end thereof over said bearing surface;
(c) bearing means between said beam-supporting arm and said one beam end;
(d) means securing said one beam end to said beam-supporting arm;
(e) a shear lug extending upwardly from said bearing surface into said one beam end to prevent shifting of said one beam end relative to said beam-supporting arm;
(f) a shear plate fastened to the bottom of said shear lug and embedded in said beam-supporting arm with the upper surface thereof substantially contiguous with said bearing surface; and

(g) a pair of shear lugs disposed at right angles and fastened to the bottom of said shear plate, said shear lugs being embedded in said beam-supporting arm.

7. In a monorail track construction:

(a) a beam-supporting pylon having a laterally extending beam-supporting arm with an upwardly directed bearing surface on the upper edge thereof;

(b) a monorail beam above said pylon with one end thereof over said bearing surface;

(c) bearing means between said beam-supporting arm and said one beam end;

(d) means securing said one beam end to said beam-supporting arm including a plurality of high strength structural fasteners extending through said one beam end and said beam-supporting arm;

(e) a shear lug extending upwardly from said bearing surface into said one beam end to prevent shifting of said one beam end relative to said beam-supporting arm;

(f) means providing a downwardly opening recess in the bottom of said one beam end; and

(g) a plate disposed in said recess with the lower surface thereof substantially contiguous with the lower surface of said one beam end, said plate having a through aperture therein, and said shear lug extending upwardly through said aperture with said plate in closely surrounding relationship thereto.

8. In a monorail track construction:

(a) a beam-supporting pylon having a laterally extending beam-supporting arm with an upwardly directed bearing surface on the upper edge thereof;

(b) a monorail beam above said pylon with one end thereof over said bearing surface;

(c) bearing means between said beam-supporting arm and said one beam end;

(d) means securing said one beam end to said beam-supporting arm including a plurality of high strength structural fasteners extending through said one beam end and said beam-supporting arm;

(e) a shear lug extending upwardly from said bearing surface into said one beam end to prevent shifting of said one beam end relative to said beam-supporting arm;

(f) means providing a downwardly opening recess in the bottom of said one beam end; and

(g) a plate disposed in said recess with the lower surface thereof substantially contiguous with the lower surface of said one beam end, said plate having a through aperture therein with said shear lug extending upwardly through said aperture, said aperture having a width only slightly greater than the width of said shear lug to prevent lateral shifting of said one beam end relative to said support arm and a length substantially greater than the thickness of said shear lug to accommodate expansion and contraction of said beam relative to said beam-supporting arm.

9. In a monorail track construction:

(a) beam-supporting pylon having a laterally extending beam-supporting arm with an upwardly directed bearing surface on the upper edge thereof;

(b) a monorail beam above said pylon with one end thereof over said bearing surface, said beam having a substantial vertical thickness and means providing a horizontal ledge intermediate the lower and upper edge surfaces thereof;

(c) bearing means between said beam-supporting arm and said one beam end;

(d) means securing said one beam end to said beam-supporting arm including a plurality of high strength structural fasteners extending through said supporting arm and the portion of said one beam end between the bottom of said beam and said horizontal ledge; and

(e) a metallic tube embedded in said beam-supporting arm in surrounding relationship to each of said structural fasteners, each of said tubes having an elliptical cross section with the major axis of said ellipse substantially normal to the length of said beam, whereby said one beam end may be laterally shifted relative to said beam-supporting arm to align said one beam end without imposing bending stresses on said structural fasteners.

10. The monorail track construction as defined in claim 1, wherein said beam end securing means include:

(a) a plurality of high strength structural fasteners extending through each beam end and the associated beam-supporting portion of one of said pylons;

(b) washer means between said structural fastener and said beam and between said supporting portion and said structural fasteners; and

(c) a resilient pad between each of said washer means and the adjacent beam end or supporting portion to accommodate expansion of said beam supporting portion and said beam.

11. The monorail track construction as defined in claim 1, wherein:

(a) each said beam supporting portion is a beam-supporting arm of substantial depth incorporated in and extending from said pylon; and

(b) said first and second beam end securing means each include at least one high strength anchor bolt extending through said pylon arm and one beam end.

12. The monorail track construction as defined in claim 4, wherein one of said fabric pads is bonded to the bottom of said one beam end and further including a bearing plate bonded to the other of said fabric pads and a layer of grout between said bearing plate and said bearing surface.

13. The monorail track construction as defined in claim 12, including an epoxy resin bonding agent between said bearing surface and said grout, said grout and said bearing plate, said bearing plate and said other fabric pad, said one fabric pad and said one beam end, and between each of said fabric pads and the associated slide plate.

14. The monorail track construction as defined in claim 6, including reinforcing means fastened to the bottom of said shear plate and embedded in said supporting arm.

15. The monorail track construction as defined in claim 7, including reinforcing means fastened to said plate and extending into and embedded in said one beam end to prevent dislocation of said plate.

16. A monorail track construction, comprising:

(a) a monorail beam-supporting pylon including a member providing an upwardly directed bearing surface;

(b) a monorail beam above said pylon with one end thereof over said bearing surface; and

(c) means for securing said one beam end to said pylon, including

(d) a plurality of elongated structural fasteners extending through said beam one end and said bearing surface defining member; and

(e) metal tubes embedded in said beam one end and said bearing surface-defining member and surrounding said structural fasteners, said metallic tubes having a cross sectional dimension in the direction normal to the length of said beam substantially greater than said structural fasteners, whereby said beam one end may be shifted relative to said bearing surface to align said beam one end without imposing bending stresses on said structural fasteners.

17. The monorail track construction as defined in claim 16, including a plurality of bearing means between said beam one end and said bearing surface, each of said bearing means having a through aperture with the wall defining said aperture surrounding one of said structural fasteners, said aperture having a dimension in the direction normal to the length of said beam substantially greater than the corresponding dimension of said structural fastener, whereby said bearing means may be shifted in a direction normal to the length of said beam to align said

beam one end without contacting said structural fastener.

18. The monorail track construction as defined in claim **16**, wherein the cross section of said beam is symmetrical about a vertical line and said beam one end is ers, said structural fasteners being substantially vertical and being disposed at equal distances from said vertical line on the opposite sides thereof, said structural fasteners being pretensioned to a predetermined tensile stress.

19. The monorail track construction as defined in claim **9**, wherein said structural fasteners are tensioned to a predetermined tensile stress and plate-like load distribution members of substantial surface area are operatively interposed between said structural fasteners and said beam-supporting arm and between said structural fasteners and said one beam end to distribute stresses imposed on said structural fasteners over a substantial area of said track-supporting arm and said one beam end.

20. The monorail track construction as defined in claim **9**, wherein said bearing means includes a shim on either side of each of said structural fasteners.

21. The monorail track construction as defined in claim **9** including a first bearing plate embedded in said beam one end and having its upper surface substantially contiguous with said horizontal ledge and a second bearing plate embedded in said track-supporting arm, said first and second bearing plates having aligned apertures for receiving one of said structural fasteners, the aperture in

said second bearing plate being elongated in a direction normal to the length of said beam.

22. The monorail track construction as defined in claim **21**, wherein one of said first bearing plates and one of said second bearing plates are provided for each of said structural fasteners.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,209,702 October 5, 1965

Eberhard Lemcke

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 66, before "embedded" insert -- and --; column 9, line 55, for "surface" read -- surfaces --; column 13, line 4, after "is" insert -- secured to said pylon by a pair of said structural fasten- --.

Signed and sealed this 31st day of May 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents