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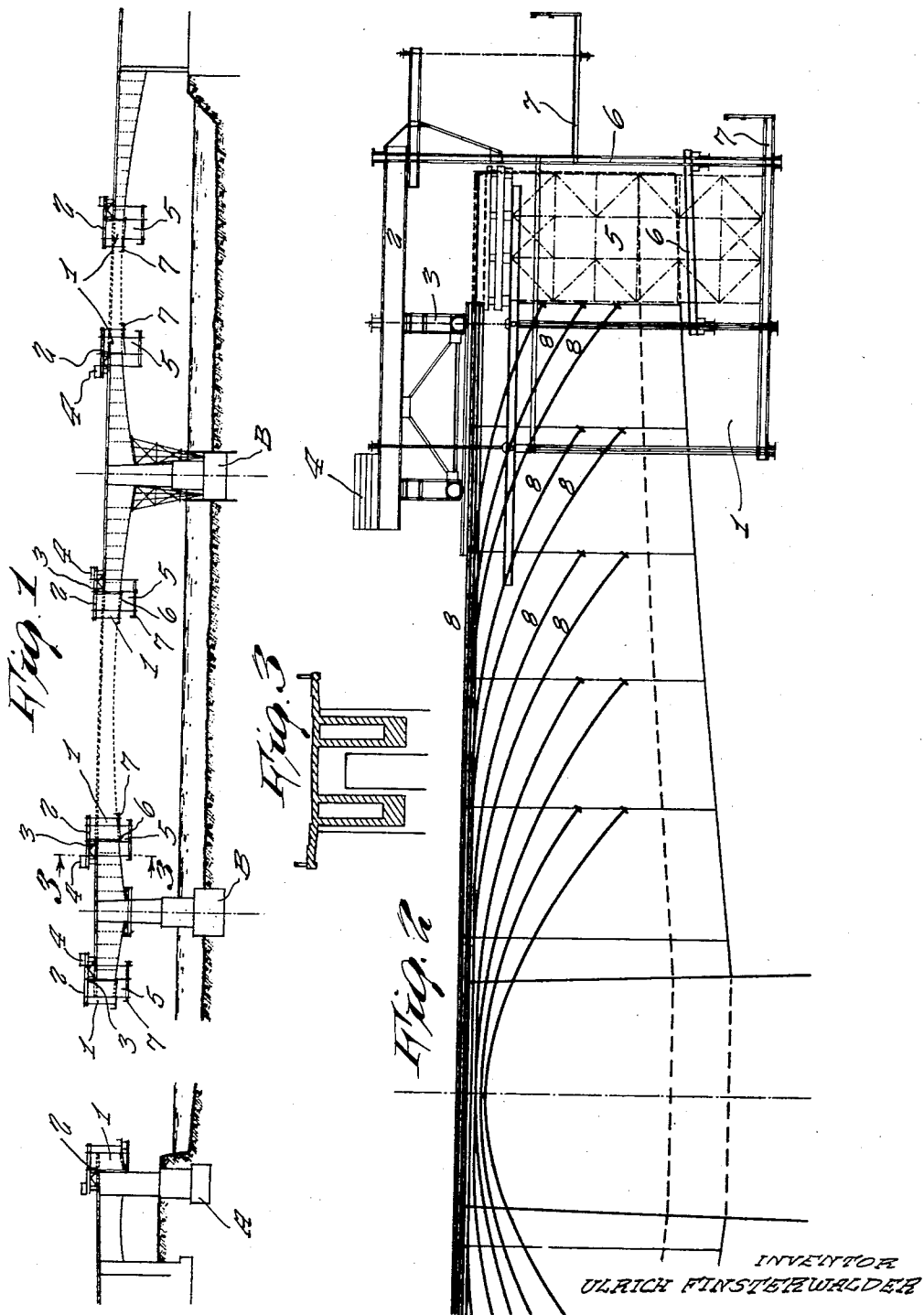
U. FINSTERWALDER

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CONSTRUCTING A PRESTRESSED CONCRETE BRIDGE

Filed Aug. 12, 1955

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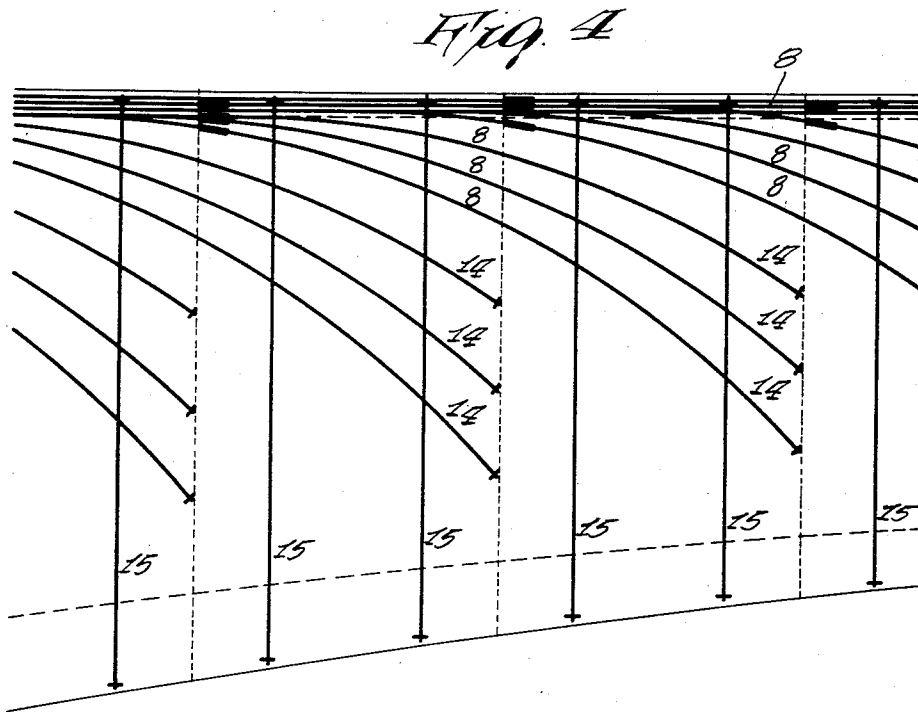
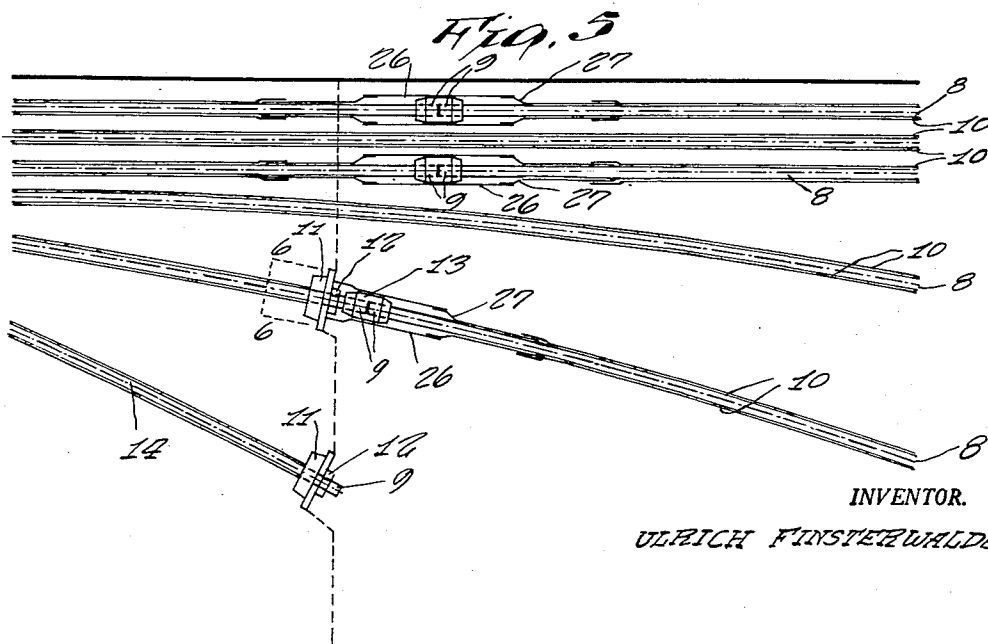
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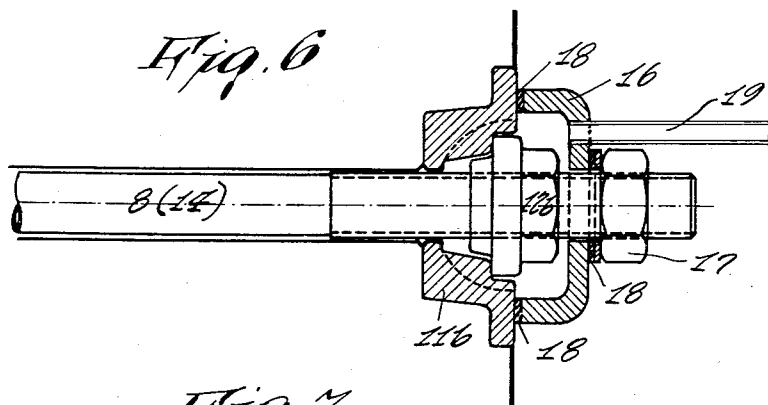
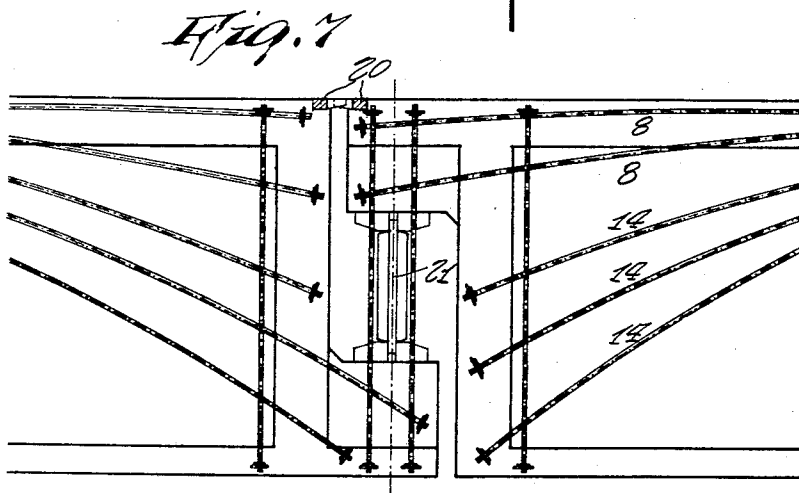
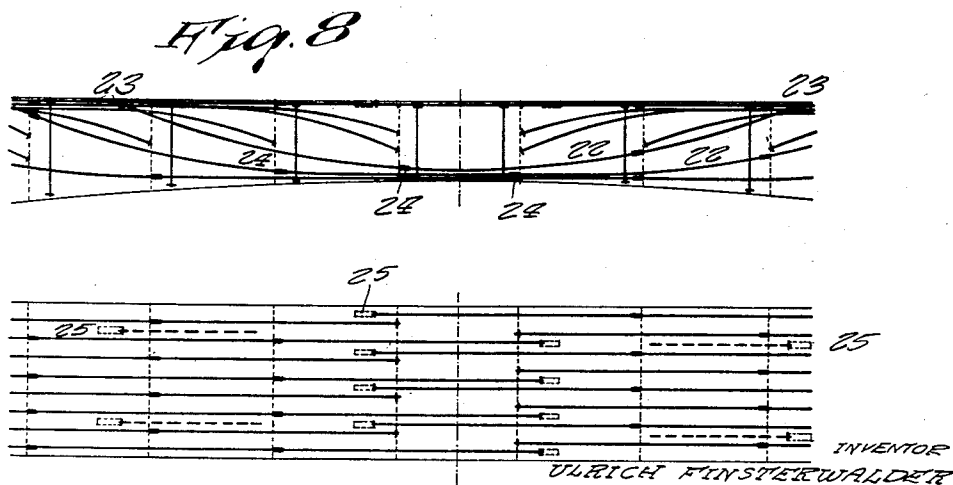
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CONSTRUCTING A PRESTRESSED CONCRETE BRIDGE

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3 Claims. (Cl. 25—154)

This invention relates to improvements in the building of reinforced concrete bridges and is particularly suitable for the building of wide-span bridges of concrete substantially without scaffolding. This is a continuation-in-part of my co-pending application Serial No. 234,989, filed July 3, 1951, and now abandoned.

In the building of wide-span bridges from reinforced concrete across deep rivers and valleys and the like, considerable difficulties and high expenses are involved because of the scaffolding or staging necessary for supporting the forms into which the concrete has to be filled.

It is the object of the present invention to make available the method of cantilevering, which is known for shorter bridges, also in the case of construction of wide-span bridges of reinforced concrete, in order to increase considerably the range of construction possible with that material.

In the following, the method of constructing wide-span bridges will be fully described.

In carrying out the construction, abutments are placed on the banks and short scaffoldings mounted thereon, from which a short section of the bridge arch is concreted. When intermediate piers are used, these, too, are made the starting points of arch construction by mounting thereon short scaffoldings and proceeding as above described.

It is also possible to build up the casings for the first short bridge section on rolled beams attached by concrete to the abutments and piers. When, as is often the case, additional shortside spans are provided for bridging water-line roads, railroads, inundation areas, and the like, these may, when appropriately constructed, serve as counterweights, for taking up negative moments, to the cantilevered bridge sections, and no special scaffolding has to be provided in that case for the construction of the first sections.

After the first sections have been concreted and the concrete has set or hardened, following sections are added without scaffolding by the use of so-called carriers which project from the finished sections. Where piers are used, the construction proceeds uniformly in both directions, so that the finished parts balance each other. In the cantilevered parts, starting from abutments on the banks, the balancing of the load has to be made by anchorage in the ground or by counterweighting with ballast.

The bridge construction proceeds without fixed scaffolding to the point where the two parts meet and where they are joined by connection methods depending on the particular construction.

The invention will now be more fully described with reference to the accompanying drawings, but it should be understood that these are given by way of illustration and not of limitation and that many changes can be made in the details without departing from the spirit of the invention.

In the drawings,

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Fig. 1 is a general view of the bridge construction with certain sections in different stages of construction;

Fig. 2 shows the concreting of one section;

Fig. 3 is a cross-section on line 3—3 of Fig. 1;

Fig. 4 illustrates the reinforcement procedure of a forward section on an enlarged scale;

Fig. 5 shows further details of the reinforcement;

Fig. 6 shows the terminal anchorage of the reinforcement to be stressed in cross-section along line 6—6 of Fig. 5;

Fig. 7 illustrates the joining of two meeting ends with pivoted connection; and

Fig. 8 the joining with rigid connection.

The method of bridge construction according to the invention will now be explained with reference to the drawings, beginning with Figs. 1 to 3.

Abutments A near the bank of the river, valley, or the like, and intermediate piers B are first erected and concreted in a known manner up to the top (roadway) of the bridge, and initial bridge sections to be built on scaffoldings are completed. A carrier designated by 1 is then built.

The carrier comprises several heavy rolled beams 2, which have a strong support 3 at the bridge ends. At the rear, the necessary amount of ballast 4 is provided for counterweighting the carrier. Another way of counterweighting consists in providing built-in anchors. A cantilevered part 5 is to support a form scaffolding 6 and working platforms 7 for building in the reinforcing members 8 and injecting the grout for concreting the same.

The building of a new bridge section is done by first introducing the reinforcing members A (Fig. 4). These reinforcing bars, which have to be pre-stressed, consist of natural hard steel with cold-rolled threads 9. The bars are placed in tubes 10 and part of them is provided on both sides with anchor plates 11 and nuts 12 for the purpose of pre-stressing; the tubes and the reinforcing bars are bent and inserted according to the required position in the structure, and secured in the concrete form by means of spacers, wire anchors or the like in a known manner. As an advantageous length for the reinforcements a double length of a forepart section of 6 meters has proven itself; whereas part of the front ends of the threads remain free so that an extension of the bars can be effected by means of sleeves 13, when it is desired to make the bars extend over a greater length of the bridge in case calculations show that this is desirable.

To a minor extent, the reinforcement is thus effected to the end of each section, the remaining part is extended by means of sleeves. The sleeves or couplings extend to the end of the form so that extensions can be coupled thereto. It has been found convenient in some cases to use prepared lengths of rolled beams of 6 meters, which extend over two building sections of 3 meters each. Anchor plates 11 and nuts 12 at the rear ends have the usual simple configuration, whereas the front plates 11b and nuts 12b have a different form in accordance with their use for pre-stressing purposes and for filling in the hollow spaces between the bars and sheathing tubes with grout.

Where the bars 8 end at a building section, they are bent downward for taking up transverse forces and shearing stresses; this is shown at 14 (Fig. 4). For equalization of stresses in the large masses, vertical rods 15 are placed approximately in the middle of each section. Since as a rule only negative bending moments occur, all reinforcement bars end in rear anchorage at the lower parts, where the stresses become compressive. The reinforcements are preferably allowed to pass intermediate piers without necessarily being anchored there-

in. Depending on the force distribution the reinforcements are led through partially over the entire length of a bridge section and partially over several forepart sections. In this case the individual lengths of reinforcing rods are pushed through threaded sleeves. The tubes must also be pushed through a middle wedging piece of a larger diameter (Fig. 5, 26) with conical-shaped fillets. At the place where the pre-stressing forces are to be transferred from the reinforcing rods to the hardened concrete, the cold-rolled threads 9 are provided with anchor plates 11 and nuts 12. The anchor plates 11b, Fig. 6, must, at this juncture, be connected tightly with the tubes. Anchor plates and nuts are secured in their position in individual openings of the concrete form so that a further security for their position is provided (Fig. 5, lower part). At the ends of the reinforcing rods which are pushed in the above indicated manner it is only necessary to provide a simple fastening for the tube and the steel rod in the concrete form (Fig. 5, above). For receiving the loads while construction is going on, however, it is also possible to provide an anchoring in the necessary dimension (Fig. 5, the second reinforcing rod from below).

After the reinforcement has been completed, concrete is introduced in conventional manner. When the concrete has sufficiently hardened, pre-stressing of the bars is done by hydraulic machinery.

For that purpose one proceeds in a known manner (not shown); a piston rod of a compression pump, which is provided with an internal thread, is screwed onto the free threaded end of the reinforcement bar, while an extension of the piston abuts against the anchor plate. One bar after another is thus pre-stressed as the hydraulic system is connected thereto. As each bar is elongated by tension, the nut is tightened by simple leverage transmission.

The control of pre-stressing is done in three ways. First, pressure is indicated on the gauge of the press, and a direct calculation is made from the piston area and the cross-section of the bar. Second, the elongation of the bars is measured by pre-arranged markers, the pre-stressing being determined by these also. Third, the amount of elongation is controlled by a counter on the gear used for tightening the nuts.

After pre-stressing is completed, the small hollow spaces between the sheathing tubes 10 and the reinforcement bars 8 are closed by forcing in of grout, whereby a complete rust proofing is accomplished and a favorable mechanical effect of the adhesion of the reinforcement to the concrete will be brought about over the entire length.

For that purpose, small cup-shaped members 16 (Fig. 6) are placed on the anchor plates 11b and nuts 12b, which are held by additional nuts 17. Escape of mortar is prevented by packing washers 18. The mortar is admitted by way of a small tube 19. Similar tubes not shown in the drawings, which are arranged at the rear ends, permit escape of air. Mortar is forced in until it escapes from the tubes at the rear ends. After the mortar has hardened, nuts 17 and cups 16 are removed.

Figs. 7 and 8 illustrate the front ends of bridge sections when they are joined; in Fig. 7 by articulated connection, in Fig. 8 by rigid connection.

In the first case only negative moments occur at the spans, which means that the reinforcement is always and everywhere subject to stresses of the same nature during construction and when the bridge is completed. The connection of the joints is effected by mutually engaging serrated members 20, or the like, in order to provide compensations for heat expansion. Furthermore, a firm union is necessary in order to prevent differences in level from forming at the joints upon uneven application of load and also for the purpose of bringing about a contributory action of the less stressed parts or the unstressed parts of the bridge. The joining is effected in

the simplest manner by means of an anchored pendulum suspension, as shown at 21.

In the case of the rigid joint also, only negative moments occur from the natural weight. Positive bending moments are produced by working loads. In order to assume these, lower reinforcement bars 22 are required, which pass through the entire structure. For constructional reasons, their anchorage is effected at the top where compressive stresses prevail in the case of negative moments. These lower bars have sometimes to be extended over several bridge sections by means of sleeves 24.

When the two bridge halves under construction from both ends are terminated, with the exception of the last section, the opening remaining after the lower reinforcements have been connected by sleeves, will be filled with concrete without leaving a joint. The lower bars are then pre-stressed at one end in remaining recesses 25, whereupon the tubes are filled with grout and the recesses are concreted. In this case, heat expansion has to be compensated by elastic deformation.

For the purposes of bridge construction, according to the invention, the use of reinforcement bars with cold-rolled threads is of great importance. In this case, the cross-section of the bar becomes only slightly reduced as compared to the untreated part by the forming of the threads. However, the load-carrying capacity is not decreased because the rolling process results in an upgrading of the material so that the strength is increased by 10 to 15% and this compensates for the reduction in cross-section.

The sheathing tubes for the reinforcement bars need only have a slightly larger internal diameter. The anchor plates fit exactly to the tubes. At the sleeve connections short connecting pieces 26 (Fig. 5) are interposed which have a larger diameter and are provided with conical parts 27 for connecting with tubes 10. Connection is made by simply sliding the members into each other or by screwing them together. Pre-stressing and anchorage are very simple as described before.

What I claim is:

1. A method of building wide-span pre-stressed concrete bridges of the solid web girder type substantially without scaffolding, which comprises first building short bridge sections directly from spaced abutments and piers on light staging supports; then projecting beyond the finished ends of said short bridge sections carriers, said carriers comprising rolled steel beams; counterweighting said beams at their rear sections which are above and supported by said short bridge sections, whereby the front section of said beams is cantilevered; supporting a form scaffolding on the cantilevered section; supporting a working platform on said cantilevered section; providing reinforcing bars of hard steel formed at their ends with cold-rolled threads, said bars being enclosed throughout their length in sheathing tubes of an inside diameter slightly larger than the diameter of the bars, said bars being further provided at their ends with anchor plates and nuts for pre-stressing same; anchoring said bars and said tubes in the said short bridge section; bending said bars and said sheathing tubes downward for taking up transverse forces and sheathing stresses; pouring concrete into the said form scaffolding; prestressing said bars after the concrete is set; filling in the hollow spaces between the said bars and sheathing tubes with grout, and allowing the same to harden; attaching couplings to the ends of the said rods and sheathing tubes at the ends of the said cantilevered section; further projecting beyond the finished ends of said cantilevered section free-span carriers; again supporting a second form scaffolding and working platforms from said cantilevered section; attaching reinforcing steel bars, enclosed in sheathing tubes, to the said couplings, again bending said bars and said sheathing tubes for taking up the stresses; pouring concrete into the said second form scaffolding; prestressing said bars after the concrete is set; filling in the spaces between the said bars

and sheathing tubes with grout, and allowing the same to harden; continuing said building method from said spaced abutments or piers towards one another until the said bridge sections meet; finally joining said bridge sections.

2. A method of building wide-span pre-stressed concrete bridges of the solid web girder type substantially without scaffolding, which comprises first building short bridge sections directly from spaced abutments and piers on light staging supports in a direction facing one another; then projecting beyond the finished ends of said short bridge sections carriers, said carriers comprising rolled steel beams; counterweighting said beams at their rear sections which are above and supported by said short bridge sections, whereby the front section of said beams is cantilevered; supporting a form scaffolding on the cantilevered sections; supporting a working platform on said cantilevered section; providing reinforcing bars of hard steel formed at their ends with cold-rolled threads, said bars being enclosed throughout their length in sheathing tubes of an inside diameter slightly larger than the diameter of the bars, said bars being further provided at their said cold-rolled threaded ends with anchor plates and nuts for pre-stressing the same; anchoring the threads at one end of said bars and said tubes in the said short bridge section and the threads at the other end of said bars and tubes at the projecting end of the cantilevered section; bending said bars and said sheathing tubes downward for taking up transverse forces and sheathing stresses; pouring concrete into the said form scaffolding; prestressing said bars after the concrete is set; filling in the hollow spaces between the said bars and sheathing tubes with grout, and allowing the same to harden; attaching couplings to the ends of the said bars and sheathing tubes at the ends of the said cantilevered section; further projecting beyond the finished ends of said cantilevered section carriers; again supporting a second form scaffolding and working platforms from said cantilevered section; attaching reinforcing steel bars, enclosed in sheathing tubes, to the said couplings; again bending said bars and said sheathing tubes for taking up the stresses; pouring concrete into the said second form scaffolding; prestressing said bars after the concrete is set; filling in the spaces between the said bars and sheathing tubes with grout, and allowing the same to harden; attaching couplings to the reinforcing bars and sheathing tubes to be extended; further projecting beyond the finished ends of said cantilevered sections carriers, until the protruding bridge ends meet when a small gap is loaded; arranging a pendulum link at the junction of the two front sections by building an upper short cantilever arm at one front end and a lower one at the other front end, respectively, inserting a vertical pendulum support between the cantilever arms and joining both cantilever arms together by means of vertical steel anchors in order to avoid differences in levels for driving; leaving a narrow open space for equalizing the heat expansion.

3. A method of building wide-span pre-stressed concrete bridges of the solid web girder type substantially without scaffolding, which comprises first building short bridge sections directly from spaced abutments and piers on light staging supports in a direction facing one another; then projecting beyond the finished ends of said short bridge sections carriers, said carriers comprising rolled steel beams; counterweighting said beams at their rear sections which are above and supported by said short bridge sections, whereby the front section of said beams is cantilevered; supporting a form scaffolding on the cantilevered section; supporting a working platform on said cantilevered section; providing reinforcing bars of hard

steel formed at their ends with cold-rolled threads, said bars being enclosed throughout their length in sheathing tubes of an inside diameter slightly larger than the diameter of the bars, said bars being further provided at their said cold-rolled threaded ends with anchor plates and nuts for pre-stressing same; anchoring the threads at one end of said bars and said tubes in the said short bridge section and the threads at the other end of said bars and tubes at the projecting end of the cantilevered section; bending said bars and said sheathing tubes downward for taking up transverse forces and sheathing stresses; anchoring steel reinforcing rods vertically in said forms; pouring concrete into the said form scaffolding; pre-stressing said bars after the concrete is set; filling in the hollow spaces between the said bars and sheathing tubes with grout, and allowing the same to harden; attaching couplings to the ends of the said bars and sheathing tubes at the ends of the said cantilevered section; further projecting beyond the finished ends of said cantilevered section carriers; again supporting a second form scaffolding and working platforms from said cantilevered section; attaching reinforcing steel bars enclosed in sheathing tubes, to the said couplings; again bending said bars and said sheathing tubes for taking up the stresses; pouring concrete into the said second form scaffolding; pre-stressing said bars after the concrete is set; filling-in the spaces between the said bars and sheathing tubes with grout and allowing the same to harden; continuing the building of sections according to said method from said spaced abutments or piers in a direction towards one another until only a field of the length of one bridge section remains free between the cantilevered bridge ends; projecting the carrier of one side forward, so that the cantilevered part covers the remaining opening; inserting reinforcement bars and sheathing tubes in such a manner that they are connected on both sides with the bars and sheathing tubes of the preceding section by means of couplings; closing of the bridge opening by pouring concrete into the casing; after hardening of the concrete, pre-stressing of the reinforcement bars of the last bridge section by means of the reinforcing bars of the preceding section connected thereto from the surface of the bridge, filling of the still remaining hollow spaces between reinforcement and sheathing tubes with grout.

References Cited in the file of this patent

UNITED STATES PATENTS

1,303,741	Thomas	May 13, 1919
2,028,741	Disney	Jan. 28, 1936
2,172,703	Freyssinet	Sept. 12, 1939
2,185,749	Kennedy	Jan. 2, 1940
2,413,990	Muntz	Jan. 7, 1947
2,712,750	Finsterwalder	July 12, 1955

FOREIGN PATENTS

195,570	Great Britain	Apr. 5, 1923
200,512	Great Britain	Nov. 8, 1923
338,934	Great Britain	Nov. 25, 1930
1,039,305	France	May 13, 1953
155,756	Australia	Mar. 18, 1954

OTHER REFERENCES

- Engineering News-Record, October 18, 1945, pages 92 and 93.
 65 Journal of American Concrete Institute, vol. 23, Issue 3, pages 273 and 274, November 1951.
 Civil Engineering, September 1949, pages 25 and 26.