A. E. LINDAU.

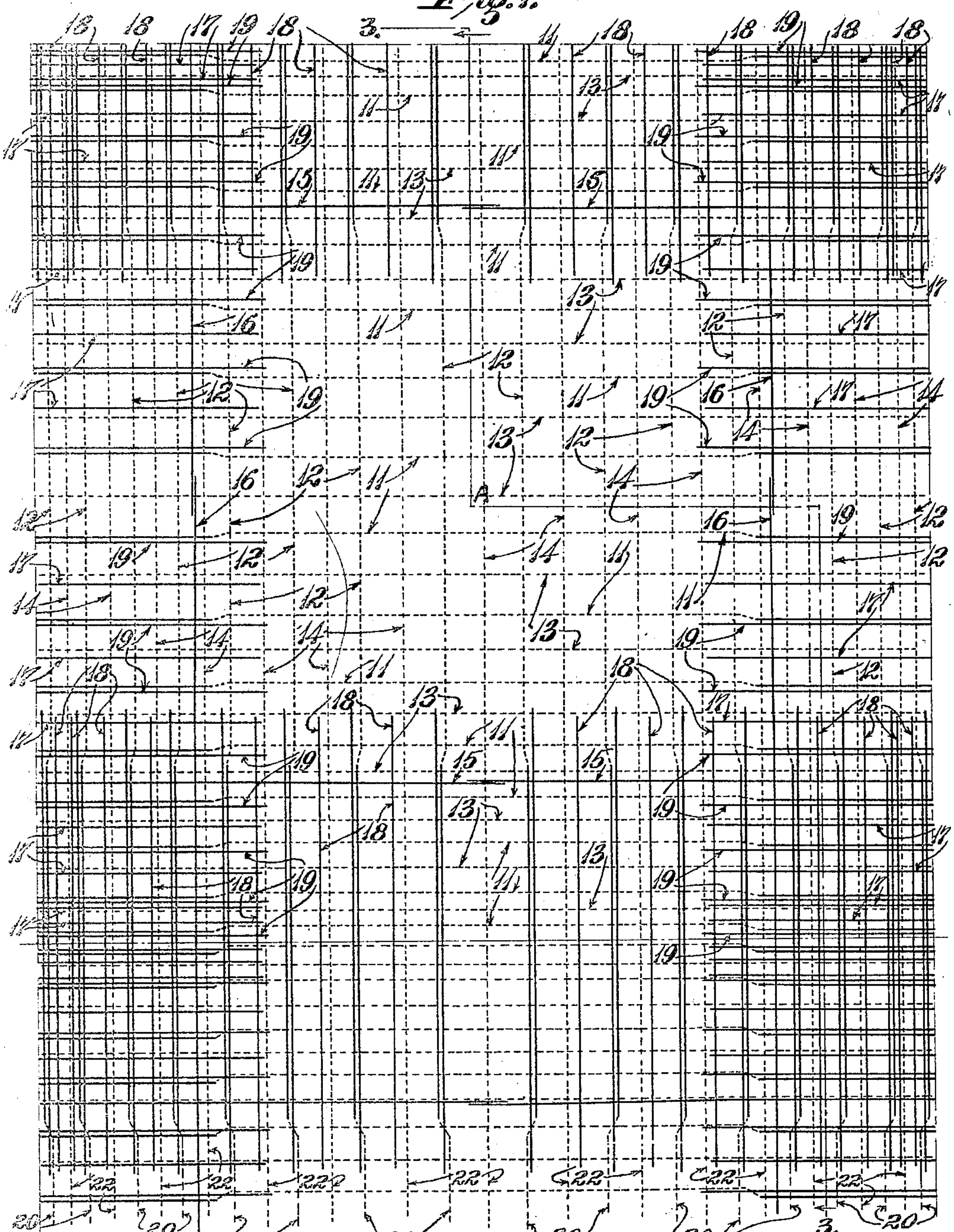
REINFORCED CONCRETE FLOOR CONSTRUCTION.

APPLICATION FILED APR. 14, 1911.

1,050,477. Patented Jan. 14, 1913.

4 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
Edgar T. Farmer.
[illegible]

Inventor:
Alfred E. Lindau
By Carr & Carr,
his attys.

A. E. LINDAU.

REINFORCED CONCRETE FLOOR CONSTRUCTION.

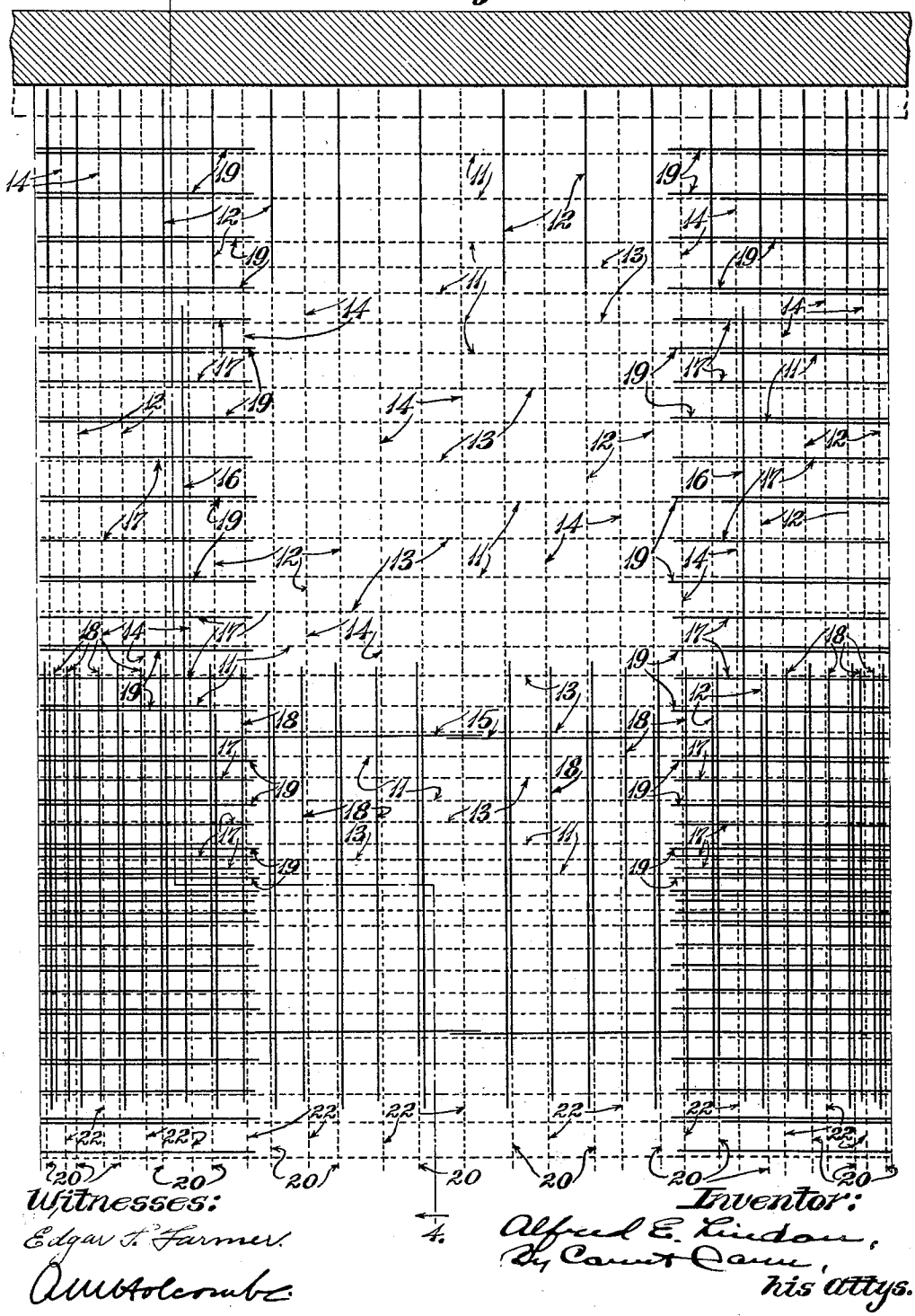
APPLICATION FILED APR. 14, 1911.

1,050,477.

Patented Jan. 14, 1913.

4 SHEETS—SHEET 2.

Fig. 2.



Witnesses:

Edgar T. Farmer.

A. W. Holcombe

Inventor:

Alfred E. Lindau,

By Cornet Cann,

his attys.

A. E. LINDAU.

REINFORCED CONCRETE FLOOR CONSTRUCTION.

APPLICATION FILED APR. 14, 1911.

1,050,477. Patented Jan. 14, 1913.

4 SHEETS—SHEET 3.

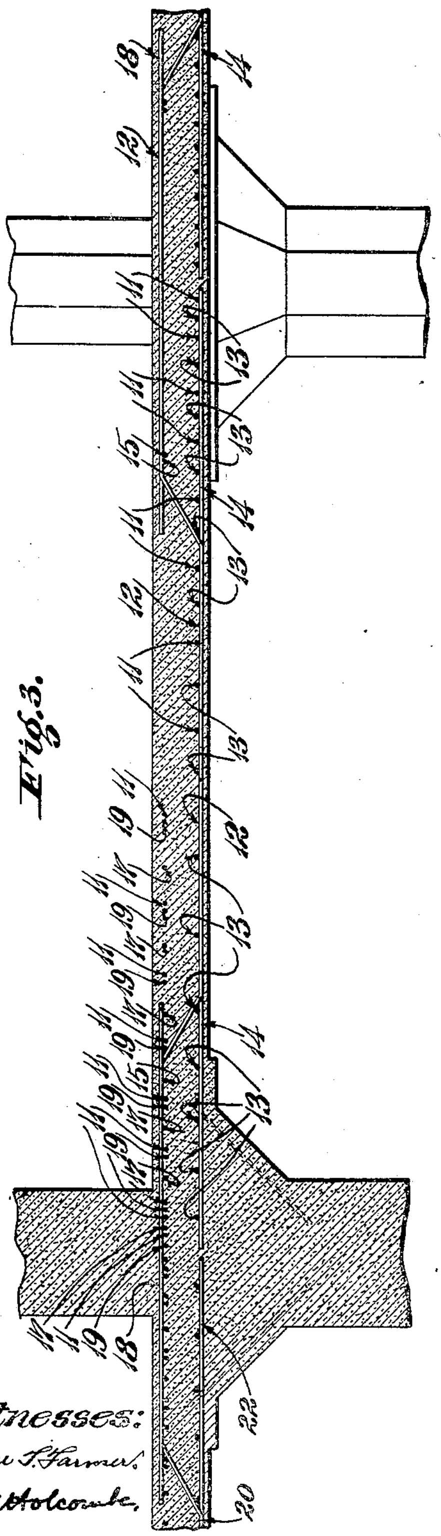


Fig. 3.

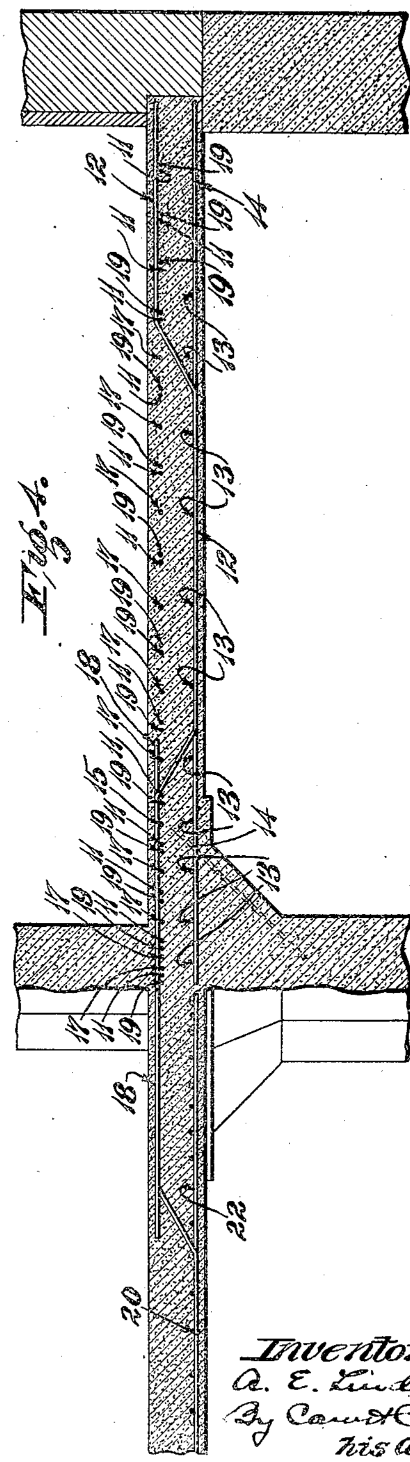


Fig. 4.

Witnesses:
Edgar S. Farmer.
A. W. Holcombe.

Inventor:
A. E. Lindau,
By Carr & Carr,
his attys.

A. E. LINDAU.

REINFORCED CONCRETE FLOOR CONSTRUCTION.

APPLICATION FILED APR. 14, 1911.

1,050,477.

Patented Jan. 14, 1913.

4 SHEETS—SHEET 4.

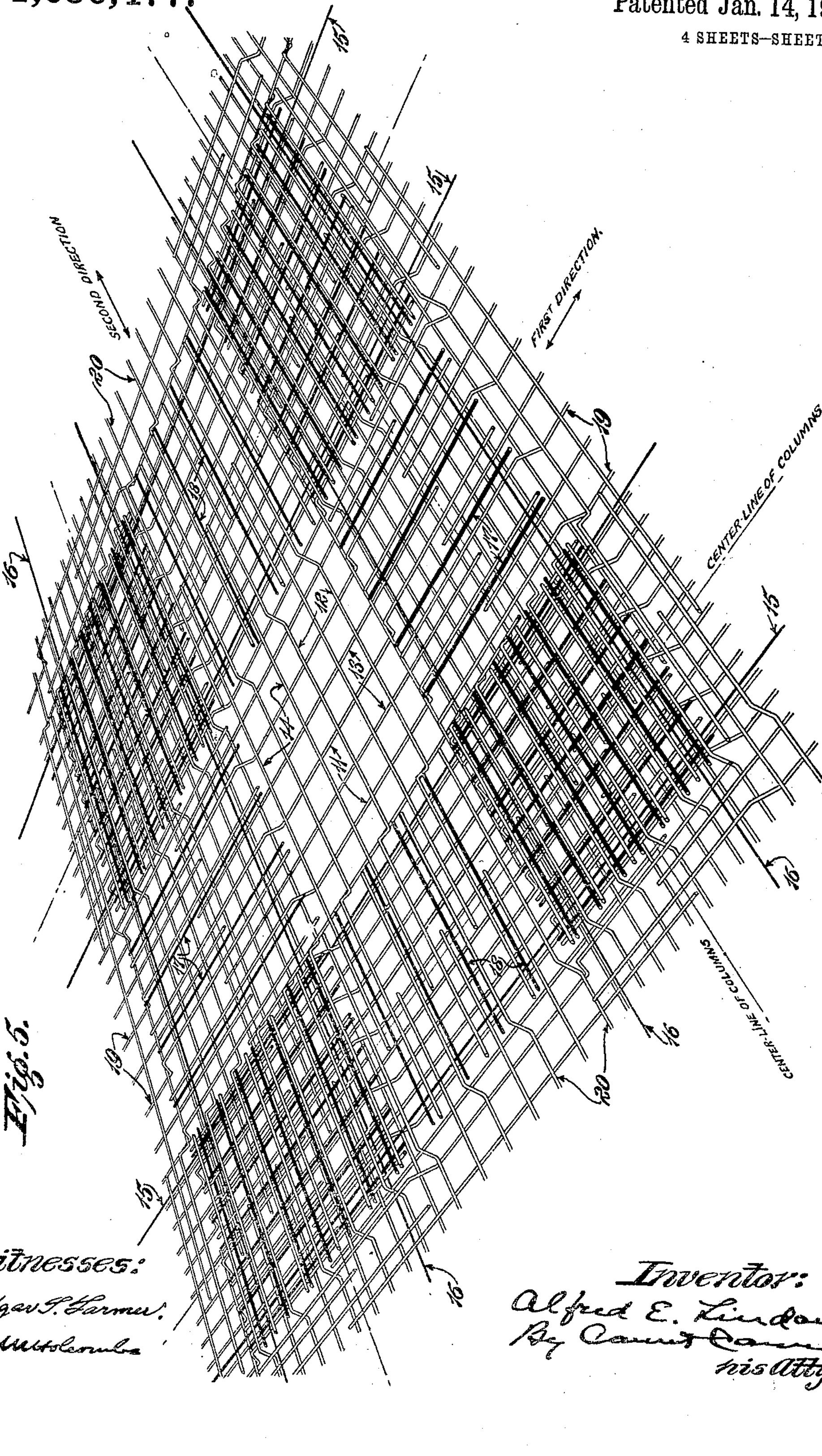


Fig. 5.

Witnesses:
Edgar T. Farmer.
A. M. Holcombe

Inventor:
Alfred E. Lindau
By Carr & Carr,
his Attys.

UNITED STATES PATENT OFFICE.

ALFRED E. LINDAU, OF ST. LOUIS, MISSOURI, ASSIGNOR TO CORRUGATED BAR COMPANY, OF ST. LOUIS, MISSOURI, A CORPORATION OF MISSOURI.

REINFORCED-CONCRETE FLOOR CONSTRUCTION.

1,050,477. Specification of Letters Patent. Patented Jan. 14, 1913.

Application filed April 14, 1911. Serial No. 621,072.

To all whom it may concern:

Be it known that I, ALFRED E. LINDAU, a citizen of the United States, and a resident of the city of St. Louis and State of Missouri, have invented a new and useful Improvement in Reinforced-Concrete Floor Construction, of which the following is a specification.

My invention relates to a new system of arrangement of reinforcing rods in concrete floors of the type in which a flat slab of concrete of substantially uniform thickness is supported directly upon the column caps, without the intervention of girders.

Investigation has shown that the distribution of tension stresses in girderless reinforced concrete floors is such that present methods of reinforcement do not adequately cover the tension regions. Particularly is this true in the upper surface of floor slabs in a direction perpendicular to the line intersecting the columns, or what may be termed along the edges of the floor panel. It is also necessary to more carefully protect the tension region immediately over and adjacent to the columns. Heretofore it has been a general practice to place layers of reinforcing bars in the bottom central region of the slab, said bars extending from the bottom central region of the slab in several directions up into, or near the upper surface of the slab at its edges, and in some cases to add to these slab bars one or more layers of additional bars, usually straight, arranged in the top of the slab. The result is first of all, to pile up so many layers of bars in the top of the slab at its edges as to bring the center of gravity of the reinforcement at these points nearer the neutral axis of the slab, making this reinforcement proportionately less effective, and in the second place the bent up bars usually dip down from the top to the bottom surface of the slab so near the columns as to leave a large portion of the tension region in the top of the slab above the columns unprotected. I have devised a system or method of reinforcing floor slabs of this type, that is, that in which girders across the columns are dispensed with, which will more adequately take care of the stresses and with a less amount of metal reinforcement, than is possible with the systems in general use.

My improvements consist in placing the bars parallel to the rows of columns or edges of the panels and crossing the panels in two directions only, at right angles to each other, and in the detail arrangement of reinforcement as is shown in the drawings accompanying this specification, and forming a part thereof.

My improvements are not restricted to girderless concrete floors but are applicable to the arrangement of the reinforcing rods in tile-concrete or composite floors, and floors divided into sections or panels by girders connecting the columns.

In the drawings, in which like parts are designated by like characters wherever they occur,—Figure 1 is a plan view of the reinforcement in a center panel of a flat slab floor embodying my invention, showing part of an adjacent panel; the reinforcement in the top of the slab being shown in full lines and that in bottom of the slab in dotted lines; Fig. 2 is a similar view of a wall panel of a flat slab floor embodying my invention; Fig. 3 is a transverse section through a center panel along the line 3—3 in Fig. 1; Fig. 4 is a transverse section through a wall panel along the line 4—4 in Fig. 2; and Fig. 5 is a diagrammatic view of the reinforcement of a portion of the floor slab.

Referring to Fig. 1 of the drawings the arrangement of bars in a typical panel of a flat slab floor supported on columns is shown, as though all the concrete in the slab above the upper layers of bars were removed, thus exposing these layers of bars in full view, while the layers of bars in the lower part of the slab are indicated by dotted lines.

The reinforce consists of two series of principal tension bars 11, 12, arranged at right angles to each other parallel to the rows of columns. These bars for approximately the middle three-fifths of the span are placed in the lower portion of the slab and are bent up at the ends to lie in the top portion thereof, the end portions of the bars extending over into the marginal portions of the adjacent panels, and overlapping the end portions of the similar bars 19, 20 in the adjacent panels. Alternating with these principal tension bars and grouped therewith are two series of combined tension and compression bars 13, 14, straight throughout their length, and placed in the lower portion of the slab. These bars are

in tension across the middle part of the span, and in compression at their ends. The bars 13, 14 terminate near the margins of each panel, where they aline with similar bars 22 in adjacent panels.

Each group of bars is coextensive in width with the width of the panels between the rows of columns, and the two groups provide all the reinforce necessary in the bottom of the slab, as whatever the direction of the stress in the slab at any given point, it may be resolved into two component stresses, parallel with the reinforcing bars. As the stresses at right angles to the lines connecting adjacent columns are found to be less in flat slab floors in the regions remote from the columns than in the regions near the columns, the lateral spacing of the bars in each group may be graduated, and the intervals between the bars may be greater toward the center of the span without impairing the strength of the floor.

Heretofore flat slab floors have been constructed having reinforcing rods crossing the panels diagonally from corner to corner or radiating from the columns through the slab in every direction. Such arrangements of reinforcing rods do not reinforce the top portions of the floor slab in the regions between adjacent columns against tension stresses transverse to the straight lines connecting said columns. By arranging the reinforcing bars in groups parallel to the rows of columns and bending up the ends of some of the bars of each group to lie in the top portion of the slab in the marginal regions of the panels in directions perpendicular to the respective sides thereof, thereby these bent up bars assist in taking care of the tension stresses in the top of the slab in the regions between the columns. Moreover, in flat slab floors the maximum stress in the slab under ordinary conditions of distribution of the load on the floor is over the columns. Heretofore belts of reinforcing bars have been placed crossing each other one above another in the upper portion of the slab over the columns to take the large tension stresses at these points. This piling up of layers of metal over the columns results in lowering the center of gravity of the reinforce and raising the position of the neutral axis of the slab, thereby greatly increasing the compression stresses in the lower portion of the slab in the regions near the columns.

By placing straight bars in the lower portion of the slab in the marginal regions of the panels and near the columns the effect of the bent up bars in changing the position of the neutral axis of the slab in these regions is partly equalized, and at the same time the compression stresses are distributed between the concrete and straight bars in such a way as to stiffen the slab at the columns and reduce the deflection of the slab between the columns, thus changing the distribution of stresses, both tension and compression, in the slab. Also, by arranging the bars in two directions only, the reinforcement over the supports above and below the neutral axis of the slab will be in two layers instead of four or more, giving the reinforcement a greater lever arm for resisting the bending moment at the supports, as the center of gravity of the reinforcement is farther from the neutral axis of the slab.

Short supplementary bars 17, 18, are placed in the upper region of the slabs over and between adjacent columns, these bars being perpendicular to the lines connecting the columns and disposed at intervals in the planes of the bent up ends of the tension bars extending in the same direction. The spacing apart of these bars is increased toward the middle of the span, for the same reason as the spacing apart of the bent up slab bars already referred to. The bent up slab bars and the supplementary bars together furnish a sufficient amount of top reinforcement in this region.

The net work or grillage of top bars may be held in place by main bars 15, 16, two for each row of columns, disposed in the top portion of the slab parallel to the rows of columns and wired to vertical reinforcing bars in the columns, which latter are not shown in the drawings. By bending down the ends of the alternate top supplementary bars over the columns, additional shear provision can be obtained wherever this may be desirable. By placing these supplementary straight or bent bars between the main tension bars in the upper region of the slab over and between the columns at graduated intervals for the greater part of the span, not only is the whole region of tension in the top of the slab between the columns reinforced, but also the bars are so disposed as to be properly proportioned to the varying amount of the tensional stresses at various distances from the columns.

The concrete slab is increased in thickness over the column for a distance varying from one-third to one-quarter of the span. This is done to decrease the shearing stress adjacent to the column, and to decrease the compressive stress in the concrete on the under side of the slab, and results in considerable economy of material, as a twenty-five per cent. increase in thickness over this area requires no more material than an increase in thickness over the total area of the slab of not more than three or four per cent., whereas the increase in strength of the slab as a whole is over twenty-five per cent. by reason of this increased thickness of the slab near the columns.

Fig. 2 shows my improved arrangement

applied to a floor slab having one edge supported in a wall, and differs from the arrangement shown in Fig. 1 in omitting the supplementary tension rods and some of the combined tension and compression rods along the edge of the slab supported in the wall.

While my system or arrangement of metal reinforce is particularly adapted to floor panels supported at their corners, it is evident that it is not restricted thereto, but may be applied to floor panels supported on walls at one or more edges.

Having described my improved floor system what I desire to claim and secure by Letters Patent is as follows:

1. A monolithic floor-slab resting on rows of columns intermediate its margins and consisting of concrete and series of reinforcing rods positioned therein, the rods of one series being arranged to extend parallel with a row of columns and disposed at graduated intervals throughout the width of said slab, and the rods of another series being arranged at right angles to the rods of said first mentioned series and disposed at graduated intervals throughout the length of said slab, the rods of both said series spanning the panels between said rows of columns and being bent to extend through the bottom region of the slab at the middle portions of the panels and through the top region of the slab at the margins of the panels.

2. In a reinforced concrete floor, a floor panel having reinforcing rods arranged parallel with the respective edges thereof and extending beyond said edges into the adjacent panels respectively, said rods intersecting at right angles to each other throughout the entire area of the panel, and supplementary reinforcing rods arranged around the edges of the panel and at right angles thereto, said supplementary rods being in the same horizontal plane with the adjacent portions of the first mentioned rods extending in the same direction, there being not more than two layers of rods on the same side of the neutral plane of the panel at any one point.

3. In a reinforced concrete floor construction consisting of a girderless flat plate slab of concrete resting on rows of columns dividing it into panels along the center lines of said rows, reinforcing bars embedded in said slab arranged in groups of parallel rods, there being two groups in each panel, said groups crossing each other and the bars in each group being parallel to a side of the panel and being spaced apart at intervals from side to side thereof, the bars of each group being all in the same plane in the bottom region of the panel throughout their middle portions, and supplementary bars in the top region of the slab crossing the edges of said panel and extending into the adjacent panels, and rods in the top region of the slab around the margins of the panels upon which the supplementary bars rest.

4. In a reinforced concrete floor construction consisting of a slab of concrete resting on rows of columns dividing it into panels along the center lines of said rows, reinforcing bars embedded in said slab arranged in groups of parallel bars, there being two groups in each panel, said groups crossing each other, and the bars in each group being parallel to a side of the panel and being spaced apart at intervals, said spacing varying and being greater at the middle of the panel than toward the margins, the bars of each group being all in the same plane in the bottom region of the panel across its middle portion, some of said bars having their ends offset upwardly into a horizontal plane, and supplementary bars in the top region of the slab crossing the edges of said panel and extending into the adjacent panels, said supplementary bars being in the same planes with the ends of main bars extending in the same direction therewith.

5. In a reinforced concrete structure having a plurality of panels supported at the corners thereof, a system of reinforcing rods crossing a panel in a direction at right angles to the line connecting the points of support at one edge thereof, and extending into the adjacent panels, a second system of reinforcing rods crossing the panel at right angles to the first mentioned system of rods, and extending into the adjacent panels, and bars alternating with these systems of rods and terminating short of the edges of the panel.

6. A reinforced concrete floor panel having a plurality of systems of parallel reinforcing rods arranged to cross each other in adjacent planes throughout the length and breadth of said panel, each of said systems comprising straight rods and bent rods extending in the same direction across the panel, the middle portions of said rods extending in the same direction being arranged in the same horizontal plane whereby not more than two horizontal layers of rods lie in proximity to each other.

7. A reinforced concrete flooring comprising substantially rectangular panels having series of reinforcing rods arranged at right angles to each other across the length and breadth of a panel parallel with the respective edges thereof, the ends of the rods of each series lying in the same plane and extending into the adjacent panels, and bars positioned in the plane of the ends of the rods of each series and parallel thereto respectively, said bars being arranged in the marginal region of the panels and crossing the same at right angles to their meeting edges.

8. A reinforced concrete flooring comprising substantially rectangular panels having series of reinforcing rods arranged at right angles to each other across the length and breadth of a panel parallel with the respective edges thereof, the ends of the rods of each series lying in the same plane and extending into the adjacent panels, and bars positioned in the plane of the ends of the rods of each series and parallel thereto respectively, the bars and rods in the regions adjacent the respective edges of the panels with which they are parallel being spaced nearer together than those arranged across the middle portion of the panels.

9. The combination of columns and a monolithic reinforced concrete floor slab extending across said columns and divided into panels defined by lines passing through the centers of said columns, the reinforcement of each panel comprising a series of rods extending longitudinally of said panel and into the panels contiguous to the ends of said first mentioned panel, and a separate series of rods extending transversely of said first mentioned panel and into the panels contiguous to the sides of said first mentioned panel, the longitudinally extending rods being spaced apart throughout the entire width of the panel, and the transversely extending rods being spaced apart throughout the entire length of the panel, all of said rods being in the lower portion of the slab in the middle region of the panel and some of the rods of each series having their end portions offset and lying in the upper part of the slab in the regions adjacent to the margins of the respective panels and the other rods of each series being straight, whereby said reinforced floor slab simulates the action of a homogeneous flat plate.

10. A reinforced concrete floor slab of uniform thickness resting on columns arranged in parallel rows in two directions approximately at right angles to each other, the lines passing through the centers of the columns in each direction dividing the floor into panels, groups of reinforcing bars in said slab lying in two directions parallel to the sides of the panels, said bars being spaced apart at graduated intervals closer together at the margins of the panels than at their middles, all of the rods of each group being in the lower portion of the slab in the middle region of the panel and some of said rods of each group having their end portions offset and lying in the upper part of the slab in the regions adjacent to and across the margins of the respective panels, and the other bars of each group being straight, whereby said reinforced floor slab simulates the action of a homogeneous flat plate.

11. A reinforced concrete floor slab resting on columns arranged in parallel rows in two directions approximately at right angles to each other, the floor slab being of uniform thickness except for the areas adjacent to the columns, where the thickness is increased, reinforcing bars extending crosswise throughout the length and breadth of said slab in two series parallel to the rows of columns, said bars being spaced closer together near the rows of columns than across the middles of the panels defined thereby, some of the bars in each series being straight, bent bars between said straight bars, said bent bars and straight bars in each series being in the same plane in the lower region of the slab at their middles, the ends of the bent bars in each series extending across the margins of said panels and being in a plane above said first mentioned plane whereby said reinforced floor slab simulates the action of a homogeneous flat plate.

12. A reinforced concrete floor slab resting on columns arranged in parallel rows in two directions, approximately at right angles to each other, said slab being of uniform thickness except for the areas adjacent to the columns, said areas being of greater thickness than the remainder of the slab, spaced parallel, reinforcing bars in said slab extending in two directions parallel to the rows of columns, the spacing apart of the bars being a minimum near the rows of columns, supplemental bars arranged in the slab in the form of grillage in the areas adjacent to the columns and means for supporting said supplemental bars in the top region of the slab whereby said reinforced floor slab simulates the action of a homogeneous flat plate.

13. A reinforced concrete floor slab of uniform thickness resting on columns arranged in parallel rows in two directions, the lines passing through the centers of the columns in each direction dividing the floor into panels, groups of parallel reinforcing bars arranged crosswise to each other, the bars in each of said groups being spaced apart from edge to edge of the panels, the spacing of the bars being a maximum in the middles of the panels and a minimum at the margins of the panels, said groups comprising bent bars passing from below the neutral plane at the middles of the panels to above it across the margins thereof and straight bars in the same plane with the middle portions of the bent bars whereby said reinforced floor slab simulates the action of a homogeneous flat plate.

14. A reinforced concrete floor slab resting on columns arranged in rows at right angles to each other, said slab being of uniform thickness except for the areas adjacent to the columns, the thickness of said

slab adjacent to the columns being greater than that of the remainder of the slab, reinforcing bars crossing each other at right angles throughout the slab, said bars being parallel to the rows of columns and spaced apart at graduated intervals, the spacing diminishing from the middles of the panels toward the rows of columns in each direction, said bars passing from below the neutral plane of the slab at the middles of the panels to above it across the regions adjacent to the lines connecting the rows of columns whereby said reinforced floor slab simulates the action of a homogeneous flat plate.

15. A reinforced concrete floor slab of uniform thickness resting on columns arranged in intersecting parallel rows, the lines passing through the centers of the columns of the rows in each direction dividing the floor into panels, main reinforcing bars parallel to the sides of said panels passing from below the neutral plane at the middles of the panels to above it across the margins thereof and intersecting throughout the slab, said bars being closer together at the margins of the panels than at the middles thereof, supplemental bars in the form of grillage placed in the slab in the areas over and adjacent to said columns, said supplemental bars being in the same planes as the main bars adjacent thereto which extend in the same direction whereby said reinforced floor slab simulates the action of a homogeneous flat plate.

Signed at St. Louis, Missouri, this 11th day of April, 1911.

A. E. LINDAU.

Witnesses:
A. M. HOLCOMBE,
M. A. SHELTON.