Jan. 28, 1941. E. S. POWERS 2,229,671

METAL JOIST AND THE LIKE

Filed Feb. 17, 1938

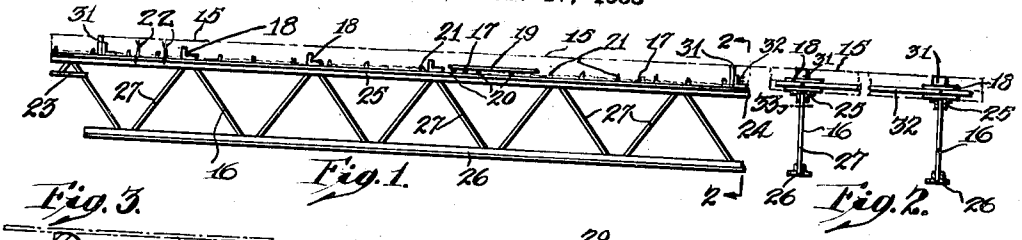


Fig. 1.

Fig. 2.

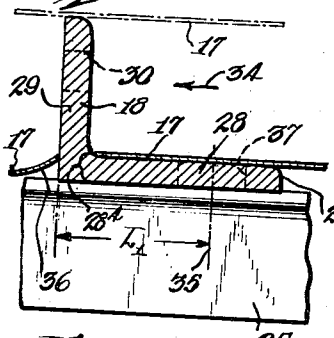


Fig. 3.

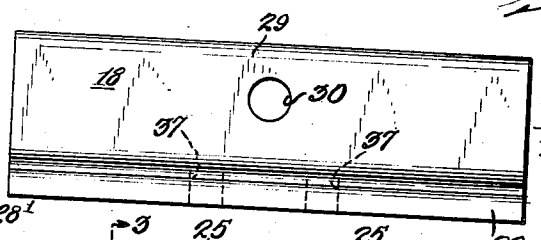


Fig. 4.

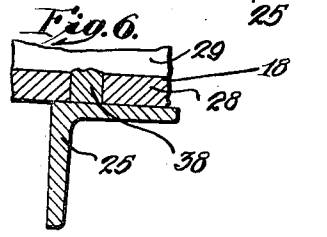


Fig. 6.

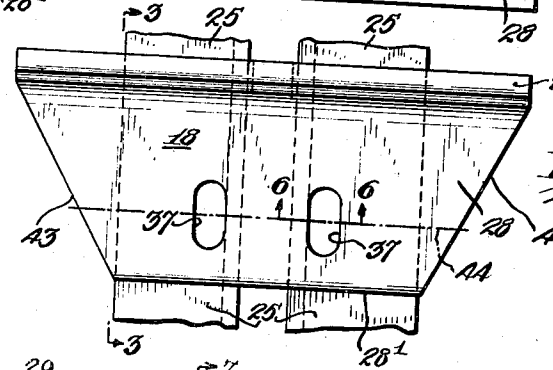


Fig. 5.

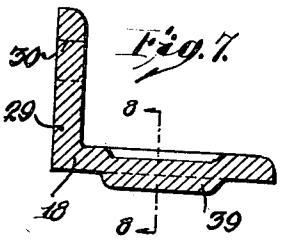


Fig. 7.

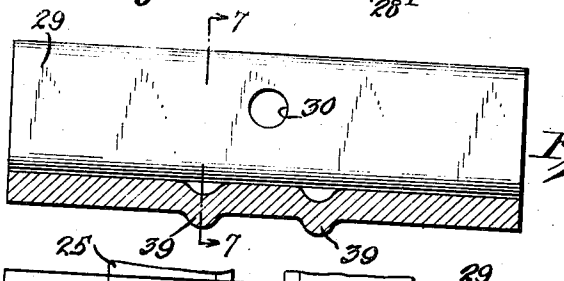


Fig. 8.

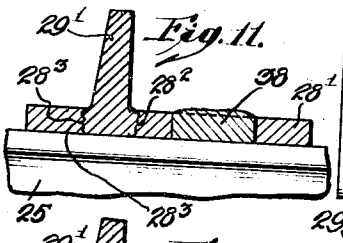


Fig. 11.

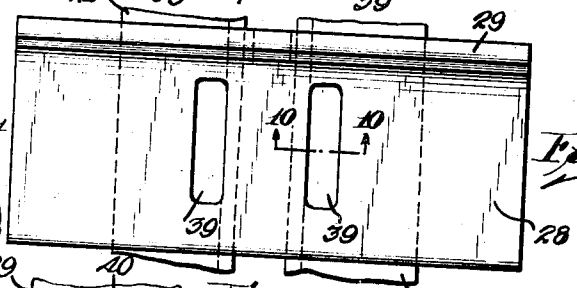


Fig. 9.

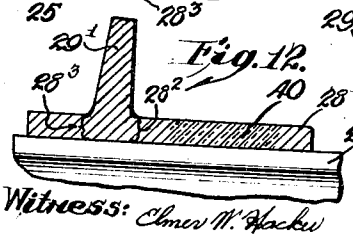


Fig. 12.

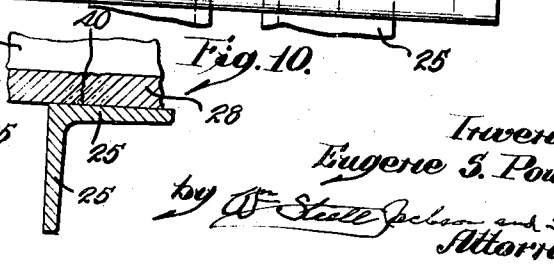


Fig. 10.

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Attorneys.

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UNITED STATES PATENT OFFICE

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METAL JOIST AND THE LIKE

Eugene S. Powers, Haddonfield, N. J.

Application February 17, 1938, Serial No. 190,958

2 Claims. (Cl. 72—110)

The present invention relates to metal joists which are employed in composite floor and roof construction, in conjunction with a concrete slab.

The invention relates more particularly to the means used to connect the slab to the joist so that the slab will serve as a flange for the joist and thus increase the moment of inertia of the joist.

The present subject matter is to some extent a development of the subject matter of my copending application Serial No. 98,547 for "Floor construction or the like," filed August 29, 1936.

A purpose of the invention is to provide metal joists for floor or roof construction of the character indicated with novel cleats upon the upper chords of the joists, adapting the joists better to the intended service and better to easy and inexpensive manufacture.

A further purpose is to provide a metal joist of the character indicated with transverse cleats having horizontal and vertical legs presented respectively flat across the top surface of the upper chord, and upwardly and embedded in the concrete of the floor or roof slab, and with the cleats of a novel form and/or position adapted to an easy and economic electric welding connection between the cleats and chords of the joists.

A further purpose is to provide an apron in front of the upstanding leg of a cleat to insure compactness and density of the concrete immediately in front of the upstanding leg in the direction of zero shear, desirably using the horizontal leg of an angle cleat as the apron.

A further purpose is to lay sheets of expanded metal rib lath centering over and around the vertical legs of angle cleats of joists of the character indicated, severing the lath upon the upwardly presented edges of the vertical legs of the cleats, to enable the lath to pass downwardly about the vertical legs of the cleats, and to turn horizontal legs of the cleats toward the center of the span from their vertical legs in order to provide an unperforated support in the form of an apron to the cleat to receive freshly laid concrete and to support the severed edge of the centering in front of the cleat on the pressure side of the vertical leg, thereby avoiding danger of any ultimate voids or imperfect concentration of the set concrete at the portion thereof adjacent the pressure receiving side of the vertical leg, which concrete portion carries and transmits the shear load presented to and supported by the vertical leg of the cleat.

A further purpose is to form one leg of an angle cleat-blank for easy welding to the top chord of a metal joist, with downward preferably die stamped projections for resistance welding, or preferably elongated perforations for arc welding.

A further purpose is to lessen the requisite welding between a metal joist and the horizontal leg of an angle cleat of the character indicated by placing the cleat so that its horizontal leg extends from the vertical leg toward the point of zero shear (i. e. toward, as distinguished from away from, the center of the span) and by locating the welding intermediate the cleat edges instead of using fillet welding at the edges.

A further purpose is to provide a cleat of the character indicated with a resistance weld or an arc type weld connection alternatively, preferably using the resistance weld with light joists and an arc weld with the more heavy joists and locating the weld in either case in the horizontal leg of the cleat and intermediate the cleat edges.

A further purpose is to electric weld a cleat to a metal joist through the body of the horizontal leg of the cleat.

A further purpose is to place cleats of the character indicated and of angle section with the horizontal leg directed toward the center of the span of the joist, with respect to the vertical leg, thereby both lessening the requisite welding connecting the joist and cleat and providing support without voids for freshly laid concrete along the pressure receiving side of the cleat.

A further purpose is to electric weld through holes punched in the horizontal leg of the cleat.

A further purpose is to substantially center the attachments of the cleats over the bends in the web bars between the upper chord angles of fabricated joists, so that the increments of pressure coming to the cleats from the slab will be passed more directly to the web system, thus eliminating the area of the upper chord as a factor in the calculations of the moment of inertia of the composite section.

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

I have elected to show one main form only of my invention, showing however minor modifications either of which under some circumstances may be preferable to the other and selecting a main form and modifications thereof that are practical and efficient in operation and which well illustrate the principles involved.

Figure 1 is a half-span sectional elevation of a floor embodying a desirable form of the present invention.

Figure 2 is a fragmentary section taken upon the line 2—2 of Figure 1.

Figure 3 is a view corresponding to an enlarged fragment of Figure 1, being a section of Figure 5 upon the line 3—3 thereof and showing in dot-and-dash and full lines expanded metal centering respectively above the cleat and in place on the cleat. The view illustrates also the apron support of the concrete that transmits pressure from the slab to the cleat and supports the edge of the severed centering where that support is needed.

Figure 4 is a front elevation of a cleat blank,

being a blank corresponding to the cleat of Figure 3 prior to its welding to the joist, except that the ends are not tapered as in Figure 5.

Figure 5 is a plan view corresponding otherwise to a fragmentary top plan of Figure 3, showing tapered ends to the horizontal leg of the cleat, not used in the form of Figure 4.

Figure 6 is a fragmentary section of Figure 5 taken upon the line 6—6 of that figure and to illustrate a desirable weld connection between the cleat and the joist.

Figure 7 shows a transverse section upon line 7—7 of Figure 8, a desirable form of cleat blank for resistance welding to a joist.

Figure 8 is a longitudinal section on the line 8—8 of Figure 7 and Figure 9 is a top plan view of the structure of Figure 7.

Figure 10 is a sectional fragment corresponding to one taken upon the line 10—10 of Figure 9 but showing a completed resistance weld.

Figures 11 and 12 are transverse sections corresponding generally to Figure 7 but modified to show cleats of T section arc-welded in Figure 11 and resistance-welded in Figure 12 to the top chord of a joist.

Like numerals refer to like parts in all figures.

Describing in illustration and not in limitation and referring to the drawing.

In Figures 1 and 2 concrete flooring 15 is carried upon laterally spaced joists 16, with permanent centering 17 of expanded metal rib lath indicated as extending from joist to joist upon which the concrete flooring 15 is to be poured and screeded down. The usual or suitable reinforcement bars or mesh are intended to be indicated at 19 and 20. The shrinkage bars 19 rest across the upstanding ribs 21 of the centering and the main reinforcing bars 20 are wired to the shrinkage bars 19. Metal clips 22 may be of usual form and number spaced along each joist intermediate my cleats 18.

In Figure 1 the usual attached bearing plate for this type of joists is indicated at 23 with the span center somewhere to the right as at or near 24.

The joist is indicated with the usual upper and lower chords 25 and 26 and the usual web bar 27. This type of joist usually has the chords and web members continuous from one end of the joist to the other, with each chord formed by a pair of angles welded to opposite sides of the web bar at the bends thereof.

The cleats 18 are spaced along and extend across the top chord of each metal joist. They are integrally fastened to the chord—preferably by resistance or arc welding. These cleats are of such size and so positioned as to prevent any slip between the slab and the chord in a direction longitudinal of the chord, as already explained in my above copending application.

In Figures 1 and 2 these cleats 18 are of angle section with the horizontal leg 28 of each cleat directed away from the vertical leg 29 toward the span center 24.

As illustrated I have provided each cleat 18 with a perforation 30 in its vertical leg 29 for mounting connection with a floor gauge 31 or/and with lateral brace bars 32 as indicated in Figure 2. The floor gauges and brace bars are placed according to need at some only of the cleats, each gauge or brace bar usually being connected to a plurality of cleats. They function respectively in gauging the depth of concrete and for lateral bracing of the joists against lateral buckling before the slab sets.

As explained in my prior application above referred to, the cleats spaced along the top of the metal joists prevent slippage of the concrete slab in a direction longitudinal of the joists.

In the earlier invention I did not appreciate advantages that can be secured in using cleats of angle section by locating the cleats with the horizontal legs extending from the vertical legs toward the span center 24, that is toward the point of zero shear, as distinguished from placing them with the horizontal legs toeing toward the joist support 23 where the shear is maximum.

This advantage is two fold; first such placement makes it possible to secure the same result with less welding of the cleat to the top chord of the metal joist than otherwise would be required, and, second, it provides an apron support for the severed edge of the rib lath and the concrete while pouring and screeding to the required slab thickness, where needed, rather than providing such support where it can be of little or no advantage.

In regard to the first advantage, it will be understood that in the type of floor or roof structure herein described the neutral axis of any composite joist and flooring is in most cases although not always some distance below the concrete flooring and therefore some distance below the top of the metal joist, as at some line 33, Figure 2. This is particularly true with light metal joist construction and thin slabs.

Under this condition the force applied by the concrete flooring 15 to any cleat is always in a direction away from the center of the span, that is, away from the point of zero shear, as indicated by the arrow 34 in Figure 3.

It will be understood that the force transmitted by the concrete at 34, Figure 3, against the cleat on the side thereof toward the center of the span of the joist (toward zero shear) tends to shear the electric weld connection between the cleat and metal joist and also tends to overturn the cleat and produce tension rupture of the weld metal connection between the cleat and the joist.

It will be understood that the resistance of the cleat against overturning is a function of the lever arm on which the weld acts in tension. In other words, the distance L_1 perpendicular to the inactive face of the cleat and extending to the center 35 of the weld should be as long as reasonably possible.

When the metal in the angles forming the chord of the joist to which the cleats are welded is thin, as in many existing joist constructions, the welds should be as near to the vertical legs of the chord angles as is possible (this is shown in Figure 5), to prevent upward deflection of the horizontal legs of the chord angles and thus prevent any tendency of the cleats to tilt and thereby allow any of the force that the cleat is to resist to be passed on to other cleats which are not designed to take it. Each cleat should transmit the force assigned to it directly to the chord angles and through the chord angles to the web system of the joist (or in the case of a rolled joist section, directly through the flange to the web).

Taking up the other advantage from directing the toe 28' of the horizontal leg 28 toward the span center 24 rather than in reverse direction; this is incident to the dependence upon the expanded metal lath for the support of the freshly laid concrete and the need for safe-guarding the compactness of the concrete and the ultimate high quality of a sufficient extent of the concrete

at the bottom of the slab on the pressure side of the vertical leg 29, that is, at the arrow 34. There is no such need on the other side of the web 29.

In practice the expanded metal laths come in large sheets having a succession of ribs suitably used in supporting reinforcement bars 19 and 20, as already explained. Along the ribs the sheet has no expansion openings while intermediate the ribs the lath has many such openings so that it is possible for freshly laid concrete to pass down through the interstices of the sheet, bonding the sheet to the concrete, and making it possible that the concrete will not be so dense at the bottom of the slab as at the top of the slab.

In Figure 3 the lath 17 is indicated in dot-and-dash in the position which it assumes when first placed above the cleats and supported on them, that is, placed upon the tops of the vertical legs 29 of the cleats. The lath is then several along the vertical legs 29 by cutting it with a chisel or hitting it with a hammer against the upper edge of each cleat, and then pressing it down to the position indicated in full line, that is so that the vertical legs of the cleats extend up through the slits made in the expanded portion of the rib lath, which thus surrounds after it has been forced down about each vertical leg 29.

The lath is now strong enough at and tight enough around the cleat to receive the fresh concrete without any danger of forming porous concrete where it is particularly important that it be dense but it will be seen that the opposite severed edges along each vertical leg of the cleat angles are without firm support except directly over the joist chord. Since the rib lath is pushed down over the vertical legs, the severed edge will turn up against the vertical leg, as shown at 36, Figure 3.

The concrete closely adjacent the cleat, above 36, takes no compression stress, it being relieved by the cleat which transfers all the force coming to it from the concrete in the direction of the arrow 34 to the chord angles and thence to the web system of the joist.

It will thus be seen that it is quite important to have all the concrete above the cleat apron 23, Figure 3, dense concrete so that it can function in transferring the desired increment of the pressure in the slab to the cleat. This condition is secured by presence of the horizontal leg 28 which forms an apron directly beneath a sufficient extent of slab and beneath the severed edge of the rib lath in the direction toward zero shear, permitting easy and firm packing of the freshly laid concrete without danger of subsequent change by settling or seepage.

In practice this is quite important and makes the difference between a structure eminently suitable to the intended service and one much less well suited. When the horizontal portion of the angle cleat is directed away from the span center instead of toward it there is danger that the concrete itself may yield immediately adjacent the pressure side of one or more of the cleats, that is at the arrow 34. Such yielding would be due, as explained, to lack of compactness of the concrete in the slab in front of the cleat for sufficient distance toward zero shear to transfer by shear in the concrete its increment of the total compression in the slab (that is, the total horizontal shear between the slab and the joist). This lack of compactness could be due to lack of firm support of the severed edge of the rib lath and leakage of the freshly laid concrete downward through the expanded metal, if the horizontal leg of the cleat angle toed away from zero shear.

Usually for light joists, I prefer to resistance-weld the cleats to the joist, while for heavy beams having thick flanges requiring thick metal in the cleats, arc welding is more desirable in view of the greater ease of preparation of the respective blanks for welding in the two cases.

The cleat blanks 18 of Figures 3, 4, 5 and 6 are illustrated as for electric arc welding to the joist.

These cleat blanks are provided with two elongated laterally spaced perforations 37 through the horizontal legs 28 of the cleat 28, located some little distance inwardly from the edge of the horizontal leg and for registry above the two angles of the top chord of the joist that are separated by the web bar.

In arc welding the weld metal may wholly or partially fill the perforations 37, for example, as indicated in Figure 6 at 38, where the weld metal may pile up somewhat above the top of the perforations 37.

In the cleat blanks for resistance welding I provide the blank with two downwardly extending laterally spaced projections 39, preferably elongated as indicated in Figures 7, 8 and 9, intended to be located above the angles of the top chord of the joist, as with the arc welding, and some little distance inwardly from the edge of the blank. In the case of the resistance weld these projections press against the adjoining face of the chord and concentrate the current and thereby concentrate the heating effect at the projections, which are pressed flat at proper welding heat to give a finished weld somewhat as indicated at 40, Figure 10.

Cleats usually are attached to the joist more economically by resistance welding than by arc welding.

Cleats of angle section generally meet all conditions better than those of any other standard section and are therefore to be preferred.

Cleats of unsymmetrical T section, however, as seen in Figures 11 and 12, have the advantage of two sections to resist the bending moment on the cleats, section 28^2 and 28^3 on each side of the vertical leg 29', enabling the horizontal leg 28 to be made thinner than in an angle cleat which has only one section 28^4 at bottom of the vertical leg to resist bending moment. The thinner the section of the horizontal leg, the better the cleat is for resistance welding, because it requires less current to make the weld and less pressure to stamp the projections on the cleat blank.

It is desirable to have the required bearing area against the concrete long and low to lower its center of gravity and thus reduce the bending and overturning moments on the cleats.

If the weld points were placed far from the vertical legs of the chord angles, as for example near the outer edges of the horizontal leg of the chord angles 25 in Figures 5 and 9, tension in the weld would tend to cause an upward distortion of the horizontal legs of the chord angles and would allow the cleat to tilt with the result previously described. By the plan of locating the welds as close as possible to the vertical legs of the chord angles, tension in the welds is transmitted as directly as possible to the web system of the joist, thus enabling the cleats to be used on joists with very thin metal in the chords or flanges.

It will be understood that in the joist used in the present invention, all vertical shear produced by the extra carrying capacity of the composite

structure due to the cleats, will be transmitted directly to and resisted by the web system of the metal joist. The horizontal shear, on the other hand, which originates in the slab, is taken up by the cleats and by them transmitted to the joist and to its web system, so that only enough cleats need be used to resist the total horizontal shear between the slab and the joist and the extent of their distribution is independent of the distribution of vertical shear. It is generally desirable to have a short cleat at or near the center of the span merely to receive a lateral brace and a slab gauge, although it does not function to take shear.

There are other advantages in having an angle cleat toe toward the point of zero shear, besides having an apron to insure dense concrete to function with the cleat in transmitting horizontal shear to the web system of the joist or beam.

When the angle cleat toes toward zero shear the effect is to transmit through the medium of the vertical leg of the cleat the downward vertical component resulting from the overturning moment on the cleat directly to the vertical legs of the chord angles and thence to the web structure. Thus none of this vertical downward component has to be taken by the horizontal leg of the cleat and the thickness of the horizontal leg of the cleat is not material in so far as this vertical downward component is concerned. Were the situation reversed, and the cleat caused to toe away from the direction of zero shear, the thickness of the horizontal leg of the cleat would be a material factor from the standpoint of transmitting this vertical downward component to the web system as well as from the standpoint of bending moment induced in it by the overturning moment on the cleat.

It will be evident that it is quite desirable to have the weld points **37** or **39** as close as possible to the vertical legs of the chord angles of built-up joist or to the webs of light rolled beams, so that the tension in the welds will not tend to distort either the thin horizontal legs of the chord angles or the thin horizontal flange in the case of light joists or beams.

In case, however, the cleat angles were to toe away from the direction of zero shear, the upward vertical component resulting from the overturning moment occurs at the vertical legs of the cleat angles (not down as before) and the downward component occurs at the toe of the horizontal legs of the cleat angles. The downward component originates all along the length of the cleat angles and consequently if the horizontal legs of the chord angles are to be relieved of bending pressure, the horizontal legs of the cleat angles would have to be stiff enough to transfer the vertical pressure to the vertical legs of the chord angles. This will require much thicker cleat angles than when the cleat angles toe toward zero shear.

Furthermore, when the cleat angles toe away from zero shear, the section of the horizontal leg of the cleat required to resist the bending moment in it will have to be maintained from the vertical leg of the cleat to the toe **28'** of its horizontal leg. Thus it would not be advisable to shear the ends as at **43** in Figure 5, to form a tapered horizontal leg, as can be done in the case of the cleat angles toed toward zero shear, making a neater job.

Considerable advantage has been obtained in the present invention by centering or substantially centering the attachments of the cleats (the welds in the specific form shown), over the points where the web bars connect with the upper chord of the fabricated joist. For practical purposes, the point of connection between the web bar and the upper chord of the fabricated joist is the bend in the web bar in most conventional joist constructions. By locating the cleat above the point of connection between the web bar and the chord of the joist (Figure 1), the increments of pressure coming to the cleat from the slab will be passed more directly to the web system. It thus becomes unnecessary to consider the area of the upper chord of the joist in calculating the moment of inertia of the composite section (the joist and the set slab). Omitting the area of the top chord in calculating the moment of inertia gives a larger moment of inertia than when the top chord area is taken into account, a larger compression area being required on the slab and the center of gravity of this larger area being farther away from the neutral axis of the composite section which is located by the maximum extreme working stresses in terms of steel.

It will thus be evident that there is special advantage in locating the cleat attachments immediately above the points of connection of the web bar to the upper chord of the joist. In Figure 5 the dotted line **44** is shown to indicate the line of centers of the welds and the centers of the points of connection of the web bar to the upper chord of the joist. Where the web bar is secured to the upper chord at two points for each attachment, the line **44** should pass equidistant between these points.

In view of my invention and disclosure variation and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain part or all 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 metal joist for use in composite floor or roof structure and including an upper chord having a vertical web, and a succession of cleats of angle section across the chord, spaced along, and with their horizontal legs welded to the chord and extending toward the middle of the span from the vertical legs, the points of welding being at a distance from the edges of the legs and being near the vertical web of the chord so as to bring strain on the web rather than on the flange of the chord.

2. A metal joint for use in composite floor or roof structure including an upper chord having a vertical web, and a succession of angle bar cleats across the chord having the legs of the cleats arranged vertically with respect to the chord and horizontally away from the vertical legs in the direction of the center of the joist span, the horizontal legs terminating in free edges and being fastened to the chord at a distance from their free edges and near the vertical web of the chord so as to bring strain on the web rather than on the flange of the chord, centering resting upon the horizontal legs of the cleats and upon the chord adjacent the vertical legs of the cleats at the other sides of the cleats and concrete resting upon the centering and embedding the vertical legs of the cleats.

EUGENE S. POWERS.