June 12, 1934. A. R. KNIGHT 1,962,820

ART OF REPAIRING AND STRENGTHENING METAL BRIDGES OF THE TRUSS TYPE AND LIKE STRUCTURES

Filed April 7, 1932 3 Sheets-Sheet 1

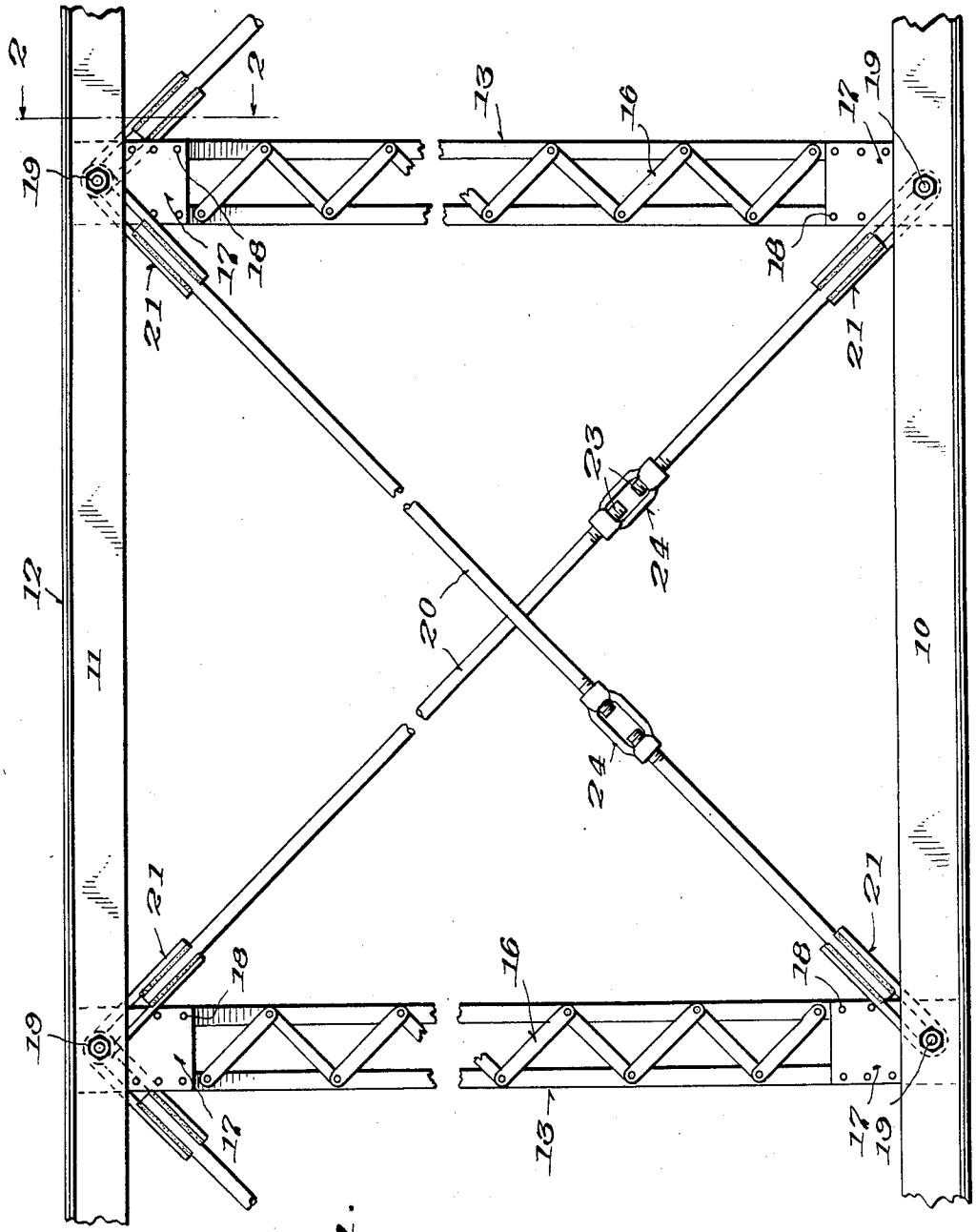


Fig. 1.

Inventor
A. RHODES KNIGHT,

By Stewart & McKay
his Attorneys

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Fig. 2.

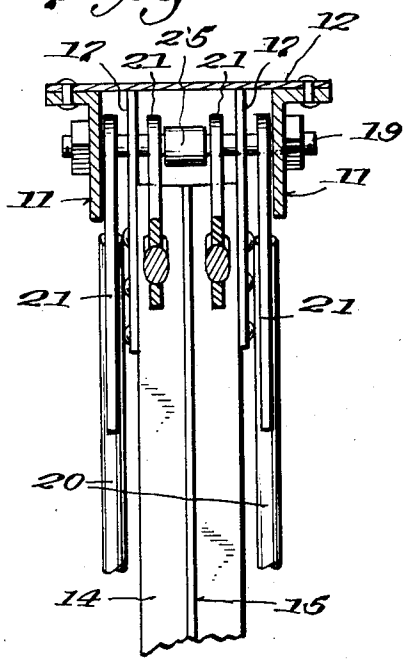


Fig. 3.

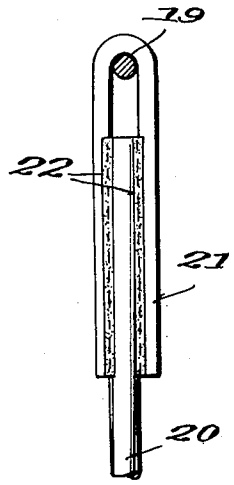


Fig. 4

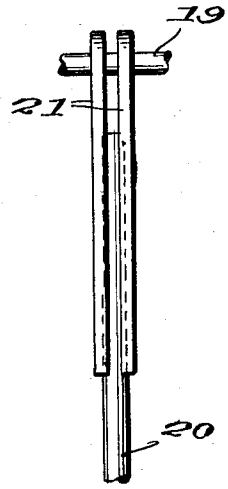


Fig. 5.

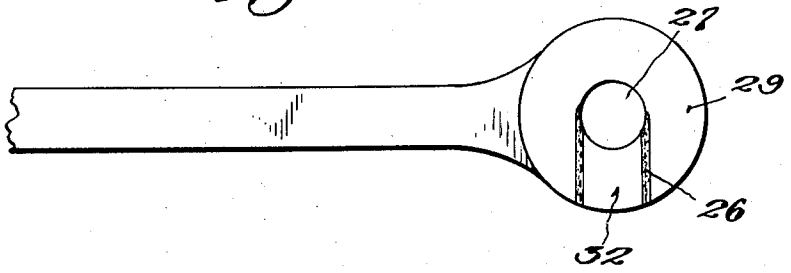
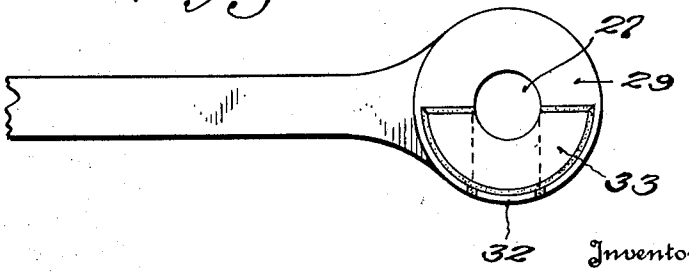


Fig. 6



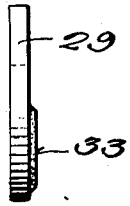


Fig. 7.

Inventor

A. RHODES KNIGHT,

By Stewart & McKay

his Attorneys

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ART OF REPAIRING AND STRENGTHENING METAL BRIDGES OF THE TRUSS TYPE AND LIKE STRUCTURES

Filed April 7, 1932 3 Sheets-Sheet 3

Fig. 8.

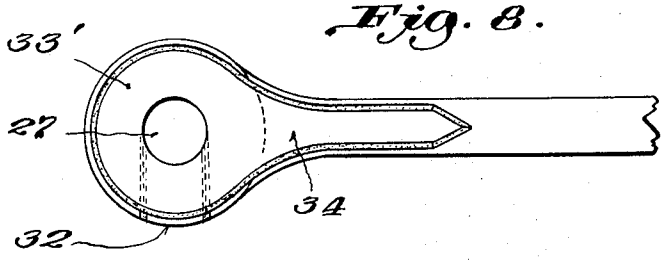


Fig. 9.

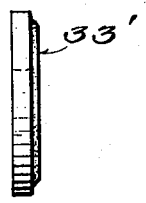


Fig. 10.

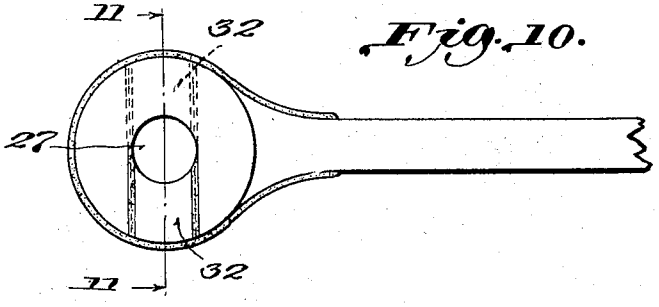


Fig. 11.

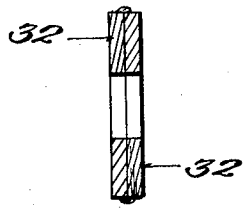


Fig. 12.

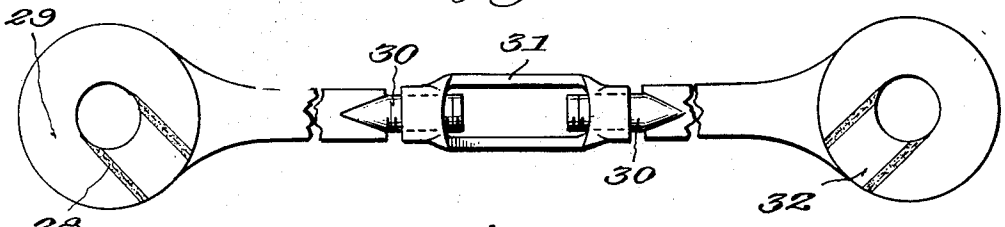


Fig. 13.

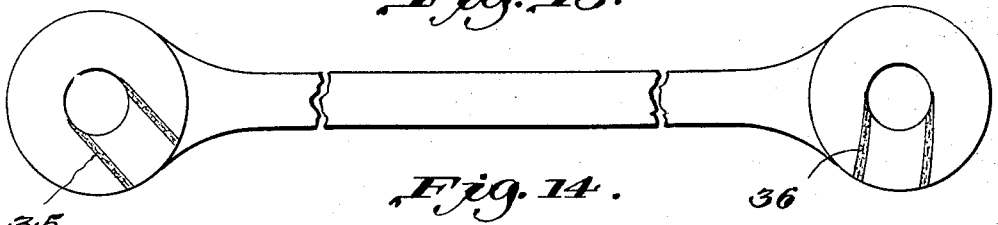
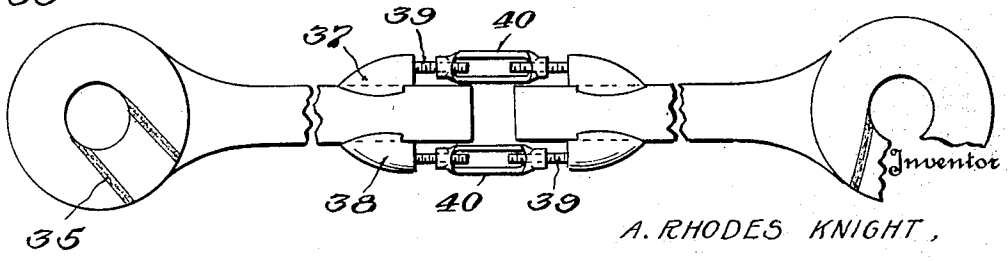


Fig. 14.



Inventor

A. RHODES KNIGHT,

By Howard & McKay

his Attorneys

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UNITED STATES PATENT OFFICE

1,962,820

ART OF REPAIRING AND STRENGTHENING METAL BRIDGES OF THE TRUSS TYPE AND LIKE STRUCTURES

Arthur Rhodes Knight, Baltimore, Md.

Application April 7, 1932, Serial No. 603,875

12 Claims. (Cl. 29—151)

This invention relates to the art of repairing and strengthening metal bridges of the truss type and like structures.

A frequent cause of the failure of an iron or steel bridge of the truss type to bear or properly distribute the maximum load for which it was originally designed is the slack which occurs after long continued use in the brace or link members which take part in distributing the load and the impulsive forces of traffic from point to point through the bridge structure to the foundation supports of the bridge. This slack in turn is due either to a permanent stretch of the metal brace or link members beyond their original length or to wear of their eye-portions upon the pins or bolts of the bridge which attach them at their extremities to the portions of the bridge structure between which they extend. Generally both these last-mentioned causes are operative in producing the slack in the brace or link members; and moreover the wear of the eye-portions of these members on their attaching pins so weakens the structural strength of the brace or link members as to present this as an additional cause of the failure of the bridge to bear or properly distribute the load for which it was originally designed.

Furthermore, present-day motor vehicles, of greatly increased weight and speed of travel even over bridges, as compared with the vehicles and their rates of travel but a few years ago, have so greatly increased the loads and the impulsive forces of those loads in traffic which bridges are subjected to as to render the bridges of a few years ago entirely inadequate to sustain those changed traffic conditions even when their original efficiency has not been impaired by the factors hereinbefore referred to. Hence, aside from these factors tending to greatly reduce or destroy the efficiency of the bridges to sustain and properly distribute the maximum load for which they were designed, modern traffic conditions have greatly added to the problem of providing adequate bridges without the prohibitive cost of replacing the older by entirely new bridges designed especially for the heavier loads and greater impulsive forces of present-day traffic conditions.

A primary object of my invention is to restore, with a minimum amount of labor and cost and with little of any interruption to traffic, the original strength and efficient functioning of bridges of the truss type to bear and properly distribute the maximum load for which they were originally designed where that strength and efficiency in functioning have been impaired by the factors hereinbefore referred to.

Another primary object of my invention is to increase the load-sustaining and load-distributing capacity of bridges of the type referred to beyond that for which they were originally designed so as to enable such bridges already in use, and which would otherwise be inadequate, to sustain the increased loads and their greater impulsive forces on the bridge structure afforded by present-day vehicles and traffic conditions.

Addressed to those objects, my invention, broadly stated, pertains to improved methods of repairing and strengthening, and where necessary entirely renewing, the brace or link members of metal bridges of the truss type, or, where necessary to increase the load-sustaining capacity beyond that of the original design, adding additional brace or link members, without appreciable dismantling of other structural parts of the bridge.

I am aware that in the prior art to which my invention relates, means have been proposed for the ready substitution of a new brace member in the bridge for one found defective or becoming defective by use, but the objection to such proposals, from the standpoint of the objects sought to be attained by my invention, is that they require the bridge to be originally designed and built in some particular manner or with some special structure enabling or facilitating the substitution of the new brace member for the old when occasion requires that substitution. As distinguished from such proposals, my invention contemplates the ready repairing, strengthening or renewal of brace or link members, or the insertion of additional ones, in all the customary forms of bridges of the truss type.

I am also aware that in the prior art to which my invention relates, devices have been employed for taking up the slack in the brace or link members of a truss bridge in an endeavor to restore them to their original condition of functioning. But one objection to such devices, from the standpoint of the objects sought to be attained by my invention, is that they do not repair or remedy the weakened structure of the brace or link member itself caused by the wear of the eye-portions of that member on its attaching pins. That wear, as hereinbefore pointed out, is also one of the sources of slack in the brace or link member between its attached terminals, and therefore taking up the slack not only does not remedy the weakened structure

about the eyes of the brace or link member but simply imposes an added strain thereon which the weakened structure is ill adapted to withstand. The result is that the devices of the prior art to take up the slack in the brace or link members do not attain the object of my invention of restoring the structure to its original strength or load-bearing capacity, and, of course, do not increase the strength or load-bearing capacity of the structure above that for which it was originally designed, which is another object of my invention.

Except for bridges specially designed for substitution of new brace or link members for old impaired ones, one reason why the methods and devices of the prior art last referred to have been restricted simply to taking up the slack or wear in the old brace or link members has been the impossibility of removing the old brace or link members from their attaching pins or bolts in the bridge structure and replacing them with new members or with the old members repaired in their eye-portions without removing and then replacing the attaching pins or bolts which would so impair the bridge structure as a whole during this work of repair as to entirely interrupt traffic.

One of the particular objects of my invention is to enable the removal of a worn brace or link member from its attaching pins or bolts and the replacement on those pins of the old link member so repaired as to present new eye-portions or an entirely new link member complete without removing those pins or bolts from the bridge structure and without appreciable dismantling of adjacent structural parts of the bridge to get at this work of removal and replacement.

Directed to this object, my invention contemplates so cutting a gap through the solid metal on one side of each eye-portion of the worn brace or link member, for example by a cutting torch, as to free this member from its attaching pins in the bridge structure by a slight lateral movement of the member. The impaired eye-portions of the removed link member may then be cut off and the shank of the old link member used, if desired, with new eye portions welded thereto, or an entirely new link member complete may be substituted for the old one. To get the thus repaired old link member or the substituted new one back in place on the attaching pins on the bridge structure, my invention further contemplates differing forms of eye-portions for those link members and different methods of procedure according to those differing forms of eye-portions.

In one form and method two eye-bars are used to be welded to the shank of the old removed brace member or to a new shank as desired, and with these eye-bars then forming the two terminal eye-portions of the brace member. These eye-bars may be substantially the same as the end or eye-portions of the old brace, having a closed bearing aperture for the attaching pin and hence with solid metal entirely surrounding the pin. With this form of eye-bars, a gap is cut out as before through the metal of the eye for the placement of the eye-bars on the attaching pins on the bridge structure, and the gap is then closed by the metal piece cut out in forming the gap or by a separate properly shaped piece as desired and the closure welded in place to form a solid metal eye structure about the attaching pin, which eye structure may be reinforced as later described. These eye-bars may be first thus placed on their attaching pins in the bridge structure and then welded to the rod or bar forming the shank of the brace member, or this welding of the eye-bars to the shank may first be done and then the structure complete as a brace member may be placed on the attaching pins on the bridge structure in the manner just described.

Or, an entirely new brace or link member complete with eye-portions as before may be employed, and then the method of placing this complete member on its attaching pins on the bridge structure is also the same as last described.

According to another form and method, U-shaped or forked eye-bars are employed and these are inserted in the bridge structure over the attaching pins and the depending limbs of these bars are then welded to the bar or rod which is to form the shank of the complete brace or link member.

In association with these methods and devices of my invention, it is desirable, and in some cases essential, to employ additional methods and means of adjusting the length of the new or repaired brace member, and my invention contemplates this, not merely for the purpose, as in the prior art devices hereinbefore mentioned, of taking up slack in the brace or link member consequent upon a permanent stretch in that member or wear on its eye-portions by long continued use, but to adjust the newly installed brace member to its proper length for carrying and distributing its share of the load.

The foregoing objects and principles of my invention and other objects and principles thereof will more fully appear from the illustrative examples hereinafter given of methods of procedure and devices used for the practice of the invention.

In the accompanying drawings illustrating certain embodiments of my invention,

Fig. 1 is a side elevation of a portion of a metal bridge of the truss type presenting one embodiment of my invention;

Fig. 2 is an end view taken on the cross-sectional line 2—2 of Fig. 1 through one of the two opposite-side structures of the bridge;

Fig. 3 is a vertical side-elevational view, on an enlarged scale, of one end portion of a brace or link member of the bridge shown in Fig. 1;

Fig. 4 is an edge view of a portion of a brace or link member similar to that shown in Fig. 2 except modified to provide two eye-bars instead of one as in Fig. 3;

Fig. 5 is a side elevational view on an enlarged scale of an eye-bar for a brace or link member differing in form from that shown in Figs. 1 and 3, and showing the lines of cut through the head of the bar to the eye thereof for the insertion of the bar on the attaching pin in the bridge structure;

Figs. 6 and 7 are side and head-end elevational views, respectively, of the eye-bar of Fig. 5, and showing a reinforcing plate over the cut above-referred to;

Figs. 8 and 9 are views similar to Figs. 6 and 7, respectively, but showing a form of reinforcing plate somewhat different from that shown in Figs. 6 and 7;

Fig. 10 is a side elevational view of two eye-bars with cuts on opposite sides for the insertions of the bars on the attaching pin in the bridge structure and then the bars welded together to form a single eye-bar structure;

Fig. 11 is a cross-sectional view of the structure shown in Fig. 10 along the lines 11—11 of that figure;

Fig. 12 is a side elevational view of a complete brace or link member formed of two eye-bars properly cut for their insertion on the attaching pins in the bridge structure and with the shank portion of two separated parts with a length-adjusting device between them;

Fig. 13 is a side elevational view of a brace or link member without a length-adjusting device and showing lines of cut through the heads of the member to the eyes therein enabling the member as a complete whole to be placed in position on the attaching pins in the bridge structure; and

Fig. 14 is a side-elevational view of the brace or link member of Fig. 13, cut through in the center of the shank to divide the member and with a length-adjustment device provided thereon.

Referring now more particularly to Figs. 1 and 2, except for the brace or link members with their eye-bars, these views present a conventional or usual form of truss bridge of iron or steel, it being understood, of course, that only one of the two opposite sides of the bridge is shown, and only a sufficient portion of that side of the bridge being shown to exemplify the application of the present invention thereto. In Fig. 1 the bottom and top rails or runners on the side of the bridge presented to view are indicated at 10 and 11, respectively, the top rails or runners only being shown in Fig. 2.

As the construction in such a bridge is substantially the same at the top and bottom so far as the construction affects the application of the present invention to the bridge, detailed reference need be made only to the structures at the top. As shown in Fig. 2, there are two top rails or runners 11, 11 on that side of the bridge to which that view pertains, the construction being the same on the opposite side. As is the usual practice, these rails are of substantial thickness and are surmounted or covered by a relatively thin plate 12.

The vertical columns for supporting the top structure from the bottom rails in such a bridge generally each consist of two solid flat beams having a central rib placed transversely of the runners so that the edges of the beams are presented to the side view of the bridge in Fig. 1 as indicated at 13 and the flat face of one of the beams is presented to view in Fig. 2 as indicated at 14, its central rib being shown at 15. A lattice work, as indicated at 16 in Fig. 1, generally extends across the open sides of the column, and the column is anchored to the lower and upper runners of the bridge by plates 17 secured by rivets 18 to the beams of the column and by a relatively large and heavy bolt or pin 19 to each pair of top and bottom rails or runners, that pin or bolt extending transversely entirely through the side rails or runners and the space between them as shown for the top structure in Fig. 2. This construction, which is the usual one, leaves side spaces between the anchor plates 17 of the supporting columns and the top and bottom runners 10 and 11 and also a center space between the extremities of the anchor plates beyond the free ends of the beams 14, as shown for example in Fig. 2, for anchorage about the pins or bolts 19 of the terminal ends of the diagonally extending brace or link members necessary in bridges of the truss type to properly brace the bridge into a relatively rigid structure capable of sustaining the loads to which it is subjected without undue vibration or sway and also to provide connecting links from part to part so as to properly distribute the strains of the loads and the impulsive forces on the bridge of those loads in traffic. In other words, the diagonally extending brace or link members 20 with their eye-bars 21 as shown in Figs. 1 and 2 are in the usual positions of brace or link members in a bridge of the truss type, and the brace or link members shown differ from those heretofore and customarily used, not in position in the bridge structure but in construction and mode of attachment to the pins or bolts 19 of the bridge structure according to the principles of the present invention as will later more fully appear.

The brace or link members of truss bridges are generally bars of rectangular cross section in the shank and with flat circular heads or eye-portions of substantially the same thickness as the shank and with the eye-apertures for the attaching pins completely closed; that is, completely surrounded by the metal of the head, so that the attaching pin must be inserted during the course of construction of the bridge. Except for the lines of cut through the metal of the heads, Fig. 13 is a representation of such a brace or link member. Less frequently, brace or link members of rod shape in the shank are employed, but in all cases the heads or eye-portions are formed, as stated above, to present solid metal completely surrounding the attaching pins, such for example as the pins 19 in Figs. 1 and 2.

As hereinbefore stated, in the course of long continued use of the bridge, there is considerable wear on the eyes of the brace or link members about their attaching pins, such as the pins 19 in Figs. 1 and 2, which wear produces a slack in the brace or link member between its attached terminals and thereby the brace or link member fails to sustain or properly distribute its share of the load. Prior to my present invention, so far as I am aware, the only way to remove such a worn brace or link member and to substitute a new one with unimpaired eyes or to repair the member has been to remove the attaching pins or bolts, such as the pins or bolts 19 in Figs. 1 and 2, which were inserted through the eyes of the member when the bridge was in process of original construction. This removal of the attaching pins or bolts was not only exceedingly difficult, however, due to the heavy weight of the other structural parts of the bridge supported thereon, as shown in Figs. 1 and 2, but the removal of those pins or bolts left those other parts so unsupported as to require discontinuance of the use of the bridge until the repairs were completed. Moreover, those repairs required not merely replacement of the new or repaired brace or link members but also a restoration of the other parts of the bridge from their unsupported and therefore disaligned positions to their original positions for insertion through them of the old or new pins or bolts, with considerable resulting delay and cost. Because of these factors, the practice has been simply to provide some device on the shanks of the brace or link members to take up the slack therein from time to time until continued wear on the eyes of those members absolutely required their replacement if the bridge was to be continued in use at all. While the taking up of the slack in the brace or bridge members enabled some further use of the bridge, it obviously did not restore those members to their

original load-sustaining and distributing capacity, for the impairment of the structure of the eyes was not remedied, and the bridge was simply continued in use at its lessened load-sustaining capacity.

In proceeding according to my invention, and assuming that brace or link members with worn eyes are in place on the bolts or pins 19 in the positions in the bridge shown for the brace or link members 20 in Figs. 1 and 2, a gap is cut through the solid metal on one side of each eye-portion of the worn member, for example by a cutting torch, so as to free the member from its attaching pin 19 in the bridge structure by a slight lateral movement of the member. In most cases the gap may be cut out along straight lines transversely of the link member as shown in Fig. 5, although it is to be understood that Fig. 5 does not show a worn member but a new one so cut according to the principles of my invention as to be inserted on the attaching pin in the bridge structure as will later more fully appear. With gaps thus cut out through the metal of the two opposite eye-portions of the worn brace or link member, there is generally room in the bridge structure for the removal bodily of the entire member by lateral movement, and the free space required for that movement may be increased by removal of the adjacent portion of the thin cover plates of the bridge runners, one of which, the cover plate of the upper runners, is shown at 12 in Fig. 2. Or the gap through one of the eye-portions of the member to be removed may be cut on an arc whose center is the eye at the opposite end and the cut end of the member removed from the attaching pin at that end by a pivotal movement of the member as a whole on the opposite attaching pin, and then the gap in the still attached eye-portion cut along the lines most convenient for removal of that end of the member. Or, it may be found most convenient under certain conditions, to cut through the shank of the brace or link member so as to leave the opposite end parts freely swinging from their attaching pins, and then cut the gap to the eye of each of these parts along the lines most convenient for the application of the cutting torch and removal of the parts.

My invention contemplates several alternative methods and means for repairing and replacing the worn brace or link member or substituting an entirely new one in the bridge. In one method, the eye-portions of the worn and removed brace or link member are cut off from the shank of the member and two new eye-bars are welded to the old shank, or an entirely new shank part may be used to which the new eye-bars are to be welded, as desired, these new eye-bars then forming the terminals of the complete brace or link member to be inserted on the attaching pins of the bridge structure.

The preferred form of new eye-bar of my invention is that shown at 21 in Figs. 1 to 3, inclusive. As shown it consists of a U-shaped bar preferably, although not necessarily, rectangular in cross-section, with the open end of the bar between its forks adapting the bar to be inserted in the bridge structure upon one of the attaching pins 19 shown in Figs. 1 and 2 so as to position its bend or curved head in bearing and anchored contact on the pin and with the forks of the bar extending therefrom clear of the runners of the bridge for the attachment thereto of the rod or bar 20, Figs. 1, 2 and 3, to form the shank of the brace or link member. When a pair of such eye-bars are in place in the required diagonally opposite positions in the top and bottom runners of the bridge on pins 19, a bar or rod 20 forming the shank part is welded to the forks of these eye-bars, as indicated by the lines of weld 22 in Fig. 3, to form a complete brace or link member, two of such completed members being shown in place in the bridge structure in Fig. 1.

The eye-bars shown in Figs. 1 to 4, inclusive, may be formed in any way found most convenient or desirable. A straight bar may be bent to the U-shaped form shown, the bending thus forming the eye-aperture for reception of the pin 19 therein in bearing contact against the metal of the bar at the head thereof as shown in Fig. 3 and also forming the passage (between the forks of the bend) from the exterior of that bar to the eye-aperture for the insertion of the pin 19 into the eye-aperture when the bar is brought up to the pin and is moved transversely of the axis of the pin. Or a solid bar of the boundary contour of the bar shown in Fig. 3 may be employed and a circular eye-aperture first drilled therein and then a gap cut through the metal of the bar from its stem end to the eye to present the completed bar as shown in Fig. 3.

The bar or rod forming the shank of such a brace or link member may be a single bar or rod extending from its welded attachment on the forks of one eye-bar to its like attachment on the companion eye-bar of the pair and without any length adjusting device. But in the preferred form and practice of my invention the shank rod or bar is divided and the divided parts threaded, as shown at 23 in Fig. 1 for the cooperation therewith of a turn-buckle member 24 of the usual type operating in threaded relation with the threads on the rod to form a length-adjusting device. This length-adjusting provision is advantageous for without it a bridge sagging in the part undergoing repair would have to be temporarily braced up to maintain the proper distance between the opposed eye-bars to be subtended by the shank part of the brace until the welding operation was completed, while with the length-adjusting device, the shank part of the brace member may be welded to the eye-bars in disregard of the sag and then the completed member drawn up to eliminate the sag and to make any further adjustment in the length of the brace member required to enable it to sustain and distribute its share of the load.

Where greater strength in the brace member is required, two of the U-shaped eye-bars 21 may be employed for each end of the brace member with the shank rod 20 welded thereto as indicated in Fig. 4. This construction is especially desirable for brace members intended to increase the load-sustaining capacity of the bridge beyond that of its original design so as to meet the conditions of present-day traffic. As a general rule these brace members with double eye-bars are placed centrally in the bridge structure shown in Fig. 2 where there is greater space about the pin 19 for the two eye-bars of the brace member thereon, the thimble or spacing sleeve 25 shown in Fig. 2 being cut away from the pin 19 to enable the double eye-bars to be placed in position on that pin.

In some instances, it may be found that the original brace members of the bridge, in the positions shown in Fig. 2 as occupied by the brace-members of my invention, are still in such good functioning condition as to justify their retention, and the repair required is merely the inser-

tion of additional brace members either to bring the load-sustaining capacity of the bridge fully up to that of its original design or to increase it to meet present-day traffic conditions. In such a case the additional brace members either of the form shown in Fig. 3 or in Fig. 4 are inserted in the central positions already referred to. That is, for one of those positions shown in Fig. 2, the eye-bar or bars of an additional brace member are placed on the pin 19 in place of the thimble 25.

Instead of the form of eye-bars shown in Figs. 1 to 4 inclusive, the new eye-bars may be substantially the same as the end or eye portions of the old brace or link members which are to be replaced, having a circular aperture or eye drilled therethrough for the attaching pin and hence with solid metal entirely surrounding the pin. With this form of eye-bar, shown in Figs. 5 to 12 inclusive, a gap is cut out, as was done in removing the old and worn brace or link member, through the metal of the eye for the placement of the eye-bars on their attaching pins, the pins 19 of Figs. 1 and 2.

Differing lines of cut may be employed in making the gap, either on straight lines transversely of the bar, as indicated at 26 in Figs. 5, 6 and 8, to the eye-aperture 27, or on oblique lines to the stem of the bar where it joins the head or eye portion as indicated at 28 in Fig. 12, the advantage of the latter being that it disposes the lines of cut farther from that portion of the eye, indicated at 29, in Figs. 5 and 12, which must bear the greatest strain when the brace member is in position and in use. In other words, the oblique lines of cut shown in Fig. 12 present more solid metal for the bearing strain on the brace member than do the transverse lines of cut shown in Fig. 5.

A pair of these eye-bars, as thus cut, may first be placed on their attaching pins, the pins 19 in Figs. 1 and 2, in diagonally opposite positions on the top and bottom structure of the bridge and then the rod or bar to form the shank part of the brace for that pair brought into position for welding to the diagonally opposite eye-bars. Or the welding of the eye-bars to the shank part may first be done and then the united eye-bars and shank part, as a single member, may be inserted, by the gaps in the eye-bars, on the proper attaching pins in the bridge structure.

Preferably, however, the eye-bars of the form shown in Figs. 5 to 12 inclusive are made long enough so that with a length-adjusting device attached between the two eye-bars of a pair at their stem ends, that device and the eye-bars together will form the complete brace or link member without the necessity of an additional shank part. Such a brace or link member is shown in Fig. 12. The length-adjusting device may be of any desired form and construction adapting it for its length-adjusting function and for connecting the two eye-bars so as to form the required rigid brace or link member of the bridge.

In the construction shown in Fig. 12, a tapered hole is drilled in the stem end of each eye-bar of the pair (or, if necessary for thickness and strength of metal, in the stem end of two eye-bars placed together on each side and welded together as shown in Fig. 11), and the tapered end of a screw-threaded lug 30 is placed in each said tapered hole and welded in place to the eye-bar. A turn-buckle member 31 of the usual type operating in threaded relation with the screw lugs then completes the connection between the eye-bars as well as completing the length-adjusting device.

After the gap is cut in the new eye-bars and they are inserted on their attaching pins 19 in the bridge structure, the gap is filled in either by the metal piece cut out in forming the gap or by a separate properly shaped piece, and the filling piece, indicated at 32 in Figs. 5, 6, 8, 10 and 12, is welded in place to the head of the eye-bar.

When the lines of cut in forming the gap in the eye-bars are transverse of the axis of the eye-bar as shown in Figs. 5, 6, 8 and 10, I preferably reinforce the head of the eye-bar by a side plate welded thereto over the lines of cut of the gap and the welded filling piece, as indicated by the plate 33 of segment form in Figs. 6 and 7. Generally the segment form of reinforcing plate is sufficient for the purpose, but if desired the reinforcing plate may extend in circular form completely over one side of the head of the eye-bar as shown by the plate 33′ in Fig. 8.

In localities where the metal of the bridge is particularly subject to deterioration from weather, especially rusting, it has been found that the metal of the eye-bars is thus attacked more frequently at the juncture of the stem with the eye-portion or head of the bar than elsewhere and its load-sustaining capacity thereby weakened. To counteract this weakening of structure, I extend the reinforcing plate in a tail formation along one side of the stem of the side-bar as indicated at 34 in Fig. 8.

Another provision for reinforcing the eye-bars is embodied in the form shown in Figs. 10 and 11. In this form, two eye-bars for each end of the brace or link member are employed, each identical with the single eye-bar shown in Fig. 5. Gaps are cut out in each of these two eye-bars, they are then inserted in the bridge structure on the same attaching pin, for example, the pin 19 in Fig. 2, but in a manner to extend the lines of cut of the gaps in opposite directions from the alined eye-apertures of the two bars, as shown in the full and dotted lines in Fig. 10 and in Fig. 11 by the locations of the filling pieces 32. The filling pieces for the two gaps are then welded in place, and the two bars welded together side by side as shown in Fig. 11 to form the united bar. When this double form of eye-bar shown in Figs. 10 and 11 is used, the eye-bars for the opposite ends of a brace member must of course be inserted on their attaching pins 19 before the length-adjusting device 30, 31 shown in Fig. 12 is attached. That procedure is also required, even with the single form of eye-bar, when the gap is cut out on the oblique lines shown in Fig. 12, for those oblique lines of the gap will not permit the placement of the brace as a completed whole on diagonally opposite pins 19 in the bridge structure.

Fig. 13, however, represents a complete brace or link member with the gap in the eye portions on lines of cut which does permit the placement of the member on diagonally opposite pins 19 in the bridge structure. The left-hand head of the member, as the parts are viewed in Fig. 13, has the gap cut on straight oblique lines 35, while the gap in the opposite head is cut on arcs 36 from the eye of the first-mentioned head as a center. This enables the head with the gap cut on the oblique lines 35 to be first placed in position on its attaching pin 19 in the bridge structure and then the entire brace member piv-

oted on that pin into position inserting the opposite pin through the curved gap in the other head of the member.

With the brace member shown in Fig. 13 thus in position in the bridge structure, there is no provision, however, for an adjustment of the length of the member, and Fig. 14 represents a length-adjusting device with which the brace member may be equipped after it is in place in the bridge. The length-adjusting device comprises two pairs of opposed blocks 37, 37 and 38, 38, one pair for each side edge of the shank of the brace member and with the blocks having angular base projections adapted to fit into notches cut in the side edges of the shank, the blocks then being welded in place on the shank, so that a fixed mounting of the blocks on the shank of the brace member is secured not only by the welding but also by the fitting of the blocks to the notches in the shank. Each pair of blocks is provided with opposed threaded lugs 39 with which an internally threaded turnbuckle member 40 cooperates to complete the length-adjusting device. When the length-adjusting device is thus mounted on the shank of the brace member, the brace member is divided by cutting through the shank so as to present the length-adjusting device as the connection between the divided parts, as shown in Fig. 14.

With all of the constructions shown, when used in the manner described, brace or link members with new eye-bars may be substituted for the old members with their worn eye-bars without substantial dismantling of the bridge. Generally, it will be found that sufficient access to the parts of the bridge structure required for the removal of the old brace members and the substitution of the new ones in the manner described may be had without removing any part of the bridge except the old brace members, and at the most where access for the work to be done is particularly difficult, it will require only the removal of the thin covering plates 12 of the bridge runners.

While the principles of my invention both as to methods and means used have been described as applied to and embodied in a bridge structure, the procedural and structural principles of the invention are not confined thereto but may be applied to and embodied in other organized structures requiring removal and replacement of members thereof or the insertion of additional members. It is therefore to be understood that the examples given of the practice of the invention are merely illustrative of the principles thereof, and that other methods and devices may be included in those principles within the scope of the appended claims.

What is claimed is:

1. The method of mounting a metal bar on a pin in metal bridges and other structures having the pin accessible for said mounting only between its ends, said method comprising forming the bar with an aperture adjacent one end to receive said pin in bearing contact with metal of said bar and with a passage from said aperture through a portion of said bar to an outer boundary surface at a point spaced from said end adapted to receive said pin between its ends and pass the same into said aperture by movement of said bar upon said pin, and executing said movement to mount said bar on said pin so as to dispose the pin in said aperture in bearing contact with solid metal of the bar between said aperture and the adjacent end of the bar.

2. The method of connecting a structural member with a pin in metal bridges and other structures having the pin accessible for forming said connection only between its ends, said method comprising forming a bar with an aperture adjacent one end to embrace said pin and with a passage from said aperture through a portion of said bar to an outer boundary surface at a point spaced from said end adapted to receive said pin between its ends and pass the same into said aperture by movement of said bar upon said pin, executing said movement to mount said bar on said pin so as to dispose the pin in said aperture in bearing contact with solid metal of the bar between said aperture and the adjacent end of the bar and then securing said structural member to the free end of said mounted bar.

3. The method of inserting a link member between oppositely disposed pins in metal bridges and other structures having said pins accessible for connecting said link member thereto only between the ends of the pins, said method comprising forming an eye-bar for each end of said link member with an eye-aperture adjacent one end of the bar to receive the pin and with a passage from said aperture through a portion of said bar to an outer boundary surface at a point spaced from said end adapted to receive said pin between its ends and pass the same into said aperture by movement of said bar upon said pin, executing said movement to connect each of said bars with the corresponding pin so as to dispose the pin in the aperture of the bar in bearing contact with solid metal of the bar between said aperture and the adjacent end of the bar, and then attaching said link members to the free ends of said bars.

4. The method of forming a brace-member connection between oppositely disposed pins in metal bridges and other structures having said pins accessible for connection thereto only between their ends, said method comprising forming an eye-bar for each end of said brace-member connection with an eye-aperture adjacent one end of the bar to receive the pin and with a passage from said aperture through a portion of said bar to an outer boundary surface at a point spaced from said end adapted to receive the pin between its ends and pass the same into said aperture by movement of said bar upon said pin, executing said movement to connect said bars with said pins so as to dispose each pin in the aperture of the corresponding bar in bearing contact with solid metal of the bar between the aperture and the adjacent end of the bar, and then completing said brace-member connection by securing to the free ends of said eye-bars a screw device adapted to adjust the length of the completed brace-member connection between said pins.

5. The method of connecting a structural member with a pin in metal bridges and other structures having the pin accessible for forming said connection only between its ends, said method comprising employing a U-shaped bar adapted to be inserted upon the pin between its ends with the forks of said bar extending from said pin, thus mounting said bar on said pin, and then securing the structural member to the forks of said bar.

6. The method of connecting a metallic structural member having a terminal portion provided with a circular eye-aperture with a pin in a metal bridge or other structure having said pin accessible for said connection only between its ends, said method comprising cutting a gap through the body of said terminal portion from a point in an

outer boundary surface thereof spaced from the adjacent end of said member to said eye-aperture adapted to receive said pin between the ends and pass the same into said aperture by movement of said member upon said pin, executing said movement to connect said member with said pin so as to dispose the pin in said aperture in bearing contact with the solid metal of said member between its eye aperture and its adjacent end and then closing said gap.

7. The method as in claim 6 and in which said gap is closed by a filling piece of metal welded in place to the terminal portion of said structural member.

8. The method as in claim 6 and in which the gap in the terminal portion of said structural member is closed by a filling piece of metal welded in place and then a reinforcing plate is welded to one side of said member over said welded-in filling piece.

9. The method of connecting a metallic link member having opposite terminals provided with circular eye-apertures with oppositely disposed pins in a metal bridge or other structure having said pins accessible for said connection only between their ends, said method comprising cutting a gap through the body of one of said terminals from a point in an outer boundary surface thereof spaced from the adjacent end of said member to its eye-aperture along straight lines adapting said gap to pass the pin for that terminal into the eye-aperture thereof by a movement of said terminal transversely of said pin to connect said terminal with said pin in a manner to dispose the pin in bearing contact with solid metal of said member between its said eye aperture and its adjacent end, and cutting a gap through the body of the other terminal of said member to its eye-aperture along an arc from the opposite eye-aperture as a center in a manner to pass the pin for said other terminal through said gap by pivotal movement of said link member when said first-mentioned terminal is connected to its pin, and connecting said terminals.

10. The method as in claim 9 and in which the length of said link member is adjusted after it is connected with said pins by welding a screw thread device to the member at spaced points, severing the link member between said points and then adjusting said screw thread device.

11. The method of connecting a structural member with a pin in metal bridges and other structures having the pin accessible for forming said connection only between its ends, said method comprising forming two bars each with an eye-aperture to embrace said pin and with a passage from said aperture through the body of the bar on one side of the aperture to an outer boundary surface at a point spaced from the adjacent end of the bar adapted to receive said pin between its ends and pass the same into said aperture by mounting movement of said bar on said pin, and mounting the two bars side by side on said pin so that the passages from the eye-apertures in the bars are on opposite sides of the axis of said pin, welding the mounted bars together, and then welding said structural member to said bars.

12. The method of removing brace or link members from a bridge or other structure in which said members have eye terminals completely embracing pins enclosed at their ends in said bridge or other structure and substituting new members therefor, said method comprising cutting a gap through the body of said terminals to the eye-apertures adapted to withdraw the old members from said pins and then cutting a gap through each terminal of the new member at an angle to the longitudinal axis of the member to the eye-aperture therein adapted to pass the pin for that terminal into the eye-aperture and in bearing contact with solid metal of the member between its eye aperture and its adjacent end, mounting the new link member on the pins, and then closing said gaps by filling pieces of metal welded in place to said terminals of the new link member.

A. RHODES KNIGHT.