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2,747,474

GRATINGS

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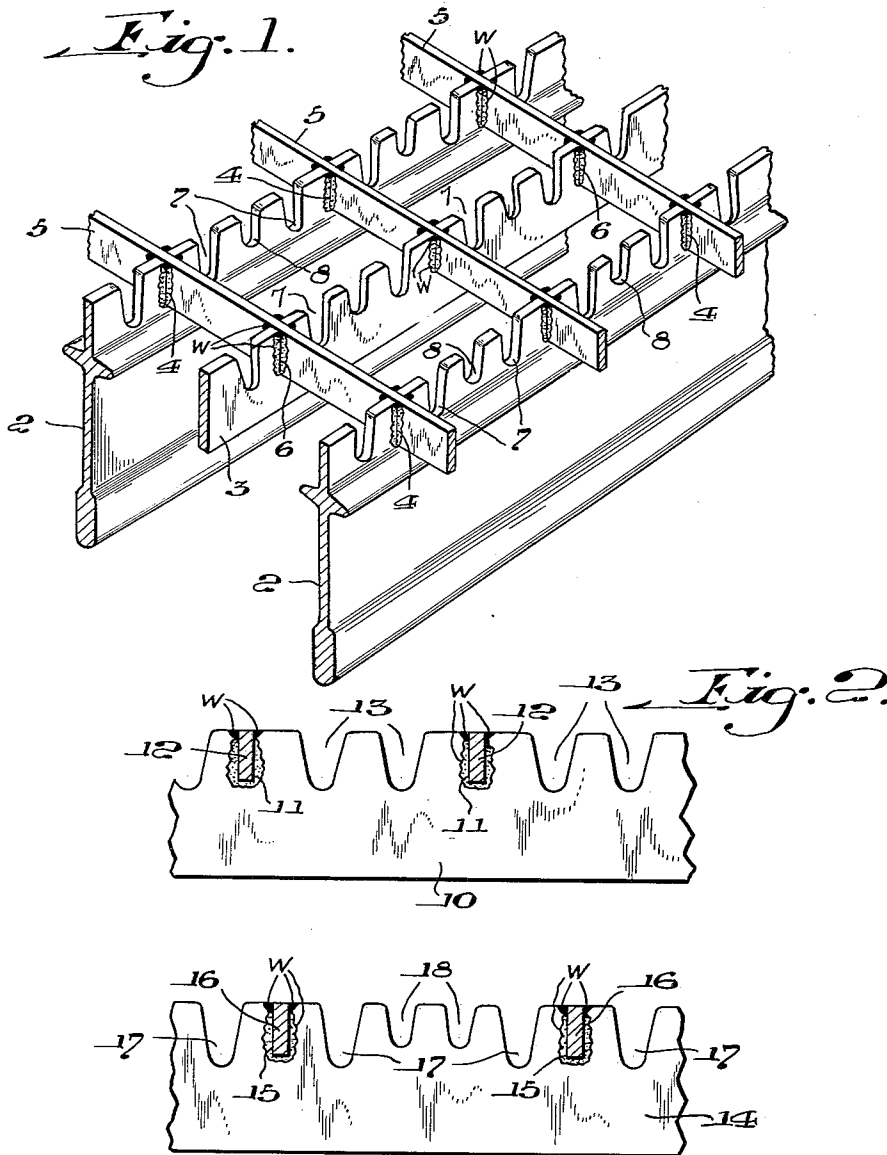


Fig. 3.

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GRATINGS

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This invention relates to gratings, and is especially applicable to gratings to be used in bridge floors and for vehicle traffic.

Traffic loads on important highways, highway bridges, viaducts, and other places where gratings are used, are becoming increasingly greater. In recent years especially, both the frequency and the weight of vehicles has increased measurably each year. The proper design of highways and highway bridges has to look forward and anticipate even more severe traffic conditions five, ten or fifteen years hence. In previous years, structures could be used with an adequate factor of safety without undue concern over the problem of fatigue of the metal. At the present time the likelihood of fatigue under the increasing traffic loads is a problem of immediate concern. Even though structures are designed with an adequate factor of safety for static loads, this gives no protection against failure under fatigue.

Structures under compression do not ordinarily fail from fatigue, but fatigue is a phenomenon which occurs in metal which is put under tension. The traffic surfaces of gratings are put under tension where they cross the supports for the grating.

Failure of metal under fatigue occurs where there is repetition of stresses, no single stress being of a magnitude sufficient of itself to cause failure of the metal. It occurs from the repetitive stressing. The metal can be stressed repeatedly for ordinary service a so-called infinite number of times without damage, but if the stress repeatedly occurs above a critical point, failure occurs rapidly. Those familiar with the phenomenon of fatigue demonstrate the phenomenon by reference to what is called its "S. N. curve," wherein "S" represents the stress, and "N" the number of stresses, and the typical curve approaches almost an L, and the sharp bend in the curve is often designated the "knee." Such a curve is shown, for example, on page 26 of the book entitled "Behavior of Engineering Metals" by H. W. Gillett and published in 1951 by John Wiley and Sons. The stresses should be kept below the knee position of the curve to avoid fatigue.

It is also well recognized that failure of metal due to fatigue generally results at a point where there is any sharp deviation in the outside surface of the metal, or where there is any sharp irregularity in its surface. An almost imperceptible nick in the surface of a piece of metal which is rapidly stressed may lead to a quick failure of the metal. This is theoretically accounted for on the assumption that in the piece of metal under stress, where the section of metal is uniform, imaginary stress lines extend uniformly in a parallel direction throughout the entire section. If there is a V-shaped notch for example formed in the surface of the metal, then these imaginary lines of stress, being unable to traverse the open notch, are deflected out of parallelism and pass through the metal at the base of the V of the notch. All

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of the stress lines which would thus normally extend in a parallel direction are focused or concentrated at the base of the notch, thus concentrating stresses at this point on the critical side of the knee of the S. N. curve. The overstressed metal at the base of the notch therefore tears or cracks, which has the effect of making the notch deeper and concentrating even greater lines of force further down in the body of the metal, with the result that the metal progressively and often almost instantaneously and without warning, breaks.

A grating is economically made of longitudinal bearing bars with transverse bars extending crosswise of the bearer bars. The top edges of the bearer bars are provided with rectangular notches into which the cross bars are set. These notches are generally punched out with square corners, so that the cross bars set firmly in them. Economy demands that the cross bars cannot be spaced too closely together, and they are ordinarily spaced several inches from one another. Each of these notches cut into the top edge of the metal, thus provides a condition favorable to the development of failure through fatigue under repeated stress of the bridge floor, especially as the weight and frequency of the stress is increased. While the cross bars are subsequently inserted in the notches provided in the bearer bars and are tightly received therein, this does not restore the continuity and uniformity of metal structure for the uniform transmission of stresses along the bearer bars. In other words when the top edge of the bearer bars is under tension the stress lines do not pass through the cross bars, and since the gratings are generally used over a plurality of spaced supports, the top edges of the bearer bars are under tension over such area of support. The stress lines, or most of them, are deflected under the cross bars under these conditions. The condition is further aggravated by the subsequent welding that usually occurs in the joint. As the joint weld is being formed, convolutions are created and folds and discontinuities are formed in the surface of the metal. These weld formations act similarly to notches by creating what is called in the art "stress raisers" or places of high stresses. Either the notch or the weld is capable of producing "stress raisers" and non-uniform stress distribution. The condition is further aggravated by the fact that the subsequent welding that usually occurs in the joint when the weld itself is being formed between the cross bars and main bars is non-uniform in character and may have sharp irregularities in its surface.

A further phenomenon having to do with the problem of fatigue is that if surface indentations occur in closely spaced series along the line of stress, the piece will be less subject to failure by fatigue than if there is a single notch or weak point. The theory in such cases is that the stress lines follow generally the contour lines extending along the base of the series of notches. Instead of sharply deflecting around the base of each notch, the stress lines stay below the series of notches. The cross bar receiving notches in the grating cannot for practical reasons be close enough to effect this result.

The present invention has for its object to provide a grating which is protected against failure due to fatigue, and which, as an incidental advantage, presents an improved traffic surface to the grating. Generally speaking, this object is obtained by providing a series of notches between the cross bars, some of which at least are of greater depth than the notches which receive the cross bars, thus providing a condition where concentration of stresses in the region of the cross bars is avoided, rendering the grating more resistant to fatigue. This of course tends to decrease the deflection resistance of the

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grating, but this can be compensated for through the expedient of using a slightly higher or deeper section to begin with, or otherwise introducing additional metal into the section below the cross bars.

My invention may be more fully understood by reference to the accompanying drawings, in which:

Figure 1 shows a perspective view of a section of grating embodying one form of my invention;

Figure 2 is a side elevation of a bearing bar embodying my invention, having a slightly different arrangement of notches from that shown in Figure 1; and

Figure 3 is a view similar to Figure 2, showing another variation in the notch pattern.

Referring to Figure 1, the grating illustrated is of the general type shown in Patent No. 2,190,214, granted February 13, 1940 to Harry S. Nagin. This grating is comprised of main bearing bars 2 which extend parallel to one another, and midway between each two main bearing bars is an intermediate bearing bar 3 of lesser depth than the bearing bars 2. This particular form is illustrated, but other conventional forms of grating which have all of the bearing bars of the same shape may be employed, and my invention is equally applicable to such more conventional types of gratings.

At intervals, the top edges of the main bearing bars 2 are notched out at 4, providing rectangular notches into which transverse bars 5 are set. A weld indicated at W is effected where the transverse bars set into the main bars. Likewise the intermediate bars 3 are notched at 6 to also receive the cross bars 5, and the cross bars 5 are likewise welded to the intermediate bars 3 at the points of intersection.

The present invention may also use a method of forming a grating by which the cross bars are connected with the bearing bars by forcing the cross bars against edges of the bearing bars with a high pressure while the bars are locally heated at the points of the joints. In this operation, the tops of the cross bars are forced down to the level of the tops of the bearing bars and the two bars are welded together at the joint. This method of connecting the bars also creates "stress raisers" so that it is important to construct the bearing bars to provide for this condition.

According to the present invention, the top edge of the bearing bars 2 are notched out preferably with rounded notches, there being a series of these notches between each two transverse bars 5. The notching is carried out uniformly along the entire length of the section 2. At least some of the notches are at least as deep, and preferably deeper, than the notches 4. In Figure 1 I have shown three notches between each two cross bars. The two notches designated 7 which are closest to the cross bars 5 are deeper than the notches 4, whereas the intermediate notch 8 is of less depth than the notch 4.

By thus continuously notching the top edges of the bearing bars 2, the imaginary stress lines do not extend along the top edges of the grating, and hence are not concentrated at the base of the notches 4. Theoretically, with the notches 7 being deeper than the notch 8, the stress lines may assume a somewhat gently undulating path immediately under the notched edge, but with no critical stress concentration due to notching at any one position along the length of the bars 2. While the cutting away of so much metal in the top of the bars 2 tends to decrease the deflection which the grating will withstand, this is compensated for by using deeper sections. In other words, the notched upper edge zone of the grating ceases to be of structural significance either in compression or tension, but is functionally important to maintain the surface of the grating as a useful surface, as well as to receive the cross bars and integrate the grating. While I have shown sections in Figure 1 which are a modified T form, this is not necessary. The metal upstanding between the notches 7 and 8 forms a roughened traction surface which improves the traffic bearing qual-

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ities of the grating. The stresses in the intermediate bars 3 are relatively insignificant, but, as shown, these bars may be similarly notched.

In Figure 2 I have shown a fragment of a grating in which one bearing bar is illustrated and is designated 10. It is provided with notches at 11 into which the cross bars 12 are set and welded. Instead of there being three notches of non-uniform depth between the notches 11, I have here shown two notches 13, each of which is of just slightly greater depth than the notches 11. Instead of the notches being of a U shape as in Figure 1, they are of a truncated V form with the metal in between the notches flat at the top, and with the bottoms of the V's rounded.

Figure 3 is the same as Figure 2, but shows a bearing bar 14 having notches 15 at spaced intervals therealong, into which the cross bars 16 are set and welded. In this figure there are shown a series of four cut-outs or notches between the cross bar receiving notches 15. These are the same form as shown in Figure 3, except the two notches 17 which are nearest the respective cross bars 16 are slightly deeper than the notches 15, while the two intermediate notches 18 are slightly shallower than the notches 15. It will be understood that the notch arrangements of Figures 2 and 3 may be used in lieu of the specific ones shown in Figure 1, and that various other forms of notches may be punched out at the edges of the sections to accomplish my invention.

By reason of my invention, I am enabled to provide an economical grating which can be installed in roadways, for example, with greater assurance of withstanding failure from fatigue due to vibrations and repetitive stresses imposed by the movement of heavy and frequent traffic over the grating. While I am aware that gratings have been provided with shallow notches in the top edges of the bearing bars for the purpose of giving an improved nonskid traffic surface, such gratings do not effect the primary purpose of the present invention, which is to protect the grating against fatigue due to the concentration of stresses where the cross bars intersect the bearer bars. As pointed out above, my invention does incidentally have the advantage of also providing a better traffic surface. In any case the successive notches must be so shaped as to avoid sharp points at the surface of the grating, that is, there must be a flat land between each two of the stress relieving notches, and these notches may have rounded as well as flat bottoms.

While I have shown and described certain specific embodiments of my invention, it will be understood that this is by way of illustration, and the invention is applicable to various types of gratings and to various arrangements of notches so long as they are disposed as herein indicated, to relieve the notches of the cross bars from excessive concentrations of strains.

I claim:

1. A grating having parallel bearing bars of deep section, cross bars of substantially less depth set into and secured in the top edge portion of the bearing bars at regular intervals, and a plurality of open notches in the top edge of the bearing bars which notches are intermediate the cross bars, said notches having a depth at least as great as the depth of the cross bars where they are secured in the bearing bars.

2. A grating comprising a plurality of main bearing bars of deep section set edgewise and having cross bar receiving recesses formed in the top edge portions therein at regular spaced intervals, cross bars of substantially less depth than the main bearing bars set in said recesses and secured to the main bearing bars, and a plurality of open notches formed in the top edges of the main bearing bars intermediate each two cross bars of a depth at least as great as the depth of the cross bar receiving recesses.

3. The grating defined in claim 2 wherein there are two such open notches between each two cross bars which are of greater depth than the cross bars, and an addi-

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tional open notch of lesser depth than said two with the notch of lesser depth being disposed between the two deeper ones.

4. A grating as defined in claim 2 wherein the open notches between the cross bars have rounded bottoms, 5 and wherein the metal between the open notches and the top edges of the bars is flat.

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