April 3, 1962 J. P. MURPHY 3,027,633

METHOD AND APPARATUS FOR BRIDGE CONSTRUCTION

Filed Aug. 19, 1955 7 Sheets-Sheet 1

FIG_1A_

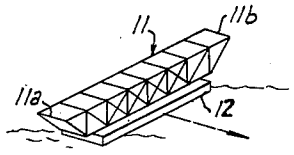


FIG_1B_

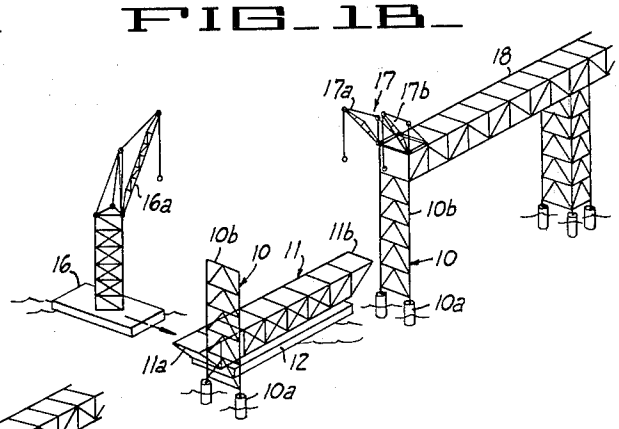


FIG_1C_

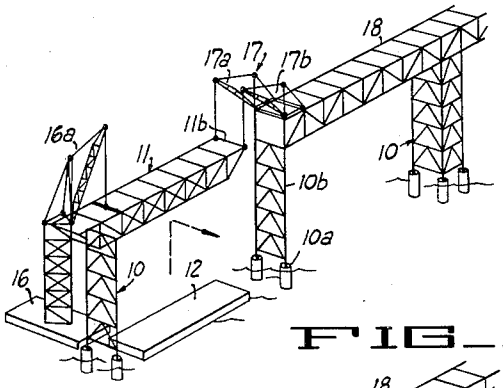


FIG_1D_

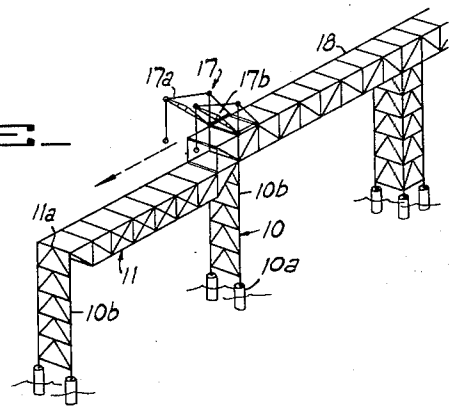


FIG_1E_

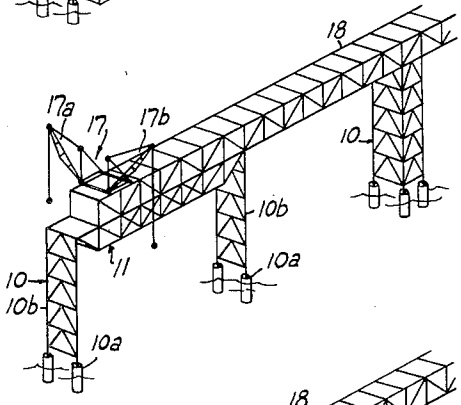
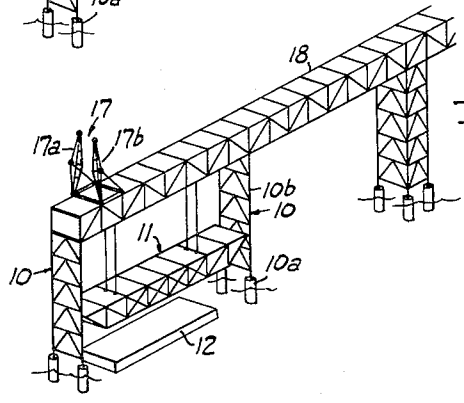


FIG_1F_



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METHOD AND APPARATUS FOR BRIDGE CONSTRUCTION

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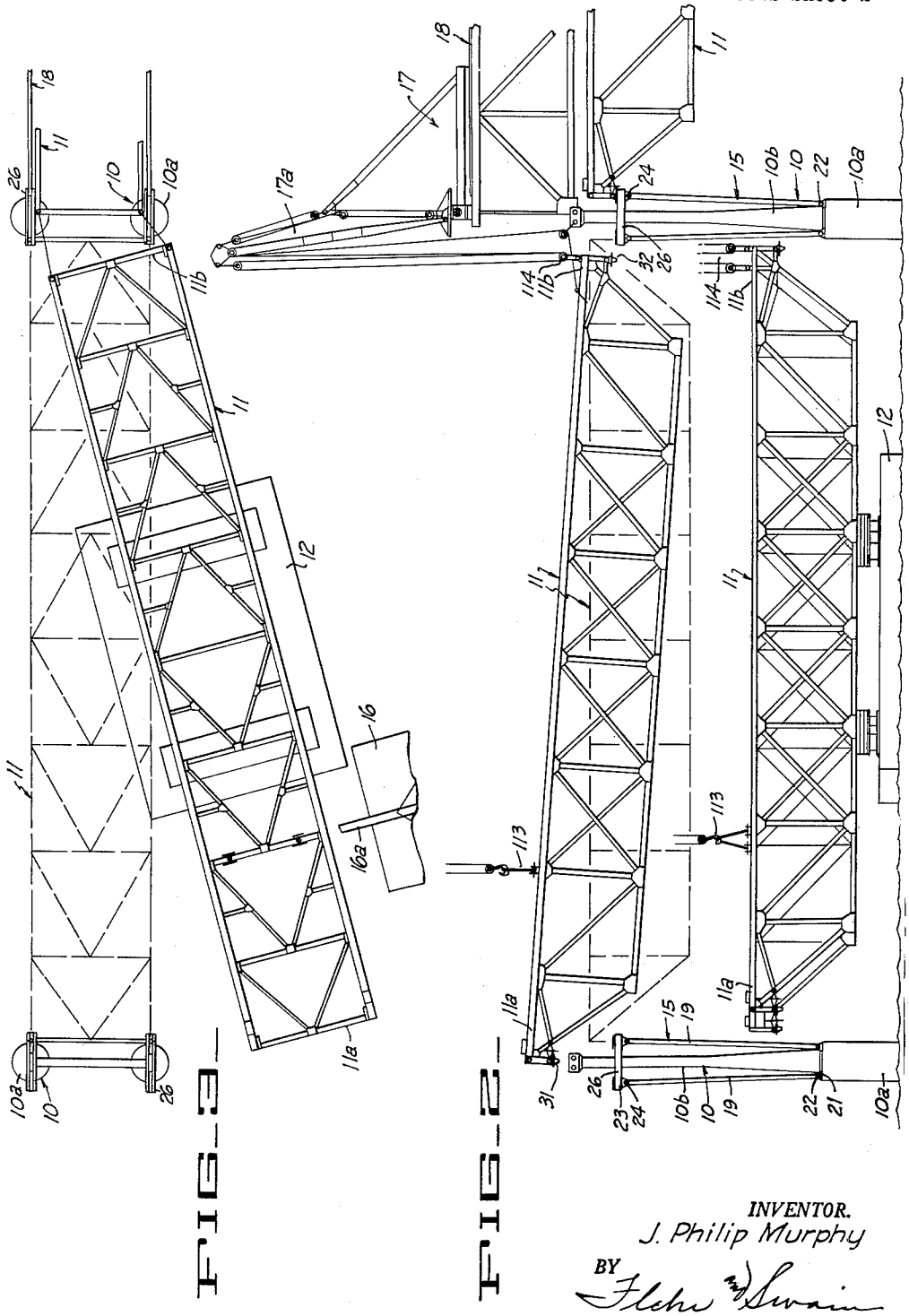

FIG. 3

FIG. 2

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METHOD AND APPARATUS FOR BRIDGE CONSTRUCTION

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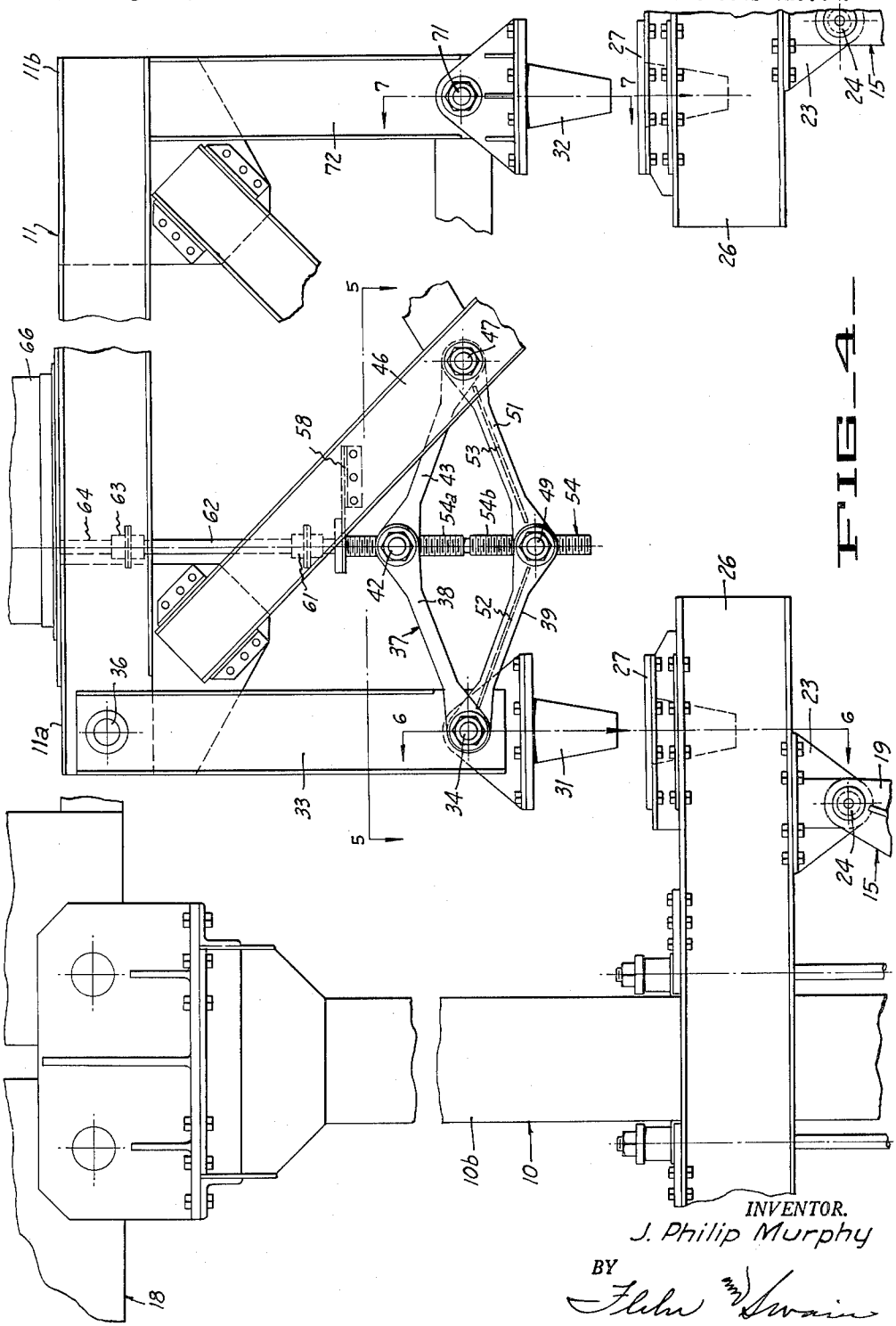

FIG. 4

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METHOD AND APPARATUS FOR BRIDGE CONSTRUCTION

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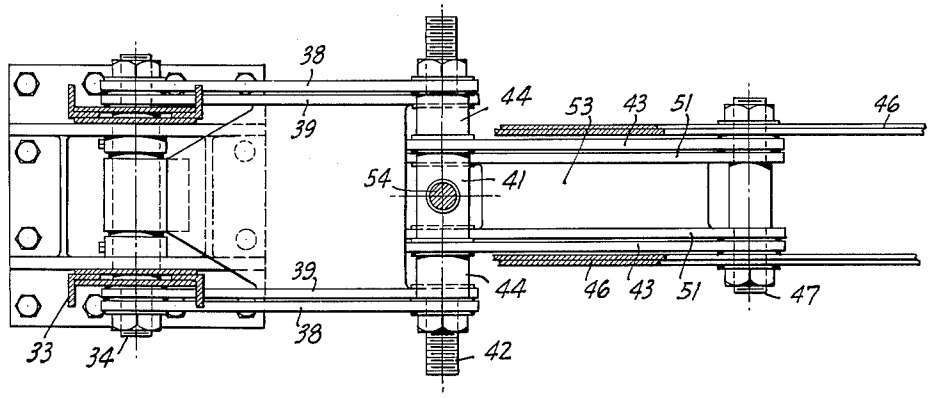

FIG_5_

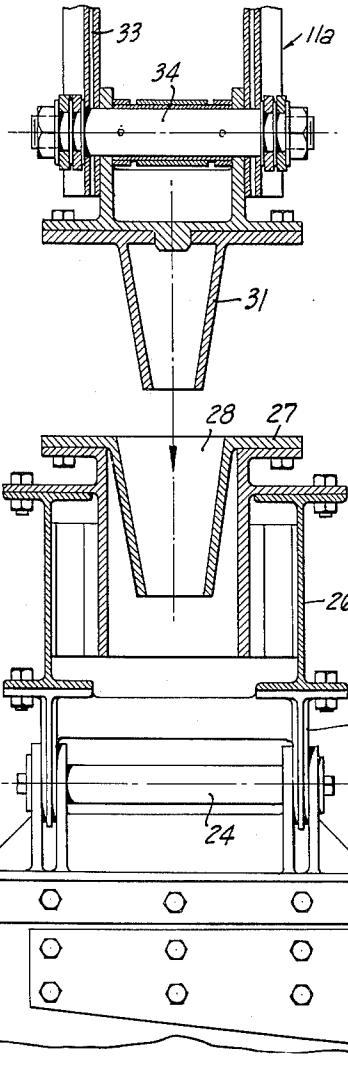

FIG_6_

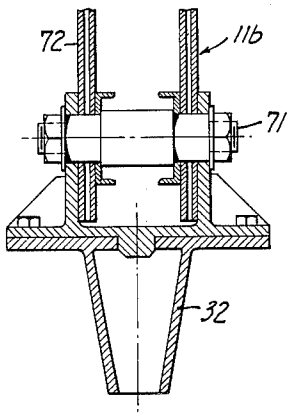

FIG_7_

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METHOD AND APPARATUS FOR BRIDGE CONSTRUCTION

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FIG. 8

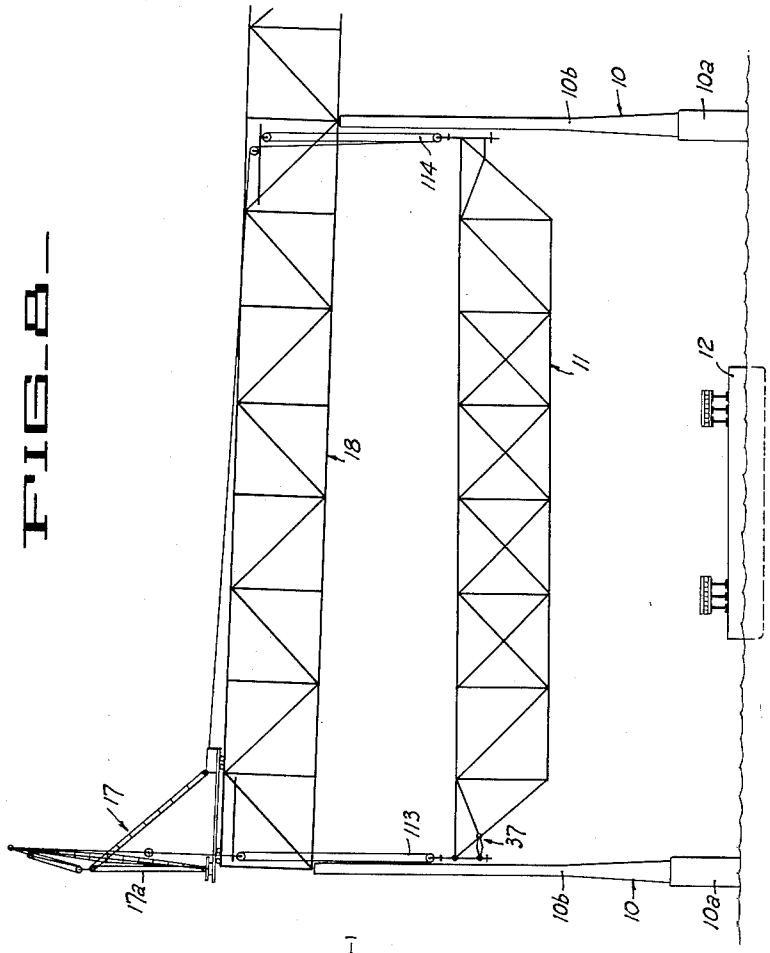

FIG. 10

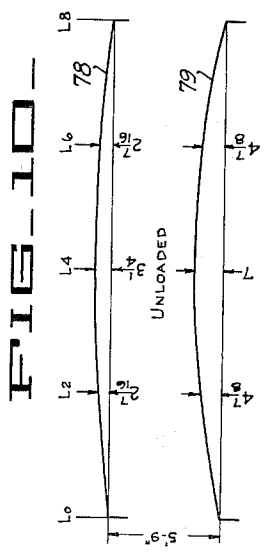

FIG. 9

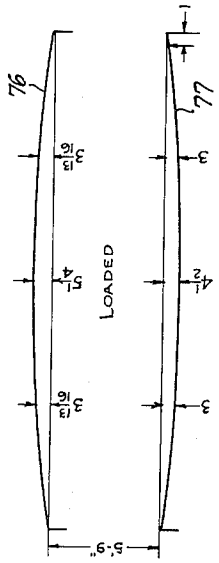

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FIG. 11

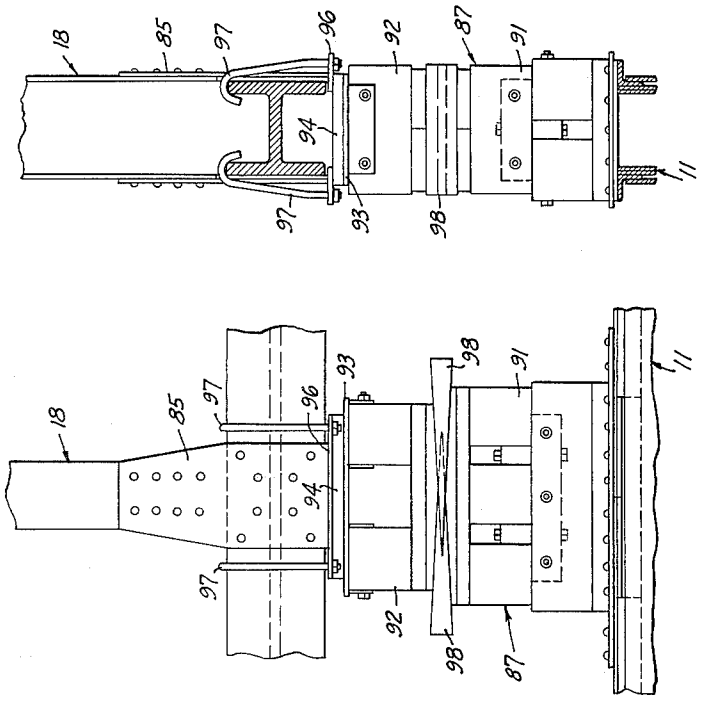
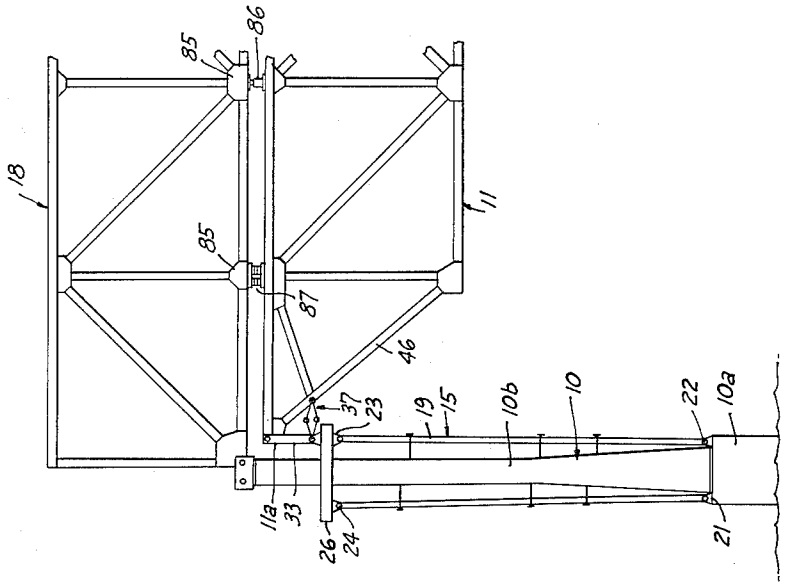


FIG. 12

FIG. 13



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METHOD AND APPARATUS FOR BRIDGE CONSTRUCTION

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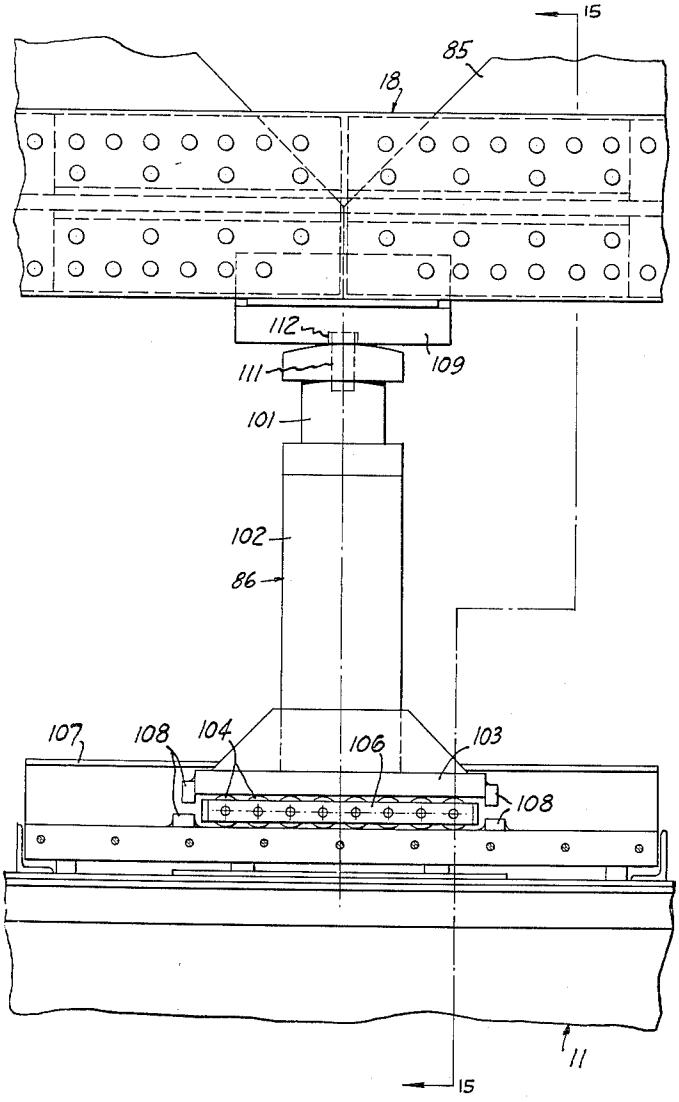

FIG_14_

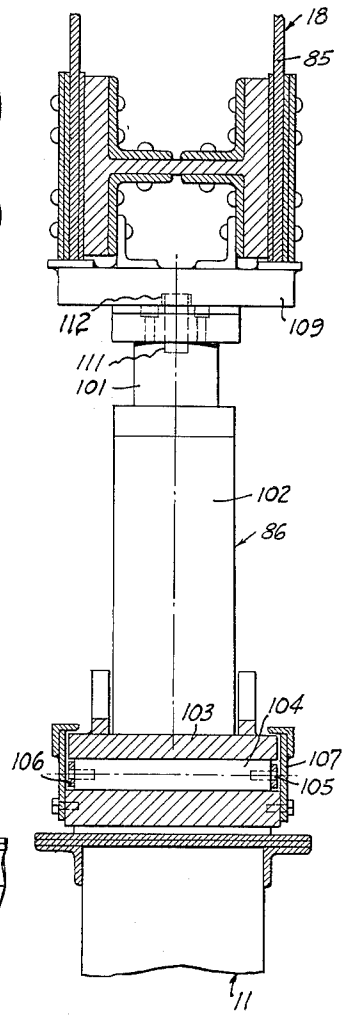

FIG_15_

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United States Patent Office 3,027,633 Patented Apr. 3, 1962

3,027,633
METHOD AND APPARATUS FOR BRIDGE CONSTRUCTION

John Philip Murphy, Piedmont, Calif., assignor, by mesne assignments, to Yuba Consolidated Industries, Inc., San Francisco, Calif., a corporation of Delaware

Filed Aug. 19, 1955, Ser. No. 529,529
14 Claims. (Cl. 29—429)

This invention relates generally to a method and apparatus for bridge construction and more particularly to a method and apparatus for constructing bridges without the use of falsework.

Heretofore, bridge spans for bridges have been erected by assembling the bridge span in place upon a falsework platform. However, in constructing a high level bridge span, the use of falsework supported by temporary pile bents is uneconomical because of the pile lengths required. Bridge spans have also been erected by preassembling the bridge spans on barges and floating them into position. This is objectionable in constructing a high level bridge because the steel bridge span assemblies are too heavy for economical hoisting operations. Floating the bridge span in at a high level is not feasible both from economic and engineering aspects. Steel bridge spans that eventually become part of a bridge have been used as temporary erection spans or working platforms but such a method is limited to a span that is relatively light and wherein the top chord of the span is flat. Such a method is also limited to a span which has been designed to support the load upon its top chord and wherein the span's ultimate position is relatively close to the water.

In general, it is the object of the present invention to provide a method and apparatus for bridge construction which avoids the use of a temporary falsework supported by piling or the use of a permanent span which evenutlly becomes a part of the bridge.

Another object of the invention is to provide a method and apparatus for bridge construction of the above character which facilitates erection of the bridge spans.

Another object of the invention is to provide a method and apparatus for bridge construction of the above character in which a temporary erection span is supported between the bridge piers and utilized as a working platform for erecting the bridge spans.

Another object of the present invention is to provide a method and apparatus for bridge construction of the above character in which the erection span is erected on a barge, floated to the bridge piers, and hoisted into position.

Another object of the invention is to provide a method and apparatus for bridge construction of the above character in which the temporary erection span is fabricated from a material lighter than steel to facilitate hoisting of the erection span.

Another object of the invention is to provide a method and apparatus for bridge construction of the above character in which means are provided to establish and maintain camber in the lower chord of the bridge span as the erection span is deflected by the progressive loading of the erection span by the progressive erection of the bridge span upon the erection span.

Another object of the invention is to provide a method and apparatus of the above character in which additional safety features are provided.

Another object of the invention is to provide a method and apparatus of the above character in which the erection span is used as a tie member to pull the bridge piers towards each other or to push the bridge piers away from each other to facilitate securing the end portions of the bridge span to the bridge piers.

Another object of the invention is to provide apparatus for bridge construction of the above character in which supporting bents are secured to the bridge piers to give vertical support to the erection span.

Another object of the invention is to provide apparatus for bridge construction of the above character in which means are provided for securing the supporting bents to the bridge piers wherein lateral loads are transferred to the bridge piers.

A further object of the invention is to provide apparatus for bridge construction of the above character in which means are provided on the supporting bents to eliminate bending moment.

A still further object of the invention is to provide apparatus for bridge construction of the above character in which laterally adjustable connecting means are utilized for connecting the temporary erection spans to the bents.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment has been set forth in detail in conjunction with the accompanying drawing.

Referring to the drawing:

FIGURE 1A is an isometric view of the fabricated erection span resting on a barge and being towed into position.

FIGURE 1B is an isometric view of the erection span after it has been towed into a position adjacent the bridge piers and shows the derrick barge coming into position.

FIGURE 1C is an isometric view showing the temporary erection span being hoisted into position by a traveler mounted on the completed bridge spans and the floating derrick barge.

FIGURE 1D is an isometric view showing the erection span supported between two bridge piers and the beginning of the erection of the bridge span in a region overlying the erection span.

FIGURE 1E is an isometric view showing the bridge span almost completely assembled by the traveler.

FIGURE 1F is an isometric view showing the lowering of the erection span onto the barge by the traveler.

FIGURE 2 is an enlarged elevational view showing the erection span in three positions, one position being shown in dotted lines, as it is being hoisted from the barge and lowered onto the supporting bents secured to the bridge piers.

FIGURE 3 is a plan view of the hoisting operation taking place in FIGURE 2 and shows the erection span in two positions, one position being shown in dotted lines.

FIGURE 4 is an enlarged side elevational view of the erection span.

FIGURE 5 is an enlarged cross-sectional view taken along the line 5—5 of FIGURE 4.

FIGURE 6 is an enlarged cross-sectional view taken along the line 6—6 of FIGURE 4.

FIGURE 7 is an enlarged cross-sectional view taken along the line 7—7 of FIGURE 4.

FIGURE 8 is an enlarged side elevational view showing the erection span as it is being lowered onto the barge after completion of the bridge span.

FIGURE 9 is a chart showing the camber in the bridge span and the reverse camber in the erection span after the bridge span has been completed but before it has been swung between the bridge piers.

FIGURE 10 is a chart showing the cambers in the bridge and erection spans after the bridge span has been swung.

FIGURE 11 is an enlarged partial side elevational view showing the bridge span supported upon the erection span by jacks and blocking means which are used to provide and maintain camber in the bridge span.

FIGURE 12 is an enlarged side elevational view of the blocking means.

FIGURE 13 is a front elevational view of the blocking means shown in FIGURE 12.

FIGURE 14 is a side elevational view of the jacks.

FIGURE 15 is a cross-sectional view taken along the line 15—15 of FIGURE 14.

The method and apparatus I have used for the erection of high level bridge spans can best be understood by reference to the drawing. Let it be assumed that a plurality of bridge piers **10** have been erected upon an underwater formation and that each consists of a foundation portion **10***a* and a tower or column portion **10***b*, the column or tower portion extending for a substantial distance above the water. Let it also be assumed that it is desired to erect a bridge span on top of and interconnecting the bridge piers. A temporary erection span **11** is first fabricated on shore or on one or more barges **12**. If fabricated on shore it is loaded onto barges after which the barges are towed to the site where the bridge span is to be erected.

The erection span may be fabricated from any suitable material but preferably from a material substantially lighter than steel such as aluminum to facilitate hoisting of the erection span from the barge. The erection span may be constructed in any suitable manner well known to those skilled in the art of bridge building. For example it may be comprised of a pair of trusses framed together by top and bottom lateral systems. The trusses may be made up of a plurality of individual panels which are tied together. Preferably the trusses of the erection span are spaced on centers which are identical to those of the permanent steel spans which are to be erected overlying the erection span.

After fabrication of the erection span has been completed and it has been towed to the span site into a general position adjacent the piers **10** as shown in FIGURE 1B, a derrick barge **16** is brought into position adjacent to the end portion **11***a* of the erection span and the derrick **16***a* of the derrick barge is connected to that end of the erection span for hoisting the same.

A deck traveler **17** equipped with two stiff-leg derricks **17***a* and **17***b* is mounted on bridge spans **18** and moves on skid-beams (not shown) mounted on the upper floor beams of the completed bridge span. Both of the stiff-leg derricks **17***a* and **17***b* are connected to end portion **11***b* of the erection span for hoisting that end of the erection span.

Before the erection span is hoisted, supporting falsework bents **15** are secured to the bridge towers. The supporting falsework bents as shown particularly in FIGURE 2, consist of a framework **19** which has its lower end pivotally connected to base shoes **21** by pins **22** and its upper end pivotally connected to beam shoes **23** by pins **24**. The base shoes rest on the foundation portion **10***a* of the bridge piers. The beam shoes are fixed to a seat beam **26** which is secured to the towers.

The bents may be fabricated from any suitable material such as wood or steel and may be made up in sections which are adapted to be assembled to secure supporting bents of different lengths. The supporting bents are substantially vertical and provide vertical support only but are secured to the bridge towers **10***b* by a seat beam **26** to provide lateral support. The pin-connected shoes serve to eliminate bending moment to the supporting bents.

The seat beam **26** may also be connected to a pair of supporting bents on the opposite side of the bridge tower, as shown in FIGURE 2, to provide support for an erection span when erecting the next bridge span. This is particularly advantageous when two or more erection spans are being utilized.

A pair of shoe seats **27** are mounted within the framework of each end of the seat beam **26**. Each of the shoe seats has a conical recess **28** which is adapted to cooperate with conical shoes **31** and **32**. Shoes **31** and **32** are connected to opposite end portions **11***a* and **11***b* respectively of the erection span and are adapted to seat or nest within the shoe seats **27**.

Shoes **31** are pivotally connected to the lower end of a substantially vertical framework **33** by pins **34** and the upper end of framework **33** is pivotally connected to the erection span **11** by pins **36** and depends therefrom.

Suitable means are provided for moving each of the shoes **31** longitudinally of the erection span for purposes hereinafter described. Such means may consist of a toggle assembly **37** comprised of a pair of upper links **38** and a pair of lower links **39** which each has one pair of ends pivotally connected to the framework **33** by a pin **34**. The other pair of ends of links **38** is pivotally connected to a block **41** by a pin **42**. A pair of upper links **43** has one pair of its ends pivotally connected to block **41** by the same pin **42**. However, the ends are spaced from links **38** by pipe sections **44** mounted on pin **42**. The other pair of ends of links **43** is connected to a structural member **46** which is a part of the end portion **11***a* of the erection span by a pin **47**.

The other pair of ends of links **39** is pivotally connected to a block (not shown) immediately below block **41** by a pin **49**. A pair of links **51** has one pair of its ends pivotally connected to the same block by a pin **49**. However these ends are also spaced from links **39** by pipe sections (not shown) mounted on pin **49**. The other pair of ends of links **51** is pivotally connected to structural member **46** by pin **47**.

A reinforcing plate **52** is provided between links **39** and a reinforcing plate **53** is provided between links **51** to give additional rigidity and strength to the toggle assembly.

A rod **54** is provided with two threaded portions **54***a* and **54***b*, portion **54***b* being threaded in an opposite direction to portion **54***a*. Portion **54***a* is threaded through block **41** which is carried between links **38** and **43** and portion **54***b* is threaded into the block (not shown) which is carried between links **39** and **51**.

Rod **54** is held in position by a stay assembly **58** which is connected to structural member **46**. Rod **54** is journalled in the stay assembly **58** and is connected to a flexible coupling **61** which is connected to a shaft **62**. Shaft **62** is connected to another flexible coupling **63**. Coupling **63** is connected to a shaft **64** and extends into a housing **66** in which suitable means are provided for rotating the shaft **64** and the rod **54**. Such means may consist of a reduction gear assembly operated by a hand crank or an electrically driven motor.

It will be apparent that as the rod **54** is rotated in one direction by shaft **64** that the blocks mounted on the rod will be moved toward each other causing the shoe **31** to be moved longitudinally of the erection span away from the erection span and that when the rod **54** is rotated in an opposite direction the blocks threaded on the rod will be moved away from each other to cause the shoe **31** to be moved longitudinally of the span towards the erection span. Thus, by rotating shaft **64** it is possible to move shoe **31** longitudinally of the erection span within a range dependent upon the size of the toggle assembly **37**.

Shoes **32** are pivotally connected to the other end portion **11***b* of the erection span by pins **71** mounted in the lower end of a vertical framework **72** depending from the erection span. It will be noted that, in this instance, the vertical framework **72** is fixed but if desired it may be pivotally connected to the erection span in much the same manner that the vertical framework **33** is pivotally connected to the erection span. Suitable means may also be provided such as the toggle assembly **37** for moving the shoes **32** longitudinally of the erection span.

Assuming that the supporting bens **15** are in position and the stiff-leg derricks **17***a* and **17***b* of the traveler **17** have been connected to end portion **11***b* of the erection span and the derrick **16***a* of the derrick barge **16** has been connected to end portion **11***a* of the erection

span, the erection span is then hoisted in a substantially horizontal plane. However, it must be hoisted at an angle with the center line of the bridge as shown in FIGURE 3 in order to clear the supporting bents **15**. After the erection span has been lifted above the supporting bents, the derrick barge is used to swing the erection span over the supporting bents. The erection span is then lowered until the shoes **31** and **32** are generally adjacent the shoe seats **27**. End portion **11***a* of the erection span is then lowered and if the shoes **31** are not in vertical alignment with the adjacent shoe seats, the toggle assemblies **37** are adjusted to shift the shoes longitudinally of the erection span as hereinbefore described until the shoes **31** lie immediately above the shoe seats **27**. If the adjustments provided by the toggle assemblies **37** are not sufficient, the bridge towers **10***b* are flexible enough so that they may be pulled with cables to provide the additional movement required. End portion **11***a* is then lowered until the shoes **31** nest within the recesses **28** of the adjacent shoe seats **27**.

After the erection span is in place, the toggle assemblies **37** are adjusted to a neutral position, that is intermediate the two extreme positions so that they can be used later for securing the steel bridge span to the bridge piers as hereinafter described.

When no bridge spans are yet in place, the normal procedure for erecting the first bridge span is to erect the first few members in the bridge span in a region overlying the erection span by the use of the derrick barge **16** after which the traveler **17** is mounted on the erected members. The remaining members of the bridge span may then be erected upon the erection span by use of the traveler and the derrick barge may be used for other tasks. The traveler moves along the upper deck of the bridge span as the erection of the bridge span progresses. It is then used for erection of subsequent bridge spans without the aid of the derrick barge as shown in FIGURE 1D.

During the erection of the bridge span upon the erection span, it is necessary to build camber into the bridge span as is well known to those skilled in the art of bridge building. In my method of erection, this is complicated by the fact that both the bridge span and the erection span move horizontally and vertically between the unloaded condition and the loaded condition. Additional complications occur because the material used in the erection span has different structural properties from the material used in the bridge span. For example, if aluminum is used in the erection span, it is apparent that the deflection of the aluminum span will be greater than the deflection of a comparable steel erection span under the same load.

In FIGURES 9 and 10 I have shown charts utilized for constructing a representative steel bridge span upon an aluminum erection span. Curve **76** of FIGURE 9 represents the center line of the lower chord of the steel bridge span and shows the camber in the bridge span after it has been erected upon the erection span but before it has been swung, that is before it has been fastened to the bridge piers and allowed to carry its own weight. Curve **77** of FIGURE 9 represents the center line of the upper chord of the aluminum erection span and shows the reverse camber in the erection span after it has been loaded with the erected bridge span.

Curve **78** of FIGURE 10 represents the center line of the lower chord of the steel bridge span and shows the camber in the bridge span after the bridge span has been swung, i.e. allowed to carry its own weight. Curve **79** of FIGURE 10 repersents the center line of the upper chord of the aluminum erection span showing the camber of the erection span in an unloaded condition after the bridge span has been swung.

To provide and maintain the desired camber in the bridge span as it is being erected upon the erection span, the panel points **85** along the lower chord of the bridge span are supported by a series of jacks **86** and a plurality of blocking devices **87**. It was found desirable to support every other panel point with jacks **86** and the remaining panel points with blocking deviecs **87**, however, other arrangements may be found suitable.

The blocking devices **87** are shown in detail in FIGURES 12 and 13 and each consists of a base member **91** formed of any suitable material such as wooden blocks and which rests on the top chord of the erection span **11**. A top member **92** is also formed of a suitable material such as wooden blocks and is provided with a graphite contact member **93**. A graphite slab **94** rests on the graphite contact member **93** and is fixed to a pair of bars **96** which are secured to the bridge span at panel points **85** by hooks **97**. A pair of wedges **98** are adapted to be driven into the space between the base member **91** and the top member **92**. As is well known to those skilled in the art, as the bridge span is pushed inwardly by the jacks **86** the wedges **98** can be driven inwardly to give proper support to the panel points **85**.

One of the jacks **86** is shown in detail in FIGURES 14 and 15 and consists of a plunger **101** mounted within a hydraulic cylinder **102**. The hydraulic cylinder is mounted on a base **103** and rests on a plurality of rollers **104** which have their ends **105** journalled into bars **106**. The rollers **104** are supported by and are adapted to move longitudinally within a U-shaped framework **107** which is secured to the erection span **11**. Stops **108** are provided to limit the longitudinal movement of the jack **86** within a predetermined range for a purpose hereinafter described.

The plunger **101** of the jack is adapted to engage a plate **109** which is fixed to the bridge span at alternate panel points **85**. A pair of bars **111** are loosely mounted in the plunger **101** and engage grooves **112** in plate **109** to prevent movement of the plunger **101** relative to the plate **109**.

The hydraulic jacks **86** are connected by piping (not shown) to a source of hydraulic fluid under pressure and to means (not shown) for individually operating each hydraulic jack.

During the erection of the bridge span, the jacks and the blocking devices are raised to the proper elevation so that the desired camber is built into the bridge span. As the various members of the bridge span are put into place, substantially all of the bottom chord rivets are driven. All the other joints are bolted and pinned with varying numbers of the holes filled depending upon the importance of the connection. The deflection of the erection span will increase as the bridge span is erected on the erection span. The jacks and blocking devices are raised to compensate for this increased deflection to maintain the desired camber in the bridge span.

The lower chord of the bridge span will move horizontally because of temperature changes and also because of vertical movement of the bridge span. The rollers **104** on jacks **86** allow horizontal movement of the jacks and the graphite members **93** and **94** on the blocking devices **87** allow horizontal movement of the top members **92**.

After all the members for the bridge span are in place, the bridge span is ready to be connected to the bridge towers or columns. The bridge span is checked again for proper camber.

The ends of the bridge span are then secured to the bridge towers. However if this cannot be done because of the spacing between the piers, the piers can be adjusted horizontally by operating the toggle assemblies **37** on the erection span. The toggle assemblies working through the supporting bents **15** actually pull the bridge towers toward each other or push the bridge towers away from each other.

Following horizontal adjustment of the bridge towers, a suitable connection such as a pin connection is made between the ends of the bridge span and the bridge towers.

The toggle assemblies are then broken or released. The blocking devices 87 are removed and the jacks 86 are slowly relieved allowing the bridge span to gradually support its own weight, which is called swinging the bridge span. In the process of relieving the jacks, the erection span will move upwardly to its unloaded camber which will result in a top chord shortening of the erection span. As the load is picked up by the bridge span, it is deflected downwardly but a camber still remains in the bridge span as shown in FIGURE 10.

After the bridge span has been swung, steps may be taken to remove the erection span. First the jacks are removed. Each end of the erection span is lifted from the supporting bents by the traveler and secured to the bridge span after which the supporting bents 15 are removed. The erection span is then slowly lowered by the traveler onto an awaiting barge. One stiff-leg derrick of the traveler working through sheave arrangement 113 is used for lowering end 11*a* of the erection span and the other stiff-leg derrick working through sheave arrangement 114 is used for lowering the end 11*b* of the erection span. After the erection span has been lowered onto the barge it may be towed to the next erection site where it can be utilized for the erection of the next bridge span. To insure continuity of operation, two or more erection spans may be utilized on the same project.

The procedure and apparatus employed to carry out my invention greatly facilitates the erection of bridges in deep water where shipping channels are required. This is particularly true whenever the bridge spans are relatively long and are at a substantial elevation above the water.

For example, in constructing a recent bridge, wherein some of the bridge spans were as much as 170' above mean sea level and wherein the steel truss bridge spans were 289' long, various conventional methods of erecting the bridge spans had to be ruled out because of the high level of the bridge and because of the excessive weight (over 450 tons) of the steel truss spans. An erection span 280' long was constructed of aluminum with a truss depth of 36' and with the trusses spaced on 42' centers (the same as the permanent steel bridge spans). It was found that such an erection span weighed 117 tons which was less than one-third of what the equivalent steel truss span would havbe weighed. The 117 ton erection span was easily hoisted itno position with equipment utilized for other phases of the erection work and therefore no heavy and expensive derrick barges had to be constructed for lifting the 450 ton steel bridge spans.

The 280' aluminum erection span moved upwardly 11½ inches at its midpoint from a loaded to an unloaded position. The upward movement of the aluminum erection span was accompanied by its top chord shortening of 3 inches. As the steel bridge span picked up its own load, it deflected downwardly 2 inches at its midpoint.

In an unloaded position the span had a 7 inch camber at its midpoint and in the loaded position it had a 4½ inch reverse camber at its midpoint. The 289' steel bridge span had a 5¼ inch camber before it was swung and a 3¼ inch camber after it had been swung.

It is apparent that I have provided a new method and apparatus for erecting bridge spans. The method and apparatus can be used for erecting continuous spans, cantilever spans, arch bridges and other like structures. The use of the lightweight erection span greatly facilitates the erection of the bridge spans and eliminates the necessity of transporting the bridge spans at a high level or hoisting them to the top of the bridge towers. The erection span also gives greater safety to the workmen. It provides a better support for the permanent members of the bridge span as they are erected on the erection span. It also makes it convenient for placing and transferring safety nets on the permanent bridge span.

I claim:

1. In a method for the construction of a permanent bridge span between adjacent bridge piers, the method comprising the steps of moving an erection span into a general position adjacent the bridge piers, the erection span being fabricated of a relatively light material in comparison to steel, hoisting the erection span to a predetermined height, securing the end portions of the erection span to the adjacent bridge piers, progressively constructing the permanent bridge span in a region overlying the erection span, supporting the bridge span at panel points along the length of the bridge span upon the erection span, providing a camber in the lower chord of the bridge span, connecting the end portions of the bridge span to the adjacent bridge piers, removing the support for the bridge span from between the bridge span and the erection span and allowing the bridge span to carry its own weight, disconnecting the end portions of the erection span from the bridge piers, and lowering the erection span between the bridge piers.

2. A method as in claim 1 together with the steps of compensating for the downward deflection of the erection span caused by the weight of the bridge span, the deflection in the erection span being greater than the deflection in a comparable steel span.

3. In a method for the construction of a permanent bridge span between adjacent bridge piers, the method comprising the steps of moving an erection span into a general position adjacent the bridge piers, the erection span being fabricated of a relatively light material in comparison to steel, hoisting the erection span to a predetermined height, securing the end portions of the erection span to the adjacent bridge piers, progressively constructing the permanent bridge span in a region overlying the erection span, supporting the bridge span upon the erection span a panel points on the bridge span, providing a camber in the lower chord of the bridge span compensating for the deflection in the erection span caused by the weight of the bridge span upon the erection span to maintain the camber in the bridge span, connecting the end portions of the bridge span to the adjacent bridge piers, removing the support for the bridge span from between the bridge span and the erection span and allowing the bridge span to carry its own weight, disconnecting the end portions of the erection span from the adjacent bridge piers, and lowering the erection span between the piers.

4. In a method for the construction of a permanent bridge span between adjacent bridge piers, the method comprising the steps of moving an erection span into a general position adjacent the bridge piers, the erection span being fabricated of a relatively light material in comparison to steel, hoisting the erection span to a predetermined height, securing the end portions of the erection span to the adjacent bridge piers, progressively constructing the permanent bridge span in a region overlying the erection span, supporting the bridge span upon the erection span at panel points of the bridge span along the length of the bridge span, providing a camber in the lower chord of the bridge span, maintaining the camber in the bridge span as the erection span is progressively loaded by the weight of the bridge span, the deflection of the erection span increasing in a greater proportion than the deflection in a comparable steel span, connecting the end portions of the bridge span to the adjacent bridge piers, allowing the bridge span to carry its own weight, disconnecting the end portions of the erection span from the bridge piers, and lowering the erection span.

5. In a method as in claim 4 together with the additional steps of utilizing the erection span as a tie member between the two adjacent piers, adjusting the spacing between the centers of the adjacent piers by utilizing adjustment means connected to the erection span for pulling the adjacent piers toward each other or pushing them away from each other.

6. In a method for the construction of a permanent bridge span between adjacent bridge piers wherein the

bridge piers have a lower foundation portion and an upwardly extending tower section for permanent attachment to the bridge span, the method comprising the steps of positioning temporary supporting bents on the piers in predetermined space relationship with the lower ends thereof having load supporting engagement with the foundation portions of the piers, moving an erection span into a general position adjacent the two piers, elevating said erection span until end portions thereof are at an elevation above the upper ends of said bents, providing load supporting engagement between said end portions of the erection span and the upper ends of said bents, progressively constructing the permanent bridge span in a region overlying the erection span, the construction commencing at one bridge pier and ending at the next adjacent bridge pier, supporting the bridge span at panel points upon the erection span, providing camber in the lower chord of the bridge span, and maintaining the camber in the lower chord of the bridge span as the erection span is progressively loaded by the progressive erection of the bridge span, adjusting the spacing between the bridge towers by operation of adjustable means connecting the erection span to at least one of the bridge piers and utilizing the erection span as a tie member to cause the pier towers to be pushed away from each other or pulled toward each other to facilitate connecting the end portions of the bridge span to the bridge towers, securing the end portions of the bridge span to the adjacent bridge towers, allowing the bridge span to carry its own weight, removing the temporary supporting bents from the piers, and lowering the erection span between the piers.

7. In a method for the construction of a permanent bridge span between adjacent bridge piers wherein the bridge piers have a lower foundation portion and upwardly extending tower sections for permanent attachment to the bridge span, the method comprising the steps of positioning temporary supporting bents on the piers in predetermined space relationship with the lower ends thereof having load supporting engagement with the foundation portions of the piers, moving an erection span into a general position adjacent the piers, the erection span being fabricated of a relatively light material in comparison to steel, hoisting the bridge span at an angle with respect to the center line of the bridge piers to a level above the upper ends of the supporting bents by using a traveler mounted on the previously completed bridge spans for hoisting one end of the erection span and a floating derrick barge for hoisting the other end of the erection span, causing engagement of the shoe means on one end portion of the erection span with the seating means carried by the upper end of the adjacent supporting bent, adjusting the lateral position of the shoe means on the other end portion of the erection span to overlie the seating means carried by the upper end of the adjacent supporting bent, the adjustment being made by adjustable means carried by the erection span, causing engagement of the last named shoe means with the last named seating means, restoring the adjustable means to a normal position, progressively constructing the bridge span in a region overlying the erection span, the construction commencing at one bridge pier and ending at the adjacent bridge pier, supporting the bridge span upon the erection span at panel points on the bridge span along the length of the bridge span, providing camber in the lower chord of the bridge span, maintaining the camber in the lower chord of the bridge span as the erection span is progressively loaded by the progressive erection of the bridge span, adjusting the spacing between the bridge towers by operation of the adjustable means carried by the erection span and utilizing the erection span as a tie member to cause the pier towers to be pushed away from each other or pulled towards each other to facilitate connecting the end portions of the bridge span to the bridge towers, connecting the end portions of the bridge span to the adjacent bridge towers, allowing the bridge span to carry its own weight, hoisting the erection span to cause disengagement of the shoe means and the seating means, removing the temporary supporting bents from the piers, and lowering the erection span between the piers by using the traveler mounted on the bridge span just completed.

8. Apparatus for constructing a bridge span between two adjacent bridge piers, each of the bridge piers having a lower foundation portion, the apparatus comprising temporary supporting bents adapted to be mounted on the piers in a predetermined space relationship with the lower ends thereof adapted to rest on the lower foundation portion of the piers, an erection span, the erection span being fabricated of a material substantially lighter than steel and being of a length that will fit between adjacent bridge towers, means adapted to connect the end portions of the erection span to the upper ends of the supporting bents, the bridge span being erected in a region overlying the erection span, and jacking means resting upon the erection span and adapted to support the bridge span at predetermined panel points, the jacking means being controlled so that a camber is provided and maintained in the lower chord of the bridge span as the erection span is progressively loaded by the progressive erection of the bridge span.

9. Apparatus for constructing a bridge span between two adjacent bridge piers, the bridge piers having a lower foundation portion, the apparatus comprising temporary supporting bents adapted to be mounted on the piers at a predetermined space relationship with the lower ends thereof adapted to rest on the lower foundation portions of the piers, an erection span, the erection span being fabricated of a material substantially lighter than steel, seating means having conical recesses mounted on the upper portions of the temporary supporting bents, conical shoe means mounted on the end portions of the erection span and adapted to nest within said seating means, adjustable means mounted on the erection span for moving at least one of the shoe means in a direction longitudinally of the erection span to facilitate nesting of the shoe means within the seating means, the bridge span being erected in a region overlying the erection span, and jack means resting upon the erection span and adapted to engage the bridge span at predetermined panel points for providing a camber in the lower chord of the bridge span and for maintaining the camber in the lower chord of the bridge span as the erection span is progressively loaded by the progressive erection of the bridge span upon the erection span.

10. Apparatus as in claim 9 wherein the means for moving the shoe means longitudinally consists of a toggle mechanism.

11. Apparatus as in claim 9 wherein the temporary supporting bents are provided with pin connected shoes to eliminate bending moment.

12. Apparatus as in claim 9 wherein the jack means permits horizontal movement between the bridge and erection spans.

13. Apapratus for constructing a bridge span between adjacent bridge piers, the bridge piers having a lower foundation portion and an upper tower portion, the apparatus comprising base shoes adapted to be mounted on the lower foundation portions, temporary substantially vertical supporting bents having their lower ends pivotally connected to the base shoes, beam shoes pivotally connected to the upper ends of the temporary supporting bents, substantially horizontal beams fixed to the beam shoes and secured to the tower portions of the piers, the supporting bents providing vertical support only and the beams providing lateral support, an erection span, the erection span being fabricated of a material substantially lighter than steel, conical seating means formed within said beams, conical shoe means pivotally mounted on the end portions of said erection span and being adapted

to nest in said conical seating means, means mounted on said erection span for moving at least one of said conical shoe means in a direction longitudinally of the erection span to facilitate nesting of the conical shoe means in the conical seating means, the bridge span being erected in a region overlying the erection span, and jack means resting on the erection span and adapted to support the bridge span at predetermined panel points to provide a camber in the lower chord of the bridge span, said last named means being adjustable to maintain the camber in the lower chord of the bridge span as the erection span is progressivelp loaded by the progressive erection of the bridge span upon the erection span.

14. In a method for construction of a permanent bridge span between adjacent bridge piers, the method comprising the steps of moving an erection span into a general position adjacent the bridge piers, the erection span being fabricated of a relatively light material in comparison to steel, hoisting the erection span to a predetermined

height, securing the end portions of the erection span to the adjacent bridge piers, progressively constructing the permanent bridge span upon the erection span so that the erection span supports the permanent bridge span, connecting the end portions of the bridge span to the adjacent bridge piers, allowing the bridge span to carry its own weight, disconnecting the end portions of the erection span from the bridge piers, and lowering the erection span between the bridge piers.

References Cited in the file of this patent

UNITED STATES PATENTS

1,967,827	Leake	July 24, 1934
1,970,966	Leake	Aug. 21, 1934
2,692,034	Tidwell	Oct. 19, 1954

OTHER REFERENCES

Engineering News-Record, Sept. 2, 1954 (page 31 relied on). Copy in Scientific Library and in Div. 33.