

May 17, 1927.

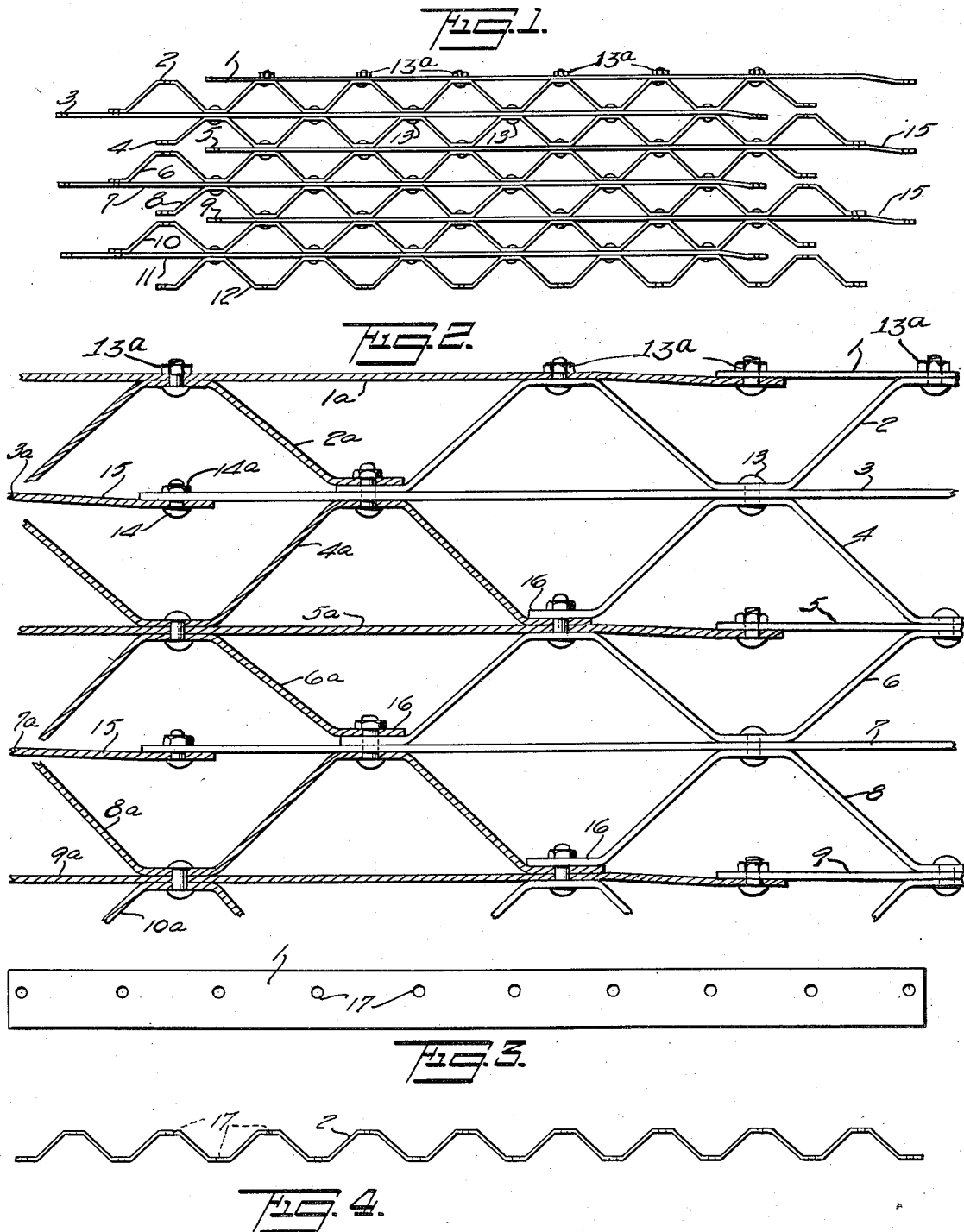
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CONTINUOUS GRATING STRUCTURE

Filed July 29, 1925

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Fig. 5.

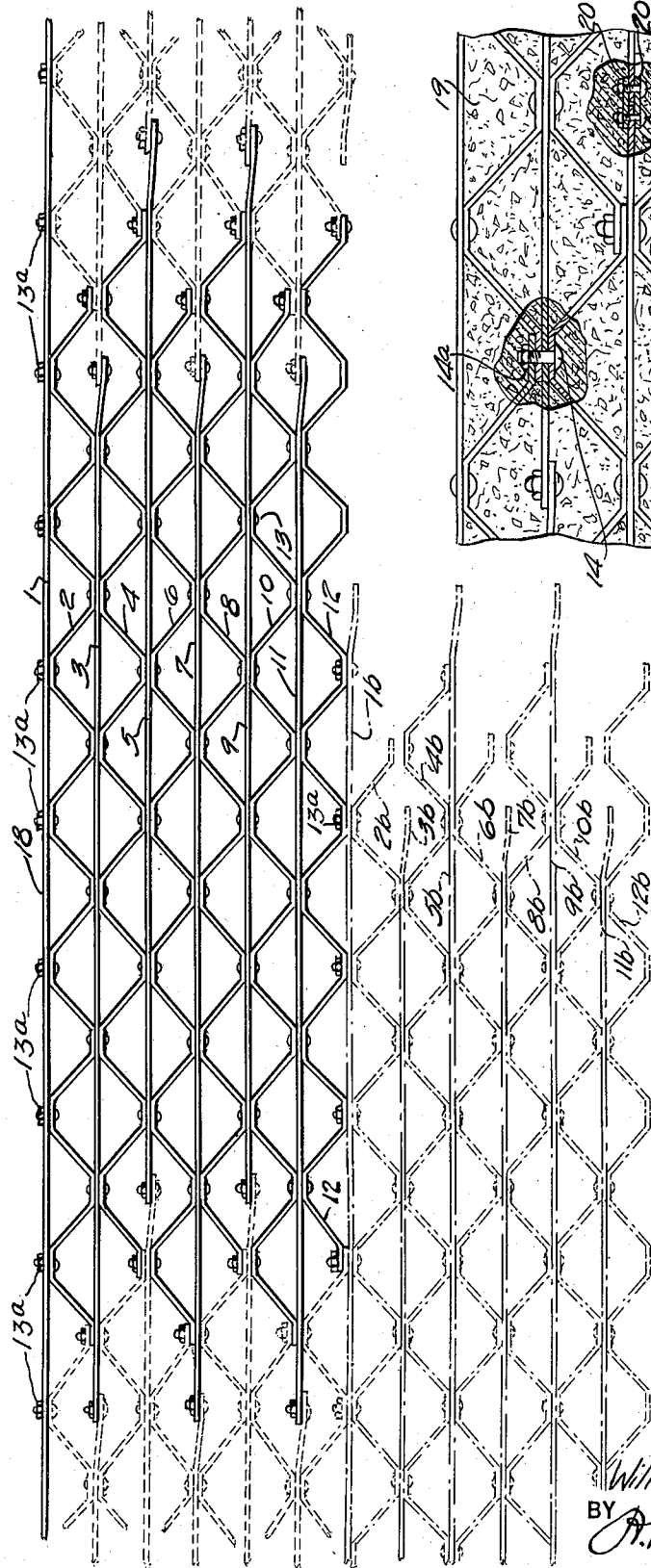


Fig. 6.

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Fig. 7.

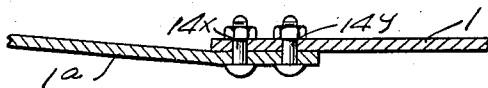
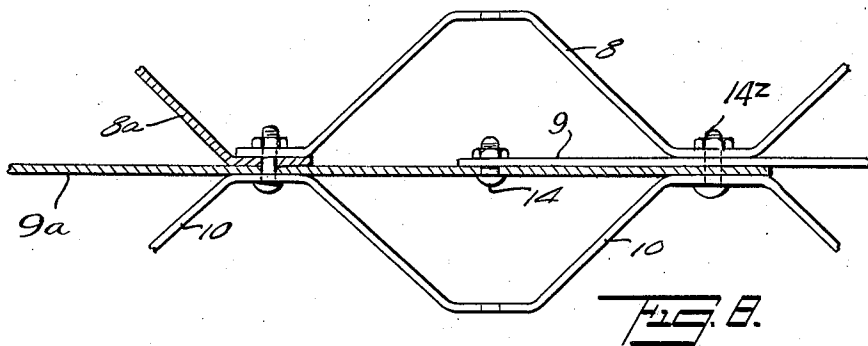


Fig. 8.

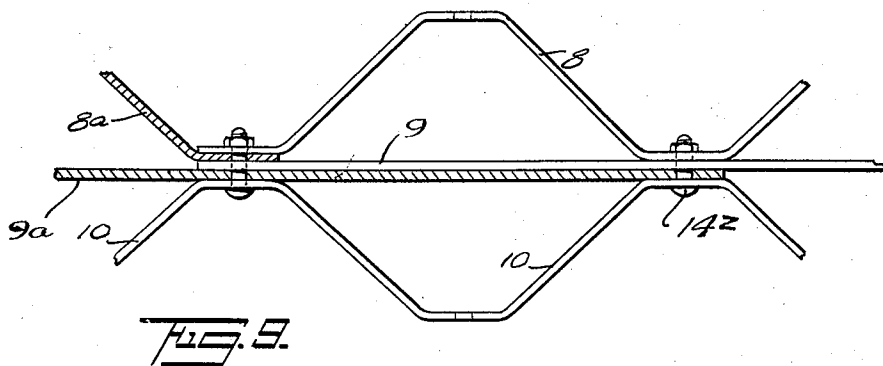


Fig. 9.

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## UNITED STATES PATENT OFFICE.

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## CONTINUOUS-GRATING STRUCTURE.

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This invention relates generally to the formation of continuous gratings of any desired dimensions, and which are particularly useful in the formation of floors for buildings, bridges and other structures.

For some time past the use of grating structures to form ventilated flooring or to form the reinforcing member of a concrete flooring, has been rapidly increasing, but such grating structures have been heretofore made in the form of separate panels, and these panels placed side by side and end to end to form floorings of larger area. Usually these panels of grating have been supported at their ends by stringers, floor beams or trusses and have been laid side by side without being connected together. As a result of the occurrence of open spaces between adjacent sides and ends of such panels, of supporting bases of different height, of unequal distortion of successive panels under moving loads, and of other causes, such structures formed of separate panels often develop considerable inequalities and unevenness in the surface of the flooring formed therefrom, either from faults in the original installation or, soon afterwards, from use. Particularly have these imperfections been developed by wear in the case of cement slabs or panels for bridges or other roadways, because the wheels of passing vehicles jump across from the end of one panel to the adjacent end of the next panel, and strike the latter a succession of hammer blows which soon crush the panel edges and so produce a rapidly widening crevice which progressively aggravates the original defect. Obviously all these difficulties would disappear if a practical grating structure of unlimited continuity could be devised, which could be extended by the act of building out in every direction, like a honeycomb, according to the requirements of any particular job and so produce a surface of absolute uniformity, devoid of crevices or seams. While, theoretically, such a grating might be built up on the job out of the constituent elements,—straight bars and bent strips in the usual way, this is commercially impracticable because that would require an infinite amount of riveting work done in the open air, often at a considerable elevation, and generally under impossible conditions. Consequently the commercial practice here-

tofore has been to make the grating in unit panels in the shop and to assemble these units on the job, and this practice must be adhered to.

The present invention however comprises a new form of grating unit so constructed that when the necessary number of them are assembled on the job they do not lie one after the other in distinct panels, end to end and side by side, but they intermesh one with another in such manner that they may be fastened together by a few small bolts or by any other convenient method in spliced joints which have all the strength and appearance of unbroken continuity of one single, jointless structure. By making these units in the shop, and of standard size and weights, all the present economies of manufacture may be retained. The expense of installation is but slightly increased over that in former practice, and the improvement in quality of flooring and in strength per unit of weight of material is marked. The best form of apparatus at present known to me, embodying the novel features of my invention, is shown in the accompanying three sheets of drawings in which,

Fig. 1 is a plan view of a standardized grating unit made according to my invention.

Fig. 2 is a similar view on a larger scale of a spliced joint, the end portions of one unit being shown in full lines, and the other in horizontal half section, still other parts being broken away.

Fig. 3 is a detail side view on an intermediate scale of a standardized straight bar forming one element of a panel such as is shown in Fig. 1.

Fig. 4 is a detail plan view of a standardized bent strip forming another element thereof.

Fig. 5 is a plan view of a section of flooring comprising one unit and parts of three others, all spliced together according to my invention, and

Fig. 6 is a plan view of a section of a concrete filled structure, parts being shown in horizontal half section, and parts being broken away, and a modified joint being shown.

Figs. 7, 8 and 9 show still other modified forms of fastenings for the adjacent ends of straight bars.

Throughout the drawings like reference characters indicate like parts. 1, 3, 5, 7, 9 and 11 represent a series of straight bars, all of the same length, which are fastened to a corresponding series of intervening bent strips, 2, 4, 6, 8, 10 and 12, by rivets 13, to form a factory unit of my improved grating structure. The outside straight bar 1, (or 18, in Fig. 5) is preferably fastened to the other portion of each unit by bolts 13<sup>a</sup> instead of by rivets 13. This is to facilitate the connecting together of adjoining units when assembled on the job. As best shown in Fig. 1 the straight bars are held in lengthwise staggered relation one to another, and the bent strips are also held in this staggered relation one to another and to the straight bars. The projecting ends of the grating members 1, 2, 3, 4, 5, etc., are in each case free from fastenings to associated elements or members of the same unit, but are perforated or otherwise provided with local fastening means adapted to engage complementary fastening means of similar character upon the projecting ends of corresponding elements on any other duplicate grating unit.

In the preferred form shown the alternate straight bars are displaced lengthwise with reference to the intervening straight bars a distance of one and a half mesh-lengths, and each bent strip is displaced lengthwise with reference both to the nearest strip and bar a distance of one half a mesh-length. By the phrase "mesh-length" I mean the distance from center to center of any two adjacent rivet holes 17, 17 in any straight bar (see 3 and 4). This length in one standard type of grating is usually seven inches.

The particular symmetrical arrangement of the bars and strips best shown in Fig. 1 is preferred, but some other symmetrical, or even an unsymmetrical, arrangement might be substituted for this preferred form so long as the elements of each grating unit so formed are staggered, or off-set, lengthwise one from another so that each unit so formed will have unevenly projecting elements at each end forming complementary sets capable of intermeshing when any two units are joined, end to end, thus producing a spliced joint when the adjacent ends of the elements are bolted together.

The preferred manner of forming and joining together the ends of two such units is illustrated in Fig. 2 where the projecting elements of the left hand end of a unit like that illustrated in Fig. 1 are shown in plan view (full lines), and the projecting elements of the right hand end of another, and duplicate, unit are shown in horizontal section (cross hatched lines). The straight bars of the second unit are marked 1<sup>a</sup>, 3<sup>a</sup>, 5<sup>a</sup>, 7<sup>a</sup>, and 9<sup>a</sup> respectively; and the bent strips are marked 2<sup>a</sup>, 4<sup>a</sup>, 6<sup>a</sup>, 8<sup>a</sup>, and 10<sup>a</sup>, respectively. Those bars or strips, as 1 and 1<sup>a</sup>, 2 and 2<sup>a</sup>,

which meet and register one with another when the units are assembled are slightly deflected, one or the other or both, and overlapped far enough to cause the end ones of the series of rivet holes 17 to register, and the bar and strip ends are then clamped together by bolts 14 passed through these holes and held in place by nuts 14<sup>a</sup>.

As at present advised I believe that the ends of the bent strips, which are usually more flexible than the straight bars, can be deflected sufficiently as shown at 16 to produce the necessary intermeshing of the unit ends by inserting a wedged tool when the units are being assembled on the job, but it may be advisable to permanently deflect one or both ends of the stiffer straight bars before the work leaves the shop. Such a bending or off-setting of the right hand extremities of the straight bars I have indicated at 15 in Fig. 1, and Fig. 2. A still stronger joint could be formed by abutting the ends of the bars together and using fish plates 20, 20, as shown in Fig. 6.

Such a modification of the simplest form is shown in Fig. 7, where greater strength is secured by using a longer overlap and two bolts 14<sup>x</sup> and 14<sup>y</sup>. Great strength and a saving of bolts may be secured by extending one straight bar, as 9<sup>a</sup> shown in Fig. 8, to the next bolted joint and interleaving it with 8, 10, and 9, using a bolt 14<sup>z</sup>. Still greater strength would result from also extending the corresponding straight bar 9 to the next bolted joint as shown in Fig. 9. Whenever two or more grating units are joined together in any one of the above described ways, there is formed between each two adjacent units a spliced joint uniting them together, each said unit joint comprising a series of element joints such as are produced by the joining of a bar 5 with a bar 5<sup>a</sup>, a bent strip 4 with a bent strip 4<sup>a</sup>, a bar 3 with a bar 3<sup>a</sup>, etc., no two of which adjacent element joints, whether composed of similar or dissimilar elements, are located in the same cross section of the unit joint in which they are included. Thus the joint between straight bars 5, 5<sup>a</sup>, does not lie in the same line transverse of the grating as does either the joint between straight bars 3, 3<sup>a</sup> forming an adjacent similar straight bar element or the joint between bent strips 4, 4<sup>a</sup> forming an adjacent dissimilar bent strip element in the same grating unit. The result is the distribution of these element joints throughout a zone of considerable length of the completed grating structure, so that a true, stiff, spliced joint between each two units is formed instead of a mere hinged connection such as would result if these element joints were all in the same cross section of the unit joint.

The above described method of assembling a series of units end to end would produce

a continuous narrow structure of indefinite length. To obtain the same feature of continuity in the matter of width other units may be bolted on to the side of the original structure as illustrated in Fig. 5, where 1<sup>b</sup>, 3<sup>b</sup>, 5<sup>b</sup>, 7<sup>b</sup>, 9<sup>b</sup> and 11<sup>b</sup> represent the straight bars of a third unit, and 2<sup>b</sup>, 4<sup>b</sup>, 6<sup>b</sup>, 8<sup>b</sup>, 10<sup>b</sup> and 12<sup>b</sup> represent the bent strips therein, said third unit being shown in dot and dash outlines.

10 In this composite structure, it is evident that the grating units are connected together at their sides by the same bolts or rivets of the same diameter as are used throughout the grating units to hold together the straight bars and bent strips forming said unit, and that the superficial distribution of these fastening means is uniform throughout, both within the respective units and along the united borders of the units, thus

15 producing absolute uniformity throughout a built-up grating area of indefinite extent.

Preferably the units of each longitudinal series should be staggered with the units of the adjacent longitudinal series so as to break joints as shown in Fig. 5. When this is done a straight line drawn transversely across the completed structure at any point will pass through more than half of the elements thereof at points free from bolted joints. This obviously produces a practical uniformity of resistance to flexure throughout the completed grating.

If desired, the outer, side edges of any given completed structure may be formed of a continuous long straight bar as shown at 18 in Fig. 5. This bar could be cut to any convenient length and punched in the shop and bolted in position on the job, or it could be riveted in position on the job by hand or with a portable riveting machine, or electrically welded to the rest of the grating.

While other uses of the whole or part of the invention above described may be developed in practice, I at present contemplate two main fields of application thereof. One of these is the use of the structure illustrated in Figs. 1 to 5 wherever ventilated floorings can be used. The other is the addition of a filling of concrete 19 shown in Fig. 6, to form a continuous, imperforate reinforced concrete floor. This latter will be particularly applicable to bridges. In producing this latter form the skeleton structure such as shown in Fig. 5 would first be built up on the floor beams, girders or other supports, then a septum of any convenient material such as sheet iron, flat or corrugated, suspended beneath it, and the plastic concrete mixture poured in around, and possibly over the skeleton, and allowed to set. In this way an integral, continuous sheet flooring would be produced, absolutely water-proof and devoid of surface inequalities. If the concrete came only to the upper edges of the metal structure, an ar-

mored surface would also be produced. This form of the invention would also be useful for ordinary concrete floors, especially where absolute smoothness and uniformity of surface is desired, as in roller skating rinks, armories, etc.

In the structure last described the nuts 14<sup>a</sup> would be embedded in concrete and could never work loose. In the case of the skeleton structure I propose to prevent loosening of these nuts by slightly peening over the protruding ends of the bolts, mutilating the threads with a cold chisel, or using any convenient form of nut lock.

Among the obvious advantages of my invention may be mentioned the uniformity of strength throughout every superficial unit thereof, the elimination of all surface joints and inequalities and the possible wider spacing apart of floor beams or other supports. In the case of the concrete filled floor the elimination of cracks will make it more sanitary, and perfectly water-proof, and will prevent the breaking down which is apt to occur at frequent abutting edges under the pounding of heavy traffic on the ordinary flooring formed of separate panels. So considerable is the increase in strength per unit of weight and the saving in weight of floor beams in a bridge designed to carry a given load, when my invention is employed, that the resulting possible saving in strength and consequent cost of supporting structure (cables, towers, girders, cantilevers, etc.) will more than pay for the entire cost of my concrete flooring.

Among the reasons why a flooring embodying my invention has greater load supporting strength per unit of weight of metal in its structure than has a flooring composed of separate panels, may be mentioned the following: Being continuous in a direction crosswise of the supporting beams, each portion of the grating between any two beams prevents the characteristics of a continuous girder and cantilever construction, being anchored to distant beams and to portions of the flooring both distant and adjacent. Consequently the portion between any two beams will not buckle under a weight placed midway of its span, under which weight a separate panel of the same grating of the same span, supported at its free ends on the same beams as a simple girder, would collapse. Being also continuous in directions parallel and inclined to the supporting beams, the downward thrust of a concentrated weight at any point between two beams is distributed radially from the point of its occurrence throughout the continuously rigid structure along the entire length of those beams, that is to say along the entire width of roadway or building, as though the floor were an integral, continuous plate, instead of being limited and accumulated on a

single panel of grating only three or four feet wide. Obviously the old style single panel when called upon alone to support a given weight might buckle and pull one end off its supporting beam while the same load could never flex a continuous grating or reinforced concrete plate of the same constituent elements which would transmit and distribute the load stresses widely and in every direction over a much greater area of support. Moreover, if the continuous grating began to flex, the tensile strength of the whole structure would then begin to absorb the catenary strains generated by the initial flexing and so help to withstand the bending moment.

Various changes and modifications in the details of structure above described and herein illustrated could be made without departing from the essential novelty and improved function and results disclosed. Special forms of grating or skeleton structure such as shown in Patent No. 1,045,795 to Keller and Nos. 1,524,035 and 1,526,069 to Irving could be used to advantage in certain situations.

In ordinary use of my invention the standardized grating units such as shown in Fig. 1 would be made up and riveted in the shop and shipped to the place of use with their ends free from local fastening means, and with the necessary number of short bolts and nuts. These parts would be assembled on the job by interleaving the free ends of the irregularly projecting complementary portions of the elements of each unit and bolting them together as shown in Fig. 2. The outer bent strips of each longitudinal series of units would then be bolted to the outer straight bars of another longitudinal series laid beside the first one, all as shown in Fig. 5, and a continuous grating structure of any desired length and breadth thus formed.

This type of continuous structure has a special advantage in resisting and withstanding what are known to engineers as "weaving strains", which result from the vibration of structures, because it presents at every point a continuous and uniform resistance to flexure in opposite directions. This increases the factor of safety, or permits a reduction of weight of material with the retention of a standard factor of safety. Structures embodying the invention also combine initial rigidity with ultimate resiliency, to a high degree.

The principle of the spliced joint which underlies this invention may also be embodied in reinforced concrete beams and columns, and in skeleton structures of other types.

Having described my invention, I claim:  
1. As a new article of manufacture a grating unit comprising a series of straight bars

and a series of bent strips fastened together, the members of each series being in staggered relation to each other lengthwise of the unit.

2. As a new article of manufacture a grating unit comprising a series of straight bars and a series of bent strips fastened together, the members of each series being in staggered relation to each other and to the members of the other series lengthwise of the unit.

3. A continuous grating structure suitable for flooring and the like purposes, said structure comprising the combination of a plurality of similar grating units, each of which units comprises a series of straight bars and a series of bent strips fastened together, the members of each such series in any one unit being in staggered relation lengthwise of the unit to each other and to the members of the other series, and each element of each unit being fastened to the registering element of an adjacent unit.

4. As a new article of manufacture a grating unit comprising a series of straight bars and a series of intervening bent strips, all being fastened together along medial portions of the unit but having their ends projecting at various distances, and no two being fastened together at their extremities, whereby, on assembling a plurality of such units end to end, the free ends of the bars and strips in each unit may be interleaved with the free ends of the bars and strips in an adjacent unit for fastening such units together in a continuous grating.

5. As a new article of manufacture a grating unit comprising a series of straight bars and a series of intervening bent strips, all fastened together along the medial portion of the unit, but free from fastenings to associated elements of the same unit at its extremities, the alternate straight bars being staggered one with another lengthwise of the unit a distance equal to one and half mesh-lengths of the grating.

6. As a new article of manufacture a grating unit comprising a series of straight bars and a series of intervening bent strips, all fastened together along the medial portion of the unit, but free from fastenings to associated elements of the same unit at its extremities, the alternate bent strips being staggered one with another lengthwise of the unit a distance equal to one half a mesh-length of the grating.

7. As a new article of manufacture a grating unit comprising a series of straight bars and a series of intervening bent strips, all fastened together, the members of the series of straight bars being in staggered relation one to another lengthwise of the unit by distances equal to one and a half mesh-lengths of the grating, and the members of the series of bent strips being in similar

staggered relation one to another and to the adjacent straight bars by distances equal to one half said mesh-length.

8. A continuous grating structure suitable for flooring and like purposes, said structure comprising a combination of a plurality of similar grating units having spliced joints uniting one with another, each of which unit joints comprises a series of element joints, no two adjacent element joints in any one unit joint being located in the same cross section of such unit joint.

9. A continuous grating structure suitable for flooring and the like purposes, said structure comprising the combination of a plurality of similar grating units comprising relatively staggered longitudinals, which units are connected side by side and end to end and having spliced joints uniting one with another at their abutting ends, said units being arranged to break joints one with another along lines transverse to the grating and being fastened together at their sides and ends by means substantially uniform with those used to hold together the longitudinals of each grating unit.

10. A continuous grating structure suitable for flooring and the like purposes, said structure comprising the combination of a plurality of similar grating units having spliced joints uniting one with another but the exterior straight bars of said structure being continuous, and the individual joints between registering elements of each pair of units forming such a spliced joint being distributed in various separated cross sections of said joint.

11. A continuous grating structure suitable for flooring and like purposes, said structure comprising the combination of a plurality of similar grating units having

spliced joints uniting one with another, each of which said unit joints comprises a series of element joints, no two adjacent element joints in any one unit joint being located in the same cross section of such unit joint, major and medial portions of the elements of each unit being riveted together and their extremities being fastened by bolts and nuts to the registering elements of an adjacent unit.

12. A structure such as described in claim 11 in which said grating units all have their constituent elements staggered with relation one to another lengthwise of the unit by predetermined distances, some of which have a magnitude of one and a half mesh-length of the grating, whereby each spliced joint extends over that length of grating.

13. A continuous skeleton structure comprising a connected series of similar units, each unit being formed of a series of straight bars and a series of alternate bent strips each located between, and fastened to, adjacent bars, the bars and strips of each unit being located in uniform staggered relation to one another lengthwise of the unit, whereby uniform spliced joints between successive units can be formed by fastening together the ends of the corresponding bars and the ends of the corresponding strips.

14. A structure such as described in claim 13 in which the ends of the straight bars at one end of each unit extend into, and interleave with, adjacent grating joints of the next unit.

15. A structure such as described in claim 13 in which the ends of the straight bars of each unit extend into, and are interleaved with, adjacent grating joints of the next units.

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