June 6, 1939. P. W. LEISNER 2,161,177

BRIDGE CONSTRUCTION

Filed July 30, 1936

Fig. 1.

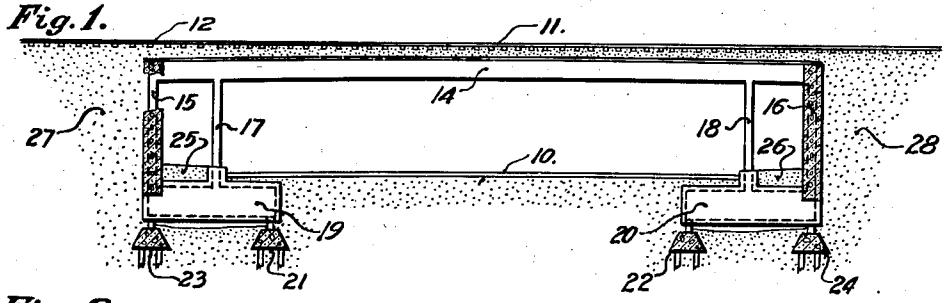


Fig. 2.

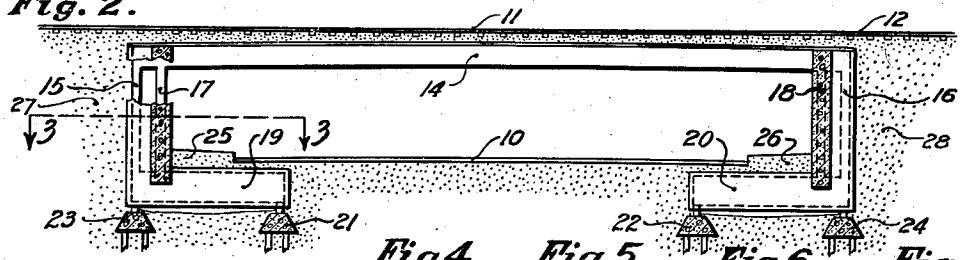


Fig. 3.

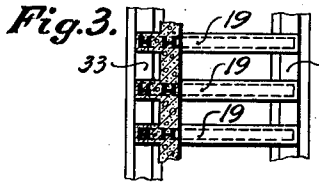


Fig. 4.

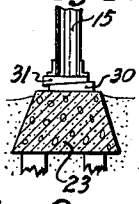


Fig. 5.

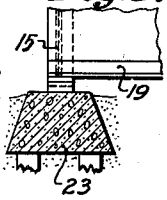


Fig. 6.

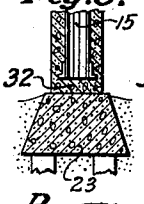


Fig. 7.

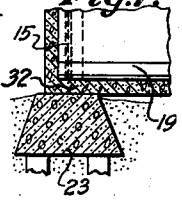


Fig. 8.

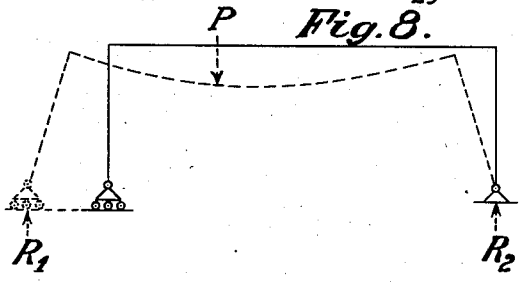


Fig. 9.

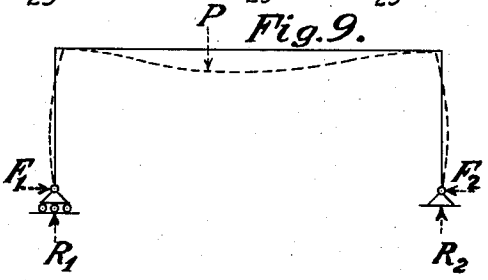


Fig. 10.

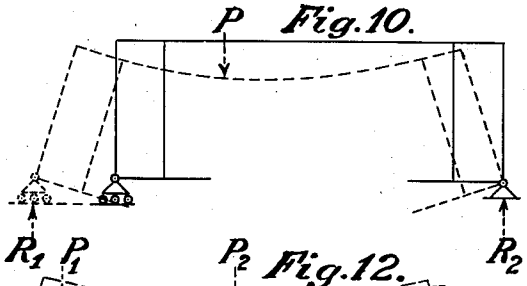


Fig. 11.

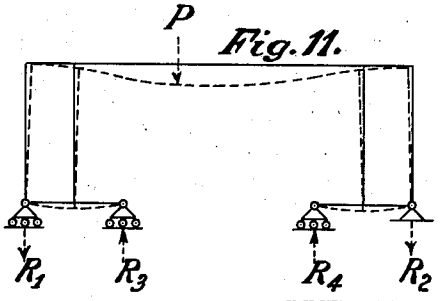
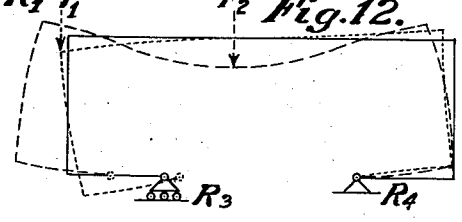


Fig. 12.



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Patented June 6, 1939

2,161,177

UNITED STATES PATENT OFFICE

2,161,177

BRIDGE CONSTRUCTION

Paul W. Leisner, Evanston, Ill.

Application July 30, 1936, Serial No. 93,415

10 Claims. (Cl. 72—56)

This invention relates to bridge constructions, and more particularly to bridges designed to effect a grade separation or to produce one roadway over another.

It is an object of the invention to produce a bridge construction which will provide a minimum vertical grade separation while retaining a maximum vertical road clearance for the lower roadway; which will provide a construction of wide span with a very shallow overhead; and which will provide a construction in which supports for the overhead between the bridge end walls may be eliminated.

It is a further object of the invention to provide means in a bridge construction for introducing a counterbending moment into the overhead solely by the vertical thrust of the supports for the construction and without the necessity of means for imparting lateral thrust to the bridge end walls or supports. In accordance with the construction of the invention tie members connecting the end walls of the construction underneath the lower roadway are eliminated, thereby eliminating obstructions beneath the lower roadway which may interfere with the laying of pipes and the like.

A further and important object of the invention is to provide a bridge construction of the type defined in which sufficient head clearance for the lower roadway is provided over the entire width thereof, the overhead being sufficiently flat and the end walls being of sufficient height so as to provide head clearance at all points on the lower roadway.

A still further object is to provide in such a bridge construction, means for preventing the ends of the structure from moving as the structure is subjected to live loads. More specifically, suitable support means are provided at the ends for holding them immovable under all conditions of live loading and under all movements to which the live loads may be subjected.

Another object of the invention is to provide a continuous bridge structure having more than two supports wherein calculations as to maximum stresses of the structural parts may be made as with a statically determinated body having but two supports.

Another object is to provide novel and improved means for mounting the ends of the bridge construction upon its end supports.

Still other objects and advantages of the invention will appear from the following description when taken in connection with the accompanying drawing, wherein certain preferred embodiments of the invention are illustrated.

In the drawing, wherein like reference numerals refer to like parts throughout:

Fig. 1 is a sectional view of one form of bridge construction embodying the principles of the invention.

Fig. 2 is a sectional view of a bridge construction of modified form also constructed in accordance with the principles of the invention.

Fig. 3 is a sectional view of the construction of Fig. 2 taken on the line 3—3 thereof.

Figs. 4 and 5 are end and side views, respectively, illustrating the method of arranging the construction upon its end supports.

Figs. 6 and 7 are similar views showing the completed end supports.

Figs. 8 to 12, inclusive, are diagrammatic views illustrating the principles of the invention.

This application is a continuation in part of my application Serial No. 32,400, filed July 20, 1935.

Overheads for bridge constructions are classified as "deep girder" overheads if the depth thereof is equal to or greater than $\frac{1}{12}$ of the length of the girder span. Girders of less depth are classified as "shallow girders." In proportioning the various parts of deep girders safe interior unit stresses for any given loading are the only requirements governing the safety of the design. On the other hand, in proportioning shallow girders, deflection considerations are the requirements which govern. Good practice requires that the deflection of any such shallow girder for a given live load shall not be substantially greater than the deflection would be if the depth of the girder were equal to $\frac{1}{12}$ of its span length. When a girder is merely mildly shallow, it is possible to design its various parts to bring it within maximum deflection requirements such as by increasing the web thickness of the girder or by adding more material to the flanges whereby to increase its moment of inertia. However, when the girder is extra shallow, considerations of economy, proportioning, ease of fabrication and the like exclude this method of decreasing deflection. It is to this class of "extra shallow girders" that the present invention relates particularly.

Referring to Fig. 1, wherein for purposes of illustration one form of the invention is shown, the reference numerals 10 and 11 designate the levels of the lower and upper roadways, respectively. The upper roadway is illustrated as a railroad track 12 carried upon suitable ballast, as the invention is particularly adapted for use in this connection. It is to be understood, how-

ever, that the invention is not limited to such use but is adapted to bridges for effecting grade separation generally, as well as for other analogous uses. The bridge construction, which for convenience will be designated as a reverse cantilever frame, comprises a main overhead girder 14 supported by end wall girders 15 and 16 and by intermediate supporting girders 17 and 18. The upright girders are secured at their lower ends to reverse cantilever beams or girders 19 and 20 extending inwardly from the end wall girders at each end of the construction. The reverse cantilever girders are supported at their inner ends by main supports 21 and 22 and at their outer ends by auxiliary end supports 23 and 24. The overhead, upright and reverse cantilever girders are all fabricated into a single integral construction, thereby forming a rigid reverse cantilever frame member. The individual pieces which are fabricated to form the various girder members have been omitted from the drawing for clarity of illustration.

The reverse cantilever beams are frictionally carried upon the main and auxiliary supports. That is, the beams or girders are free to move laterally within limits relative to the supports. Such movement may take place if the live loads to which the construction is subjected are of sufficient magnitude, the frictional resistance to lateral movement in such instances being overcome. It is to be understood that rollers may be applied to two or more of the supports whereby to permit more free movement, but this is generally not necessary as the degree of any movement is relatively small. The reverse cantilever girders 19 and 20, and the end wall girders 15 and 16 may be suitably encased in concrete as shown.

In Fig. 1 sidewalks are indicated at 25 and 26 arranged between the upright end wall girders and the upright intermediate supporting girders. The earth fills 27 and 28 at the ends of the construction may be merely loose earth and are not designed to impart any lateral support to the structure.

The construction shown in Fig. 2 is the same as that shown in Fig. 1 except that the intermediate supporting girders 17 and 18 are in this instance moved outwardly in juxtaposition to the end wall girders 15 and 16. In this instance, therefore, the sidewalks 25 and 26 may be arranged inwardly of the intermediate supporting girders, and the said girders may also be encased in concrete or the like as shown, forming in effect a part of the side walls.

As best indicated in Fig. 3, the bridge construction is formed of a number of reverse cantilever rigid frame members arranged in spaced relation. The number of frame members and their lateral spacing will be determined by the size and load requirements of the bridge. The reverse cantilever girders, such as the girder 19 in Fig. 3, may be supported upon cross beams 33 and 34, which are then in turn supported upon the main support 21 and the auxiliary or end support 23, respectively.

In either form of construction as shown in Fig. 1 or Fig. 2, as a live load approaches the frame from the left it will first be transferred directly to the auxiliary end support 23 by means of the end girder 15. The end support under this condition prevents any downward movement of the end of the reverse cantilever rigid frame. As the live load moves inwardly toward the center of the overhead some of the load is transmitted to the intermediate supporting upright 17 and to the main support 21. As the load reaches the center of the overhead, the point at which it tends to induce the maximum deflection in the overhead, the load is carried entirely by the main supports 21 and 22. Due to the fact that these supports are spaced inwardly from the outer ends of the overhead, they introduce a counterbending moment into the overhead, which to a considerable extent neutralizes the downward bending moment introduced in the overhead by the live load, thus reducing overall downward deflection. The action as the load passes along toward and past the other end of the reverse cantilever rigid frame is the same. It will thus be seen that the auxiliary or end supports which come into action as the load is arranged at the extreme ends of the frame prevent any movement at the ends. When the load is at the center of the overhead, a condition which subjects the overhead to maximum deflection, the load is carried by the main supports 21 and 22 which are spaced inwardly from the ends of the overhead and set up a counterbending moment therein, materially reducing overhead deflection.

The action of the reverse cantilever rigid frame with four supports will best be understood by reference to the diagrammatic showings in Figs. 8 to 12, inclusive. Fig. 8 shows a simple frame and illustrates how the overhead is free to deflect to a maximum deflection when subjected to a load P. In Fig. 9 lateral forces F1 and F2 have been applied to the supports R1 and R2, respectively, whereby to hold said supports from separation. Such lateral forces introduce a bending moment into the uprights which in turn introduce a counterbending moment into the ends of the overhead whereby to reduce the deflection due to the load P. Fig. 9 illustrates what is known as the common rigid frame. The lateral forces F1 and F2 may be produced by tying the supports together by means of tie-rods or by anchoring them to suitable foundations. However, frequently it is undesirable to arrange tie-rods under the lower roadway as they interfere with the laying of pipes, etc., and unless the frame is supported upon a rock ledge it is difficult, if not impossible, to so anchor the supports so as to prevent lateral movement, thus setting up the forces F1 and F2.

Figs. 10 and 11 illustrate how the same counterbending moment may be introduced into the overhead by means of the reverse cantilever rigid frame. Fig. 10 illustrates how the overhead tends to deflect under the load, spreading the supports R1 and R2, and Fig. 11 illustrates how the addition of the inwardly spaced reverse cantilever supports R3 and R4 prevents material separation and introduces a counterbending moment into the overhead solely by the action of the vertical supporting forces. In the diagrammatic showings the various deflections and movements have been exaggerated to show the principles of action of the structures. In Fig. 11 a negative reaction is indicated at the supports R1 and R2 when the load P is in the center of the overhead. This negative reaction is slight and in practice is more than overbalanced by the dead load of the concrete encasement for the end girders so that at no time will the end girders be lifted from their supports.

The reverse cantilever rigid frame introduces a counterbending moment into the overhead solely by the vertical thrust of the inwardly spaced supports. This counterbending moment reduces the deflection of the overhead, allowing the use

of a shallow overhead girder. The shallow girder provides a maximum vertical head clearance for the lower roadway while retaining a minimum vertical grade separation between the upper and lower roadways. The introduction of the counterbending moment makes the use of supports at the center of the overhead unnecessary, thus ensuring a wide, clear opening for the lower roadway. No tie members through the lower roadway are necessary, and it is unnecessary to anchor the frame to its supports against lateral movement relative thereto, an expensive type of construction. Due to the horizontal character of the overhead and the definite upright girders which are provided, the overhead is appreciably spaced from the lower roadway not only at the center but also at the ends thereof. Headroom is thus provided for the lower roadway not only at the center but at the sides, insuring a clear opening for the entire roadway width.

In Fig. 12 there is illustrated diagrammatically a reverse cantilever rigid frame with two supports. It will be seen that as a load P1 is applied to the end of the structure, the end is deflected downwardly as indicated by the dotted line from the original, normal condition. As the load passes to the center of the frame to the point P2 there will be a tendency for the end of the frame to be lifted above its normal position. In practice the actual lifting of the frame end from its normal position would be prevented by the dead weight at the end, but it is clear that the end is constantly moving vertically as the load moves across the overhead. This end movement is avoided by the use of the present invention wherein the reverse cantilever rigid frame is provided with four supports. Not only does the four-support structure prevent movement of the structure at the ends, but it further reduces the overhead deflection, over that which will be obtained in a two-support reverse cantilever structure. In the two-support structure as shown in Fig. 12, end loading at the point P1 tends to lift the center of the overhead whereas central loading at the point P2 tends to deflect the overhead downwardly at the center. The overhead thus deflects between the two limits defined by the two kinds of loading. In the four-support structure end loading at the point P1 produces no deflection of the overhead due to the presence of the outer or auxiliary support. The limits between which the overhead may deflect under different kinds of loading is therefore reduced in a four-support structure. This reduction in deflection allows the use of an even more shallow overhead than is permissible in a two-support reverse cantilever rigid frame.

Comparing the four-support structure of Fig. 11 with the two-support structure of Fig. 12, it will be seen that the negative reactions R1 and R2 in the four-support structure increase the positive reactions R3 and R4 and cooperate therewith to further reduce overhead deflection.

The four-support structure is a continuous structure, but due to the very shallow overhead which may be provided it has been found that it may be calculated as to maximum stresses in the same manner as a statically determinate two-support structure. The four-support construction therefore provides the advantages heretofore pointed out, while at the same time retaining simplicity in calculation.

One very satisfactory method of mounting the frame upon its end supports is illustrated in Figs. 4 to 7, inclusive. Wedges 30 and 31 are first employed, as shown in Figs. 4 and 5, as the means for supporting the end girder 15 upon the end support 23. A set of wedges is provided at each end support of the structure. During the course of fabrication of the frame assembly, the wedges may be adjusted to maintain the reverse cantilever girders horizontal and in proper position. After the fabrication of the frame has been completed the wedges are removed and the extreme outer ends of the frame allowed to drop. The entire weight of the frame is thus transferred to the main supports 21 and 22. The concrete encasements are now poured around the end wall girders, the concrete being allowed to flow between the bottom of the girder and the support as indicated at the point 32 in Figs. 6 and 7. Normally, therefore, the weight of the frame is carried entirely by the main supports 21 and 22, and the weight of the concrete encasements for the end wall girders is carried upon the supports 23 and 24. As a live load strikes the end of the overhead the concrete at the point 32 prevents downward movement of the end wall girder. As the live load moves to the center of the overhead and the end wall girder tends to lift from its support, the dead weight of the concrete encasement will be transferred to the girder whereby to prevent any upward movement. The end wall girders are thus prevented from either upward or downward movement under all conditions of loading.

Various changes may be made in the embodiments specifically shown and described for the purposes of illustration without departing from the spirit of the invention. The invention is therefore not to be limited to such embodiments but only as indicated in the following claims.

The invention is hereby claimed as follows:

1. In a bridge construction, an overhead span member, reverse cantilever members arranged beneath said overhead and extending toward each other from the ends thereof, main supports for supporting the inner ends of said reverse cantilever members, auxiliary supports for supporting the outer ends of said reverse cantilever members, and means for connecting said reverse cantilever members to the overhead span member, said means being spaced outwardly of said main supports.

2. In a bridge construction, an overhead span member, reverse cantilever members arranged beneath said overhead member and extending toward each other from the ends thereof, main supports adjacent the inner ends of said reverse cantilever members, auxiliary supports adjacent the outer ends of said reverse cantilever members, and upright means for rigidly connecting the reverse cantilever members to the overhead member, said means being spaced outwardly of the main supports.

3. In a bridge construction, an overhead girder, uprights secured at their upper ends to the ends of the overhead, reverse cantilever girders secured to the lower ends of the uprights and extending inwardly therefrom, main supporting means for the reverse cantilever girders arranged inwardly of the uprights, and auxiliary supporting means for the outer ends of said reverse cantilever girders.

4. In a bridge construction, an overhead girder, uprights rigidly fixed at their upper ends to the ends of the overhead, reverse cantilever girders rigidly fixed to the lower ends of the uprights and extending inwardly therefrom, main supporting means for the reverse cantilever girders arranged

inwardly of the uprights, and auxiliary supporting means arranged axially of the uprights.

5. In a bridge construction, an overhead girder, a pair of end girders connected at their upper ends to the ends of the overhead girder, a pair of intermediate girders spaced inwardly of the end girders and connected at their upper ends to the overhead girder, reverse cantilever girders connected to the lower ends of said end and intermediate girders and extending inwardly toward each other therefrom, main supports for the inner ends of said reverse cantilever girders, and auxiliary supports for the outer ends thereof.

6. In a bridge construction, a reverse cantilever rigid frame comprising an overhead member, uprights fixed at their upper ends to the ends of the overhead member, and reverse cantilever girders fixed to the lower ends of said uprights and extending inwardly therefrom, main supports for the inner ends of said reverse cantilever girders, and auxiliary supports for holding the outer ends thereof against movement.

7. The method of making a bridge construction which comprises providing a main support and an auxiliary support for a metal girder frame, supporting the frame upon the main support in spaced relation to the auxiliary support while permitting the frame to flex due to its own weight, and encasing the frame in concrete while so supported, said concrete being permitted to flow between the frame and the auxiliary support whereby to be supported thereby while the frame remains supported by the main support.

8. In a bridge construction, a reverse cantilever rigid frame comprising an overhead girder, upright girders secured at their upper ends to the ends of the overhead girder, and reverse cantilever girders secured to the lower ends of the upright girders and extending inwardly toward each other therefrom, main supports for supporting the inner ends of said reverse cantilever girders, concrete encasements for said upright girders, and auxiliary supports for supporting said concrete encasements.

9. In a bridge construction, an overhead span adapted to receive live loads, means for supporting the span contiguous its ends, means for thrusting said support means counter to the deflection of the span as the span is subjected to central loading whereby to introduce a counter-bending moment into the span, and means for restraining the ends of the span against vertical deflection as the span is subjected to end loading.

10. In a bridge construction, an overhead span adapted to receive live loads, a support structure for supporting the span contiguous its end, a primary support means for supporting the support structure, said primary support means being so disposed that an extension of its resultant supporting line of force lies in a plane transverse to the span which is spaced inwardly from the point at which the support structure is secured to the span, and an auxiliary support means for supporting the support structure, said auxiliary support means being so disposed that an extension of its resultant supporting line of force lies in a plane transverse to the span which is substantially coincident with the point at which the support structure is secured to the span.

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