Oct. 4, 1938. E. S. POWERS 2,132,220

FLOOR CONSTRUCTION OR THE LIKE

Filed Aug. 29, 1936 6 Sheets-Sheet 1

Fig. 1.

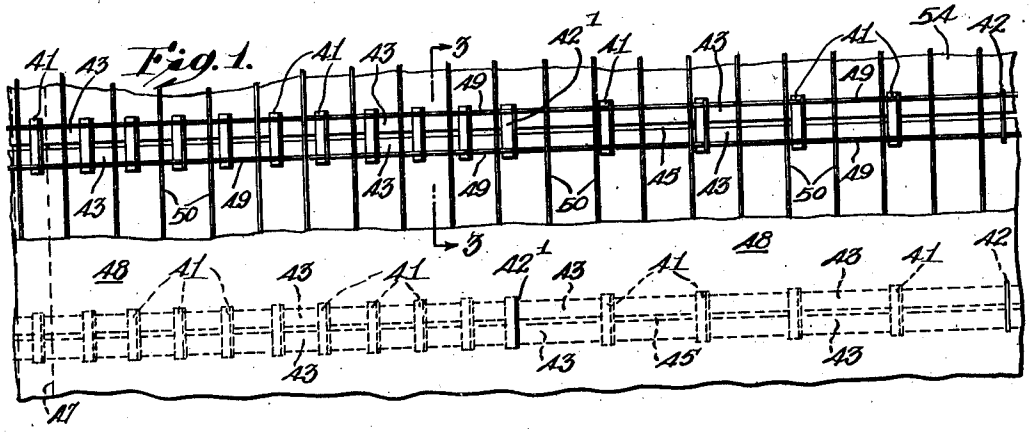


Fig. 2.

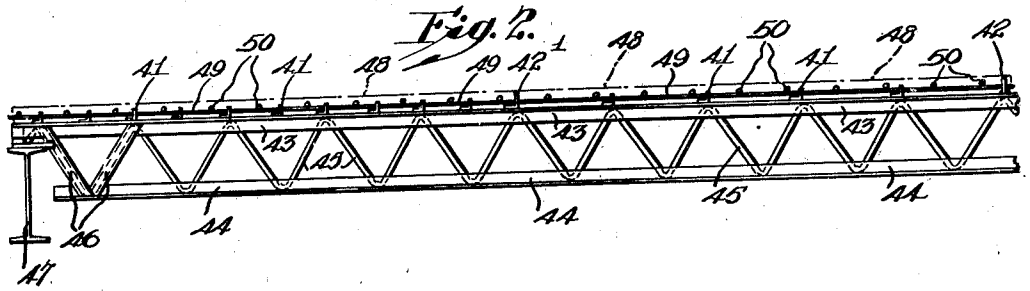


Fig. 3.

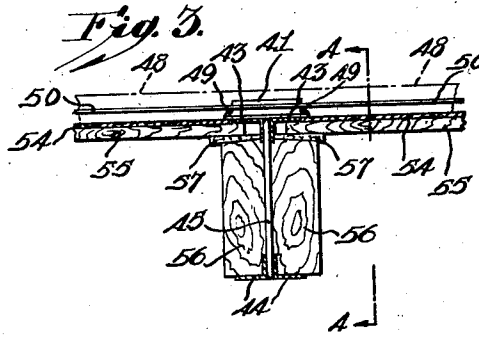


Fig. 4.

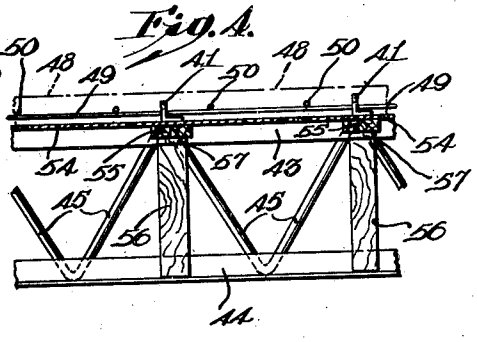


Fig. 5.

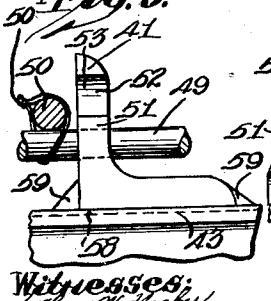
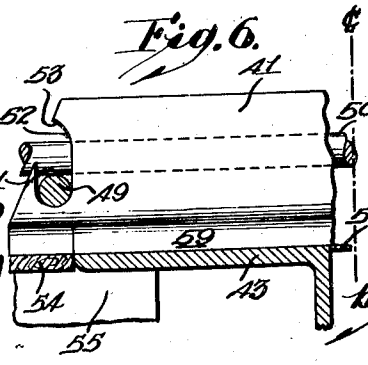


Fig. 6.



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Oct. 4, 1938. E. S. POWERS 2,132,220

FLOOR CONSTRUCTION OR THE LIKE

Filed Aug. 29, 1936 6 Sheets-Sheet 2

Fig. 7.

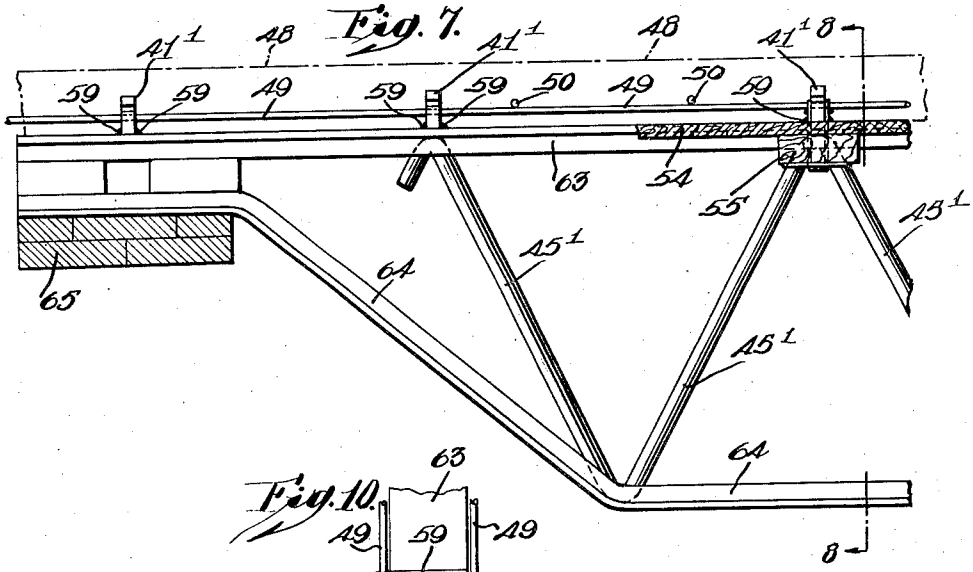


Fig. 10.

Fig. 8.

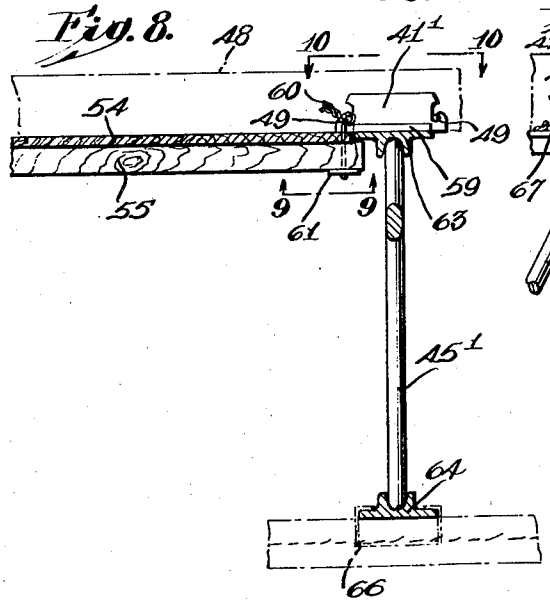


Fig. 11.

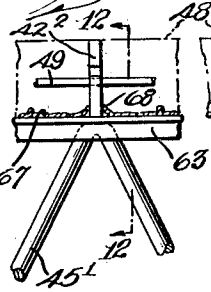


Fig. 12.

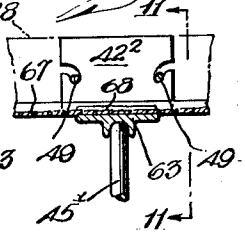
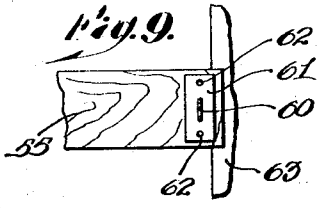


Fig. 9.



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Oct. 4, 1938. E. S. POWERS 2,132,220

FLOOR CONSTRUCTION OR THE LIKE

Filed Aug. 29, 1936 6 Sheets-Sheet 3

Fig. 13.

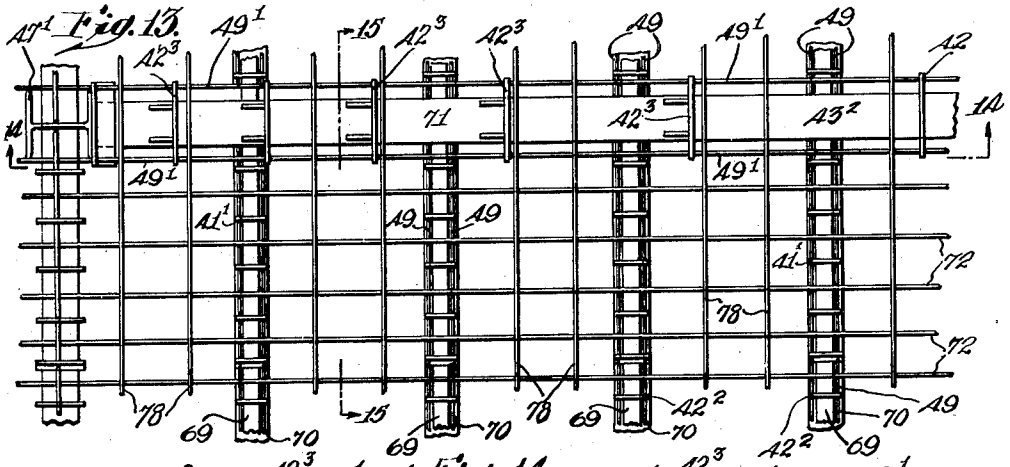


Fig. 14.

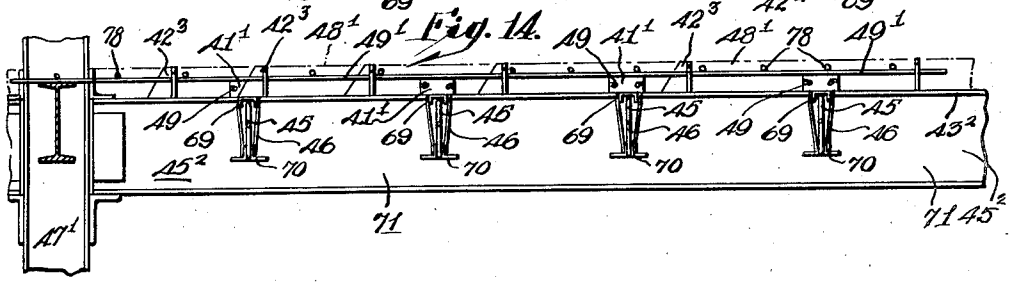


Fig. 15.

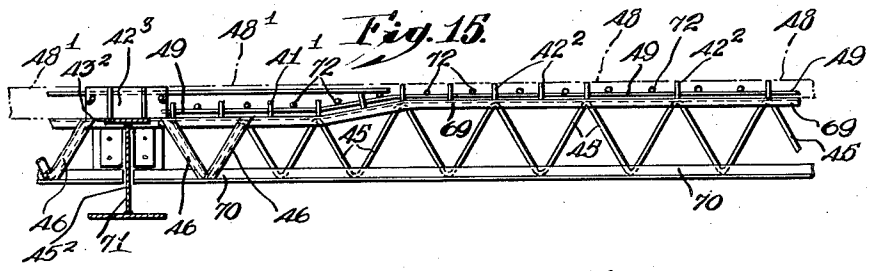


Fig. 16.

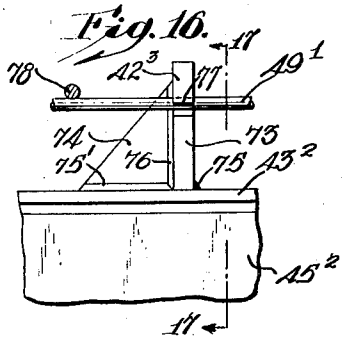


Fig. 17.

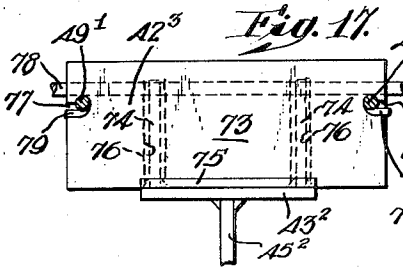
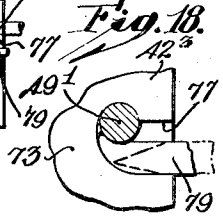


Fig. 18.



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Oct. 4, 1938. E. S. POWERS 2,132,220

FLOOR CONSTRUCTION OR THE LIKE

Filed Aug. 29, 1936 6 Sheets-Sheet 4

Fig. 19.

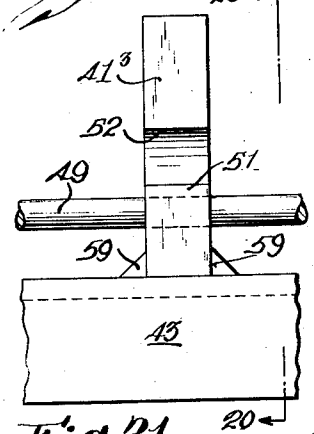


Fig. 20.

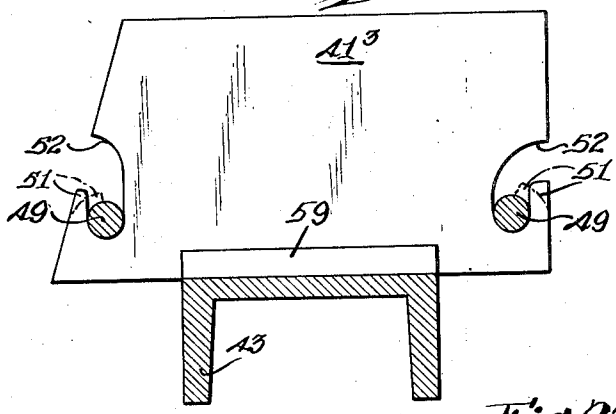


Fig. 21.

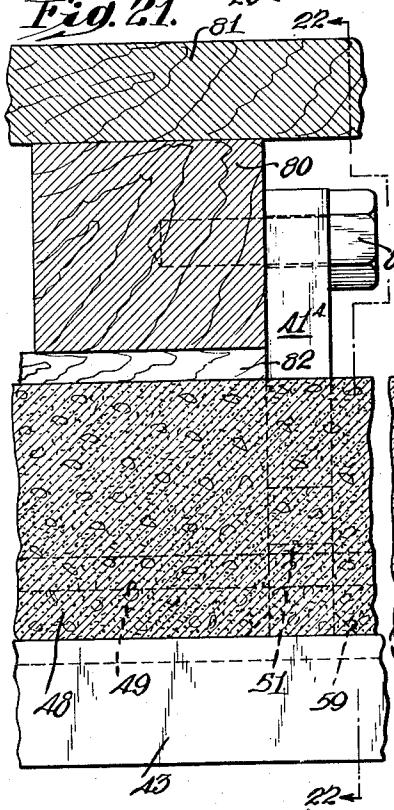
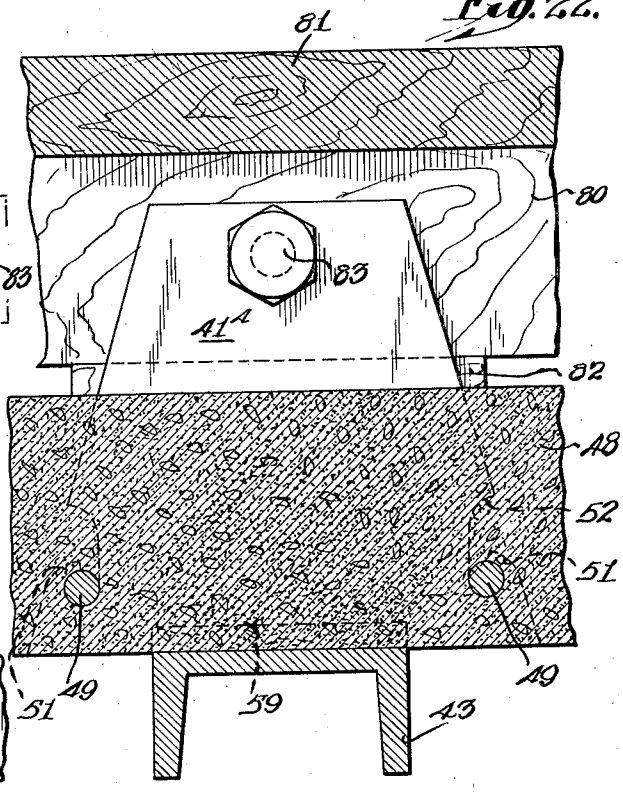


Fig. 22.



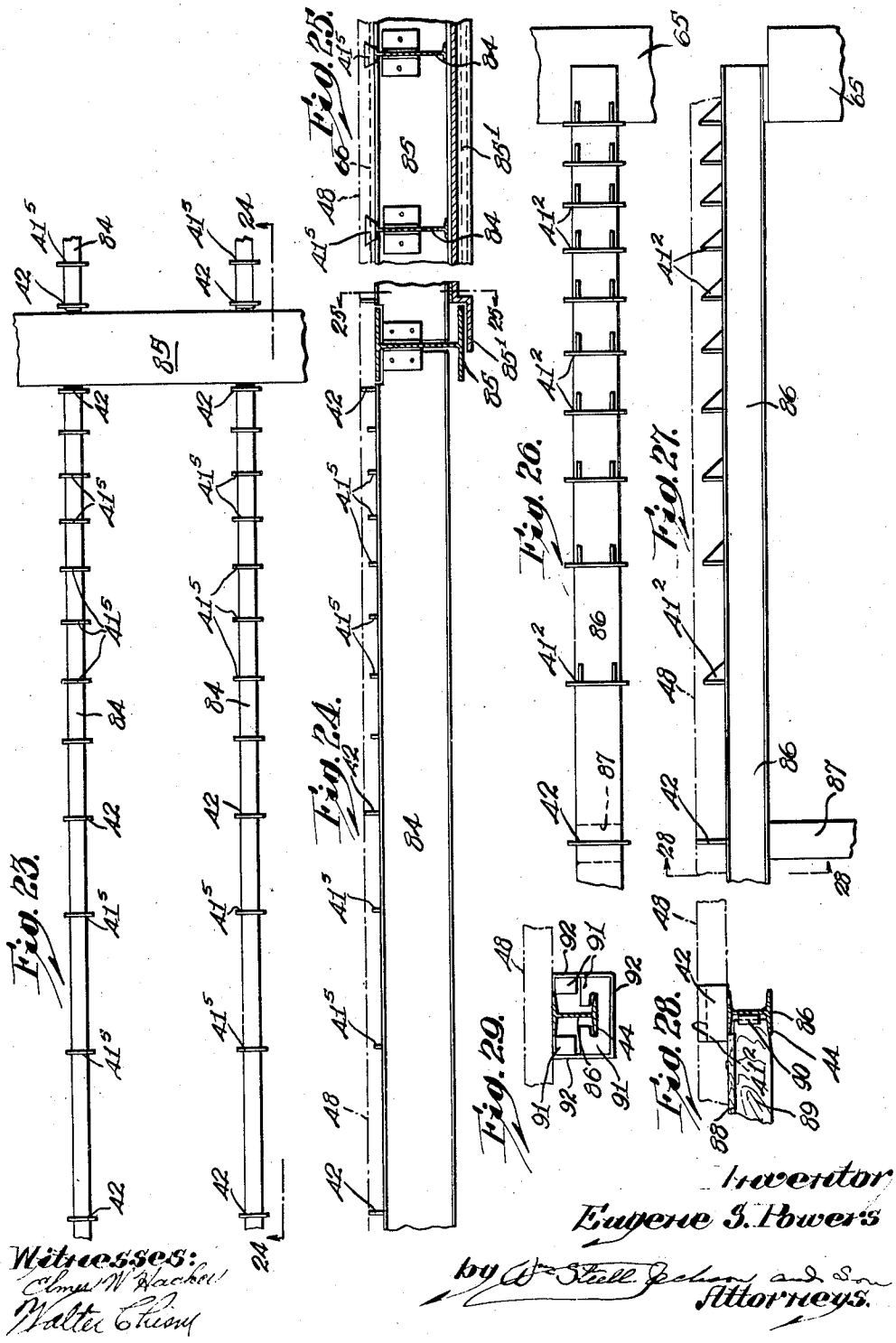
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Oct. 4, 1938. E. S. POWERS 2,132,220

FLOOR CONSTRUCTION OR THE LIKE

Filed Aug. 29, 1936 6 Sheets-Sheet 5



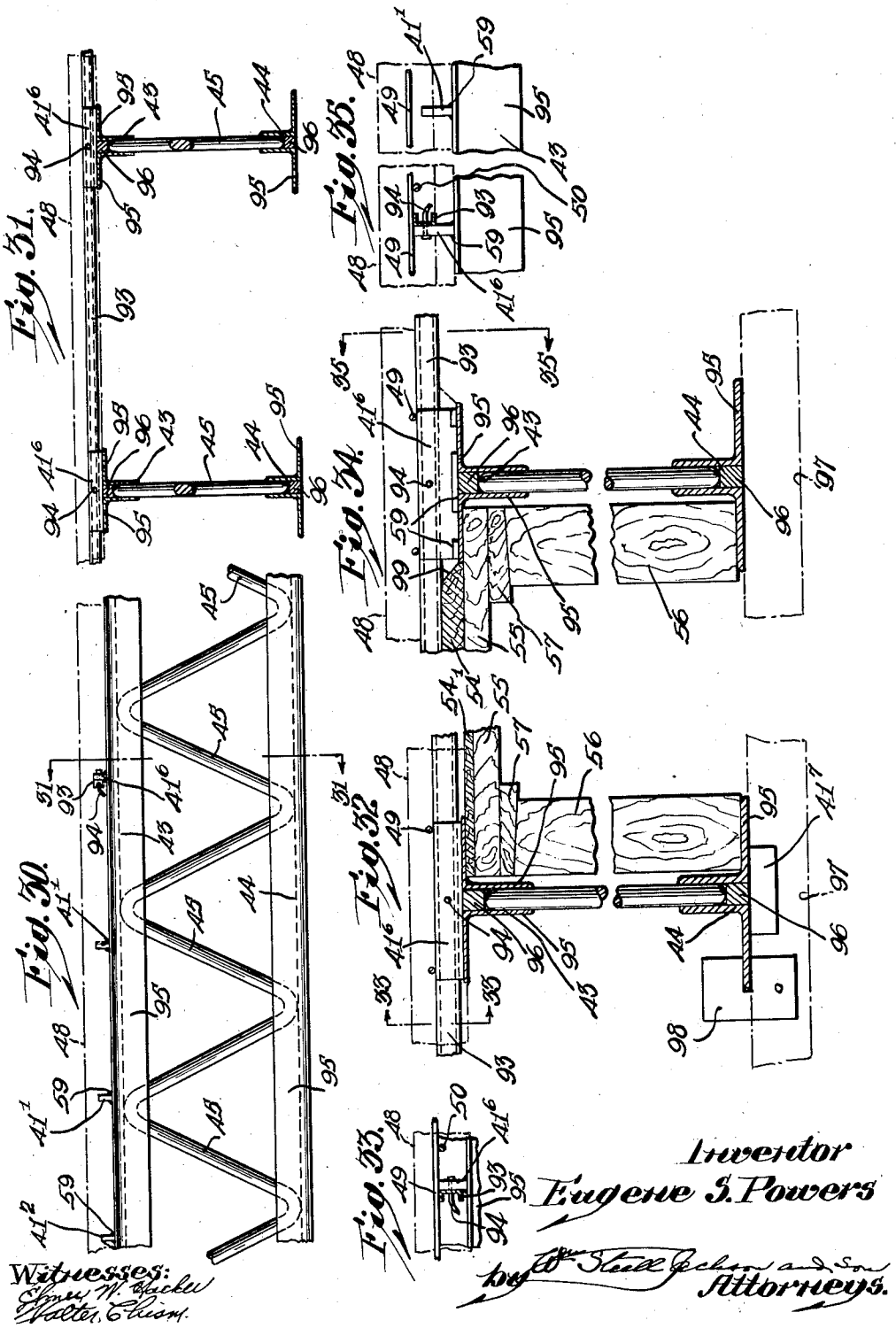
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FLOOR CONSTRUCTION OR THE LIKE

Filed Aug. 29, 1936 6 Sheets-Sheet 6



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Patented Oct. 4, 1938

2,132,220

UNITED STATES PATENT OFFICE

2,132,220

FLOOR CONSTRUCTION OR THE LIKE

Eugene S. Powers, Haddonfield, N. J.

Application August 29, 1936, Serial No. 98,547

20 Claims. (Cl. 72—71)

The present invention relates to improvements in floor, roof and deck structure and the like that consist of concrete or other non-metallic slabs on the upper flanges or chords, of metal members, such as joists, beams, girders, trusses and the like. Such slabs and structures are herein conventionally referred to respectively as concrete slabs and as floor structures of joists, beams and girders.

A purpose of the invention is to increase the strength of floor structure of the type indicated by novel means for insuring against slip between the adjoining surfaces of the top chords of structural members and of a sab or slabs supported by the chords.

A further purpose is to provide a series of transverse top cleats at intervals along the top chords of members that support concrete slabs in order effectively to prevent, or support, the slabs from movements with respect to the chords longitudinal of the chords, preferably making the cleats progressively nearer together and/or larger toward the ends of the chords than nearer the middles thereof.

A further purpose is to provide top cleats at intervals along the chord members of joints, etc., or the like that support concrete slabs, with considerable upward extension into the concrete and with longitudinal extensions to laterally overlap or overhang the chords.

A further purpose is to connect cleats located at intervals along chords by longitudinally extending metal bars spaced above the chords and at opposite sides of the chords, using the longitudinally extending bars and transverse cleats to provide effective and unitary connection between the slabs and the chords of the structural supporting members, and preferably also using the bars for the support and spacing of other reinforcing bars of the slab, and/or for permanent or temporary support of "centering" between the chords of successive joists.

A further purpose is at intervals to cross connect alined cleats of different joists, providing cleats on different joists with common lateral bracing.

A further purpose is to extend cleats sufficiently above the chords to provide gauges of the thickness of the slab.

A further purpose is to secure sleepers or other floor supports by means of the cleats to the chords of joists.

A further purpose is to project cleats beyond the lateral edges of the chords, and to use the overhanging portions of the cleats for securing centering.

A further purpose is to notch the tops or lateral edges of the cleats and secure longitudinally extending rods in the notches by deforming part of the walls of the notches or driving wedges into the notches.

A further purpose is to construct cleats of angle bars which are either integral or assembled.

A further purpose is to space cleats progressively more widely from the end of the span to the middle of the span and to limit the maximum spacing to a distance that is not greater than the slab can safely stand as a strut between cleats conservatively considered as 12 times the thickness of the slab.

Further purposes will appear in the specification and in the claims.

I have elected to illustrate my invention by a few forms only as applied to a number of different structural metal joists, girders and beams, but have selected those which illustrate particularly well the principles involved, and which are practical and efficient in operation.

Figure 1 is a broken top plan of floor structure embodying a desirable form of my invention. The view shows one-half of the span of two joists, showing on one joist a slab that conceals all but two of the cleats, the concealed cleats being shown dotted. The two cleats that come to the top of the slab to act as gauges are shown by solid lines. The other joist is shown without the slab to disclose the cleats, slab reinforcement bars and top of the joist.

Figure 2 is a front elevation of Figure 1, showing in side elevation a joist of the MacMar type, supported on a standard rolled I-beam.

Figure 3 is a section of Figure 1 on the line 3—3 thereof and to enlarged scale.

Figure 4 is a section of Figure 3 upon the line 4—4 thereof and showing cleats, slab reinforcing bars and removable centering.

Figures 5 and 6 are enlarged views of the cleats of Figures 1 to 4, Figure 5 being an end elevation of Figure 6 and Figure 6 a half-length face elevation of a single cleat that is intended to be suitably symmetrical with respect to the center line of the joist shown in dot and dash in Figure 6.

Figures 7 to 12 are enlarged views to show the application of the cleats to joists of the Havemeyer type.

Figure 7 is a sectional elevation parallel to a joist and near the end of the joist, showing the joist end bearing on a wall.

Figure 8 is a section of Figure 7 taken upon the line 8—8 thereof.

Figure 9 is a fragmentary bottom plan of Figure 8 in the position indicated by the line 9—9 of Figure 8.

Figure 10 is a fragmentary top plan of Figure 8 in the position indicated by the line 10—10 of Figure 8.

Figures 11 and 12 are respectively fragmentary sectional elevations, upon the lines 11—11 and 12—12 of Figures 12 and 11, showing the structure of a rectangular cleat such as could be used at the center of the span of the joist of Figure 7, where the cleat has been extended to the intended top of the slab for use as a gauge to determine the slab top. Figures 11 and 12 also show the slab as poured on ribbed lath which act as reinforcement and centering for the slab.

Figure 13 is a fragmentary plan showing my cleats applied to joists, an I-beam and a girder, with the joists of special design and the girder of special design.

Figure 14 is a section of Figure 13 taken on the line 14—14 thereof showing the girder in elevation framing into a column.

Figure 15 is a section of Figure 13 taken upon the line 15—15 thereof and showing one of the joists framing into the girder.

Figures 16 and 17 are views of the cleats on the girder, Figure 16 being an end elevation at one of the cleats and Figure 17 a section of Figure 16 taken upon the line 17—17 thereof.

Figure 18 is an enlarged scale fragment corresponding to a portion of Figure 17 and showing a lock pin in an end of a cleat to hold a reinforcing bar rigidly in position.

Figures 19 to 22 inclusive are enlarged views of cleats made of "flats" or bars of rectangular sections, Figure 19 being an end elevation and Figure 20 a section on the line 20—20 of Figure 19.

Figure 21 is a fragmentary end elevation, partly in section, showing a cleat extended above the top of a slab to act as an anchor for a floor sleeper.

Figure 22 is a section of Figure 21 take upon the line 22—22 thereof.

Figures 23 to 25 inclusive illustrate an application of the cleats to Jones and Laughlin Junior beams, Figure 23 being a plan view illustrating two beams framing into a wide flange Carnegie beam.

Figure 24 is a section of Figure 23 on the line 24—24 thereof, showing the Carnegie beam as a girder, the slab optionally to be poured or formed on a metal sheet to be left in place.

Figure 25 is a section on the line 25—25 of Figure 24. Figure 26 is a plan view showing cleats applied to a 6 inch H-beam.

Figure 27 is a front elevation of Figure 26 showing in side elevation a half-span of a beam with a temporary support at the middle.

Figure 28 is a section of Figure 27 taken upon the line 28—28 thereof and showing removable centering supported on the lower flange of the H-beam.

Figure 29 is a section of one of the H-beams showing a portion of the slab on top of it and showing one way of protecting the beam to meet requirements of first-class "fire-proof construction".

Figures 30 and 31 are fragmentary elevations showing my cleats applied to a joist that has top and bottom chords formed of angles and bars, also showing a lateral brace to be used at intervals between cleats of the different joists, Figure 31 being a section of Figure 30 taken upon the line 31—31 thereof.

Figure 32 shows a case where removable centering laterally overlaps and is wedged upwardly against the outside legs of the top chord angles to avoid the need for close fitting of the centering that will be required if the centering is flush with the top of these angles.

Figure 33 is a section of Figure 32 taken upon line 33—33 thereof and showing the lateral brace for joists embedded in the slab.

Figure 34 is a fragmentary section, generally similar to Figure 32 and shows a case where the removable centering has been formed and placed to raise the bottom of the slab above the top of the top chord angles.

Figure 35 is a section of Figure 34 on the line 35—35 thereof, showing the cleats that receive the lateral brace made high enough to bring the bottom of the lateral bracing members flush with the bottom of the slab.

Similar numerals refer to like parts in all figures.

Describing in illustration and not in limitation and referring to the drawings:—

It has already been recognized that the strength of floor structures that include concrete slabs upon joists, beams and girders, can be increased by securing connection between the slabs and the structural members, so that the slabs increase the areas of the compression flanges of the joists, beams, or girders. It is already known, for example, that it is generally economical in unitary, or composite floor structure to use concrete and metal respectively for supporting the compression and tension stresses in the unitary structure.

Reference is made, for example, to an article on "Shear spiral for composite steel and concrete slabs", in the Engineering News Record of January 10, 1935, and to United States Patent Nos. 1,885,883 and 1,936,147, to Howard F. Young. I believe the known methods of supporting the floor and structural members from relative movement, or preventing relative movement, at their adjoining surfaces have disadvantages which I intend to correct in my present invention.

The "shear spirals" shown in the Engineering News Record are not adaptable to slabs of the thickness commonly used on light joists. Furthermore such spirals cannot take up the full horizontal shear developed between the slab and the beam under uniformly distributed loads that will develop the full working stress of either the slab or the beam. My invention overcomes these limitations. Furthermore the "shear spirals" can only be used in a plastic material such as concrete poured in place, whereas my cleats can be used not only in such slabs but in slabs made of preformed units such as brick or tile which are laid on centering or in slabs made of long tile or of long preformed slab units, made like short plank that will span from joist to joist avoiding the use of centering of any kind.

The "prongs" shown in the Young patents have the following limitations that my invention overcomes. The "prongs" that are formed by shearing and bending the top flange at intervals reduce the strength of the composite structure besides involving an unnecessarily expensive process of manufacture. The "prongs" so formed are necessarily limited in their resistance to bending and horizontal shear. In other words they cannot be designed to meet any condition of span and loading. The "prongs" made of a continu-

ous deformed strip represent a very expensive way of attempting to solve the problem.

I aim not only to prevent slippage at the adjoining surfaces between the slab and the joists, beams, girders, or trusses, but also to render available a method of spacing the means of preventing slippage, my cleats, that will give the exact number of cleats required, thus saving material and labor.

The slabs between the cleats function as a series of struts; therefore a safe slenderness ratio,

$$\frac{l}{t},$$

must be established for the slab, where l is the distance between the cleats and t is the thickness of the slab. I consider a slenderness ratio of 12 very conservative for concrete slabs reinforced with bars.

I can extend my cleats beyond the edges of the members to which they are attached to increase their bearing area or to provide means for suspending the centering from the members, joists, etc.

The spacing of the cleats will depend upon the distribution of the load over the span, whether uniformly distributed, concentrated, or a combination of both, as well as upon the amount of load on the joist, etc.

The cleats can be varied in design to suit the force coming on them or they can all be of one design for a member uniformly loaded, with the spacing varied to suit the distribution of the horizontal shear.

The adaptability of my invention is shown not only by the foregoing but by the following uses to which it is put:—

The cleats serve to hold the slab reinforcing bars in their proper position by means of one or two longitudinal bars run between and attached to the cleats, to which longitudinal bars the reinforcing bars are attached in the usual way. These longitudinal bars running between and attached to the cleats also serve to bind the slab to the cleats and through the cleats to the joist, etc., thus preventing the slab from buckling up from the joist when the floor is supporting heavy concentrated loads.

When self-centering having uniformly spaced ribs is used with joists, etc., provided with my cleats, it will be desirable to have the cleat spacing vary by an amount equal to the spacing of the ribs on the self-centering.

The cleats can be used as a means of attaching the lateral bracing required by floor systems using light metal joists. They can also be used as anchorages for floor sleepers.

Furthermore I aim to have the bearing faces of my cleats extend up substantially at right angles to the top chord, or flange, of the joist or other structural member to which they are attached. This is done with the object of having the bearing areas of the cleats substantially at right angles to the forces to be resisted by the cleats. For the same reason the faces of the cleats are placed on the joist, etc., substantially at right angles laterally to the span of the joists. The bearing faces of the cleats have their areas scientifically determined from the pressures they will have to resist and their shapes and dimensions, vertically and laterally, determined from their areas in accordance with the particular correlated purposes for which the cleats are being designed.

It should be understood that a slab of any material capable of supporting a roof or floor load between its supporting members is a source of potential strength to these members in proportion to its compressive strength and its modulus of elasticity in compression. I propose to utilize this compressive strength in such a way as to develop the maximum strength of the composite structure, or any desired portion of the maximum strength; the way is by the use of cleats.

In this way it is possible for me to produce floors which are thinner in proportion to the span, and also floors with greater load capacity for a given span in proportion to their weight and thickness. By my invention the slab is so connected to its supporting members that the composite structure functions as a unit under flexure. To accomplish this result, the stiffness of the cleats against bending, the resistance of the cleats to shear, the security of attachment of the cleats to the top chord of the beam, etc., the areas of the cleats and their spacing are all important. The cleats can meet all conditions of loading and work with all types of slabs and all sorts of supporting joists, girders, beams, etc.

The main use of the cleats is to transfer from the slab to its supporting members the increments of pressure that produce shear at and parallel with the top of the supporting members. The cleats also serve a number of other useful functions. They hold the slab to its supporting members as the floor, roof, etc., deflects under any system of loading.

The cleats also hold reinforcing bars in their proper positions during pouring of the slab if it is poured in place or during laying of the slab if preformed bricks or tiles are used. The cleats provide points of attachment for lateral bracing concealed in the slab. The cleats will also act as gauges for the thickness of the slab. Removable centering may be held in line with the top chord by the cleats. The centering may also be held by the cleats against the sides of the top chords so as to laterally brace the supporting members while the slab is being placed and hardened. Floor sleepers can very conveniently be anchored to the cleats.

Each cleat must contribute bearing and shearing area and section modulus requisite to transmit the forces which it encounters to the supporting structure. The prior art devices referred to, function by supplying bond and tension areas like inclined stirrups.

By a cleat I intend to designate any stiff projection which functions as a cantilever supported on the upper chord. It may be of one piece or several pieces as in the case of a bracket.

The maximum strength from the composite beam can only be developed when its elements are so proportioned that the finished beam behaves like a one-piece metal beam under flexure. To make the composite beam so function, we must know the relation n of the modulus of elasticity of the metal in compression, E_m, to the modulus of elasticity of the non-metal in the compression, $E_{non\text{-}m}$

$$n = \frac{E_m}{E_{non\text{-}m}}$$

Knowing the value of n, the non-metal compression area of the slab can be converted into its equivalent metal compression area, and the working stress thereon determined in terms of metal stress by multiplying the working stress of the slab, f_c, by n. After this conversion of area it is possible to find the moment of inertia

of the composite beam by the usual formula. The next step is to find the value, per unit length of the beam, of the increments of pressure which the slab must transmit to the beam. These increments of pressure constitute the horizontal shear between the slab and each beam which the cleats must resist. Comparison of my cleats with the prior art devices above referred to in accordance with the method of computation just outlined has shown that my cleats are much more efficient and more adaptable to various conditions, and that the prior art devices do not develop the full possibilities of composite structures consisting of concrete slabs on steel beams, etc., under various conditions of loading on long and short spans, as do my cleats.

In Figures 1 to 4, cleats 41 are lengths of metal angle bars, a special rectangular-shaped cleat 42 is shown at the half span and a special angle bar, cleat 42' is shown at the quarter span. Cleats 42 and 42' run to the top of the slab to act as gauges in screeding the concrete. In these figures the top chord 43 and the bottom chord 44 are both formed of angles. The web members 45 are formed of continuous round bars bent diagonally up and down between and along the angles. Near the end of the span additional web members 46, comprising rectangular bars, are used to give needed extra section to the web members at this portion of the span. The joist is shown bearing on a standard I-beam 47. The dot-and-dash line 48 represents the top of the slab.

It will be noted that the spacing of the cleats 41 is rather close near the beam 47, and becomes progressively wider toward the center of the span where the shear for a uniform load is lower than near the beam 47.

Reinforcing bars 49 pass through and attach to the cleats 41, 42 and 42' substantially as shown in Figures 5, 6 and 7, where the bars 49 are received in notches 52 in the sides of the cleats. Prong portions 51 may be hammered down to hold the bars in place as shown by the dotted line in Figure 6. As indicated, Figure 6, the bars 49 support the cross bars 50 and also serve to prevent the slab from lifting slightly from the joist when the slab is deflected by concentrated loads. The bars 50 are positioned high enough in the slab to function as negative tension bars, by virtue of the height of bars 49 above the upper chord. The cross bars 50 preferably are wired to the bars 49, thus preventing them from being displaced during pouring of the slab. The wiring is shown at 50'.

In Figure 6 the notches in the ends of the cleats 41 have their tops curved outwardly at 53, the better to interlock vertically with the concrete and the better to support the chord and concrete structures in unchanged relative positions.

In Figures 3 and 4 are shown removable centering 54 on which to form the slab. The cleats 41 project beyond the sides of the chord both to present greater surfaces to the concrete and for use in lining the centering 54 up with the top face of the chord, as seen more clearly in Figure 6. In Figures 3 and 4 pieces 55 are shown spanning from joist to joist to support the centering 54, the pieces 55 being supported by pieces 56 and wedges 57 at the tops of pieces 56, the wedges being used to force the centering up tightly against the under surfaces of the cleats and to hold it securely.

The metal ribbon 58, Figures 5 and 6, is to prevent the concrete from escaping between the top chord angles. This ribbon can be placed in the shop on top of the web members flush with the top of the chord angles and may have its ends welded to the end cleats.

In Figures 5 and 6 are shown welds 59 that hold the cleats to the top chord angles 43.

In Figures 7 to 12 the cleats 41' are rectangular bars welded at 59 to the top chord of the joist. The cleats are shown at the intersection of the top chord and web bars, but they can be at any place on the chord. Cross pieces 55 supporting the centering 54 are shown suspended from the cleats by bars 49 and wires 60. These wires, as shown in Figure 9, pass through openings in the ends of pieces 55 and openings in washers 61 on the under side of pieces 55. The wires 60 are passed around bars 49 and made secure by twisting in front of the cleats, Figures 8 and 10, and the washers 61 are shown secured to the ends of pieces 55 by screws 62, Figure 9. The joists of Figures 7 to 12 have chords 63 and 64 of a design special for Havemeyer joists. The web members 45' are of two sizes of round bars, the smaller size, being used toward the middle of the span, not shown. The joists in Figure 7 rest on a masonry wall 65.

In Figure 8 a ceiling construction of metal lath and plaster on channels is indicated by dotted lines 66. This is a common type of ceiling construction. Any type of ceiling construction can be used that the occupancy of a building may require for protection from fire.

In Figures 11 and 12 ribbed lath self-centering 67 is shown on top of the joist. The slab is generally poured on ribbed lath self-centering in light metal joist construction.

If the concrete or mortar is properly designed, mixed, and placed on the self-centering it will develop considerable strength as a compression flange. In use with my cleats the self-centering would be slit or punched between its ribs at 68 to pass the cleats, as illustrated in Figures 11 and 12. The cleat 42^2 of Figures 11 and 12 extends to the top of the slab to act as a gauge of the slab thickness. Bars 49 when used with self-centering serve as "shrinkage bars" and to tie the slab to the joists through the cleats.

In Figures 13, 14 and 15 are shown joists of special design framed into a girder of special design, which girder is supported on a column 47'. This column is shown braced laterally by an I-beam which also supports the floor slab.

The top chords 69 of the joists are illustrated as made of standard Jones and Laughlin channels and the bottom chords 70 made of two standard L's. The web members 45 and 46 are as described for Figures 1 to 4 inclusive. The cleats 41' and 42^2 on the joist are shown as rectangular bars or flats, see Figure 15. The ends of these cleats are notched to receive the bars 49, as shown in Figure 6 for the angle-type cleats.

In Figure 15 the joist is shown of reduced depth toward the ends to permit a thicker slab to be formed at 48' over and near the girder 71 in order that the slab may function better as a compression flange for the girder in composite floors that include joists and slabs that are too thin for this purpose. Bars 72 are suitably supported on and wired to the bars 49 and run transversely of the joists.

In Figures 13 and 14 the cleats 42^3, on the girder 71, having an upper chord 43^2 and a web 45^2, are built up as heavy brackets since the

forces in the slab acting as a flange to the girder are much greater than the forces in the slab on the joist. These bracket cleats 42^3 are best seen in Figures 16 and 17. The face piece 73 of the cleat is proportioned to support the greatest amount of pressure to be transferred from the slab to the girder by a single cleat. The spacing between the cleats is preferably lessened toward the girder ends since the horizontal shear progressively increases from zero at the middle of the girder to a maximum at the girder ends with uniform load, and the close spacing of the joists on the girder produces the effect of such a load. Change in spacing is preferred to using heavier cleats near the points of support than toward the middle of the span.

Bracket pieces 74 are provided to adequately and economically resist the overturning moment on the individual faces of the larger cleats. The face piece 73 is preferably on the side of the cleat toward the center of the span and the bracket piece 74 on the side toward the nearest end. The face piece 73 is given a section sufficient to resist the maximum bending moment on the face piece which may be at the brackets from the cantilever portion of the face, or between the brackets. The welds 75 are designed to take the tension produced by the overturning moment, and the welds 75' are proportioned to the shear that is to be resisted. The welds 76 connect the face and bracket pieces.

In Figure 17 the face piece 73 of bracket 42^3 has notches at its ends, which notches are of different shape from the notches 52 in Figure 6. These notches which are to receive the bars 49', are placed to locate the bars 49' so that the bars 49' hold the cross bars 78 near the top of the slab so as to enable the slab to cantilever out from the girder. In Figure 17 the bars 49' are locked in position by wedge-shaped keys 79 which are driven under the bars 49' so that the ends of the keys will curl up back of the bars, as in Figure 18, showing an enlarged view of notch 77 and key 79. The key 79 before it has been driven in is shown by dotted lines, and after it has been driven in under the bar 49' is shown by solid lines.

In Figures 19 and 20 is shown a cleat 41^3 made of a bar of rectangular cross section. In Figure 20 two different ways of treating the ends of cleats are shown, the notches 52 to receive the bars 49 being generally similar to those shown in Figure 6 and the prong portions 51 being driven down as in Figure 6.

In Figures 21 and 22 are shown a cleat 41^4 used also as an anchor for a sleeper 80 to which the wood floor 81 is nailed. The sleepers are leveled by wedges or spacers 82 and secured to the cleats by lag screws 83. Cleats 41^4 are reduced in width at their tops to save metal.

In Figures 23, 24 and 25 are shown cleats 41^5 made of rectangular bars on Jones and Laughlin Junior beams 84 that are framed into a wide flanged Carnegie girder beam 85. The cleats are spaced for uniformly distributed load with the closest distribution near the ends of the span. The space between successive cleats increases as the horizontal shear between the slab and beam decreases, with the cleats preferably located to transmit the same amounts of shear.

In Figure 24 the cleats 42 respectively at the center of the span, at the quarter point, and at the ends of the beam 84 are shown extending to the top surface of the slab to serve as gauges for use in screeding the concrete.

In Figure 25 the cleats are shown wider at the top than at the bottom for a better gripping of the slab; bars 49 have not been shown. In Figure 25 the tops of the ribs on self-centering 66 are indicated by a dotted line; also the top of the slab 48 is shown by a dot-and-dash line. The self-centering can be a solid metal sheet with ribs of height and spacing to suit the span of the slab and its load. A ceiling is indicated at 85'.

In Figures 26 to 28 inclusive are shown cleats 41^2 that are similar in form and character of spacing to the cleats 42^2 in Figures 13 to 17 inclusive, except that the cleats 42^2 extend to the top of the slab to act as gauges in screeding the concrete, while the cleats 41^2 do not extend to the top of the slab. The cleats in Figures 26 to 28 inclusive are suitably designed for a 6-inch 20-pound H-beam and develop 60 inches of 4-inch thick, 2000-pound concrete slab when the span is 17 feet, 3 inches. The beam bears on masonry walls 65, only one of which is shown.

Figure 26 shows a half span of beam 86 in plan and Figure 27 shows a half span in side elevation. A temporary support 87 is indicated in the center of the span for use until the slab develops sufficient strength to permit the removal of the temporary support. The beam in this case would not be capable of supporting the structural load before the slab sets if the temporary support were not used.

In Figure 28 the wood centering 88 is shown supported on wood joists 89 that span between lower flanges 44 of laterally successive beams 86. Wedges 90 may be driven between the ends of the joists and the webs of the beams.

In Figure 29 the beam is shown encased with fireproofing 91. This fireproofing may be in the form of tiles of any material having the required fire resistance. Plaster is shown at 92 over the tiles. The beams may of course be protected by concrete poured around them in the usual way.

In Figures 30 to 35 inclusive, lateral bracing 93 is shown cross-connecting alined cleats 41' and 41^6 of successive joists at one set of the cleats. This bracing can consist of a bar, or a small channel, or a small angle against the faces of the cleats and is attached to the cleats by any suitable means as by nails, pins or bolts 94 passing through openings in the cleats 41^6 and bracing. Figure 33 shows the relation of the lateral bracing 93 to the top and bottom of the slab. The reinforcing rods 49 are omitted in Figures 30 and 31.

In order to illustrate that the cleats toward the end of the span may be of different construction from those at the center, and preferably stronger than those at the center, with uniform cleat spacing, I show in Figure 30 a bracket cleat 41^2 toward the end of the span.

Figure 32, to larger scale than Figures 30 and 31, shows the chords made up of angles 95 and bars 96 between the angles, which bars serve to locate the center of gravity of the chords 43 and 44 further from the neutral axis of the joist and also give the required sectional chord area with lighter angles than would be otherwise possible, which facilitates spotwelding. The bars 96 also fill the space between the chord angles and at the top chord prevent any downward escape of concrete or mortar between the angle members of the chord.

In Figure 32 a ceiling is indicated by dot-and-dash lines as consisting of pre-cast slabs 97 supported from the joist by metal hangers 98. This type of ceiling, not new, is not generally used on

light fabricated metal joists because of its weight, but the increased strength obtained by uniting the top slab and joist by means of my cleats makes it feasible. Such pre-cast ceiling slabs produce a more fire-resisting construction. Cleats 41' can be used on the lower chord to engage these ceiling slabs near the support of the joists to resist negative bending moments. The centering of Figure 32 is similar to that of Figure 3.

Figure 34 is generally similar to Figure 32 except in the following points. The centering 54' is thicker in Figure 34 than in Figure 32, having its edges 99 beveled and the lower side of the centering set flush with the lower side of the outstanding legs of the top chord angles 95. This elevates the bottom of the slab above the top of the chord angles except for that portion immediately above the angles where the slab becomes thicker. Elevating the slab in this way increases the moment of inertia of the composite structure, giving a correspondingly greater section modulus.

In Figures 32 and 34 the cleats 41[6] that receive the lateral bracing 93 are shown. They are higher than the cleats which do not receive the lateral bracing. This is shown more clearly in Figure 35. The heights of other cleats are preferably determined by the area required to give the necessary bearing on the slab.

As the structure of my invention differs materially from devices available in the art, I will give an example of the application of my invention to a Jones and Laughlin Junior 10 inch, 8.96 pound I-beam on a 20 foot span without temporary supports. In this instance the beam will be required to support all permanent dead load by itself. The extra strength to be derived from the slab will only be available for load coming on the floor after the slab sets.

With the beams spaced 2 feet on centers and supporting a concrete slab 2 inches thick, the permanent dead load will be 59 pounds per lineal foot. The bending moment will then be

$$59\times20^2\div8=2{,}950 \text{ foot-pounds}$$

Since the section modulus of the beam is 7.78, the extreme stress is $2950\times12\div7.78=4{,}550$ pounds per square inch. The ultimate extreme tension stress is limited to 18,000 pounds per square inch; that is, the sum of the extreme tension stresses produced by the loads on the beam both before and after the slab sets should not exceed 18,000 pounds per square inch. Therefore the extreme tension stress available to function with the slab is 18,000—4,550=13,450 pounds per square inch.

Using concrete having a compression strength of 2,000 pounds per square inch, with

$$\frac{E_s}{E_c}=n=15$$

where E_s is the modulus of elasticity of steel in compression, E_c is the modulus of elasticity of concrete in compression, and n is the ratio, the area of the slab in terms of steel is $2\times24\div15=3.2$ square inches. Knowing this area, the center of gravity of the composite section can be located and the moment of inertia of the composite section can be found by the usual formula

$$\Sigma(ad^2+i)$$

where a is the area of an element of the composite section, d is the distance from the centre of gravity of that element to the neutral axis, or centre of gravity of the composite section, and i is the moment of inertia of that element whose area is a.

Let the distance from the top of the slab to the center of gravity or neutral axis of the composite section in terms of steel be C_1 and the distance from the center of gravity to the bottom of the beam be C_2. These distances control the relative values of the working stresses, f_{cs}, the extreme fiber stress under compression of the concrete in terms of steel, and f_s, the extreme fiber stress in tension of the steel. The same relation must exist between f_{cs} and f_s as between C_1 and C_2. With $f_{cs}=800\times15=12{,}000$, and $f_s=18{,}000$ pounds, C_1 becomes $4/10\ d^1$ and C_2 becomes $6/10\ d^1$, where d^1 is the distance from the top of the slab to the bottom of the beam, etc. When C_1 is less than $4/10\ d^1$, 18,000 pounds is the working stress and when C_1 is more than $4/10\ d^1$, 12,000 pounds is the working stress.

In the case under consideration, $C_1=3.7$ inches and d^1 is 12 inches, so that the working stress is 18,000 pounds. C_2 is 8.3 inches, and therefore the maximum compression on the concrete is $13{,}450\times3.7\div8.3=5{,}996$ pounds per square inch. The moment of inertia of the composite section, I=90.0. The resisting moment of the composite section is $90\times13{,}450\div8.3=145{,}843$ inch-pounds. This resisting moment gives a safe load of

$$\frac{145{,}843\times8}{12\times20}=4{,}857 \text{ pounds}$$

With the beams spaced 2 feet apart the safe live load per square foot is

$$\frac{4{,}857}{2\times20}=121.4 \text{ pounds per square foot}$$

This safe live load only applies if there is no ceiling supported from the beam, since the beam supports all permanent dead load before the slab sets.

From Jones and Laughlin Beam Tables we find that the safe load for a 10 inch 8.96 pound beam on a 20 foot span is 4,670 pounds, or the equivalent of 233.5 pounds per lineal foot. Subtracting the 59 pounds per lineal foot permanent dead load, there is a safe live load of 174.5 pounds per lineal foot or $174.5\div2=87.25$ pounds per square foot on the beams as used in the prior art without any means of causing the slab to function with the beam in resisting flexure.

By the use of my cleats, this live load may be increased to 121.4 pounds per square foot, an increase of 39.14%.

The reaction is one-half the total live and dead loads, or

$$\frac{4{,}857+(59\times20)}{2}=3{,}018.5 \text{ pounds}$$

According to the manufacturer, the permissible reaction is 8,240 pounds.

In designing the cleats, provision must be made to take up all compression in the slab produced by the maximum bending moment from live or superimposed load, and this compression must be transferred to the beams by the cleats between the point where the shear is zero and the reactions. This compression, P, equals the area of the slab section in terms of steel, or 3.2 square inches, multiplied by the average stress on the slab in terms of steel. This average stress is

$$f_s\frac{C_3}{C_2}$$

where C_3 is the distance from the center of gravity of the composite section to the center of the slab section. In the case under consideration P is $13{,}450\times2.7\div8.3\times3.2=14{,}000$ pounds. The value of P is distributed over half the span in incre-

ments increasing uniformly for a uniformly distributed load from zero at the center of the span to a maximum p at the reactions. The distribution per lineal inch of span may be represented by the ordinates of a right triangle spaced one inch apart. The area of the right triangle is P, and

$$p=\frac{14,000\times 2}{120}=234 \text{ pounds}$$

The force on any one cleat equals the average ordinate between the cleats multiplied by the distance between the cleats. If the spacing of the cleats be fixed arbitrarily, the average ordinate can be determined and the force to be resisted by each cleat can be calculated. However, generally the best practice is to keep one size of cleat throughout and increase the cleat spacing as the ordinate p reduces. To do this, it is necessary to fix the size of the cleat and determine the force that it will resist. To fix the first space from the reaction, divide this force by p. Then determine the second space from the reaction by using the ordinate that is 1½ times the first space from the reaction. For the third space use the ordinate that is 1½ times the first space plus the second space from the reaction. Proceed thus until a space is obtained that is 12 times the thickness of the slab. Then use this space as a maximum for the rest of the distance, if any, to the center of the span. This method is quite accurate, erring slightly on the side of safety.

Applying these rules to the present case, we must first determine the bearing area of the cleat. The upper flange of the beam is 2.69 inches wide. Based on 400 pounds per square inch safe bearing value, the preferable area of the cleat is 2.625 square inches. Therefore the cleats need not be more than 1 inch high. Using 400 pounds per square inch safe bearing value for concrete, the force to be resisted by the cleat is $2.625\times 400=1050$ pounds. The first space is $1050+234=4.5$ inches. The distance to the second average ordinate is $4.5\times 1.5=6.75$ inches. The average ordinate for the second space is

$$\frac{234(120-6.75)}{120}=220.8 \text{ pounds}$$

This figure divided into 1050 gives the second space. All of these factors are constant except the value in brackets, so the constants may be reduced to $1050\times 120+234=$ about 538, erring on the side of safety. Then the second space is

$$\frac{538}{120-6.75}=4.75 \text{ inches}$$

The above calculation may be summarized in a formula:—

$$\frac{FL^2}{2P(L-\frac{1}{2}S_1-S_1-S_2-S_3\ \ldots)}$$

where F is the force in pounds which one cleat can safely resist, L is the length in inches of one-half the span of the joist, P is the compression in pounds produced in the slab by the maximum bending moment on the composite structure produced by the live load alone (that is the superimposed load alone) when the joist is not temporarily supported, and by the total dead and live load when the joist is temporarily supported before the slab is poured or formed, and S_1, S_2, S_3, etc., are the spacings in inches between adjoining cleats numbered from the reaction of the beam toward the center of the span where the horizontal shear as well as the vertical shear is zero, and continuing to the two cleats whose spacing is in question.

For approximate work, erring on the side of safety, the quantity $\frac{1}{2}S_1$ may be neglected, especially in finding the spacings near the center of the span. In that case it will be seen that the spacing between any two adjoining cleats other than a pair at one end of the span is approximately a constant (in this instance 538) divided by the distance from the center of the span to the approximate center of the space being determined.

There will be 28 cleats with 11 inches space at the center of the span.

The maximum overturning moment to be resisted by any cleat is $1050\times 0.5=525$ inch-pounds. Using this as the maximum bending moment with an extreme fiber stress of 18,000 pounds, the required section modulus of the cleat is

$$\frac{525}{18,000}=0.0292=\frac{bd^2}{6}$$

where b is the assumed length of the section resisting bending and d the required depth in inches of the section resisting bending, that is, the thickness of the cleat.

$$d=\sqrt{\frac{0.0292\times 6}{2.625}}=0.264 \text{ inch}$$

The cleat should be attached to the beam by welds on each side along its length. In designing the welds the shear stress at the throat of the weld used for the calculation is 11,300 pounds per square inch. The tension through the throat of the weld is taken at 13,000 pounds per square inch in the calculation. The shear requires a weld area of $1050\div 11,300=0.093$ square inch. The welds stiffen the cleats in bending so that the thickness of the cleat can be 0.25 inch. Using this 0.25 inch as the resisting lever arm, the tension on the weld will be

$$1050\times 0.5\div 0.25=2100 \text{ pounds}$$

The weld area required for the tension is

$$2100\div 13,000=0.17 \text{ square inch}$$

Half the weld area required for shear is placed on each side of the cleats. Therefore the throat area of the weld is

$$\frac{0.093}{2}+0.17=0.217 \text{ square inch}$$

If the weld is run the full width of the flange of the beam, say 2.625 inches, the throat width of the weld will be $0.217\div 2.625=0.09$ inch. Fillet welds of width less than 0.25 inch are seldom used.

If this same beam were used with temporary supports to prevent the beam from being stressed until the slab had set sufficiently to develop its working stress; then the resisting moment would be

$$\frac{If_s}{C_2}=\frac{90\times 18,000}{8.3}=195,180 \text{ inch-pounds}=\frac{wl}{8}$$

where w is the total safe load and l the length of the span of the beam in inches. Then

$$w=\frac{195,180\times 8}{12\times 20}=6,506 \text{ pounds.}$$

The reaction is 3253 pounds and the permissible reaction 8240 pounds. The safe load per lineal foot is $6506\div 20=325.3$ pounds. Subtracting from this the 59 pounds per lineal foot dead load, there remains 266.3 pounds per lineal foot live load, or $266.3\div 2=133.15$ pounds per square foot live load.

The safe live load of the beam itself is only 87.25 pounds per square foot. There is then a gain of 45.9 pounds per square foot or 52.6%. This is a 13.46% gain in live load over the case in which the beam has no temporary supports.

This maximum total load on the composite beam will produce a deflection of only

$$\frac{5\times 6{,}506\times 240^3}{384\times 29{,}000{,}000\times 90}=0.448 \text{ inch}$$

The permissible live load deflection is

$$20\div 30=0.66 \text{ inch}$$

The deflection from the safe total load on the beam by itself, without the cleats, is

$$\frac{5\times 4{,}670\times 240^3}{384\times 29{,}000{,}000\times 39.01}=0.766 \text{ inch}$$

There is then a 41.51% reduction in deflection due to the cleats as well as a 52.6% increase in live load.

It will be evident that the benefits of my invention may be obtained with any construction of metal shapes covered or enclosed with concrete, or other material as well as without such protection.

It will be evident that an important feature of the invention is the use of stiff projections called cleats, disposed on the chord of the metal support to engage with a non-metal slab. The cleats perform the function of transferring to the beam, increments of pressure induced in the slab by flexure of the construction.

The particular form of the cleats is immaterial in the broader aspects of the invention, providing they are stiff cantilever members extending generally transversely with respect to the length of the beam, having sufficient bearing area for the pressure to be transferred from slab to beam, etc., have adequate shearing area, adequate section modulus and adequate anchorage.

It will also be evident that in the broader aspects of the invention the spacing of the cleats along the chord is immaterial so long as each cleat is capable of withstanding the pressure to which it is subjected at its particular location.

It will also be evident that the manner of connection between the cleats and the chord is immaterial in the broad aspects of the invention. The cleats are preferably welded, but they might conceivably be riveted or formed integral with the chord.

Of course the supporting member may be of the type commonly designated as a joist, beam, girder, or truss and no particular significance is to be attached to the use of one of these terms rather than another. For convenience I use the word "joist" in the claims to include also beams, girders, and trusses. Such members may be rolled or fabricated in any suitable shape, section or dimension.

It is also evident that the cleats can be used on the top and bottom chords of the supporting members to assist in resisting positive and negative bending moments in continuous constructions. The cleats may also be used on the chords of curved structures such as arches, vaults, etc.

By a chord, I intend to include any similar portion of a structural member such as a flange, etc., or any part of a structural member subject to compression due to flexure.

It will further be evident that I do not weaken my upper chord by upsetting portions of the upper chord to form projections into the slab. The upper chord will desirably be imperforate except for the possible bolt holes, etc.

It will further be evident that the longer the cleats are, the less height they will require and consequently the less bending moment they will have to resist and the thinner the cleats can be. The relations of length to height of cleats are generally controlled by other considerations than bending moment.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure shown, and I, therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

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

1. A structure for a composite floor, roof, deck system or the like, comprising a metal joist having cleats secured to it at intervals along its length and extending laterally substantially at right angles to and upward from the joist to engage with a non-metallic slab to be formed on the joist, in which the spacing of the cleats, in inches proceeding from the ends of the joist to the centre of the span, when the floor system is designed for a uniformly distributed load, is approximately a constant divided by the distance from the centre of the span to the approximate centre of the space being determined.

2. A structure for a composite floor or the like, comprising a metal joist having an upper surface provided with cleats attached at intervals along its length and extending laterally substantially at right angles to and upwardly from the joist to engage with a non-metallic slab to be formed on the joist after it is set in place; in which the spacing in inches between any two adjoining cleats other than the pairs at the ends of the joist is substantially:

$$\frac{FL^2}{2P(L-\frac{1}{2}S_1-S_1-S_2-S_3\ \ldots)}$$

where F is the force in pounds which one cleat can safely resist, L is the length in inches of one-half the span of the joist, P is the compression in pounds produced in the slab by the maximum bending moment on the composite structure produced by the live load alone, that is, the superimposed load alone, when the joist is not temporarily supported, and by the total dead and live load when the joist is temporarily supported before the slab is poured or formed, and S_1, S_2, S_3, etc., are the spacings in inches between adjoining cleats numbering from the end of the half span for which the spacings are being determined and continuing to the two cleats whose spacing is in question.

3. A metal structure for use in a composite floor or the like of metal and a non-metal slab, comprising a metal joist having an upper chord and a plurality of generally similar cleats secured to the upper chord at intervals along it, and extending generally transversely to the upper chord and above the upper chord into the slab, in which the spacing in inches between any two adjoining cleats other than a pair at an end of the span is substantially:

$$\frac{FL^2}{2P(L-\frac{1}{2}S_1-S_1-S_2-S_3\ \ldots)}$$

where F is the force in pounds which one cleat can safely resist, L is the length in inches of

one-half the span, P is the compression in pounds produced in the slab by the maximum bending moment in the finished composite floor and S_1, S_2, S_3, etc., are the spacings in inches between adjointing cleats numbering from the end of the half span for which the spacings are being determined and continuing to the two cleats whose spacing is in question and in which, where the answer from this spacing calculation exceeds the product of the safe slenderness ratio of the slab times the thickness of the slab, the spacing of the two cleats in question is limited to this product.

4. A metal structure for use in a composite floor or the like of metal and concrete or masonry, comprising a metal joist having an upper chord, a plurality of cleats secured to the upper chord at intervals along it, and extending generally transversely to the upper chord and above the upper chord into a slab, in which the first two cleats at an end of the span are spaced by a distance substantially equal to the force in pounds which one cleat may safely resist multiplied by the length in inches of one-half the span and divided by twice the compression in pounds produced in the slab by the maximum bending moment.

5. A composite floor structure or the like having a plurality of metal joists each of which has a continuous undeformed upper chord, a slab extending across and supported upon the upper chords and a plurality of individually separate cleats, each presenting a substantially flat bearing surface to the force that the cleat is to resist, each cleat extending up into the space occupied by the slab and extending transversely of the upper chord for the preponderant part of the width of the upper chord, and resting upon and secured to the top of the upper chord.

6. A composite floor structure or the like having a plurality of metal joists each of which has a continuous undeformed upper chord, a slab extending across and supported upon the upper chords and a plurality of individually separate cleats, each presenting a substantially flat bearing surface to the force the cleat is to resist, each cleat extending up into the space occupied by the slab and extending transversely of the upper chord for the preponderant part of the width of the upper chord, and resting upon and secured to the top of the upper chord in which the spacing of the cleats, in inches, proceeding from the end of each joist to the center of its span, under uniformly distributed load, is approximately a constant divided by the distance from the center of the span to the approximate center of the space being determined.

7. In a metal joist construction for use with a concrete slab, to form a composite construction, a metal joist having an upper chord which is adapted to support the slab and a plurality of metal cleats extending transversely of the length of the joist and distributed at intervals along the upper chord, each cleat having an element which is substantially flat, upstanding from the upper chord and extending in length transverse to the upper chord and having a bracket portion which extends substantially longitudinally of the joist, and engages and supports one side of the upstanding element against overturning moments, the upstanding element and the bracket resting upon and being secured to the upper chord.

8. In a metal joist construction intended to be used with a concrete slab to form a composite structure, a metal joist having an upper chord, a plurality of individually separate cleats resting upon and secured to the upper chord, extending transversely of the joist and extending away from the joist into the space to be occupied by the slab and a metal bar extending longitudinally of the joist above the upper chord and secured to the successive cleats.

9. In a composite floor structure or the like, metal joists having upper chords, a slab extending across and supported by the upper chords, a plurality of cleats distributed along the upper chord, extending generally transversely to the lengths of the joists and extending above the upper chords into the slab, there being notched ends to the cleats, and rods extending longitudinally of the joist above the upper chord secured in the notches.

10. In a composite floor structure or the like, joists having upper chords, a slab extending across and supported upon the upper chords, cleats distributed along and secured to the upper chords, extending transversely of the lengths of the joists and extending vertically above the upper chords into the slab and reinforcing rods secured to the cleats and extending longitudinally of the joists.

11. A plurality of laterally spaced joists, cleats recessed at their ends spaced laterally along and fastened transversely across each joist on the top thereof, a metal bar along and above each side of each joist seated in the end recesses of the cleats and means at the recesses fastening the bars to the cleats.

12. A plurality of laterally spaced joists, cleats recessed at their ends spaced laterally along and individually fastened transversely across each joist on the top thereof, a metal bar along and above each side of each joist seated in the end recesses of the cleats and key means at the recesses fastening the bars to the cleats.

13. In a composite floor structure or the like, metal joists having upper chords, a slab extending across and supported upon the upper chords and a plurality of cleats distributed along and secured to the upper chords, extending transversely of the joists for at least the full widths of the upper chords and extending vertically above the upper chords and into the slab, the cleats being wider at a position above the chords than at the chords to interlock with the slab.

14. In a composite floor construction or the like, metal joists having upper chords, a slab extending across and supported upon the upper chords, a plurality of cleats extending transversely of the upper chords of the joist for the preponderant part of the widths of the upper chords and extending vertically above the upper chords into the slab, there being extensions of the cleats above the slab, floor sleepers and means for attaching floor sleepers to the extensions of the cleats.

15. A plurality of laterally spaced joists having upper chords, cleats spaced at intervals along the joists, extending transversely of the joists and supported upon and secured to the upper chords of the joists, a metal bar extending longitudinally of each joist above its upper chord and engaging the ends of and secured to the cleats of each joist, centering between the joists and means for supporting the centering from said bars.

16. In a construction for pouring the slab of a composite floor structure or the like, metal joists having upper chords, a plurality of cleats

distributed along the upper chords, secured to the upper chords, extending transversely of the lengths of the joists for a distance greater than the widths of the upper chords so as to project beyond the edges of the upper chords and extending vertically above the upper chords and into the space to be occupied by the slab, centering laterally adjoining the upper chords and means for holding the centering in place up against the projecting edges of the cleats.

17. In a construction for pouring the slab of a composite floor structure or the like, metal joists having upper chords, a plurality of cleats distributed along the upper chords, secured to the upper chords, extending transversely of the lengths of the joists for a distance greater than the widths of the upper chords so as to project beyond the edges of the upper chords and extending vertically above the upper chords and into the space to be occupied by the slab, centering laterally adjoining the upper chords and structure including wedges for forcing the centering from the joists up against the projecting edges of the cleats.

18. A composite floor including laterally spaced metal joists, transverse metal cleats at intervals along and fastened to the chord of each joist, a metal brace extending transversely of the joists rigidly connecting one of the cleats on one joist with one of the cleats on another joist, and a concrete slab incorporating the cleats, brace, and joists into a unitary bonded structure utilizing the slab as a compression member of the floor.

19. A composite floor structure or the like, having a plurality of metal joists with upper chords, a slab extending across and supported upon the upper chords, and a plurality of stiff cantilever cleats separated from one another, distributed along and secured to the upper chords, extending transversely of the lengths of the joists for a distance at least as great as the widths of the upper chords and extending vertically up from the upper chords and into the slab, each cleat at its particular location presenting a bearing area substantially at right angles to the length of the joist, proportioned to the compressive resistance of the slab and having a cross section and attachment to the joist capable of resisting horizontal shear and resisting bending without the aid of the material composing the slab.

20. A composite floor structure or the like, having a plurality of metal joists with upper chords, a slab extending across and supported from the upper chords, and a plurality of stiff cantilever cleats separated from one another, distributed along the upper chord, each cleat comprising an angle attachment, one arm of which rests upon and is secured to the upper chord and the other arm of which extends transversely of the length of the joist for a distance substantially as great as the width of the chord and vertically up from the other arm and from the upper chord into the slab, each cleat at its particular location presenting a bearing area on its upstanding arm proportioned to the compressive resistance of the slab and having a cross section and attachment to the joist capable of resisting horizontal shear and resisting bending without the aid of the material composing the slab.

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