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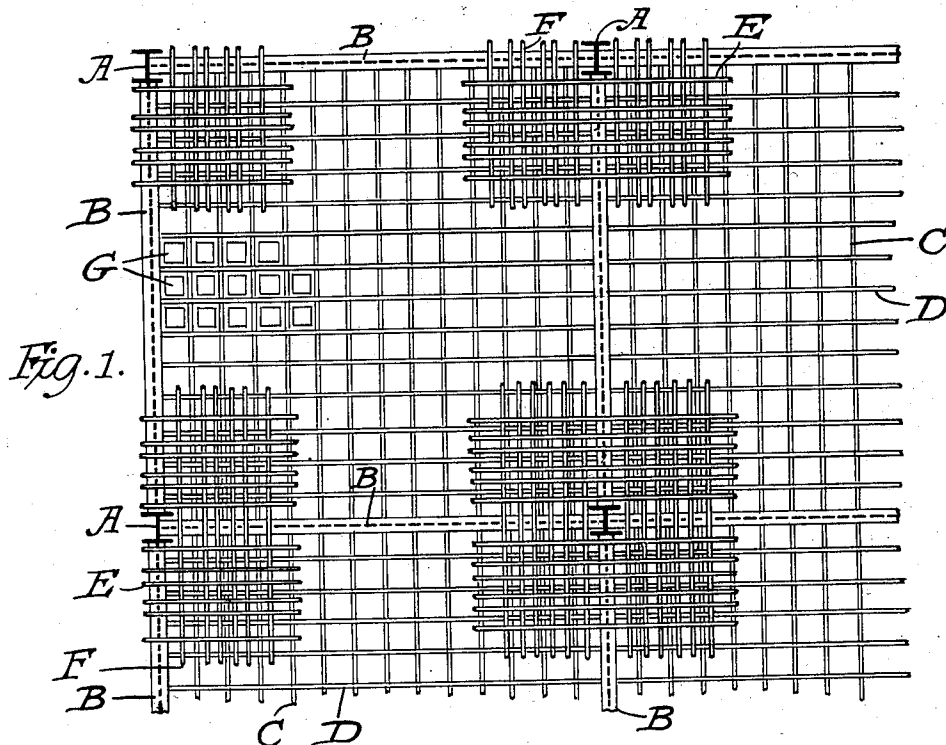
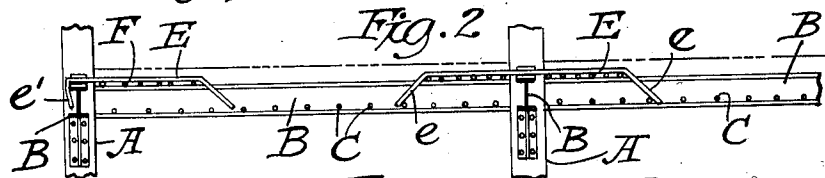
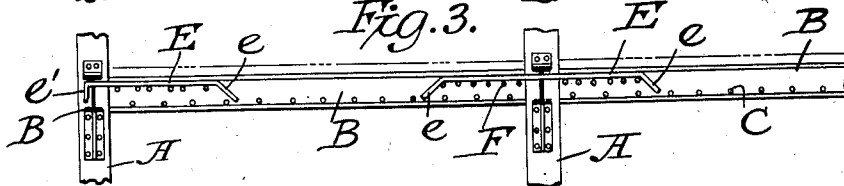
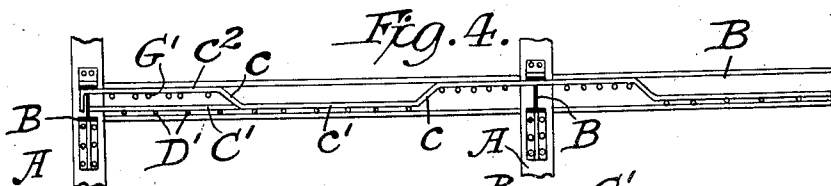
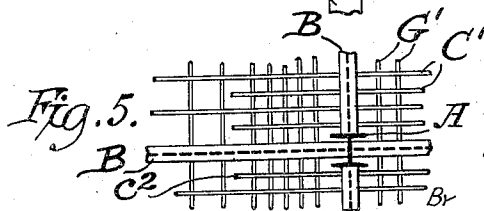
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K. R. SCHUSTER

BUILDING CONSTRUCTION

Original Filed Aug. 1, 1914

4 Sheets-Sheet 1



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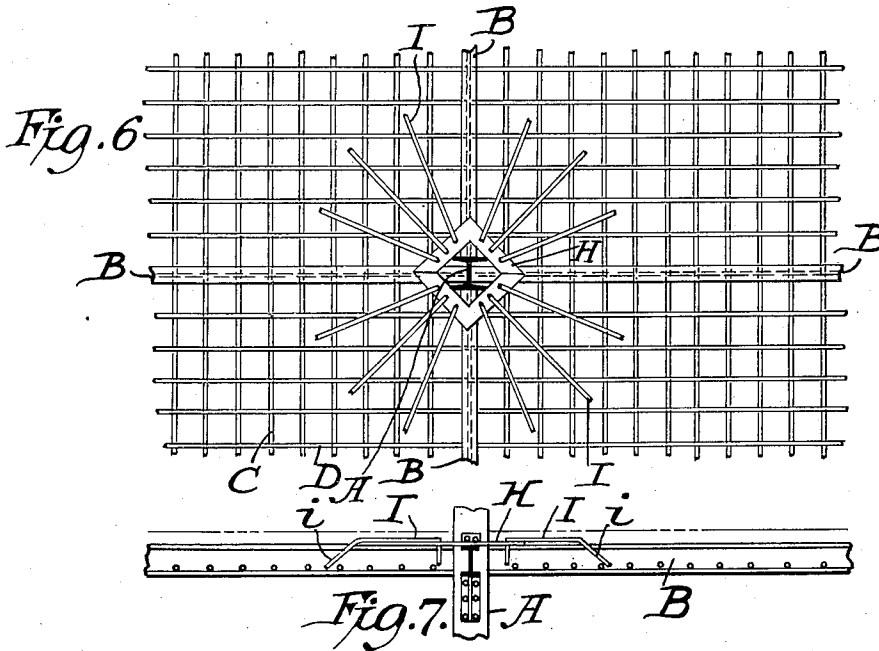
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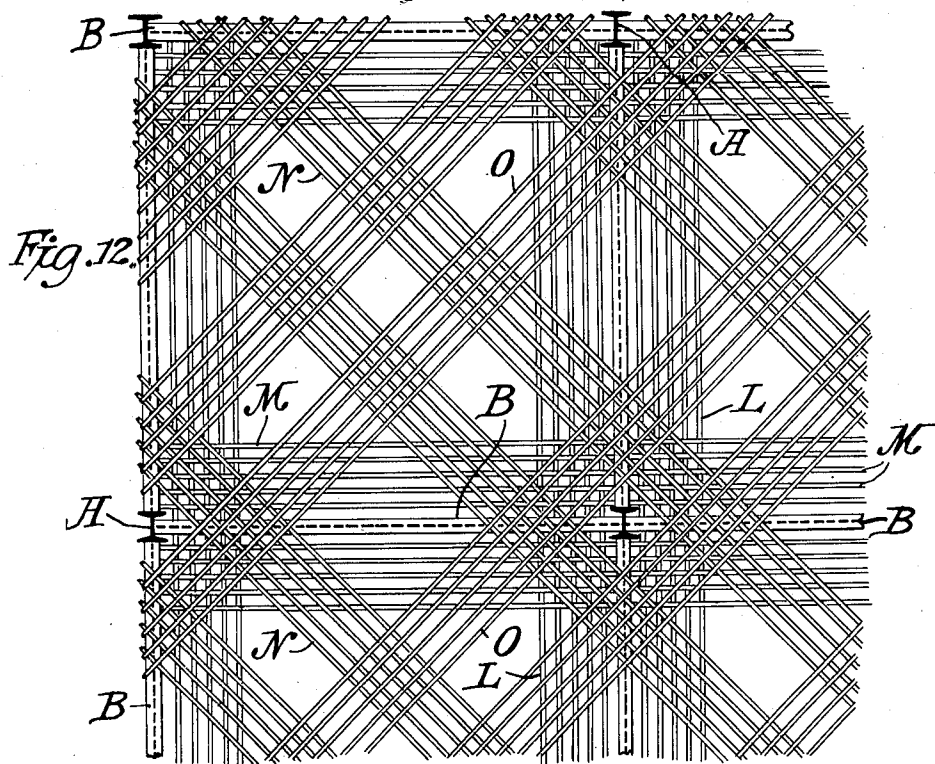
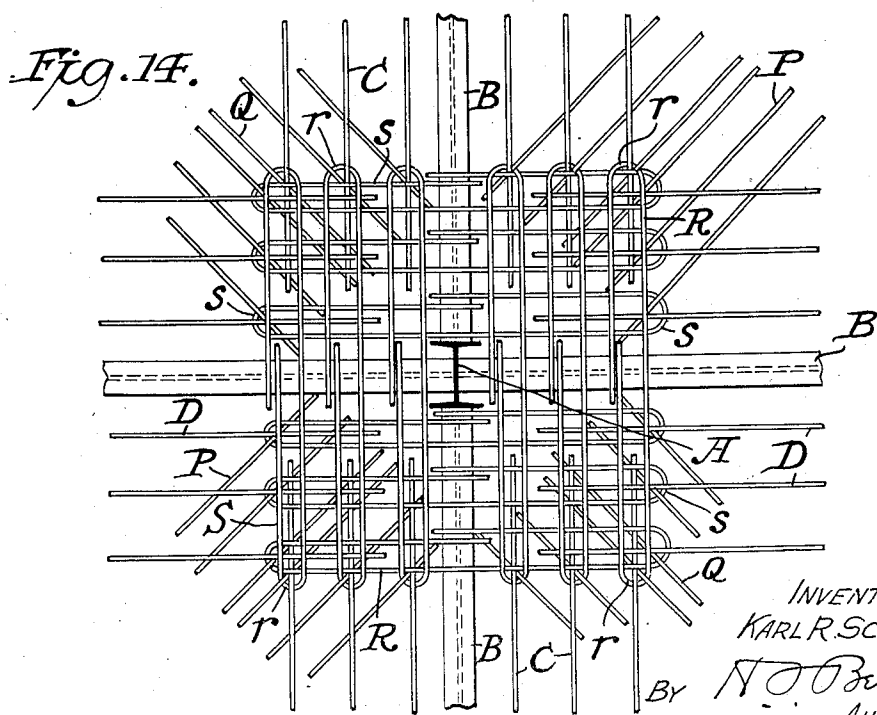
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BUILDING CONSTRUCTION

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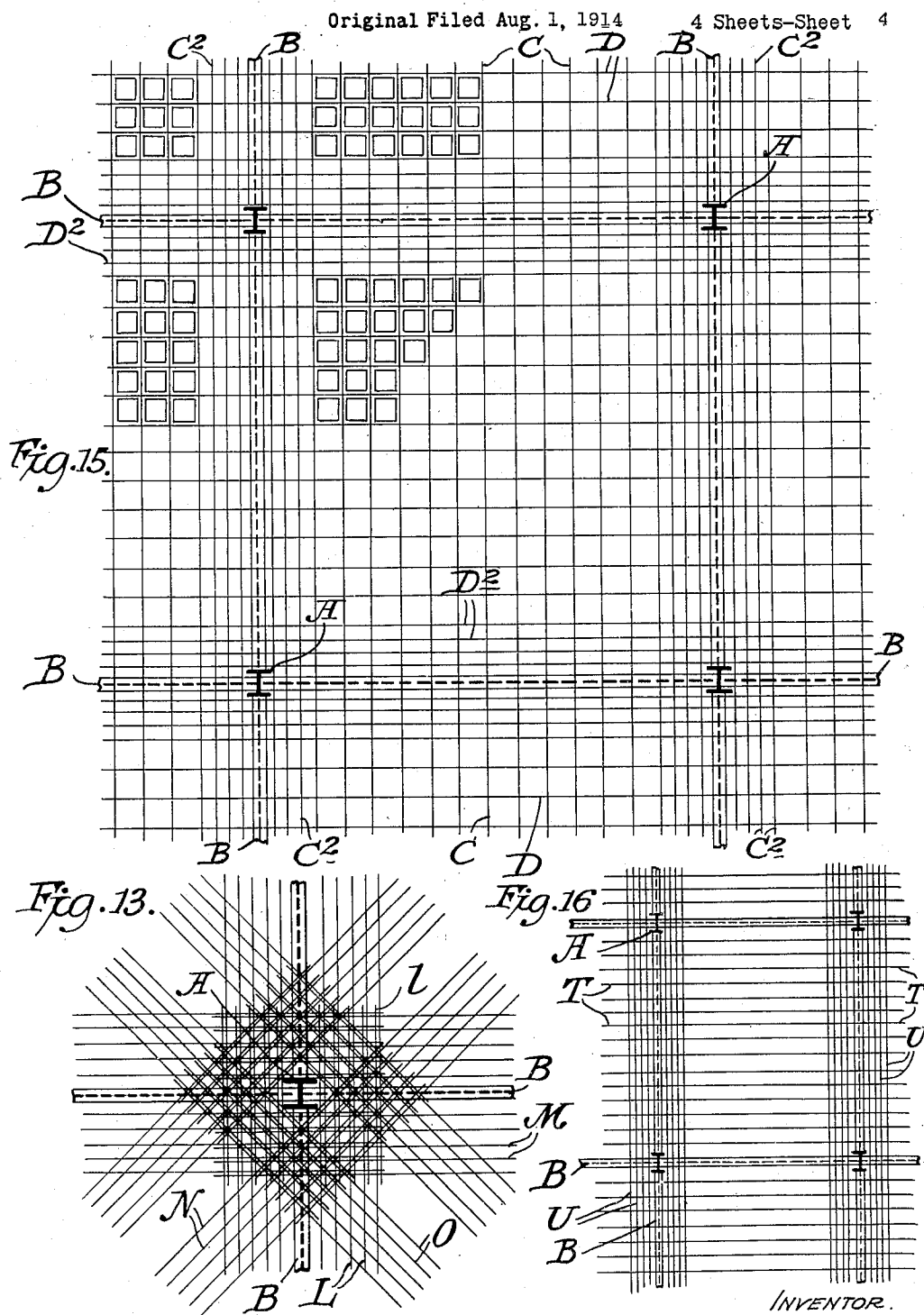
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE.

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BUILDING CONSTRUCTION.

Continuation of application Serial No. 854,571, filed August 1, 1914. This application filed December 9, 1921. Serial No. 521,269.

This invention pertains to building construction wherein a frame, composed usually of steel, and a homogeneous flat slab of reinforced concrete are so organized and combined as to attain rapidity and economy of erection or installation, and at the same time a homogeneous flat slab is associated with a skeleton frame in a manner to wholly dispense with the use of cumbrous column heads or capitals which are essential in ordinary flat slab constructions, and which column heads are flared out and made of greater cross sectional area than the cross sectional area of the column itself, so as to attain a massive construction necessary for reducing within permissible safe limits the vertical shear in the slab.

This application is a continuation of my prior application filed August 1, 1914, Serial No. 854,571, entitled "Reinforced concrete steel frame building construction", renewed December 3, 1921, Serial No. 519,806.

As is well known to those skilled in the art, the predominant building constructions are of two types, mainly; first, the ordinary frame or wall bearing floor construction comprising a floor slab supported along its several sides, said supports being either walls or stiff metal beams or girders, and said floor slab being reinforced by metal rods extending in one direction or several directions; and, second, the flat slab floor construction employing a homogeneous slab on which the load is carried directly to the columns without the agency of elements such as beams or girders, said homogeneous slab being free from supports afforded by girders along its several sides, and said homogeneous slab being ordinarily reinforced by metal rods extending in two or more directions, and said homogeneous slab being supported, structurally and functionally considered, by columns, usually of concrete, at the four corners of each of its component panels.

It is recognized by those skilled in the art pertaining to building construction that in floor slabs of the first type, the load results in stresses on the material, the lines of which stresses run parallel and perpendicular to the sides of the panels, whereas in homogeneous flat slabs of the type second named above, the lines of stresses are radial to the corners of the panels and radial to the columns positioned at such corners of the panels.

It follows that in the ordinary floor construction the beams or girders between the columns are positioned along the span of the floor, so that the load is imposed directly upon the beams or girders and the latter in turn carry the load to the columns. It follows, furthermore, that in the case of the homogeneous flat slab where no beams or girders are used, the load is supported solely by the columns at the several corners of the panels, which construction makes it essential in ordinary flat slabs to employ column heads or capitals of massive construction.

My object is to associate a homogeneous flat slab with a frame, the columns of which are composed, preferably, though not essentially, of metal. A structure wherein columns (such as metal) are utilized devoid of the massive capitals or column heads, and the association of a homogeneous flat slab with such columns, presents a problem for solution, in that a substitute must be provided for the column heads or capitals, with a view to taking care of the vertical shear in the slab in the areas adjacent the union of the slab with the columns.

In my invention I use metal ties, usually in the form of beams, between columns composed of appropriate material, usually steel columns, although concrete columns free from column heads or capitals may be employed. The column ties are secured to, or united with, the several columns in an appropriate manner, and the homogeneous slab of reinforced concrete is supported at its several corners and in the areas close to the columns by the column ties, whereas in the middle portion of the span between the columns, said ties are supported by the material composing the homogeneous plate or slab. My slab provided with ties embedded in the concrete material thereof is more stable on lines between the columns than on the diagonals between said columns, such stability in certain areas of the slab being due to the fact that the slab on lines between the columns is of shorter span than on lines running diagonally to the columns. The increased stiffness in the areas of the slab extending between the columns is utilized in my invention as a support for the beams constituting the column ties in order to afford a support for said column ties at the middle of the span between columns. This mode of supporting the ties at the middle of

their span by the materials of the slab enables me to utilize relatively light weight beams as the column ties, the depth of which beams is equal to, or less than, the thickness of the composite slab. In effect, the two ends of each column tie are attached to and supported by the columns, whereas at the middle of its span the column tie is supported by the flat slab due to the greater stiffness of said slab in the areas between the columns.

Other functions and advantages of the invention will appear from the following description taken in connection with the drawings, wherein—

Figure 1 is a plan view of my building construction wherein steel rods are used in a flat slab supported by columns which are devoid of the massive heads or capitals essential in prior flat slabs supported by columns composed of concrete.

Figure 2 is a vertical section through the construction of Figure 1, the dotted line illustrating the thickness of the floor slab.

Figures 3 and 4 are vertical sections similar to Figure 2 illustrating different arrangements of the steel embedded in the concrete material of the floor slabs.

Figure 5 is a plan view of the construction of Figure 4.

Figures 6 and 7 are respectively a plan view and a vertical section of a flat slab wherein a somewhat different reinforce is employed for taking care of the negative bending moment in the areas of the slab surrounding the column.

Figures 8 and 9 are a plan view and a vertical section, respectively, of another arrangement of rods for the flat slab.

Figures 10 and 11 are a plan view and a vertical section, respectively, of a still further arrangement of the steel for reinforcing the flat slab.

Figures 12 and 13 are plan views wherein diagonal rods are used in the flat slab in addition to two series of rods, the latter comprising a two-way reinforcement.

Figure 14 is a plan view on an enlarged scale as compared with the other figures, illustrating a mat or grille employed around the columns and in connection with the rods constituting a multiple-way reinforcement for the slab.

Figure 15 is a plan view of a two-way reinforced slab characterized by a close grouping of rods in the areas of the slab between the columns, said closely grouped rods being parallel to the beams comprising the ties between the columns.

Figure 16 illustrates my invention in connection with a slab provided with a one-way reinforcement.

In the constructions shown in the various drawings, the structure includes columns A arranged in rows extending in two directions, and these columns carry a homogeneous flat

slab or a plurality of such flat slabs, the latter being positioned one above the other as usual.

As shown, each column A is composed of metal, usually I-shaped cross section, but the right is reserved of substituting columns composed of concrete, and preferably reinforced by embedded metal rods, or of any other material, for the metal columns, such columns whether of metal or of reinforced concrete being free from or devoid of the enlarged capitals or heads at all points where the flat slabs join with said column.

Each flat slab may be of all concrete construction reinforced by embedded steel in any desired manner, or said slab may be of composite construction wherein tiles such as G in Figures 1 and 15 are incorporated with the concrete and the steel. When the homogeneous slab is reinforced by two series of crossing rods, the latter composing a two-way reinforcement, it is preferred to space the rods of each series at uniform distances so as to produce square spaces between the crossing rods, which square spaces are adapted for the reception of hollow tile blocks G.

An essential feature of my flat slab construction used in conjunction with columns free from the massive heads or capitals consists of column ties B embedded within the concrete material of the slab and positioned in the areas between the columns. Said ties may take different constructional forms, but as shown in the drawings, such ties are embodied as beams, I-shaped in cross section, the depth of each beam-shaped tie being substantially less than the thickness of the slab, or said beam-shaped tie may be of a depth equal to but not exceeding the thickness of the slab. The beams constituting the ties are unitary with the flat slab in the areas between the columns, and the metal composing said beams or ties add stability to the slab in the areas surrounding the columns and adjacent thereto, whereby the increased stiffness given to the slab in the areas surrounding the columns enables me to wholly dispense with the flared heads or capitals invariably employed hitherto in flat slab constructions of the prior art and which are objectionable not only for reasons of economy, but largely because such flared heads or capitals obstruct the light and take up considerable head room within the space enclosed by the building as a whole.

My invention is a combination of columns, free from heads or capitals, with a homogeneous flat slab the stability of which in the areas between the columns is secured by metal ties in the form of beams united with the columns. It is well known that concrete buildings of any considerable height require interior columns of massive construction in the lower stories, but in all instances of the prior art, it is required to enlarge the col-

umns next to the floors so as to produce capitals of great cross sectional area in order to safely carry the slab and the load thereon. Reinforced concrete buildings are more economical to construct than fireproof buildings of the steel frame type using metal beams and girders, but special requirements make the steel frame construction preferable to the concrete construction notwithstanding the relatively low cost of the latter, as, e. g. in tall buildings, or in factory or storage structures designed to carry heavy floor loads, reinforced columns of concrete buildings may require such massive construction in the lower floors as to be objectionable because of the space occupied, and such massive columns obstruct, to a great extent, the light within the lower stories.

In my structure, as stated, I use, preferably, columns composed of metal, and tie such columns together at the floor levels by column ties composed of beams, the latter being unitary with the floor slabs and being embedded therein in the areas between the columns as distinguished from the areas diagonal to the columns. The stresses in a flat slab are radial to the columns, and it is necessary to use enlarged capitals or heads on concrete columns to take care of the vertical sheer in the areas surrounding the columns. In my structure the beam-like ties add the required stability to the slab in the areas surrounding the columns and adjacent thereto, so that the capitals or heads are omitted. By imposing the load upon the beam-like ties in the areas surrounding the columns, the bending moment of the beams forming the ties is reduced to an appreciable extent, and this makes it feasible to employ relatively light beams as the column ties in connection with metal columns; in fact, the depth of the beam composing the column tie does not exceed the thickness of the slab, resulting in a perfectly flat ceiling. Furthermore, where a flat ceiling is desired for architectural reasons, my construction attains a material saving in the quantity of the steel used, for the reason that I am able to use lighter beams and thereby secure a desired economy in the steel used. An ordinary steel frame construction, as distinguished from a flat slab structure, requires beams and girders of deep cross section, which project below the floors and involve an increase in the height of the building where a certain clear headroom is required at each floor. In my invention the steel required for the column ties is of a depth equal to or less than the thickness of the flat slabs, thus obtaining economy in the aggregate quantity and weight of steel and effecting a saving in the headroom owing to the elimination of deep beams and girders. Again, in concrete buildings the centering or false work is quite expensive for the reason it must be self-supporting, requires a skilled workman to install in order to obtain accu-

rate lines and levels, and the centering for the column heads or capitals is rather complicated and difficult of erection. In the present case, the centering necessary for molding the flat slab is suspended from the beam-like ties united to the columns, so that the required lines and levels are determined by said ties and the complicated and expensive centering for the column capitals is wholly omitted.

The beams, composing the column ties adapted to be embedded within the floor slab, are installed concurrently with the erection of the columns and prior to molding the concrete and installing the rods composing the steel reinforcement of the slab. Said beam-like ties B are placed in position at the time the columns are erected, and said ties are secured or attached to the columns in a desired manner, as e. g. by bolting or riveting the end portions of the ties to the columns or by employing suitable brackets for this purpose. The beams thus act as ties or stays for the columns during the erection of the steel work, and they afford means prior to the installation of the flat slab for suspending the centering or false work requisite for molding the concrete of said slab and for supporting the steel rods, as well as for supporting the hollow tiles in cases where such tiles are incorporated with the concrete.

The flat slab may be reinforced by embedded steel in various ways. As shown in Figures 1 and 2, the steel consists mainly of two series of rods C D, positioned in the lower chord of the slab, one series of rods C extending in one direction through the slab and parallel to the beams B composing the column tie, whereas the other series of rods D extend in the opposite direction through the slab and parallel to certain other beams composing the column ties. The two series of rods C D cross each other at right angles and they extend from one panel of the slab into an adjacent panel or panels of said slab; in other words, the rods cross over or through the beams which divide the slab into adjacent panels. As shown in Figure 2, the web of beams B is provided near the lower flanges thereof with perforations through which pass the rods C D, said rods being thus embedded within the material of the slab so as to lie near the under surface thereof, whereby the rods act as tension members and take care of the positive bending moment of the slab. It is thus apparent that the rods extending in one direction are in contact with certain of the beams extending between the columns, whereas the rods which run in the other direction are in contact with other beams, the latter, also, extending between the columns, it being apparent that the rods extending in two directions within each panel are run beyond the beams and into adjacent panels. If desired, however, the steel rods constituting one

series within each panel may extend from the two beams at two sides of the panel, whereas the other series of rods may extend between the two remaining side beams, in which event the rods embedded in one panel do not extend into the other panel, but, on the contrary, the ends of all the rods terminate at the beams.

For taking care of the negative bending moment in the slab within the areas surrounding the columns, I employ short additional rods E F constituting a mat or grille. Two series of rods E F are employed, the rods E of one series crossing the rods F of the other series. The two series of rods are positioned above the beams constituting the column ties, and adjacent to the columns, so that the rods are adapted to be embedded in the material of the slab near the upper surface thereof and adjacent to said columns. As shown at the right of Figure 2, the end portions of the rods E F are inclined downwardly, as at *e*, so as to constitute shear members, but if desired the end portions of the rods E, as shown at the left of Figure 2, may be hooked at *e'* around the beams, particularly in cases where the metallic mat or grille is employed in conjunction with the beams and columns at a wall of the building.

During the erection of the columns, the beams B are attached to said columns at the several stories, and in installing the floors the usual centering is suspended from the beams in the manner well understood by those skilled in the art. The steel rods C D are laid on the centering in crossing relation, the rods of each series being spaced uniformly apart throughout the length and width of the slab, and the two series of rods being in crossing relation so as to form the square spaces at their intersections. If desired, hollow tile blocks G are placed in the squares between the rods and the short rods E F are assembled in crossing relation so as to lay upon the beams and occupy the area adjacent to the columns near the top surface of the resulting slab. The concrete material is deposited upon the steel, the centering and the tile blocks, assuming the latter are used, but it is obvious that these tile blocks may be omitted and the slab composed wholly of concrete material within which the rods C D E F are embedded so as to result in a homogeneous slab which encases the beams, the latter being either embedded within the concrete material or occupying a substantially flush relation to the top and bottom surfaces thereof. It is preferred, however, to install the concrete material to a depth exceeding the height of the beams, the concrete material filling the spaces between and over the beams to a depth indicated by the dotted line in Figure 2.

While it is preferred to position the supplemental rods E F over the beams and in a horizontal plane above the top of the beams, it is apparent that these short rods may be posi-

tioned quite close to the top flange of said beams, as indicated in Figure 3. The rods E F are assembled in crossing relation in the plane of the web of the beam so as to lie substantially below the top flange of said beam, and as in the prior construction described, the end portions of the rods are inclined to constitute shear members *e*, or one end of certain rods may be passed through perforations in the beams and hooked around them, as at *e'* in Figure 3. It is apparent that certain of the short rods, such as the rods F in Figure 3, will pass in one direction through perforations in certain of the beams, whereas the other rods E will pass in an opposite direction through perforations in certain other beams. It will be understood, of course, that the rods E F constituting the mat or grille are in the upper portion of the slab and adjacent to the columns and beams for taking care of the negative bending moment of the slab.

In Figures 4 and 5 of the drawings there is illustrated a construction wherein the main reinforcing rods C' D' are bent intermediate their ends so as to have certain parts of said rods embedded in the slab near the lower surface thereof, whereas other parts of the rods extend through the slab near the upper surface thereof adjacent to the columns. The rods C' D' are embedded in the slab near the lower surface thereof, but certain of these rods C' are bent at *c*, whereby the part *c'* of rods C' are in the lower part of the slab at the middle region thereof, whereas the upwardly bent parts *c''* are in the slab near the upper surface thereof. These upper portions of the rods may extend over the beams B or they may pass through perforations in the beams, as shown in Figure 4. It is apparent that the crossing rods C' D' may thus be positioned in the lower part of the slab at the middle region thereof and throughout its length and width or the rods D' as well as the rods C' may be bent upwardly so as to lie in the upper part of the slab, particularly in the region of the columns, thus resulting in a metal reinforcement the rods of which are positioned in the slab to take care of the negative bending moment and positive bending moment. The rods C' with the upwardly bent portions co-operate with short rods G' adjacent to the columns, said short rods G' crossing the rods C' and constituting a mat or grille for taking care of the negative bending moment adjacent to the columns.

The construction of Figures 6 and 7 embodies the columns A and the column ties in the form of beams B, together with the two-way reinforcement consisting of the rods C D adapted to be embedded in the concrete, or concrete and tile, material to constitute a homogeneous flat slab, said rods co-operating with the beams for imposing the load stresses upon said beams. In lieu of the short rods adjacent to the columns for taking

care of the negative bending moment in the slab, I may employ the construction illustrated, to-wit, a flat apertured plate or ring H and a series of diagonal rods I, the ends of which are inclined, as at *i*. The ring or collar H is positioned loosely around the column A so as to rest upon the beams B. The rods I extend outwardly from the ring or collar so as to have a diagonal relation to the two-way reinforcing rods C D. The rods I are shown as having their inner ends hooked into apertures of the ring or collar H so as to be attached or anchored thereto. The rods I extend radially from the beam and the inclined end portions *i* of said rods extend downwardly into the slab so as to act as shear members. The collar H and rods I thus cooperate with the beams and with the concrete material of the flat slab for performing the function of a reinforcement to take care of the negative bending moment.

Instead of employing the loose collar H, the short rods for taking care of the negative bending moment may be connected directly with the beams, as in Figures 8 and 9, or they may be threaded around the columns, as in Figures 10 and 11. The beams B' in Figures 8 and 9 are provided in the webs thereof with perforations through which run the short rods J adapted to be embedded in the slab near the upper surface thereof, said rods J having the inclined end portion *j* to act as shear members.

The short rods K arranged diagonally to the column may be looped around said column, as at *k* in Figure 10, instead of connecting said short rods either to the loose collar, as in Figures 6 and 7, or threading said short rods through the beams, as in Figures 8 and 9, said rods K having the inclined ends *k'* to act as shear members. It will be understood that the short rods in the construction of Figures 8 to 11, inclusive, are employed in connection with the two series of main rods C D as in the constructions heretofore described.

The construction illustrated in Figure 12 embodies the columns A arranged in rows extending in two directions and beams B attached to said columns to serve as ties therefor. The floor slab is composed of concrete material carried by the columns and reinforced by a multiple-way reinforcement extending in divers directions through the slab, said multi-way reinforcing rods co-operating with the beams for imposing thereof the load stresses of the slab. The metal reinforcement consists of rods arranged as follows. The series of rods L extending parallel to certain of the beams and from one panel of the slab into the other panel of the slab; a second series of rods M extending at right angles to the rods L and disposed parallel to other beams B; a third series of rods N extending diagonally to the columns and crossing the rods L M adja-

cent to the columns, and a fourth series of rods O crossing the rods M of the third series, and extending diagonally to the columns over the rods L M adjacent to said columns. All the rods composing the series L M N O are positioned in the bottom chord of the slab at the middle region thereof to serve as tension members for said slab, but as the rods approach the beams and columns, said rods rise or are carried upwardly toward the top surface of the slab. It is preferred to have rods L and M extend through perforations near the upper flange of the I-beams B, whereas rods N O extend over the top of the beams, this arrangement being desirable in order to avoid crowding or bunching of the rods on the top of the beams. The concrete material is deposited upon the centering so as to encase the beams and the rods L M N and O, and all these rods are in contact with said beams for the purpose of utilizing said rods in transmitting the load stresses of the slab to the beams, whence said load stresses are transmitted to the columns.

In the construction of Figure 12 the rods extend continuously from one panel into adjacent panels, said rods crossing the beams, but in Figure 13 I have shown an arrangement of rods wherein the end portions of the corresponding rods in the adjacent panels are brought into lapping relation. Thus, the rods L in one panel extend across the beam B separating that panel from the one adjacent to it, and the corresponding rods L in the two panels separated by the beam B are brought at their end portions into lapping relation, as shown by the double thickness of lines at 1. Similarly, the rods M in the adjacent panels are extended across the beam B separating said panels so that the respective end portions of the two series of rods in the adjacent panels will overlap each other at the beam B. Again, the diagonal rods N in two adjacent panels are assembled for the end portions of the rods in the respective series to overlap each other and the same is true with respect to the end portions of the other diagonal rods C in the adjacent panels. In all these constructions, however, the series of reinforcing rods are so related to the beams as to impose the load stresses of the slab upon said beams, whereby the beams transmit said load stresses to the columns.

The construction of Figure 16 embodies the metal columns A and the metal beams B attached to said columns, two-way reinforcing rods C D and the diagonal rods P Q. In addition to these rods, there is employed a mat or grille for taking care of the negative bending moment of the slab in the areas adjacent to the column, said metal mat or grille consisting of loop-shaped rods R S. One series of rods R cross the other series of rods S, and the rods of one series are bent to form the loops *r*, whereas the

rods of the other series are bent to form the loops *s*, said looped ends of the rods being downwardly inclined to the plane of the rods so as to serve as shear members.

- 5 The rods C are received within the loops of the rods S; the rods D are received within the loops of the rods R and the rods P Q constituting the diagonal reinforcement extend into the loops of the rods R S respectively.
- 10 The rods R S are interlaced or bound together so as to constitute a unitary mat adapted to be placed around the column with ease and facility, and when the main rods are properly assembled with reference to the
- 15 short rods all of them are bound together into a homogeneous mass by the concrete material within which the rods are embedded.

- Figure 15 of the drawing illustrates another embodiment of the invention wherein
- 20 the metal columns A, the metal beams B, and the two-way reinforcement consisting of the rods C D are employed in the slabs so as to extend from one panel across the beams and into the next panel or panels, said rods C and
- 25 D being spaced uniformly to receive the tile blocks G in the middle region of the panels or within the margins of said panels. This embodiment of the invention is distinguished from the other heretofore described in the
- 30 following particular: Certain rods C² of the series C are grouped quite closely together adjacent to one of the beams B. Similarly, certain rods D² of the other series D adjacent to the cross beam or beams B are grouped
- 35 more closely together than the rods extending through the middle region of the panel. It is thus apparent that the rods C² of one series are grouped closer together than other rods of the same series, said closely grouped rods
- 40 being adjacent to and at the respective sides of the beams which extend in one direction, whereas the rods D² of the other series D are grouped more closely together adjacent to and parallel with crosswise extending beams
- 45 B. When the rods C² D² arranged as described near the beams are encased in the concrete material, there results composite beams or girders reinforced by an excess of metal as compared with the metal employed
- 50 in the middle region of the panels, said composite beams or girders bounding the marginal portions of the panels, and said closely grouped rods extending from the margins of certain panels into and through the margins
- 55 of adjacent panels, all as clearly shown in Figure 15, all of the rods acting to transmit the load to the beams and thence to the columns. It is preferred to arrange the rods C D the two-way reinforcement to extend
- 60 over and across the rods C² D², so as to have certain parts of rods C D near the top surface of the slab and thus preclude upward buckling of the slab at the marginal portions thereof, said crossing parts of the rods C D
- 65 acting as tension members in the top part

of the slab and thus neutralizing the negative bending movement of the beam construction.

The closely grouped rods extending between the columns and adapted to be encased within the concrete material so as to constitute a composite beam or girder is the salient feature of the one-way reinforced construction illustrated in Figure 16. In this figure the metal column and beam constructed is employed as heretofore, and the slab is reinforced in one direction by the rods T. Extending between the columns and adjacent to one of the beams is a series of closely grouped rods U, the latter crossing the rods T and being positioned parallel to the beams at the respective sides thereof. The rods U extend across the intersecting beams and between the columns so that when these rods are encased in the concrete material the result is the production of a composite beam or girder extending between the columns and co-operating with the crosswise reinforcing rods T so as to produce a one-way reinforced monolithic slab.

In my invention, the beams B perform functions conjunctionally with the columns and the flat slab. In the first instance, such beams couple the columns so as to act as stays therefor during erection, and when the structure is completed, said beams laterally stiffen the columns. In the second instance, the beams are embedded in the material composing the slab, and thus are unitary therewith and constitute an integral part thereof, whereby the beams so add to the stability of the slab in the areas surrounding the columns and adjacent the latter as to dispense with the objectionable enlarged heads or capitals on said columns in the areas immediately next to the slab on the under surface thereof. Said beam-like ties B extend within the slab in the areas between the columns, and not diagonally thereto, but in view of the fact that the flat slab is shorter, and hence stiffer, on the lines between the columns, my construction reduces the bending moment on the beam-like column ties and utilizes the strength of the slab for supporting the beams at the middle of the span thereof, whereas the end portions of the beams where attached to the columns increases the stability of the slab in the areas surrounding the columns and adjacent thereto. Furthermore, the structural members embedded in flat slabs and connected with said columns act to resist the vertical shear of said slabs in the areas adjacent to the columns.

In addition to its utility as a building construction wherein the columns are erected to a desirable height for housing and factory purposes, and flat slabs are carried by said columns in a manner to wholly omit the light and head room obstructing enlarged capitals at the juncture of slabs and columns, my invention is adapted, also, for steel-and-con-

crete constructions used for various purposes other than for housing and factory purposes, such as elevated motor highways, for the reason that in the installation of such motor-highways the columns may be erected and the flat slabs installed without in any manner interfering with the movement of surface traffic along streets and roads, the flat slabs possessing the strength and stability required to support the weight of the elevated traffic.

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

1. Building construction embodying metallic columns and metallic beams connected therewith, floor slabs extending between said columns and beams, rods embedded in the slabs at the lower chords thereof and extending crosswise of the beams below the neutral axis of the latter, and auxiliary rods contacting with said beams next to the columns and embedded in the slabs at the upper chords thereof, said first and second rods co-operating with the beams to reduce the bending moment in the beams, the depth of said beams being equal substantially to the thickness of the slabs.

2. A structure for the purposes described embodying columns, structural members the depth of which is substantially equal to the depth of a slab, said structural members connecting said columns, reinforcing mat-like members surrounding the columns, reinforcing rods co-operating with said structural members and stiffening said slab to create a cantilever action, and a slab substantially encasing said reinforcing rods and structural members, said slab having a substantially constant depth.

3. A structure for the purpose described embodying columns, structural members connected therewith, reinforcing rods engaging with said structural members, negative reinforcing members surrounding said columns, and slabs substantially encasing said reinforcing rods, the negative reinforcing members and the structural members; said slabs and rods co-operating with the structural members for reducing the bending moment in said structural members and stiffening said slab to create a cantilever action.

4. A steel-and-concrete construction substantially of the class described embodying metal columns, structural members connected therewith and acting during erection as ties for the columns and functioning in the ultimate structure as a reinforcement for the slabs, reinforcing rods engaging with said structural members, slabs substantially encasing said structural members and wholly encasing the reinforcing rods, and negative reinforcing rods embedded in the upper chord of the slabs, said rods co-operating with the structural members and with the slabs for

reducing the bending moment of said structural members.

5. A steel-and-concrete construction embodying columns, structural members connected mechanically with said columns and functioning as ties for the columns during erection of the structure and as slab reinforcements in the ultimate structure, slabs extending between the columns, crossed rods in mechanical engagement with the structural members and embedded in the slabs in the lower chord thereof; said slabs supporting said structural members at substantially the middle of the span intervening the columns, and negative rods in the areas surrounding the columns, said negative rods being embedded in the slabs in the upper chords thereof.

6. A steel-and-concrete construction embodying columns, structural members connected with said columns and functioning as ties for said columns during erection thereof and as slab reinforcements in the ultimate structure, flat slabs the stresses of which are radial to said columns, rods in the slabs connecting said structural members, and negative rods in the areas surrounding the columns; said structural members in the middle of the span being supported by the reinforced flat slabs.

7. A steel-and-concrete structure embodying columns, tie beams extending between said columns, flat slabs, negative reinforcing rods in the areas surrounding said columns, and rods in the slabs co-operating with the tie beams and imposing substantially all the floor loads on said tie beams, said tie beams being connected to said columns, whereby the punching shear of the columns on said slabs is resisted.

8. A structure of the class described embodying columns, flat slabs, reinforcing rods embedded in said flat slabs, tie beams unitary with said flat slabs, said tie beams being mechanically connected to the columns, and negative reinforcing rods in the areas surrounding said columns, said negative reinforcing rods co-operating with said tie beams to carry the loads thereto, whereby the tie beams act to carry the load to said columns.

9. A structure of the class described embodying columns, flat slabs extending between the columns, crossed reinforcing rods embedded in said slabs, reinforcing rods embedded in the upper chord of the slabs for counteracting the negative bending moment, and structural shapes connecting said columns, said slabs and rods co-operating to support the structural shapes at substantially the middle of the span intervening the columns, whereby a cantilever action is created in said structural shapes.

10. A structure of the kind specified, embodying metal columns, structural shapes connecting said columns and functioning as

ties for said columns during erection of the structure and as slab-reinforcements for the ultimate structure, slabs between the columns, negative reinforcing rods in the areas surrounding the columns, and reinforcing rods embedded in the slabs in the lower chord thereof, said rods extending through and me-

chanically engaged with said structural shapes adjacent the lower portions thereof.

In testimony whereof I have hereunto signed my name this 2nd day of December, 1921.

KARL R. SCHUSTER.