Aug. 20, 1963 G. W. SETZER 3,101,272

PROCESS FOR IMPROVING STRUCTURAL MEMBERS AND IMPROVED STRUCTURAL MEMBERS

Filed Aug. 4, 1959

Fig. 1.

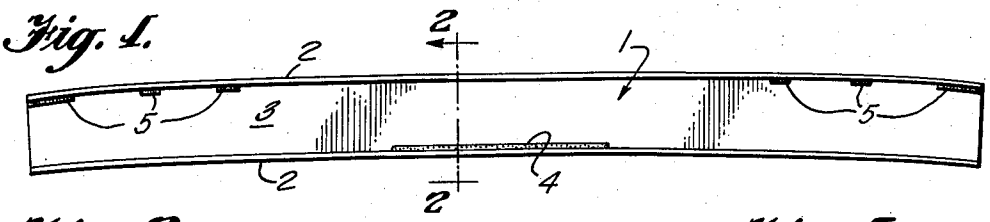


Fig. 2.

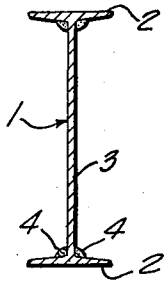


Fig. 5.

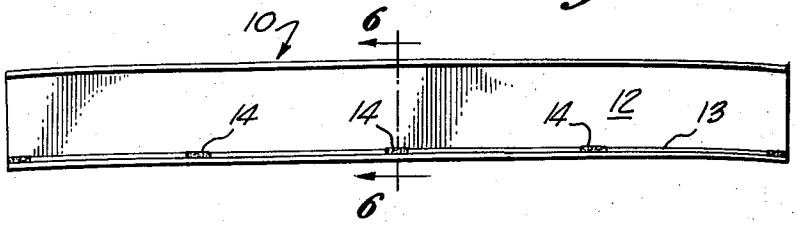


Fig. 6.

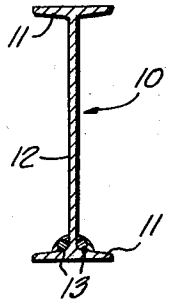


Fig. 3.

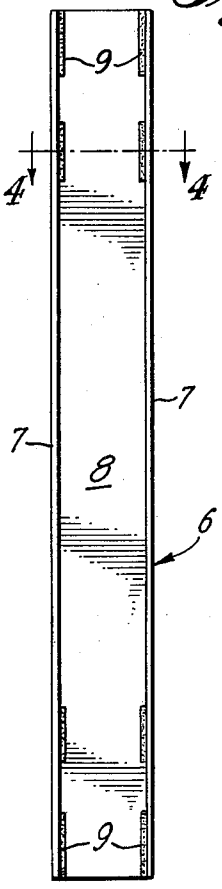


Fig. 4.

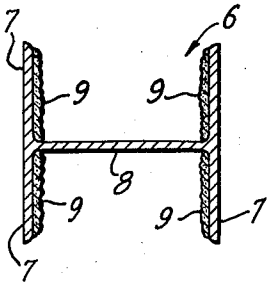


Fig. 8.

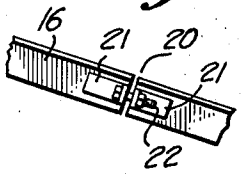
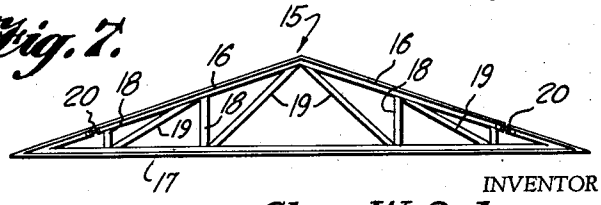


Fig. 7.



INVENTOR

Glenn W. Setzer

BY Mason, Fenwick & Lawrence

ATTORNEYS

United States Patent Office 3,101,272 Patented Aug. 20, 1963

3,101,272

PROCESS FOR IMPROVING STRUCTURAL MEMBERS AND IMPROVED STRUCTURAL MEMBERS

Glenn W. Setzer, Johnson City, Tenn.
(21 3rd St., Bristol, Tenn.)

Filed Aug. 4, 1959, Ser. No. 831,670
3 Claims. (Cl. 117—7)

This invention relates to the art of load-bearing members, and to new processes for the designing of structural members and structures, for their manufacture, and for reinforcing existing structures, and to the new members so designed and manufactured.

The principal object of the present invention is to provide a process for permanently improving the load-bearing qualities of structural elements and members, whereby structural members of given size, weight and design may support increased loads within allowable deflection, or support presently normal loads without deflection.

A more specific object of the invention is to provide a process for improving the load-bearing qualities of structural members by imposing permanent pre-loads in the members, acting in a reverse direction to the direction of the bearing load to be imposed.

Another object is to provide such a process by which a reverse pre-load is incorporated in a structural member which must be overcome by the imposed bearing load before the member is put to work in a normal fashion.

A further object is to provide a process of this nature, and members produced thereby, whereby structural members of increased stiffness will be provided with the result that there will be less damage in transportation, greater ease in erection, and improved rigidity of erected structures.

Yet another object is the provision of a process of pre-loading structural members whereby the members, being reversely pre-loaded, will carry loads in opposition to one another when in use, so that beams, for example, will be loaded top and bottom.

Another object is the provision of such processes and members which will enable greater spans to be utilized and normal framing depths to be materially reduced.

A still further object is to provide such processes and members which, by reason of the reverse load, will be less subject to deformation under concentrated and moving live loads.

Other objects of the invention will become apparent from the following disclosure of practical embodiments thereof, when taken in conjunction with the drawings which accompany, and form part of, this specification.

In the drawings:

FIGURE 1 is a side elevation of a beam, treated in accordance with the process of the present invention to impart a permanent reverse load;

FIGURE 2 is a vertical transverse section through the beam, taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a side elevation of a column fabricated in accordance with the present invention;

FIGURE 4 is a horizontal section through the column, and is taken on the line 4—4 of FIGURE 3;

FIGURE 5 is a side elevation of a beam treated in a slightly different manner from that of FIGURE 1 in order to obtain pre-loading;

FIGURE 6 is a vertical transverse section through the beam shown in FIGURE 5, taken on the line 6—6 of FIGURE 5;

FIGURE 7 is a somewhat diagrammatic view of a truss, the members of which have been improved by the new process; and

FIGURE 8 is a detail view of one member of the truss, with the member shown on a greatly enlarged scale.

In general, the invention consists in a process by which structural members and elements are pre-loaded by permanently imparting reverse loads to the members to resist the loads which are to be imposed in use, and to the members so processed. The preloads can be imposed by compressing, and holding compressed, those areas of structural members which will be in tension under load, and tensioning, and holding tensioned, those areas which will be subjected to compression forces. These forces may be put in singly, or in opposition so as to control the camber of an element and to increase its rigidity before imposition of the physical load which it is to carry. The preloading may be applied to structural elements such as beams, columns, etc. or to fabricated structural members, such as trusses.

Referring to the drawings in detail, and first adverting to FIGURES 1 and 2, there is shown a beam 1, or I-beam cross-section, having horizontal flanges 2 top and bottom and a central vertical web 3. This is the conventional beam used for floor and ceiling joists, and for spanning between two walls, piers, etc.

It is well known that whenever a beam, such as that shown in FIGURE 1, is supported at its ends and subjected to load intermediate the bearing points, that the beam will flex, or bend, downwardly. The bending will take place about a central, horizontal, neutral axis, and the beam above this axis will be in compression, while below the axis the beam will be in tension. These two forces work together to support the load. It has been proposed to camber beams of this type so that the initial load will be taken entirely in compression. A cambered beam, however, is completely inert when unloaded, and the material of the beam is put to work immediately upon imposition of the load. If the load causes the beam to assume a horizontal position, the effect of the camber is eliminated, as the beam will be put into compression and tension as outlined above for the uncambered beam.

The present invention provides for the actual pre-loading of the beam in an opposite direction from the direction of load to be applied. In other words, if the beam is to lie horizontally and have a load seated upon it to act downwardly, the beam will be provided with an actual upward thrust to offset, in part at least, the downwardly acting load. This is achieved primarily by putting the lower chord of the beam in compression, and tying in the compression, to provide a real opposing force for the load to be placed upon the beam.

There are various ways that the above result can be accomplished. In FIGURES 1 and 2, the beam is improved by adding welding metal to the lower flange central web areas where the pre-load is desired. For example, welding metal is applied along the central part of the beam, in the angle formed between the bottom flange and the central web, as at 4. The metal 4 is applied by a conventional welding operation which causes some heating of the beam in and adjacent the area where the molten welding material is laid. The degree of heating of the beam, however, is much less than the heat of the molten welding material and, consequently, the welding metal will shrink in cooling to a greater degree than the beam. As the welding metal commonly used has far greater tensile strength than the metal of the beam, the shrinking welding material will act to draw the material of the beam with it, so that the lower chord of the beam will be put, and held, in compression along the full length of the weld material.

It will be readily apparent, that by controlling the length of weld material and the placement of the weld, or welds, as the case may be, the degree of compression

of the lower chord, and the areas of compression, can be closely controlled.

It has been found that the strength and rigidity of the beam can be further improved, and the degree of camber caused by the placement of the weld metal along the lower flange controlled by adding welding material at selected places along the top chord of the beam. By placing weld material on the beam at spaced points, the beam material in the area of the weld is compressed, as described, but the shrinking of the material in those areas will serve to draw, or tension, the beam material intermediate the areas of weld. Thus, the welding in areas of short length along the top chord will create areas of tension between them and the major portion of the top chord can be so tensioned if desired. It will be noted from FIGURE 1 of the drawings that several areas 5 may be welded along the top chord to produce the desired result. These are located near the ends of the beam so that the center section of the top chord will be tensioned in the general region of the compressed section of the lower chord.

It will be obvious that beams treated in this manner will be definitely strengthened and rigidified, and with the arrangement shown in FIGURE 1 particularly in the central section, so that they will be capable of supporting heavier loads and being used to span greater distances. The reverse load which is permanently imposed must be overcome by the load placed upon the beam before the material of the beam begins to work. In other words, the only load which the beam material must carry is the difference between the actual load and the reverse load which has been put into the beam.

The same method of pre-loading has been illustrated in FIGURES 3 and 4 in connection with a column. The column 6 is also of I-beam cross-section, having the side flanges 7 and central web 8. A column takes its load in compression throughout. The tendency of overload is to crush, or buckle, the beam. To offset this, the beam has both side flanges treated to stretch the major portions of their lengths and put them in tension. This is done by welding in selected areas, preferably adjacent the ends, as at 9, or in other non-critical zones, to shrink the metal in those areas and thereby stretch the metal in the intervening zones. This will provide tension in the opposed areas of the flanges, considerably rigidifying the member and increasing its resistance to collapsing forces. The application of the welding metal in the treated areas will so reinforce these areas that they will withstand any compression overload that may ever be imposed through the balance of the member. It will be seen in FIGURE 4 that the weld may cover the entire flange if needed for strength.

In FIGURES 5 and 6, there is shown a slightly different method of reverse loading a beam. Here, the beam 10 which has flanges 11 top and bottom and central web 12, is treated by the attachment of one or more rods 13 by means of a plurality of welds 14. The rod is laid on the beam at the juncture of the bottom flange and the central web, and then attached by first welding its ends to the beam. Weld metal is then applied to the rod at points intermediate the ends of the rod to shrink the rods at these points. This results in shortening the rod, so that the rod serves as a plurality of short tie rods, intermediate the points of attachment to the beam, to pull and hold, the beam into compression along its lower chord. Thus, the amount of preload and camber can be very closely controlled.

The methods outlined above for improving structural elements may also be used for improving the load-carrying characteristics of fabricated structural members. For example, there is shown in FIGURE 7 a somewhat diagrammatic illustration of a conventional Pratt truss 15 having inclined top chords 16, horizontal base chord 17, vertical posts 18 and inclined braces 19. Under normal loading, the inclined top chords 16 and the vertical posts 18 are under compression and all of the other members are in tension. In order to offset the load, the present invention contemplates preloading each element of the member, placing the members in compression or in tension after fabrication of the truss. All elements which are to be subjected to compression under actual load, that is the chords 16 and posts 18, will be placed in tension, and those to be subjected to tension will be put in compression. Thus, every element will be pre-loaded with a load to oppose the actual load when in use. The preloading can be accomplished as previously described by the application of weld metal or those elements to be tensioned can be shortened by other means. However, it has been found that due to the presence of many triangular shapes in the truss, the tensioning of the top chords will be effective to change the loading of all of the elements of the truss. In other words, by changing the length of one side of the outer triangular structure all sides of all triangles within the structure are proportionately affected.

One practical way of achieving the reverse loading of a truss is to cut the top chord adjacent one of the vertical poses 18 to provide a gap 20. Appropriate brackets 21 are affixed to the cut ends of the chords, and draw bolts 22 are used to pull the cut ends toward one another to impose a tension strain upon the chord. As described, this will reverse load all of the elements of the structure. After the bolts have been tightened the desired amount, the adjacent ends of the chords may be welded to permanently hold the tension. This method, or variations thereof, of imposing the reverse load will be suitable for use with the trusses, or other structural members, irrespective of the material from which the truss is formed.

By this means, the same pre-loading may be applied to fabricated structures as to single structural elements. It will be realized that the truss shown and described is merely illustrative of all trusses including bar joists, long span joists, underslung trusses, cantilever trusses and all framing that resists the imposed loads by a combination of compressive and tensile strengths.

The pre-loading methods described above can be used also to reinforce existing structures, to enable them to better withstand existing loads, to receive greater loads, or to permit the removal of columns to allow greater use of existing space. Weld metal can be applied to the elements of these structures (if the structure is metal) to shrink or stretch the elements, or their chords, as described, and thereby impose a reverse load to counteract the load already in place, or the greater load to be carried.

It will be readily apparent that the application of the principles of this invention to structural elements and members will greatly rigidify them and, at the same time, incorporate in the elements and members a force acting oppositely to the load to be carried, which force must be overcome by the load before the element or member is put to work to support the load. This greatly increases the load-carrying capabilities of the structural units and permits the designer to utilize smaller load-carrying units for supporting given loads. The variation permitted in locating the reverse pre-load in the units opens unlimited design possibilities. The preloading principle will also lend itself to the design of new structural shapes by reason of the improved load-carrying capabilities. The pre-loading can be practised industrially by the shrinking and stretching of the metal members, or parts thereof, by applying very hot, or molten, metal as disclosed or by other appropriate means. The same processes form very economical means for strengthening and improving existing structures.

While in the above practical examples of the invention have been disclosed, it will be understood that the precise details of procedure and structure described and shown are merely for purposes of illustration, and the invention may take other forms within the scope of the appended claims.

What is claimed is:

1. A process for improving load-bearing metal struc-

tural members comprising, applying molten metal along a portion of the member normally acting in tension under load, and allowing the applied metal to cool and shrink to draw the portion of the member to which said molten metal has been applied into compression and hold it compressed.

2. A process for improving load-bearing metal structural members comprising, applying molten metal at spaced points along that portion of the member normally acting in compression under load and outside of the point of greater load, and allowing the applied metal to shrink to draw the portions of the member to which said molten metal has been applied into compression and hold them compressed and thereby stretch the portions of the member intermediate the compressed portions into tension and hold them tensioned.

3. A process for improving metal load-bearing members as claimed in claim 2 wherein molten metal is applied along a portion of the member normally acting in tension under load, and allowing the applied metal to cool and shrink to draw the portion of the member to which said molten metal has been applied into compression and hold it in compression.

References Cited in the file of this patent

UNITED STATES PATENTS

1,967,827	Leake	July 24, 1934
1,970,966	Leake	Aug. 21, 1934
2,039,398	Dye	May 5, 1936
2,108,373	Greulich	Feb. 15, 1938
2,299,778	Wissler	Oct. 27, 1942
2,389,386	Russell	Nov. 20, 1945
2,735,168	Leonhardt et al.	Feb. 21, 1956
2,811,773	Baskin	Nov. 5, 1957
2,882,068	Hendrix	Feb. 4, 1958
2,887,762	Dobell	May 26, 1959
3,010,257	Naillon	Nov. 28, 1961

FOREIGN PATENTS

1,048,852	France	Aug. 12, 1953