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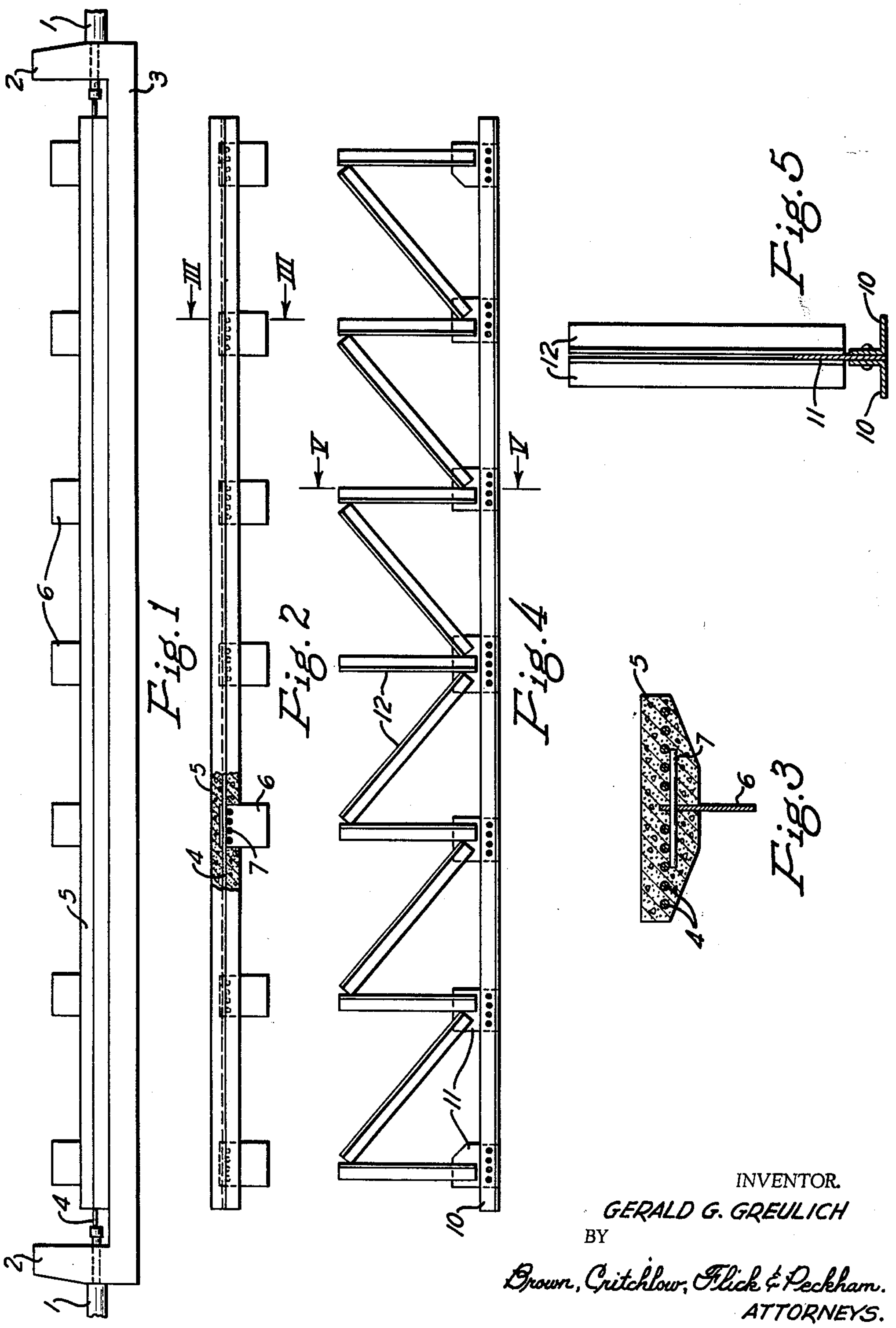
3,166,830

METHOD OF MAKING PRESTRESSED GIRDER

Filed May 2, 1962

2 Sheets-Sheet 1



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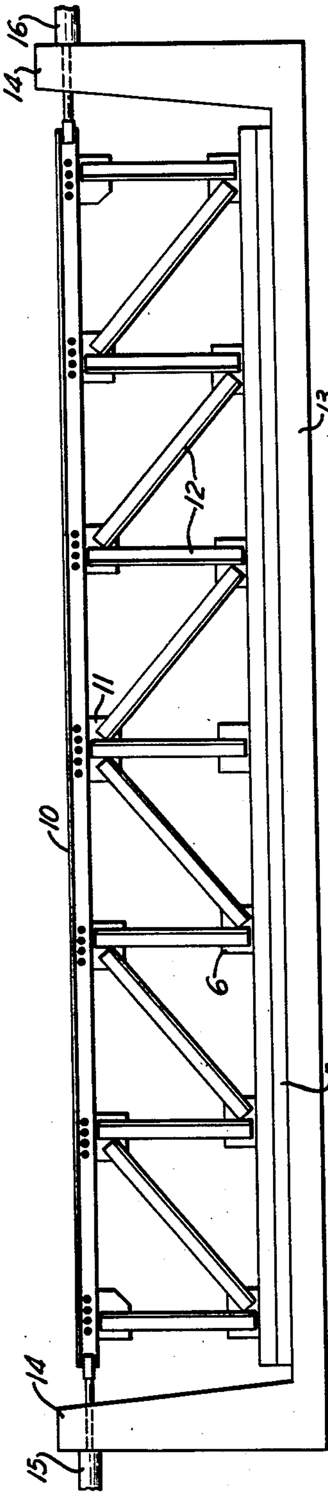

Fig. 6

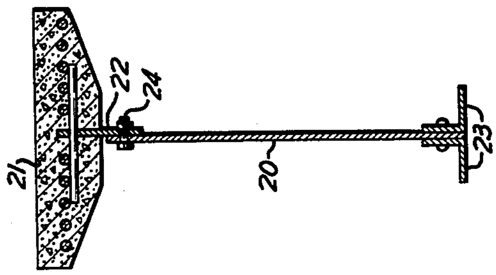

Fig. 9

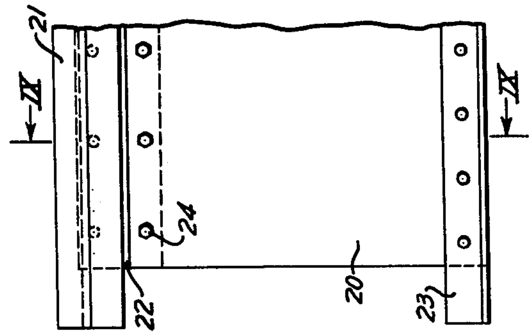

Fig. 8

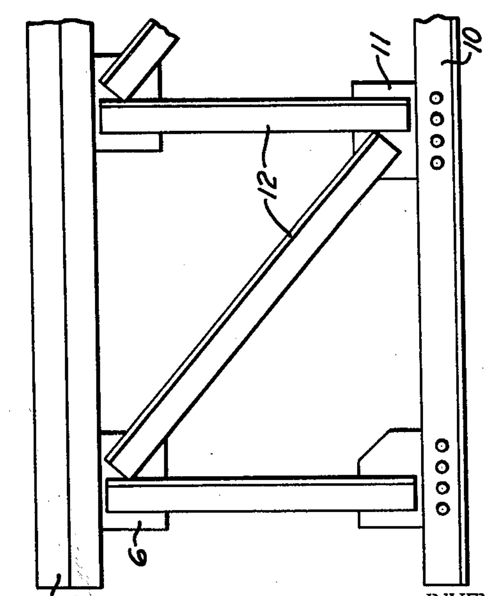

Fig. 7

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METHOD OF MAKING PRESTRESSED GIRDER

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This invention relates to a method of making prestressed girders, and more particularly to one in which only the top chord is made from prestressed concrete.

Prestressed concrete construction has attained its present acceptance and widespread use because, by reducing dead loads or permitting the use of larger clear spans with the same dead load or weight, as well as greater stiffness of construction with less deflection, a less costly and more flexible building design is possible. It is also known that because prestressing uses concrete more fully, less of it is required for a given loading condition so that the benefits of a lighter building are obtained without sacrificing strength or rigidity. Lower overall weight naturally reduces column and foundation size requirements, with attendant reduction in their costs. The factor of lower deflection also reduces problems of fitting long rows of window frames or prefabricated partitions into buildings. Nevertheless, in spite of all of these advantages, prestressed concrete beams and girders are very heavy to transport and handle, while it is quite an undertaking to do the prestressing at the site of the construction.

It is among the objects of this invention to provide a method of making a prestressed girder which is relatively easy to make, which can be constructed either at the prestressing plant or at the building site, and which expedites building.

In accordance with this invention only the top chord of a girder is made from prestressed concrete. It is made separately from the rest of the girder before the girder is assembled. Also in a separate operation a metal web is secured to a metal bottom chord. Then the bottom chord, and preferably at least part of the web, are stretched lengthwise in suitable apparatus. While the bottom chord is maintained in its stretched condition, the metal web is rigidly secured to the top chord, such as to gusset plate means projecting from the concrete. Then the stretching apparatus is disconnected from the bottom chord and the girder is complete. The concrete upper chord of the girder is under material compression, due to the prestressing, and the lower chord is under material tension because of the pretensioning which is maintained by the web.

The invention is illustrated in the accompanying drawings, in which

FIG. 1 is a side view of the top chord of my girder in inverted position in prestressing apparatus;

FIG. 2 is a side view of the finished top chord right side up, with a portion broken away in section;

FIG. 3 is an enlarged cross section of the top chord taken on the line III—III of FIG. 2;

FIG. 4 is a side view of the bottom chord and the web secured to it;

FIG. 5 is an enlarged cross section taken on the line V—V of FIG. 4;

FIG. 6 is a side view of the elements of the girder inverted in apparatus for prestressing the bottom chord;

FIG. 7 is a fragmentary side view of the finished girder;

FIG. 8 is a view similar to FIG. 7 of a modification; and

FIG. 9 is a vertical section taken on the line IX—IX of FIG. 8.

The top chord for my girder is made by molding concrete into the desired shape around cables or rods, hereinafter called tendons. The tendons are disposed side by side in the mold and their ends are fastened to suitable tension jacks. Before or after the concrete has been poured in the mold the jacks are actuated to stretch the tendons short of their elastic limit, and they are held in that condition until after the concrete sets. Then the tendons are released from the jacks, and their tendency to contract places the concrete under compression to form a prestressed chord. In FIG. 1 of the drawings, some of the apparatus which can be used for carrying out this method is shown. It includes jacks 1 mounted in horizontally spaced anchor members 2 that may be held a fixed distance apart by a horizontal beam 3 joined to their lower ends. Each anchor member supports one or more rows of the jacks, which are detachably secured in any suitable manner to the opposite ends of a plurality of parallel tendons 4. If desired, the jacks can be eliminated at one end and their places taken by fixed clamps. The drawing shows the top chord after the concrete 5 has set and the forms have been removed, but before the tendons have been released from the jacks. The chord is bottom side up.

To enable the web of the girder to be readily connected to the concrete top chord, it is preferred that at the time of molding the chord a line of upwardly projecting metal gusset plates 6 should be embedded in the concrete. To help anchor the plates in the concrete, they may be provided with holes, through which extend dowel pins 7 that are likewise embedded in the concrete as shown in FIGS. 2 and 3. After the concrete has set, the jacks are released from the tendons, which then will tend to contract to their original length. In doing so, they will compress the concrete lengthwise of the chord and thereby form a prestressed top chord for a girder. The projecting ends of the tendons will be cut off flush with the ends of the concrete member.

In an entirely separate operation, the web of the girder is secured to the bottom chord. Both of these parts are all metal. The web and chord may take various well-known forms, a very suitable form being shown in FIGS. 4 and 5. It will there be seen that the bottom chord is formed from parallel angle bars 10 riveted or welded to the opposite sides of a line of gusset plates 11. The web is formed from short angle bars 12, preferably arranged in pairs, riveted or welded at one end to the opposite sides of the gusset plates. Some of the bars are vertical and some are inclined, the inclined bars at one side of the center of the web being inclined opposite to those at the other side of the center of the web. In the finished girder the vertical bars usually will be compression members and the inclined bars usually will be tension members.

The next step is to secure the web bars 12 to the gusset plates 6 of the top cord. This is done by placing the inverted top chord on a suitable support, such as a long rigid beam or platform 13 having anchor members 14 at its opposite ends. Mounted in one of the anchor members near its top is a pulling jack 15, while a similar jack 16 or a rigid clamp is mounted in the other anchor member. They are clamped to the adjoining ends of the bottom chord, which is held by them in inverted position with the web bars extending down and straddling the lower row of gusset plates 6 projecting from the inverted top chord. Before fastening the lower ends of the web bars to the adjoining gusset plates, the jack or jacks are actuated to stretch the chord bars **10** and hold them under tension. This spreads the lower ends of the web bars farther apart. While the bottom chord of the girder is held in tension in this way, the web bars are riveted or welded to the lower gusset plates to form a complete girder.

It will be seen that when the bottom chord subsequently is released from the tensioning means, its longitudinal contraction will be restrained and largely prevented by the inclined web tension bars pulling against the prestressed top chord at their lower ends. The same action causes the inclined bars to help tendons 4 hold the top chord under longitudinal compression. When the girder is removed from the tensioning apparatus and turned right side up, it will appear as shown in FIG. 7, with a prestressed (compressed) top chord and a prestressed (tensioned) bottom chord. As has just been explained, both chords of the girder were prestressed before they are connected together. The resulting girder will be much stronger than an ordinary girder and therefore can be used in longer lengths without intermediate support. The components of the girder will not change their lengths appreciably until loads greater than design loads are applied to them. Also, due to the greatly reduced deflection in such a prestressed girder, shallower girder depths can be used, thereby reducing the overall heights of buildings while maintaining the same clearance between floor and ceiling.

Girder deflection under load can be reduced still further by elongating the inclined web bars before fastening their free ends to the top chord. The elongating can be done by applying heat in any suitable manner to the bars throughout their lengths. At the same time, where possible, it would be desirable to shorten the vertical web bars by chilling them throughout their lengths. While the web bars are longitudinally expanded and contracted in this manner, their free ends are secured to the gusset plates of the top chord. Then, when the web returns to room temperature, the inclined bars will be under greater tension than otherwise and the vertical bars will be under greater compression. Conseqeuntly, deflections under load, due to the web changing its dimensions, will be even less than if the web were not treated as just explained.

A big advantage of my method and the girder produced by it is that I can use a commercially produced prestressed top chord, instead of having to prestress at the building site. There is no waiting for concrete to set after the girder has been assembled. There is no prestressing to be done after the girder has been mounted in place in the structure, of which it is to form a part. The concrete top chord can be made wide and massive enough to form a part of the floor slab. The prestressed top chords, made at a manufacturing plant, can be assembled with the web and bottom chord either at the same plant or at the location where the web and bottom chord are made. In case there are a sufficient number of duplicate girders to be used on a given job to justify it, the assembly of the top chords with the preassembled webs and bottom chords could be done in assembling equipment at the job site.

Concrete is a most economical material for carrying compressive stresses, while steel is ideally suited for tension. In my girder the two materials are combined in their proper relationship to the greatest advantage. Shipment of the girder is lower in cost than the shipment of all-concrete members, because the steel webs and bottom chords weigh appreciably less than the concrete webs and bottom chords or flanges of precast concrete beams or girders. This reduction in weight also makes my girder easier to handle and reduces building weights.

In the modification shown in FIGS. 8 and 9 the web **20** of the girder is formed from a steel plate that may be solid or have sections punched out of it. The concrete top chord is made and prestressed in the same way as the one previously described, except that instead of embedding a series of gusset plates in the concrete **21**, it is preferred to embed a single continuous gusset plate **22**. The lower edge of the web plate is secured by means of welding rivets or bolts to the bottom chord of the girder, which may be formed from a single member or a pair of angle bars **23**. The top chord is laid bottom side up in tensioning apparatus similar to that shown in FIG. 6, and stretching apparatus is secured to both ends of the inverted bottom chord and the web plate above the top chord to stretch them. While thy are under tension, the lower edge of the web plate may be welded to the long gusset plate **22** projecting from the top chord, or a line of holes may be drilled along the lower edge of the web plate to match holes previously drilled in the gusset plate. This plate and the web then can be secured together by bolts **24** or the like. The bottom chord and web then are released from the jacks and the girder is removed from the tensioning apparatus and may be turned right side up as shown in the drawings. The prestressed top chord of the girder prevents the stretched web and bottom chord from contracting longitudinally. A solid web girder of this type is preferred where it is desired to use a girder having an unusually shallow depth.

According to the provisions of the patents statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. The method of making a girder, comprising prestressing a separate concrete top chord to place it under permanent material compression, rigidly securing a metal web to a metal bottom chord, stretching the bottom chord lengthwise until it is under material tension and then rigidly securing the web to the top chord while maintaining the bottom chord stretched.

2. The method of making a girder, comprising prestressing a separate concrete top chord to place it under permanent material compression, rigidly securing one edge of a metal web plate to a metal bottom chord, stretching the plate and bottom chord lengthwise together until they are under material tension, and then rigidly securing the opposite edge of the web plate to the top chord while maintaining the plate and bottom chord stretched.

3. The method of making a girder, comprising prestressing a separate concrete top chord to place it under permanent material compression, rigidly securing one end of metal web bars to a metal bottom chord with some of the bars at each side of the center of that chord inclined therefrom outwardly toward its ends, and stretching the bottom chord lengthwise until it is under material tension and while stretched rigidly securing the opposite end of the bars to the top chord.

4. The method of making a girder, comprising prestressing a separate concrete top chord to place it under permanent material compression, rigidly securing one end of metal web tension bars and of metal web compression bars to a metal bottom chord, stretching the bottom chord lengthwise until it is under material tension, heating the tension bars to elongate them, and then rigidly securing the free ends of all of said bars to the top chord while the tension bars remain elongated and the bottom chord remains stretched.

5. The method of making a girder, comprising prestressing a separate concrete top chord to place it under permanent material compression, rigidly securing one end of metal web tension bars and of metal web compression bars to a metal bottom chord, stretching the bottom chord lengthwise until it is under material tension, heating the

tension bars to elongate them, chilling the compression bars to contract them, and then rigidly securing the free ends of all of the bars to the top chord while the tension bars remain elongated and the compression bars remain contracted and the bottom chord remains stretched.

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