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Ogletree

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[54] **ERECTING SEGMENTAL SPANS**

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[52] **U.S. Cl.** **14/1,** 52/86, 14/77

[51] **Int. Cl.** **E01d 1/00**

[58] **Field of Search** 14/77, 1, 7, 23, 13; 52/73, 86, 747, 741; 404/73, 72, 99

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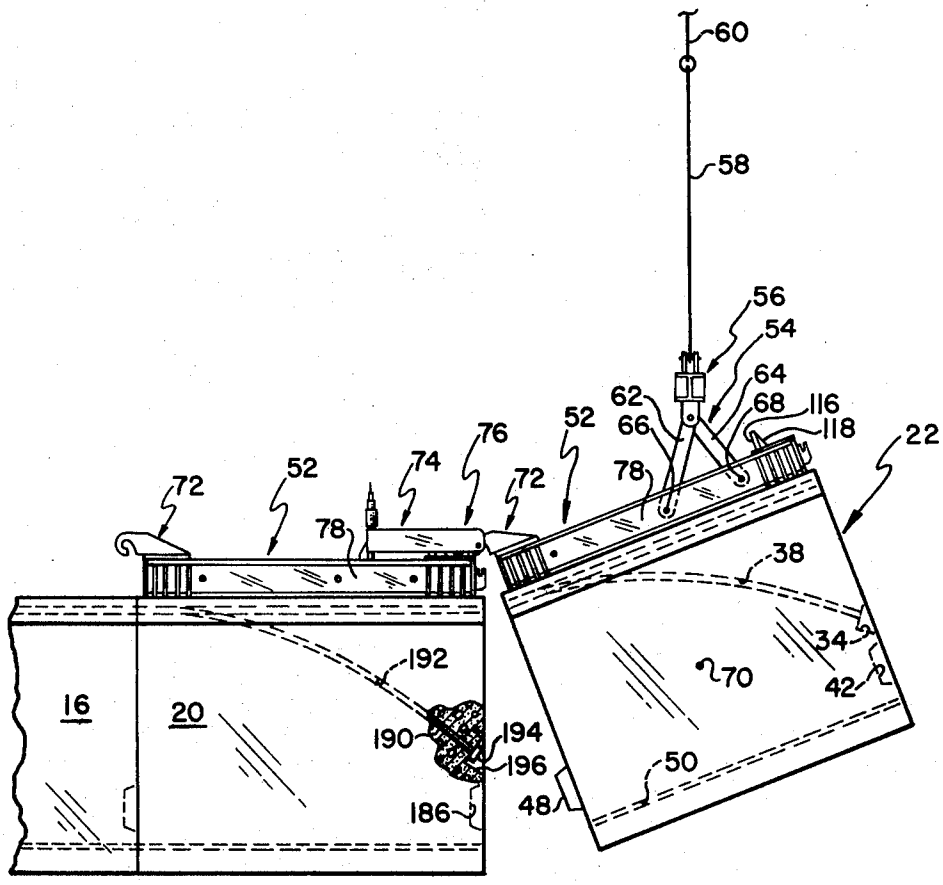
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Primary Examiner—Nile C. Byers, Jr.
Attorney, Agent, or Firm—G. Turner Moller

[57] **ABSTRACT**

There is disclosed a technique for erecting segmental bridge spans. Means are provided for temporarily connecting the segments to each other in preparation for permanently joining the same together. The temporary connectors incorporate a pivotal connection, capable of adjustment under load, allowing relative adjustable pivotal movement between the movable segment and the stationary segment. The adjustable feature of the pivot connection allows the segments to be shifted for close mating engagement.

17 Claims, 8 Drawing Figures



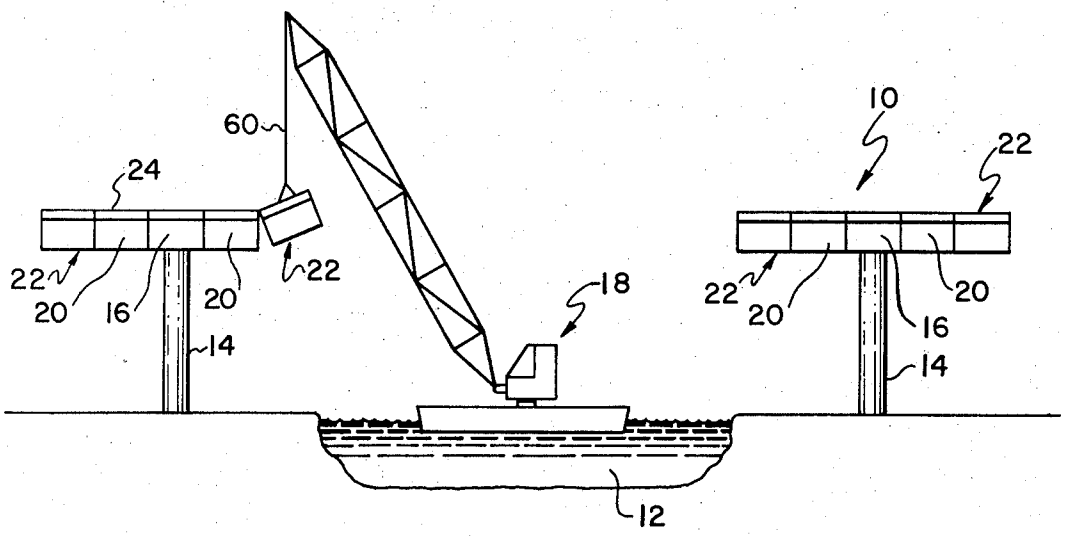

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FIG. 1

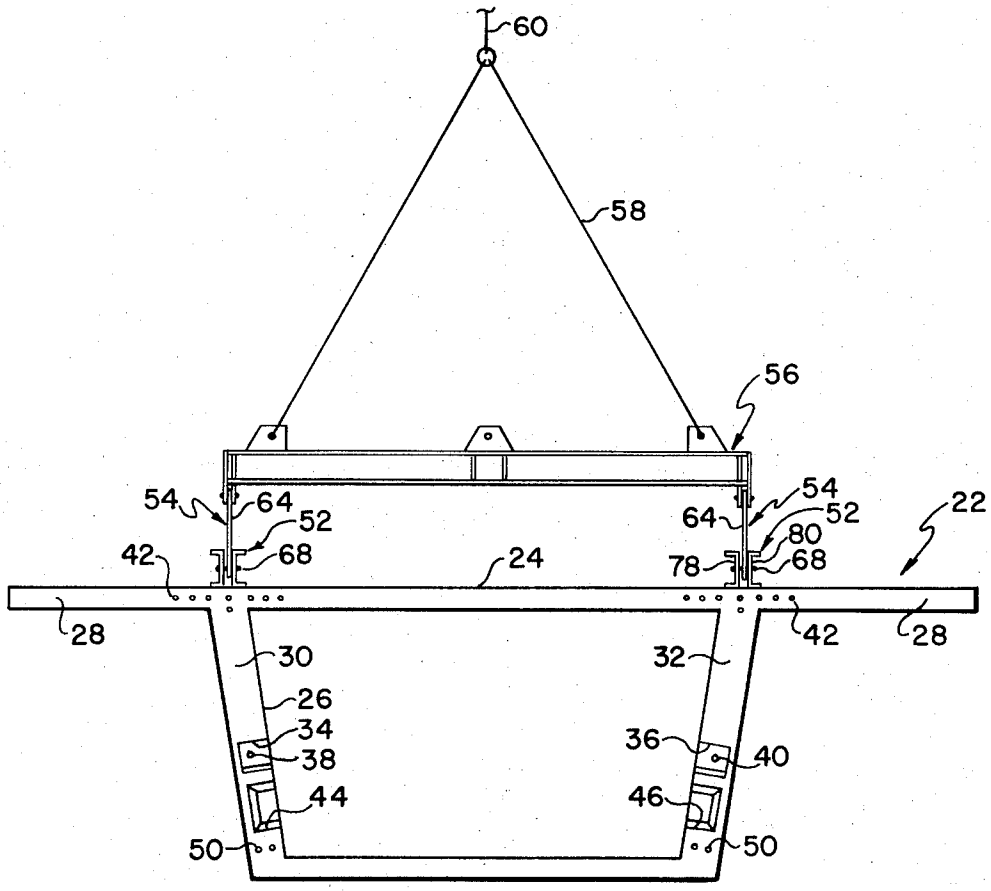

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FIG. 2

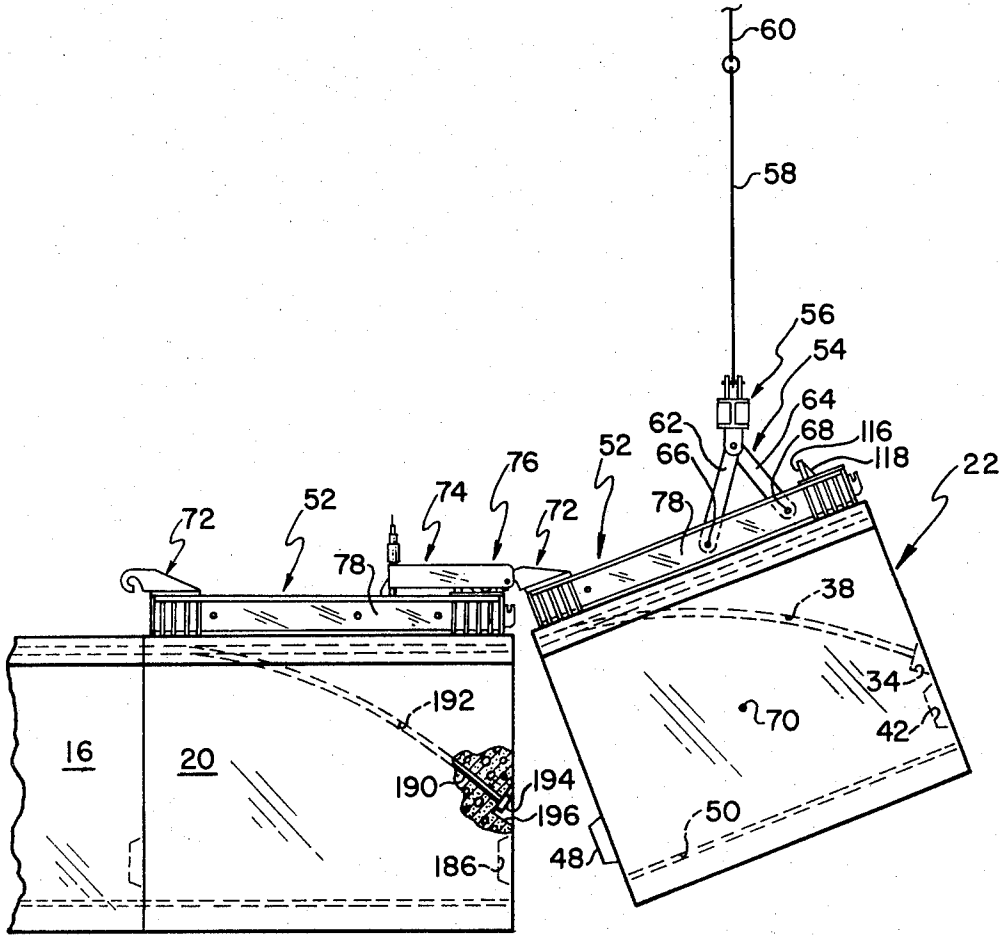

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196
186
50
48

FIG. 3

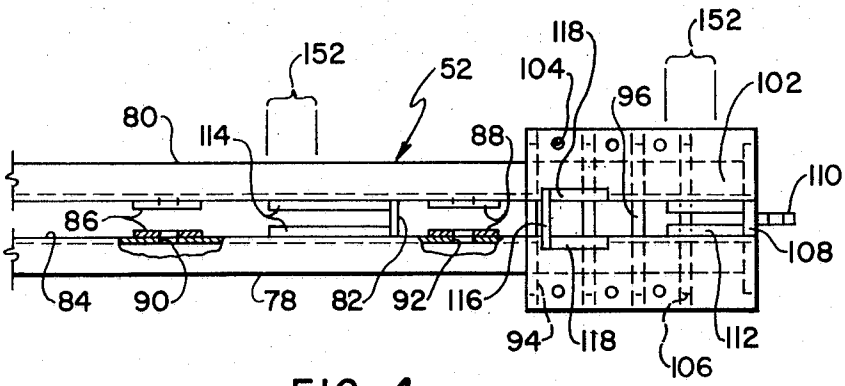

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FIG. 4

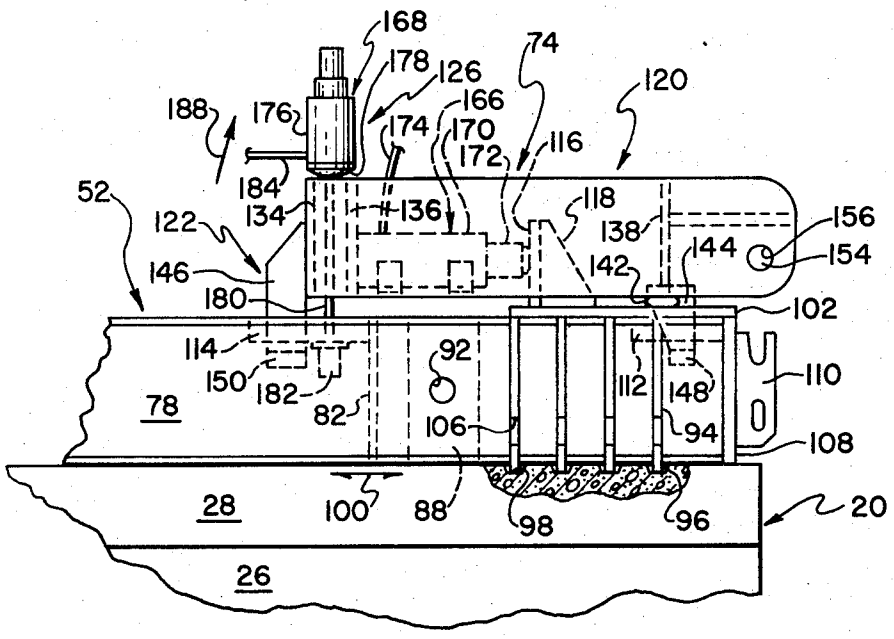


FIG. 5

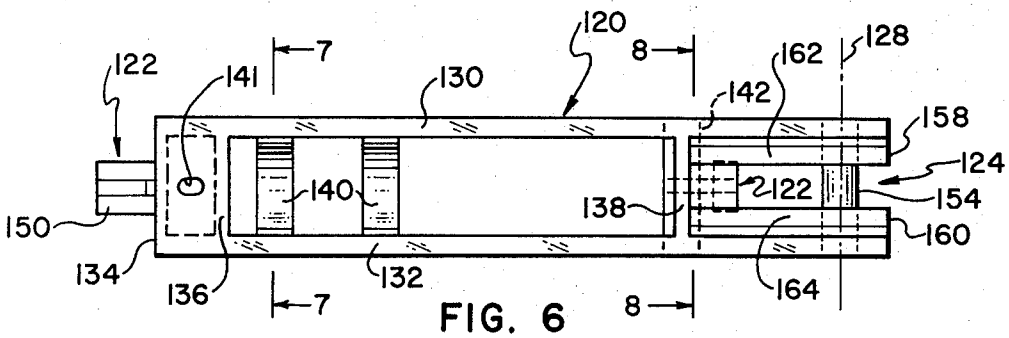


FIG. 6

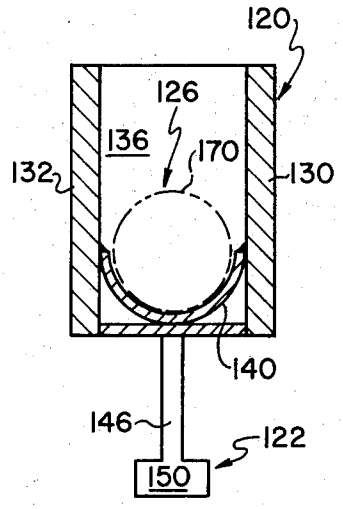


FIG. 7

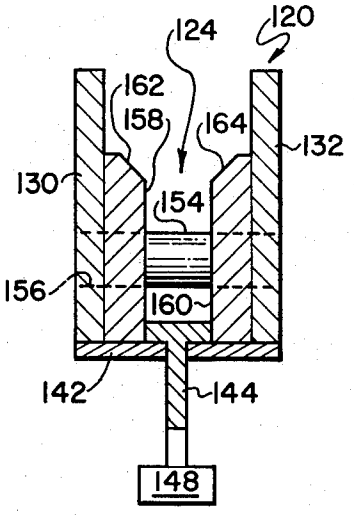


FIG. 8

ERECTING SEGMENTAL SPANS

BACKGROUND OF THE INVENTION

This invention relates to method and apparatus for erecting segmental spans, such as bridges. Segmental bridge design is known in the prior art as indicated in an article entitled "High Hopes for Segmental Design" in Texas Highways, pages 8–10.

A major problem in bridge construction of this type resides in the temporary support of the unconnected segments or modules so that a permanent connection can be made. It is not now practical merely to suspend the unconnected modules adjacent the stationary modules and then permanently connect them together. The reasons therefor are myriad and involve the inability to hold a suspended load completely steady during wind loading, normal cable lengthening during loading, shifting of the crane platform, as in the case of a barge mounted crane, and the like. The two major techniques which have actually been used to provide a temporary support are (1) erect a scaffold under the unconnected module to support it during permanent attachment to the stationary module and (2) erect a gantry and overhead crane immediately adjacent the stationary module to support the unconnected module. Both of these techniques involve building a bridge in order to build a bridge and are consequently onerously expensive.

As shown in Great Britain Patent No. 1,210,680 and corresponding France Pat. No. 1,516,851, it has been suggested in the prior art to secure temporary connecting members to the modules for temporarily supporting the outboard module from the inboard module in preparation for the final or permanent connection. This suggested approach requires laterally moving the outboard module toward the inboard module. It is not clear whether the outboard module is suspended, as from a crane, during the approaching linear movement caused by the temporary connectors. If the outboard module is not suspended, the temporary connectors must necessarily cantilever the outboard module in preparation for linear movement thereby requiring the temporary connectors to be massive. Furthermore, if the outboard module is not suspended, the linear adjustment of this proposal fails to provide a vertical adjustment of the outboard modules. If the outboard module is suspended from a crane, the temporary connectors need not be so massive and a vertical adjustment is available through the crane load line. It will be appreciated, however, that a very small vertical adjustment, on the order of less than about one inch, is somewhat difficult to obtain in a 30 ton module suspended 50 feet above the ground from a crane which may be carried on a barge.

This invention has been tested under the following conditions. A center module was placed on suitable shoring approximately one foot off the ground. The center module and the first pair of outboard modules were equipped with the devices of this invention. A suitable hoisting device was used to raise the outboard modules into position for temporary connection to the center module. The first pair of outboard modules were temporarily connected to the center module in a total elapsed time of approximately thirty minutes. The connection between the center module and the first pair of outboard modules was demonstrably adequate to support the outboard modules from the center module. It will accordingly be apparent that this invention allows safe and rapid erection of a segmental span.

SUMMARY OF THE DISCLOSURE

It is an object of this invention to provide method and apparatus for erecting a segmental span wherein temporary connecting elements defining therebetween a pivot connection are used to temporarily support the modules during a final connection step.

In summary, one aspect of this invention comprises a method of erecting a segmental span comprised of laterally abutted modules including the steps of attaching connector parts to each of a stationary and a movable module to be abutted, the connection parts defining therebetween a pivotal connection; positioning the movable module adjacent the stationary module at a first angular position and engaging the connection parts; pivoting the movable module relative to the stationary module to a second angular position defining a load support between the stationary module and the movable module; and installing a discrete connector to the modules for permanently joining the same.

In summary, another aspect of this invention comprises a structural installation including adjacent modules having means for permanently connecting the modules together; and means for temporarily joining the modules together in load supporting relation in preparation for permanent connection including first and second mating connectors rigidly connected to adjacent modules, the first connector comprising a base rigid with one of the modules, a mateable connector part mounted on the base for movement relative thereto for mating engagement with the second connector, and means for moving the mateable connector part relative to the base.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side schematic view of a segmental span during erecting thereof;

FIG. **2** is an end elevation of a typical segment resting on a ground surface in preparation for hoisting;

FIG. **3** constitutes an enlarged side elevation illustrating the movable and stationary modules during temporary connection;

FIG. **4** is an enlarged partial plan view of one end of the hoisting beam of FIG. **3**;

FIG. **5** is a partial side elevational view of one end of the beam of FIG. **4** illustrating an erection shoe secured thereto;

FIG. **6** is a plan view of an erection shoe, certain parts being omitted for purposes of clarity;

FIG. **7** is a cross sectional view of the erection shoe of FIG. **6** taken substantially along line **7—7** thereof as viewed in the direction indicated by the arrows; and

FIG. **8** is a cross sectional view of the erection shoe of FIGS. **6** and **7**, taken substantially along line **8—8** thereof as viewed in the direction indicated by the arrows.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, there is illustrated a segmental bridge **10** in the process of erection. The bridge **10** is illustrated as spanning a waterway **12** and comprises a pair of spaced columns **14**. The basic construction technique of segmental bridges is to erect two T's

which meet in the middle to provide the bridge span.

To this end, a center module **16** is placed by a crane **18** on top of each of the columns **14** and affixed in place. A first pair of outboard modules **20** are connected to the inboard module **16.** A second set of outboard modules **22** are attached to the stationary inboard modules **18.** For purposes of clarity, it will be noted that the modules **20** are outboard with respect to the center module **16** and inboard with respect to the modules **22.** It will be appreciated that this technique is continued until the structures on each side of the waterway **12** meet or very nearly meet. The upper surface **24** of the modules accordingly provide the base for the roadway of the bridge **10.** Suitable traffic bearing layers may be applied to the surface **24** in any convenient manner.

The modules or segments of the bridge **10** are substantially identical. As shown best in FIG. **2,** the module **22** basically comprises a precast, open-end trapezoidal concrete box **26** having wings **28** extending from the upper end of the box **26.** The box **26** includes webs **30, 32,** having tie-down recesses **34, 36** respectively. A cable passage **38, 40** terminates in the recesses **34, 36** respectively. As shown best by a comparison of FIGS. **2** and **3,** the cable passages **38, 40** arcuately extend through the webs **30, 32** and become parallel with a plurality of additional cable passages **42** along the upper section of the module **22.** The webs **30, 32** also comprise keyways **44, 46** for mateably receiving suitable keys provided by the next adjacent module. The keyways **44, 46** are tapered along the long and short axes of the webs **30, 32.** The keyways **44, 46** open into the interior of the box **26** and accordingly each provide lateral restraint for the adjacent module in only one direction. Because the lateral restraint provided by the keyways **44, 46** are in opposite directions, this has proved quite satisfactory. The lack of restraint to the inside of the box **26** affords easier mating of the key carried by the adjacent module. The module **22** provides keys **48** for receipt by the keyway provided by the module **20** as shown in FIG. **3.** The module **22** may also provide a plurality of cable passages **50** adjacent the lower end thereof.

Although the modules **16, 20, 22** are substantially identical, they may differ slightly in several regards. For example, the center module **16** is not typically provided with the inclined cable passages corresponding to passage **38** nor is it typically provided with a recess corresponding to the recess **34.** The inclination of the inclined passages **38, 40** may vary depending upon the position of the module relative to the center module **16.** Although the modules **20, 22** have a male side and a female side, the center module **16** may be provided with keyways on both sides thereof or with keys on both sides thereof depending upon the configuration of the adjacent modules.

The modules comprising the bridge **10** are normally cast in a suitable yard in a conventional manner. As explained in Great Britain Patent No. 1,210,680, each module is preferably cast against the finished module which will be adjacent thereto when the bridge **10** is assembled. By using the previously cast element as a mold for the adjacent element in the area of the joint, the tolerances in and around the mating keys and keyways are within acceptable limits.

In order to handle the modules, suitable beams **52** are secured to the modules in any suitable fashion. Typically, this may be accomplished by welding, clamping or bolting a beam flange to re-enforcing steel protruding out of the module **22.** As many of the beams **52** may be provided as is necessary or desirable for convenient handling of the modules, although two beams per module has proved satisfactory. A pair of linkage mechanisms **54** are conveniently used to secure the beams **52** to a hoisting frame **56** suspended by a suitable bridle **58** from the crane loadline **60.**

For reasons more fully explained hereinafter, it is desirable to cant the movable module during the erection process. To this end, the linkage mechanisms **54** include long and short links **62, 64** secured to the beams **52** by suitable pins **66, 68.** As suggested in FIG. **3,** the relationship between the cable loadline **60** and the center of gravity **70** of the module **22** is such as to cant the same when freely suspended.

The beams **52** provide several important operating features in this invention. It will be apparent that the beams **52** afford a suitable connection to the concrete modules for the hoisting frame **56.** In addition, the beams **52** provide a hook **72** at one end thereof and allow connection of an erection shoe **74** at the other end thereof. As will be more fully explained hereafter, the hook **72** and erection shoe **74** comprise a temporary connection **76** between a stationary or inboard module and a movable or outboard module. Accordingly, the beam **52** is designed to support a module during lifting thereof and is also designed to support an outboard module during temporary connection thereof to the stationary partial bridge span.

The beams **52** conveniently comprise a pair of channels **78, 80** spaced apart by suitable spacers **82** to provide a slot **84** therebetween. It will be apparent that the slot **84** receives the links **62, 64** of the hoisting mechanism. Suitable re-enforcing plates **86, 88** are welded to the web of the channels **78, 80** to provide additional strength around the openings **90, 92** which receive the pin connections **66, 68** between the beams **52** and the linkage mechanism **54.**

Adjacent each end of the beam **52** are a plurality of generally vertical U-shaped members **94.** The members **94** include a section **96** transverse to the beam axis below the flanges of the channels **78, 80.** As shown best in FIG. **5,** the upper surface of the module **20** is provided with a plurality of troughs or depressions **98** for receiving the sections **96.** Epoxy resin or the ike is normally applied between the sections **96** and troughs **98** to provide a measure of resistance against slippage in the direction shown by the arrow **100.**

As shown best in FIGS. **4** and **5,** a plate **102** is welded to the upper end of the members **94** and to the channels **78, 80.** The plate **102** provides a plurality of openings **104.** The openings **104** provide a convenient means for securing the beam **52** to the module **20** since re-enforcing cable may be passed therethrough and clamped. It should be apparent that the flanges of the channels **78, 80,** if of sufficient width, may be used as an attachment to the re-enforcing steel in the module **20.** It will be seen that the re-enforcing steel passes vertically between the vertical members **94.** After installation of the module to which the beam **52** is attached, the re-enforcing steel may be cut, as with a torch, to release the beam **52.** The members **94** may provide a slot **106** affording access to the re-enforcing steel.

An end plate **108** is welded between the plate **102** and the channels **78, 80** and provides a convenient attachment for a bracket **110.** The bracket **110** may be used as an attachment for a safety cage in order to suspend a workman over the side of the module **20.**

As previously mentioned, the beam **52** affords a connection to the erection shoe **74.** To this end, the beam **52** comprises a first pair of spaced abutments **112** in the slot **84** adjacent the plate **108** for receiving a first generally T-shaped connector carried by the erection shoe **74.** The beam **52** also comprises a second set of abutments **114** for receiving a second generally T-shaped connector carried by the erection shoe **74.** It will be noted that the abutments **112, 114** cooperate with the plate **108** and the spacer **82** respectively to provide a pair of slots having only one open end.

Secured to the plate **102** is a stationary vertical abutment **116** which is supported by a pair of gussets **118** on opposite sides of the slot **84.** As will be more fully explained hereinafter, the abutment **116** comprises a reaction member for adjusting the position of the erection shoe **74.**

The erection shoe **74** is best illustrated in FIGS. **5–8** and comprises, as major components, a frame **120,** means **122** connecting the frame **120** to the beam **52** while allowing relative movement therebetween, a pivot-half **124** for cooperation with the hook **72,** and means **126** for adjusting the position of the pivot-half **124** under load. As will be more fully apparent hereinafter, it is highly desirable to have the capability of adjusting the pivot axis **128** in order to position the module **22** for close mating engagement with the module **20.** This capability is afforded by the movable connections **122** and the adjusting means **126.**

The frame **120** conveniently comprises generally parallel plates **130, 132** spaced apart by suitable members **134, 136, 138.** Disposed between the plates **130, 132** are a pair of cradles **140** for a motor comprising part of the adjusting means **126.** A suitable passage **141** is provided through the frame **120** for an extensible member of another motor comprising part of the adjusting means **126.** The frame **120** also provides a foot **142** spanning the slot **84** and engaging the plate **102.** As explained more fully hereinafter, the foot **142** acts as a fulcrum for pivoting the erection shoe **74** relative to the beam **52.**

The connecting means **122** comprise first and second inverted generally T-shaped members **144, 146** having cross-pieces **148, 150** disposed beneath the abutments **112, 114** respectively. It will accordingly be seen that the connecting members **144, 146** cooperate with the beam **52** to allow horizontal adjustment of the erection shoe **74** throughout a limited predetermined range as suggested by the brackets **152** in FIG. **4.** It will also be seen that the T-shaped members **144, 146** allow a certain amount of vertical movement since the cross pieces **148, 150** normally reside below the undersurface of the abutments **112, 114.** It will be noted that the entrance to the abutments **112, 114** is away from the pivot-half **124** where the load of the adjacent module is imposed. It will accordingly be seen that the plates **82, 108** constitute safety stops for the T-members **146, 144** respectively.

The pivot-half **124** is best illustrated in FIGS. **5, 6** and **8** and comprise a pin **154** sized to cooperate with the hook **72.** The pin **154** is disposed in an opening **156** extending through the frame plates **130, 132.** A pair of centering members **158, 160** provide upper surfaces **162, 164** inclined toward the center of the frame **120** which act to deflect the hook **72** toward engagement with the pin **154.**

The adjusting means **126** comprises first and second motors **166, 168** of any suitable type but which are illustrated as single acting hydraulic motors. The motor **166** includes a housing **170** supported by the cradles **140** and abutting the spacing member **136.** Received inside the housing **170** is an extensible member **172** which engages the abutment **116.** It will be apparent that the delivery of power fluid through a conduit **174** causes the member **172** to extend thereby moving the erection shoe **74** toward the left in FIG. **5.** In similar fashion, opening the conduit **174,** as to a fluid reservoir, frees the erection shoe **74** for movement toward the right which will occur if the pin **54** is loaded. Although many different types of hydraulic motors are suitable, a Simplex, model RC506S, 50 ton rating, has proved satisfactory in field trials.

The motor **168** comprises a housing **176** having a leveling head **178** thereon engaging the upper surface of the frame **120** adjacent the opening **141.** The leveling head **178** presents a surface of spherical curvature to allow orientation of the motor **168** relative to the frame **120** during pivotal movement thereof. The motor **168** includes an extensible member **180** passing through the frame **120** and through the slot between the abutments **114.** A suitable fastener **182** is secured to the lower end of the extensible member **180** and is of sufficient width to contact the abutments **114.** The delivery of pressurized fluid to the conduit **184** retracts the member **180** into the housing **176** and thereby presses the erection shoe **74** toward the beam **52.** Opening of the conduit **184,** as to a fluid reservoir, frees the extensible member **184** for movement out of the housing **176** as may be caused by pivoting of the erection shoe **74** in a clockwise direction under loading of the pin **154.** It will be apparent that there is sufficient clearance provided between the T-shaped connectors **144, 146** and the restraining abutments **112, 114** therefore to enable pivoting of the erection shoe **74** relative to the beam **54** using the foot **142** as a fulcrum.

Referring to FIG. **3,** the outboard module **22** is raised by the crane **18** to a position above the stationary or inboard module **20.** The module **22** is lowered such that the hook **72** on the beam **52** passes between the vertical frame plates **130, 132.** Continued lowering of the module **22** causes the hook **72** to engage one or the other of the inclined surfaces **162, 164** thereby centering the hook **72** for engagement with the pin **154.** Continued lowering of the module **22** causes the pin **154** to pass into the eye of the hook **72.** It will accordingly be seen that, at this juncture, the module **22** is mounted for pivotal movement from an inclined position as shown in FIG. **3** to a second position substantially coplanar with the stationary module **20.**

It will be immediately apparent that the keys **48** on the module **22** must mate with the corresponding keyways **186** in the module **20.** Since the key **48** was cast against the keyway **186,** it will be apparent that the tolerances between these elements is quite close. Accordingly, a misalignment of the pivot axis **128** of the module **22** will prevent the key **48** from mating with the keyway **186.** It is accordingly desirable to have the capability of adjusting the pivot axis **128.**

Referring to FIG. 5, mating engagement of the hook 72 with the pivot-half 124 and consequent loading of the pin 154 creates a clockwise moment on the erection shoe 74 as symbolized by the arrow 188. It will be apparent that the erection shoe 74 will pivot in a counterclockwise direction about the foot 142 until either the fastener 182 or the crosspiece 150 engages the spaced abutments 114. Assuming for purposes of illustration that the keys 48 do not mate with the keyway 186 upon lowering of the module 22 and a judgment is made by a workman that the pivot axis 128 must be moved outwardly or toward the right in FIG. 5. Hydraulic fluid is bled off the motor 166 through the conduit 174 to allow the motor 166 to retract. Since the counterclockwise moment produces a force vector axial to the motor 166, the motor 166 will retract in accordance with the quantity of fluid bled off through the conduit 174. Retraction of the motor 166 causes the erection shoe 74 to move to the right in FIG. 5 thereby spacing the pivot axis 128 further to the right.

Assuming for purposes of illustration that the pivot axis 128 needs to be moved inwardly or to the left in FIG. 5, power fluid is passed through the conduit 174 to extend the motor 166 thereby moving the erection shoe 74 and consequently the pivot axis 128 to the left.

It may be that the keys 48 do not mate with the keyways 186 due to a vertical misalignment thereby requiring vertical adjustment of the pivot axis 128. Assuming that a workman judges that the pivot axis 128 needs to be raised, power fluid is passed through the conduit 184 to retract the extensible member 180 thereby lowering the left end of the erection shoe 74 and raising the right end thereof as the frame 120 pivots about the fulcrum or foot 142. This accordingly raises the pin 154 and consequently raises the pivot axis 128. Conversely, if a judgement is made that the pivot axis 128 needs lowering, fluid is bled from the motor 168 through the conduit 184 to allow extension of the member 180. Since the moment produced by the load on the pin 154 tends to induce clockwise movement in the erection shoe 74, the right end thereof is depressed while raising the left end thereof.

The overall erection plan for the span 10 should now be apparent. After the center module 16 is affixed to the column 14, the mating faces between the modules 16, 20 are coated with an epoxy resin or the like. By using the beams 52, the hooks 72 and the erection shoes 74, one of the modules 20 is placed on either side of the module 16 and temporarily connected thereto. A conventional cable or tensioning element 190 is passed through a cable passage 192 in the module 20, through a connecting passage in the module 16 and through a connecting passage in the opposite module 20. Suitable devices are attached to the cable 190 for tensioning the same with conventional connectors 194 being placed in recesses 196 to clench the modules 16, 20 together. This technique is repeated until the span meets or very nearly meets between the columns 14.

I claim:

1. A method of erecting a segmental span comprised of first and second adjacent interfitting modules including the steps of

stationarily supporting the first module above an underlying surface;

attaching connection parts to the first and second modules to be abutted and interfitted, the connection parts providing a pivotal connection defining a path of pivotal movement of the second module toward and away from the first module;

positioning the second module adjacent the first module at a first angular position and engaging the connector parts;

adjusting the path of pivotal movement of the second module for affecting the interfitment of the modules;

pivoting the second module relative to the first module through the adjusted path of movement to a second position abutting and interfitting the modules;

supporting the second module from the first module; and

then installing a discrete connector between the modules for permanently joining the same.

2. The method of claim 1 further comprising the step of removing the connection parts from the modules after the installing step.

3. The method of claim 1 wherein the path adjusting step comprises the step of moving the pivotal connection relative to only one of the modules while the connector parts are engaged.

4. The method of claim 3 wherein the moving step comprises linearly moving the pivotal connection relative to the first module.

5. The method of claim 1 wherein the installing step comprises threading elongate tensile elements through the modules.

6. A structural installation comprising first and second adjacent interfitted modules including means for permanently attaching the modules together; and means for temporarily joining the modules together in load supporting relation in preparation for permanent attachment including first and second mating connections providing a pivot defining a path of movement of the first module toward and away from the second module, the first connection comprising a base rigid with one of the modules, a first mateable connector part, mounted on the base for movement relative thereto, in mating engagement with the second connection, and means for altering the path of pivotal movement of the first module including means for adjusting the first mateable connector part relative to the base while the connections are mated.

7. The installation of claim 6 wherein one of the connections provides a first half of the pivot and the other connection provides a second half of the pivot, the second pivot-half being mated with the first pivot-half and wherein the adjusting means comprises means for moving the pivot relative to the second module.

8. The installation of claim 6 wherein the first connection comprising a frame carrying the first mateable connector part and means mounting the frame on the base for limited movement relative thereto along substantially perpendicular paths.

9. An erection shoe for temporarily connecting a movable span module to a stationary span module comprising

a frame having a pivot-half thereon;

a member for mounting the frame on one of the modules including means connecting the member and the frame providing a path of substantially linear pivot-half movement through a limited predetermined range; and

power means carried by the frame for adjusting the position of the pivot-half through the predetermined range.

10. The erection shoe of claim **9** wherein the connecting means provides for pivot-half movement in another path generally perpendicular to the substantially linear path and the power means comprises means for adjusting the position of the pivot-half in two directions along the paths.

11. The erection shoe of claim **10** wherein the axis of the pivot-half and the two paths are substantially mutually perpendicular.

12. The erection shoe of claim **9** wherein the connecting means comprises means for mounting the frame for pivotal movement about an axis, means restraining the pivotal movement to a limited predetermined range and means for mounting the frame for substantially linear movement in a direction generally perpendicular to the pivot axis.

13. A method of erecting a segmental span comprised of adjacent modules including the steps of

attaching connection parts to first and second modules to be abutted, the connection parts providing a pivotal connection;

positioning the first module adjacent the second module at a first angular position and engaging the connector parts;

then pivoting the first module relative to the second module about an axis of the pivotal connection to a second position aligned with the second module and defining a load support through the connection parts wholly supporting the second module from the first module;

then installing a discrete connector between the modules for permanently joining the same; and

then removing the connection parts from the modules.

14. Apparatus for temporarily connecting interfittable movable span modules to stationary span modules comprising

a member for attachment to one of the modules;

a pivot-half carried by the member and defining an arcuate path of movable module movement toward and away from the stationary module; and

means carried by the member for alternating the arcuate path of movement for affecting the interfitment of the modules.

15. The apparatus of claim **14** wherein the altering means comprises means mounting the pivot half on the member for movement through a limited predetermined range, and means for selectively moving the pivot half through the range.

16. The apparatus of claim **15** wherein the mounting means includes means mounting the pivot half on the member for substantially linear movement.

17. The apparatus of claim **16** wherein the mounting means includes means mounting the pivot half on the member for limited pivotal movement in a path substantially perpendicular to the path of linear movement.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,832,748 Dated September 3, 1974

Inventor(s) William B. Ogletree

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 14, line 8 change "alternating" to --altering--.

Signed and sealed this 3rd day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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