March 26, 1929. K. R. SCHUSTER 1,707,026

REENFORCED FLOOR CONSTRUCTION

Filed April 17, 1926 3 Sheets-Sheet 1

Fig. 1.

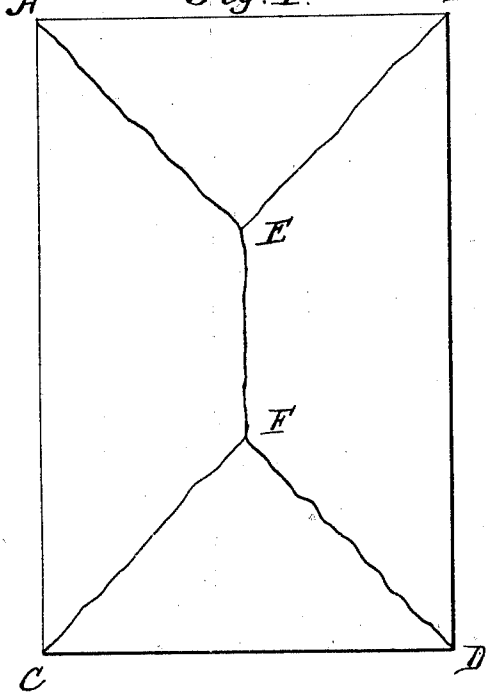


Fig. 2.

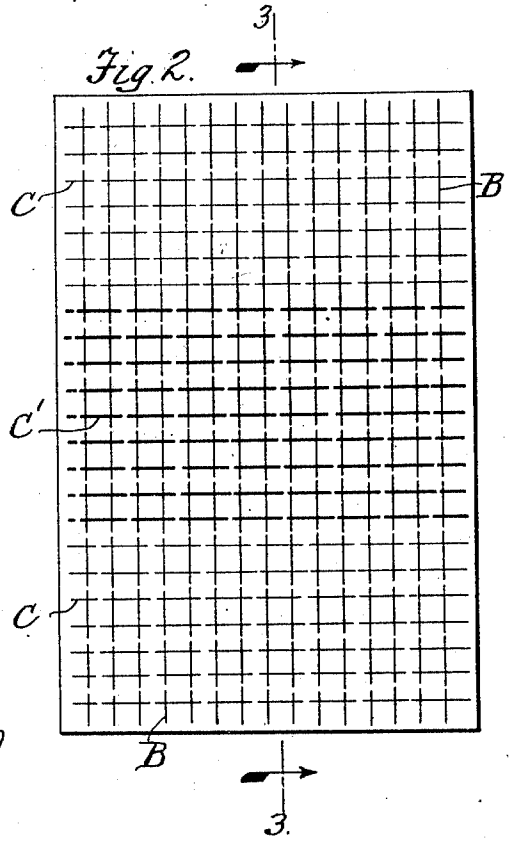


Fig. 3.

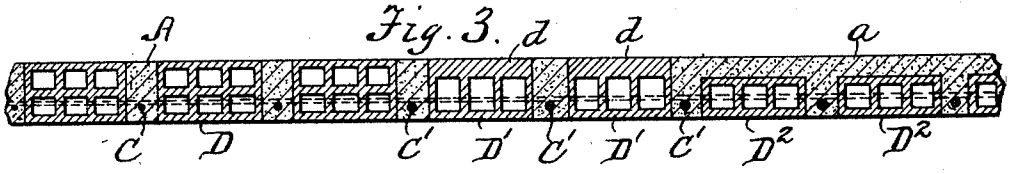
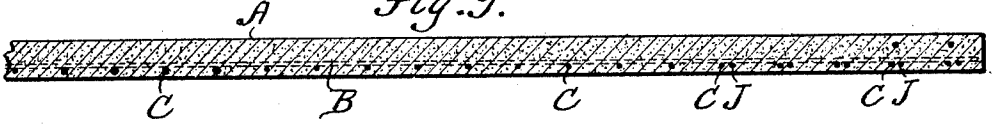


Fig. 9.



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REENFORCED FLOOR CONSTRUCTION

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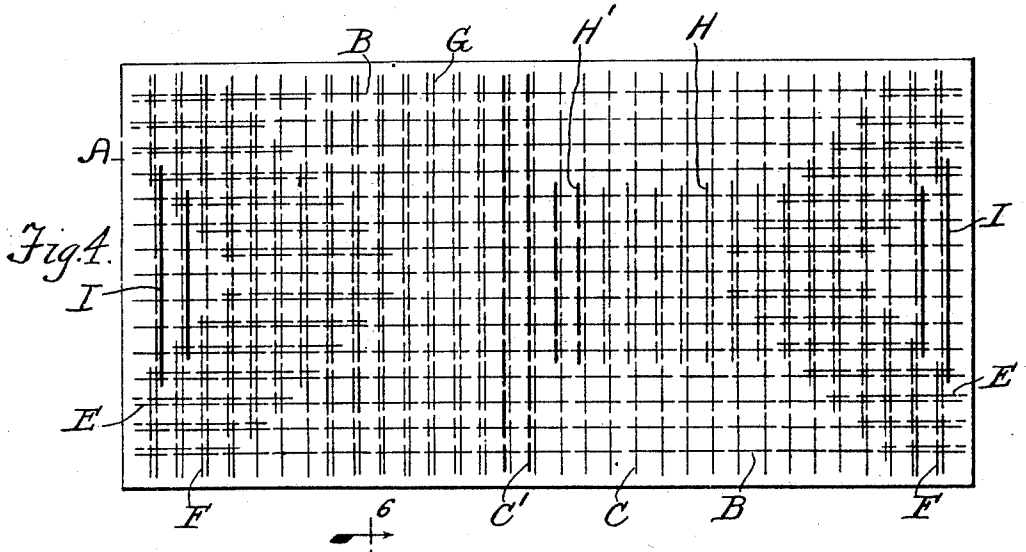


Fig. 4.

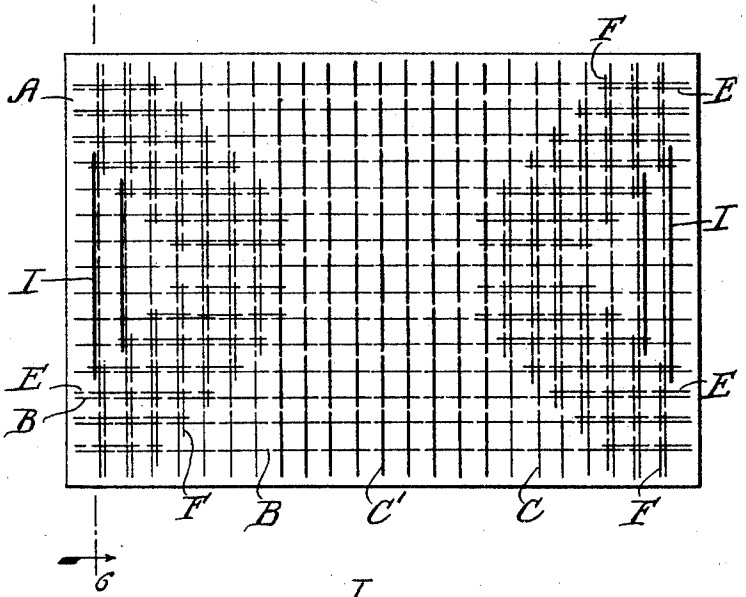


Fig. 5.

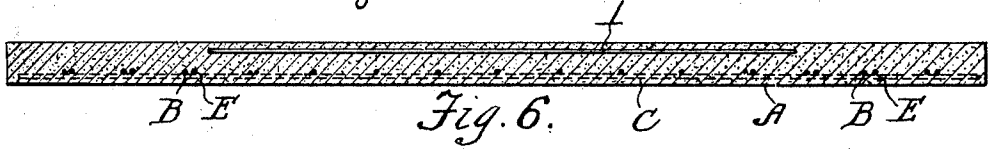


Fig. 6.

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REENFORCED FLOOR CONSTRUCTION

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Fig. 7.

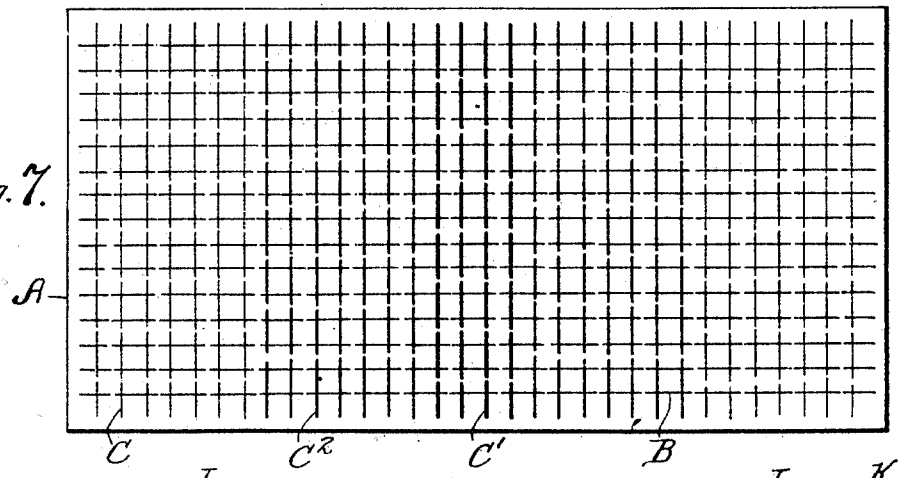
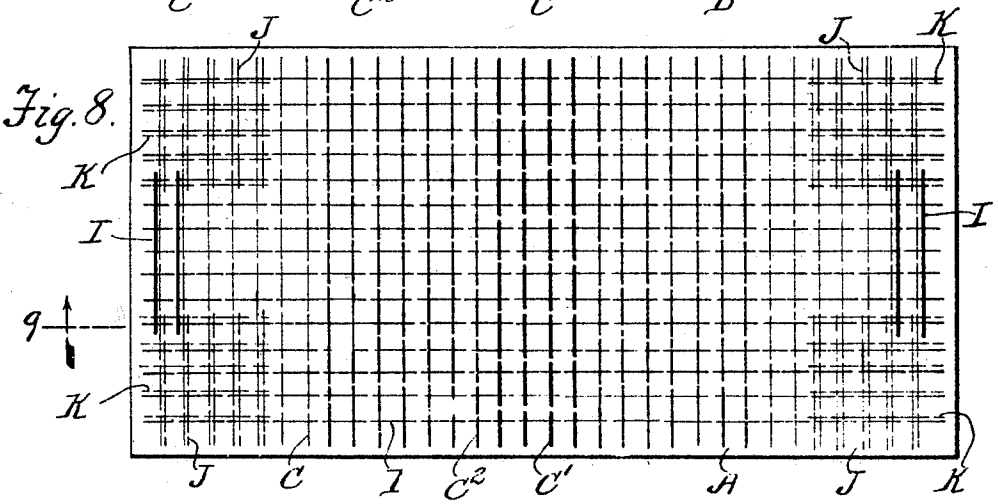


Fig. 8.



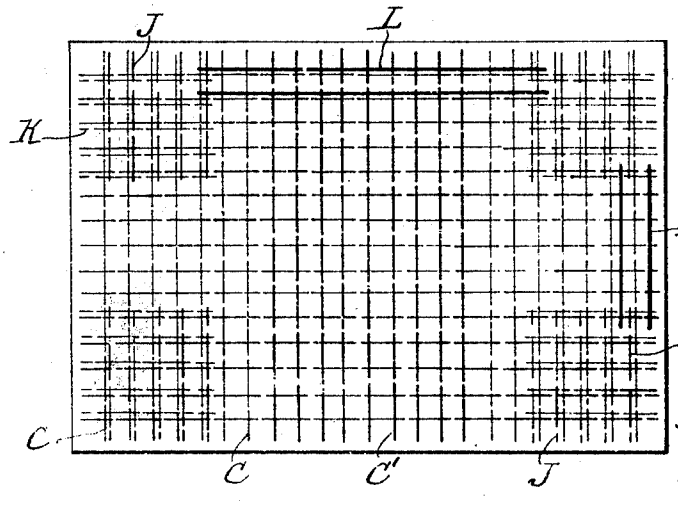


Fig. 10.

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UNITED STATES PATENT OFFICE.

KARL R. SCHUSTER, OF HOPATCONG, NEW JERSEY.

REENFORCED FLOOR CONSTRUCTION.

Application filed April 17, 1926. Serial No. 102,792.

This invention is a reenforced floor construction, and it pertains to that type wherein a composite plate is supported on all four sides or along its several margins by subjacent beams or walls, such type of composite plate being in contradistinction to a monolithic flat slab, wherein the slab is supported at its several corners "on points" afforded by columns.

In this invention, provision is made for reenforcing a wall or beam-supported composite plate the two dimensions of which are unequal, or which is an oblong, such reenforcement being in the nature of steel rods or bars disposed in a novel manner for avoiding waste of material, and to attain economy of labor. Generally speaking, the rods or bars are positioned at those parts of the composite plate which show a tendency to fracture under excessive loading, whereby the rods or bars in an oblong flat plate are positioned to secure a balanced construction.

Engineers and others skilled in this art have sought to reenforce an oblong wall or beam-supported plate by disposing the rods or bars for taking care of fractures extending centrally and lengthwise of said plate on lines parallel to the supporting beams or walls; but I have found by experimentation and by conducting scientific tests with fully loaded composite oblong slabs that the accepted theory concerning the direction of such fractures in oblong slabs is not warranted, for the reason that fractures in oblong slabs take place in the directions shown graphically in Figure 1 of the accompanying drawings, and which are described as follows: First, there is a line of fracture along the central line of the plate between the points E and F, which line is parallel to the longer sides of the oblong, and, second, there are diagonal lines of fracture between the points A, E, and B, E, at one end portion, and other diagonal lines of fracture between the points C, F, and D, F, at the other end portion, of said plate, such diagonal lines of fracture diverging from the central line and toward the four corners, and are due to the reaction of the supporting beams or walls at the corners of the plate being in excess of the reaction of said beams or walls at the middle region of the plate. As is well known, fracture of a plate occurs along the line of the highest bending moment (B M) of a composite plate, and in an oblong plate my experience demonstrates conclusively that in addition to the longitudinal central line of rupture there occur diagonal lines of fracture each extending at an angle of about 45° from said central line to one corner of the plate, thereby dividing an oblong plate into different areas, the two areas at the end portions of the plate being of triangular form as at A, B, E, and C, D, F, whereas the areas at the longer sides of the plate are irregular figures each with long and short parallel sides and inclined ends, one being bounded by lines between A, C, E, F, and the other between B, D, E, F. The bending moment of the plate is higher along the line E, F, than on the 45° or diagonal lines running to the corners of the plate, for the reason that the plate is deflected more readily in the direction of its longer sides than it is deflected in the direction of the shorter sides, and thus a larger part of the load is naturally carried in a direction parallel to the short sides of the plate. In view of these conditions, the most efficient and economical reenforcement for the plate consists in the employment of rods or bars extending both lengthwise and crosswise of said plate throughout the full area thereof, resulting in a balanced construction, taking care of the load stresses equally in all directions, including the areas bounded by the diverging lines extending diagonally to the corners of the plate, the series of rods in the middle region of the plate being in all instances heavier than the rods in the other courses running lengthwise and crosswise of the plate.

In the drawings,—

Figure 1 illustrates diagrammatically the lines of fracture occurring in an oblong composite plate when loaded to the point of destruction.

Figure 2 is a plan view and Figure 3 a vertical section on the line 3—3 of Figure 2 of one embodiment of the invention.

Figure 4 is a plan of another embodiment of the invention.

Figure 5 is a plan and Figure 6 a section on the line 6—6 of Figure 5 showing an oblong plate reenforced in accordance with another embodiment of the invention.

Figures 7, 8 and 10 are plan views of still other forms of reenforcement in oblong plates, and

Figure 9 is a longitudinal section on the line 9—9 of Figure 8.

The composite plate shown in Figures 2 and 3 is composed of concrete, or concrete and tile, reenforced by two main courses or belts of rods B, C, whereof the rods B extend lengthwise, and the rods C are arranged crosswise, of the plate, attention being directed to the fact that the crosswise rods C′ in the middle region of the panel are heavier or of greater cross section than the remainder of the rods B, C.

Said rods B, C, C′, are all positioned in the panel below the neutral axis thereof, and are as close to the under surface of the composite plate as is consistent with adequate protection against fire by the bottom layer or strata of concrete, it being apparent that all the rods are in the bottom chord of the plate to serve the function of tension members. The rods B of one series are spaced equi-distantly and run in one direction, i. e., lengthwise, whereas the other rods C, C′, are also spaced equi-distantly and run in a direction crosswise of the rods B, so as to intersect therewith and result in spaces adapted to receive the material. The crossing relation of the longitudinal and transverse rods spaced equi-distantly produces a metallic grid well adapted for the reception of blocks D, usually of tile, in the manner disclosed in my prior Patent No. 1,134,164, although it is to be understood that the plate of this application may be composed of concrete reenforced by steel rods to the exclusion of the tile blocks. The crossing rods extend throughout the full area of the composite plate, and said crossing rods are in the triangular areas bounded by diagonal lines of possible fracture running to the corners of the plate.

The rods B and C are of the same cross section, but as the bending moment on the central longitudinal line of fracture E, F, is higher than on the diagonal 45° lines of fracture, because the plate deflects more readily in the direction of its long sides, I employ the belt course of rods indicated at C′, which rods are heavier or of greater cross section than the rods C, B. These heavier rods C′ extend crosswise of the central longitudinal line of fracture E, F. The rods B, C, cross the diagonal lines of fracture running from the central line to the corners of the plate, and thus the rods B, C, C′, are so related to all the lines of fracture ordinarily occurring in the plate under excessive loading as to preclude such fracture by an economical disposition of the steel.

It is apparent that in regions of the plate where the bending moment is higher, it follows that the tensile stresses and the compression stresses run correspondingly higher, and in order to take care of such higher compression stresses, I utilize tile at D′, in Figure 3, with a thicker top slab at *d* in the top chord of the plate, or the same result is obtained by the employment of smaller tile at D^2, in Figure 3, with a heavier and stronger layer of concrete at *a*, all as shown in Figure 3.

Oblong slabs of the character herein under consideration have a tendency under excessive loading to buckle upwardly at the middle portions of the sides thereof, more particularly at the middle of the short sides of the oblong plate. In Figure 4 I have disclosed a means for reenforcing the plate substantially in accordance with the invention, said Figure 4 illustrating, also, means for precluding said upward buckling of the middle side portions of the plate. In view of the fact that the composite plate of Figure 4 exceeds in length the plate of Figure 2, I employ the two series of crossing main rods B, C, with the heavier cross rods C′ in the middle region of the plate, as hereinbefore described, and in addition thereto the plate of Figure 4 is provided with other rods, as follows:—

Short rods E, F, are positioned within the slab below the neutral axis thereof, said short rods being parallel to the main rods B, C, respectively, in the corner portions of the plate. Said short rods extend across the diagonal lines of possible fracture and into the triangular areas bounded by the diagonal lines of fracture, and the groups of corner rods extend from the corners toward the central longitudinal lines of the plate, said rods E being parallel to each other and to one margin of the plate, whereas the other rods F are parallel to each other and to another margin of the plate. The cross rods C′ at the middle region of the plate are heavier than the other cross rods C, and in addition to these cross rods C, C′, in the middle region, I may use other cross rods G, of the same cross section as rods C, and extend them parallel to rods C from side to side, or I may use other cross rods H, shorter than the rods C or C′, said rods H crossing the middle portion of the plate and parallel to rods C, said rods H being of a cross section similar to rods C or being composed of heavier rods at H′. It should be noted that all the rods B, C, C′, E, F, G, H, H′, are embedded in the material of the plate below the neutral axis and in the tension chord thereof, but in order to preclude upward buckling of the middle portions of the plate at the ends thereof I employ rods I, the latter being in the upper or compression chord of the plate and parallel to the short end sides of said plate and parallel, also, to the cross rods C therein.

The plate of Figures 5 and 6 is crosswise reinforced throughout its area by the longitudinal rods B, and by the transverse rods C, C′, the rods C′ in the middle region of the plate being considerably heavier or

larger in cross section than the other cross rods C. Along the diagonal lines of fracture in the end portions of the plate are the two series of shorter rods E, F, parallel to rods B, C, respectively, all of the rods being in the bottom chord of the plate, but in addition thereto I use the short rods I in the top chord of the plate near and parallel to the short end sides thereof. The heavier bars C′ cross the central longitudinal line of the plate, and extend from side to side thereof, whereas the shorter bars E, F, are positioned crosswise of the diagonal lines of fracture and at the respective end portions of the plate.

In Figure 7 there is shown a long rectangular composite plate provided with the longitudinal belt course of rods B, and with the crosswise belt courses of rods the cross section of which increases from the end portions of the plate toward the middle region thereof. Thus the bars C at the ends are of the same cross section as the rods B; the cross rods C′ in the middle region of the plate are larger or heavier than the rods C, whereas the rods C^2 are of a cross section intermediate the rods C, C′, the thickness of the cross rods being graduated by increasing the same from the end portions toward the middle region of the plate.

The oblong plate of Figures 8 and 9 is reenforced similarly to the plate of Figure 7 in so far as concerns the rods B, C, C′, C^2, and in addition thereto said plate is provided with short rods J, K, in the corners and in the tension chord thereof, and is provided also with the short rods I in the compression chord at the middle of the end portions thereof. The short rods J in each corner group are parallel to rods C, whereas the short rods K are parallel to rods B, said groups of corner rods reenforcing the plate against fracture on the diagonal lines, and taking up the vertical shear in the plate near the corners thereof. As stated, the rods I in the top chord of the plate adjacent the end portions, and in the middle, reenforces the plate against a tendency to buckle upwardly at said places.

In oblong plates the longitudinal dimensions of which substantially exceed the transverse dimensions, the increased steel in the middle region of the plate as shown in Figures 2, 4, 5, 7 and 8, is of great importance, for the reason that in such long plates the main longitudinal rods B parallel to the long sides of the panel lose their effectiveness near the central part of said plate, in consequence of which it is necessary to take care of the load stresses by rods extending in the short direction, and this is accomplished in my invention by the use of cross rods the cross section of which is graduated in thickness from the end portions toward the middle of the plate.

The composite plate of Figure 10 is reenforced by the longitudinal rods B, the cross rods C, C′, whereof the heavier rods are at the middle of the panel, and the corner portions are strengthened by the groups of corner rods J, K, arranged as described in connection with Figure 8 and located on the bottom chord of the plate. I employ, also, the short rods I at one or both ends of the panel and in the top chord thereof, and in addition thereto the short rods L at one or both of the long sides of the plate, and in the top chord thereof, said rods I, L, operating to stiffen the plate so as to preclude upward buckling at the middle portions of the plate along the short and long sides thereof.

The different groups of reenforcing rods herein shown in connection with oblong plates are used to good advantage in plates having the form of rectangles, wherein the ratio of the short sides to the long sides is equal to 1:1.3 down to a ratio of 1:3.

In all cases where rods of a heavier cross section are used with equi-distant spacing, rods of the same section but spaced closer together can be used.

These plates may be used for foundations, retaining walls, concrete ships, etc., as well as for floors or roofs.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. A floor construction wherein an oblong composite plate is supported on its several margins and tends to fracture under excessive loading on lines one running centrally of the plate and others running diagonally from the central line to the several corners, embodying two series of crossing rods in the bottom chord of the plate, whereof one series of rods extends lengthwise of the plate throughout the area thereof and the rods of the other series extend crosswise of the plate throughout the area thereof and at a right angle to the rods of the first series, the cross rods of the second series being graduated in thickness from the end portions of the plate toward the middle region thereof and said crosswise rods extending transversely to the specified lines of fracture in the plate.

2. A floor construction wherein an oblong composite plate is supported on its several margins and tends to fracture under excessive loading on lines one running centrally of the plate and others running diagonally to the central line from the several corners, embodying two series of crossing rods in the bottom chord of the plate, whereof one series of rods extends lengthwise of the plate throughout the area thereof and the rods of the other series extend crosswise of the plate throughout the area thereof and at a right angle to the rods of the first series, said crosswise rods of the

second series being of greater cross section in the middle region of the plate and in the corner regions thereof than are the rods of the first series or the remainder of the rods of the second series.

3. A floor construction wherein an oblong composite plate is supported on its several margins and tends to fracture under excessive loading on lines one running centrally of the plate and others running diagonally from the central line to the several corners, embodying two series of crossing rods in the bottom chord of the plate, whereof one series of rods extends lengthwise of the plate throughout the area thereof and the rods of the other series extend crosswise of the plate throughout the area thereof and at a right angle to the rods of the first series, said crosswise rods of the second series located in the middle region and in the corner regions of the plate being of increased cross section relatively to the other rods of the two series, and shorter rods positioned in the top chord of said plate adjacent the margins thereof to preclude upward buckling of said plate at the middle of the marginal portions thereof.

4. A floor construction wherein an oblong composite plate is supported on its several margins and tends to fracture under excessive loading on lines one running centrally of the plate and others running diagonally from the central line to the several corners, embodying two series of crossing rods in the bottom chord of the plate, whereof one series of rods extends lengthwise of the plate throughout the area thereof and the rods of the other series extend crosswise of the plate throughout the area thereof and at a right angle to the rods of the first series, said crosswise rods of the second series located in the middle region and in the corner regions of the plate being of increased cross section relatively to the other rods of the two series, and shorter rods positioned in the top chord of said plate adjacent the margins on the long sides and the short sides of the plate for precluding upward buckling thereof along the several margins.

5. A floor construction wherein an oblong composite plate is supported on its several margins and tends to fracture under excessive loading on lines one running centrally of the plate and others running diagonally from the central line to the several corners, embodying two series of crossing rods in the bottom chord of the plate, whereof one series of rods extends lengthwise of the plate throughout the area thereof and the rods of the other series extend crosswise of the plate throughout the area thereof and at a right angle to the rods of the first series, said crosswise rods of the second series being of increased cross section in the middle region of the plate, and short rods in the bottom chord of the plate and at the respective corners thereof, said short rods being parallel to the main rods and crossing the diagonal lines of fracture extending to the corners of the plate.

6. A floor construction wherein an oblong composite plate is supported on its several margins and tends to fracture under excessive loading on lines one running centrally of the plate and others running diagonally from the central line to the several corners, embodying two series of crossing rods in the bottom chord of the plate, whereof one series of rods extends lengthwise of the plate throughout the area thereof, and the rods of the other series extend crosswise of the plate throughout the area thereof and at a right angle to the rods of the first series, said crosswise rods of the second series being of increased cross section in the middle region of the plate, short rods in the bottom chord of the plate and in the respective corners thereof, and other short rods in the top chord of the plate and adjacent the marginal portions thereof.

7. A floor construction wherein an oblong composite plate is supported at its several margins and tends to fracture on lines resulting in triangular areas at the end portions of said plate, embodying two series of rods in the lower chord of the plate, one series of said rods extending lengthwise of the plate and equi-distantly spaced throughout the area thereof, and the other series of rods extending crosswise of the plate and equi-distantly spaced throughout the area thereof, said crosswise extending rods being graduated in thickness in increasing ratio from the end portions to the middle region of the plate, and said rods of the two series crossing each other within the triangular areas at the corner portions of the plate.

In testimony whereof I have hereto signed my name this 12th day of April, 1926.

KARL R. SCHUSTER.