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BOX BEAM

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2 Sheets-Sheet 2

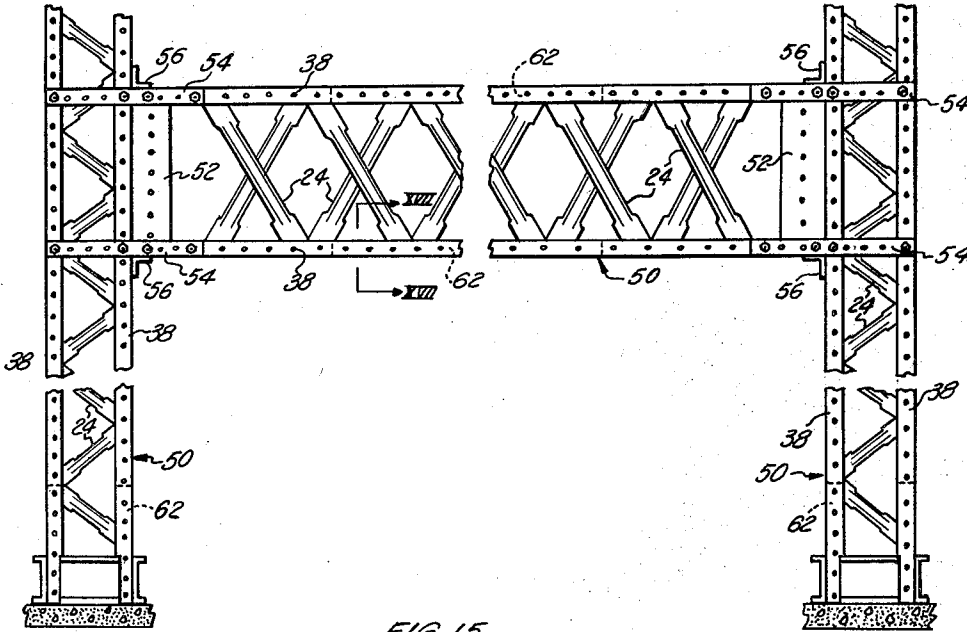


FIG. 15

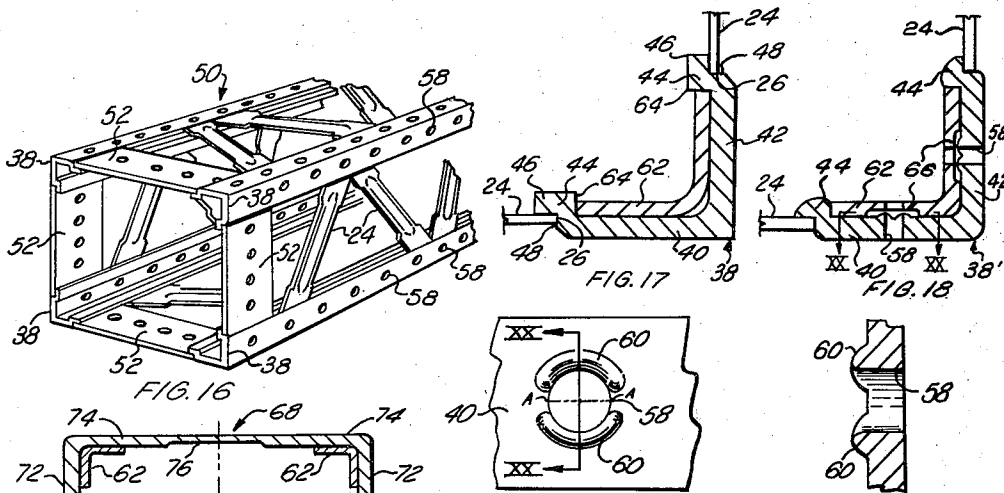


FIG. 19

FIG. 20

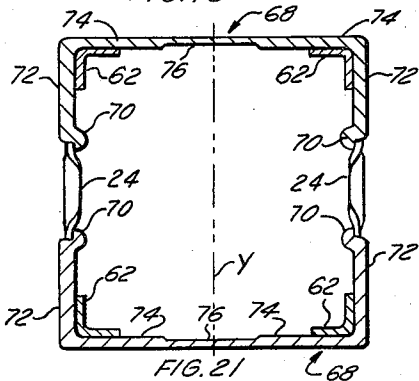


FIG. 21

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3,103,262 BOX BEAM

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14 Claims. (Cl. 189—37)

The invention relates to box beams and similar structural members and particularly pertains to such structural members which are fabricated from aluminum.

Heretofore structural members wherein strength is of importance are usually constructed of steel and the use of steel beams, either rolled or fabricated, is quite satisfactory in many applications. However, installations such as an electrical substation, wherein the primary structure of the members is exposed to the weather, are costly to maintain and construct when made of steel due to the steel corroding and requiring periodic repainting and the weight of the structural means is such that heavy equipment and manpower is required during erection of the beams and columns. Aluminum has been considered as a possible substitute for steel in installations where light weight and resistance to corrosion are important factors, however, the increased bulk of aluminum necessary to provide comparable steel strength characteristics with conventional structural forms makes aluminum economically unfeasible.

It is thus an object of the invention to provide a structural form fabricated from aluminum components which is of such design as to provide a very high strength to weight ratio whereby aluminum may be economically employed as a structural material.

Another object of the invention is to provide an aluminum structural beam construction wherein relatively thin members may be welded together without damage to the metal due to excessive heat and clean, flush welds may be produced.

A further object of the invention is to provide a box beam construction wherein a positionable reinforcing member may be selectively located within a standard beam to increase the strength of the beam at the area of greatest stress in accordance with the type beam support employed.

Yet another object of the invention is to provide standard truss components which may be assembled in several forms to provide either "I" or box sections minimizing inventory requirements and permitting versatile use of the components.

These and other objects of the invention due to structural novelty and design will become apparent upon consideration of the following description and accompanying drawings wherein:

FIGS. 1 and 2 are elevational views of possible "I" section trusses in accordance with the invention,

FIGS. 3 and 4 are elevational views of possible box-section beams having double lacing,

FIGS. 5 and 6 are elevational views of modifications of box trusses having triple lacing,

FIG. 7 is a sectional view of an "I" section truss as in FIGS. 1 or 2,

FIGS. 8 and 9 illustrate sectional views of box beams having double and triple lacing, respectively,

FIG. 10 is a modification of an "I" beam.

FIGS. 11, 12 and 13 are cross sectional views taken along lines XI—XI, XII—XII and XIII—XIII of FIG. 2, respectively,

FIG. 14 is a sectional elevational view of a modification of truss flange,

FIG. 15 is an elevational view of a typical installation incorporating the beam of FIG. 16 and reinforcement insert,

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FIG. 16 is a perspective view of a box beam in accordance with the invention, and

FIG. 17 is a cross sectional view taken along line XVII—XVII of FIG. 15,

FIG. 18 is a modification of a chord angle construction shown in sectional view and taken through holes formed in the angle,

FIGS. 19 and 20 are plan and elevational views, respectively, of a hole construction which may be employed with the beams and trusses of the invention, and

FIG. 21 is a sectional elevational view of a modification of a box beam employing channel flanges and double lacing.

The present invention is an improvement over the box beam of my copending application 697,168, filed November 18, 1957, now Patent No. 3,044,585, wherein improved welding and strength characteristics over the copending application are obtained.

Truss structure employing the concept of the invention is shown in FIGS. 1—14 wherein three types of beam flanges are shown and several lengths and shapes of lacing section are used to produce many variations of trusses and beams. One type of beam flange 10 is best illustrated in FIGS. 7—9 which may consist of an aluminum extrusion, casting or forging of elongated form. The flanges used for the top and bottom are identical and hence an explanation of one will suffice for the other.

The flange 10 includes three positions at which the lacing may be affixed, each of the edge portions of the flange include for such purpose an enlarged section 12 on which a projection 14 is formed to define a surface 16 and a shoulder 17. The surface 16 is formed with a sharply defined intersection with shoulder 17 and the projection 14 is of a length greater than the width of the lacing material as will be later apparent.

Intermediate the longitudinal edges of the flange a third lacing anchorage is provided in the form of the centrally disposed rib 18 which extends the length of the flange 10 and projects from the general plane of the flange. The rib 18 is formed with a bulbous end 20 which is recessed at 22 to provide a shoulder to receive the ends of the lacing struts.

The lacing 24 employed by the instant invention is similar to that of the co-pending application and is formed from aluminum extrusions of a cross sectional form somewhat similar to that shown in FIG. 12. The extruded length is then cut to length and forged to final shape whereby the central portion is shaped as in FIG. 13, the ends are flattened to planar form as in FIG. 11 and the lacing portion in the transition area between the ends and central section will be of the configuration of FIG. 12. The planar ends are then trimmed whereby an end edge 26 is presented at the desired angle to the axis of the lacing depending on the angular relationship of the lacing to the flange. The manufacture of the lacings 24 from forged extrusions is considered important to the invention in that by cold working the extruded lacing to obtain the final form the strength of the lacing struts is materially increased over that of the original extruded form and this added strength is one of the factors which make the aluminum structures of the invention comparable to similar steel structures strengthwise.

The lacing 24 may be assembled to the flanges in a plurality of arrangements. To form a truss or beam of "I" section the lacing is interposed between flanges 10 as shown in FIG. 7, the ends of the lacing being abutted in the recess 22 of the rib 18 and welded thereto. The lacing struts 24 may be arranged in several patterns, two such arrangements being shown in FIGS. 1 and 2 and the planar ends of the lacing struts are trimmed such that the edge 26 is parallel with and fully engages the recess 22, the smaller

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the included angle between the strut and flange the greater the length of the edge 26. As the outer surface 28 of the flanges 10 are planar the resulting beam may be employed in the usual fashion. It will be appreciated that the rib 18 aids in strengthening the flanges 10 and the resulting beam or truss weighs only 35% to 50% of the weight of a similar steel structure of equivalent load bearing capacity.

FIG. 8 illustrates another arrangement of lacings with a pair of flanges 10 to produce a box beam. In this construction lacing 24 is interposed between the opposed ends of the flanges, the ends of the lacing abutting the surface 16 and being welded thereto. In most instances wherein the beam is supported at both ends the lacing 24 is arranged as in FIG. 3 where a uniform pitch zig-zag pattern is illustrated, however, the beam strength may be increased when supported in cantilever fashion as in FIG. 4 by decreasing the pitch of the lacing near the supporting end.

A double box beam of very high strength may be assembled from the flanges 10 by using a combination of the construction of the beams of FIGS. 7 and 8 to provide a beam with triple lacing as in FIG. 9. Such a beam may be assembled with the use of the standard flanges 10 and lacings 24, it being apparent that the lacing interconnecting the ribs 18 is not of the same length as the outside lacing in that the ribs will decrease the distance between the flanges. FIGS. 5 and 6 illustrate double box beam lacing arrangements, FIG. 6 being of a unique design wherein the outside lacing struts are vertical and are spaced closer together near the cantilever support to maintain a uniform load-weight beam ratio as in FIG. 4.

FIG. 10 illustrates an embodiment of flange 30 which may be used in the construction of "I" beams. The flange 30 is substantially rectangular in sectional configuration and has a thickened central portion 31 having a shoulder 33 to which the lacing 24 may be welded. This simplified construction is not as versatile as the flange design of FIGS. 7-9 and FIG. 14 but permits economical fabrication of aluminum "I" beams.

Another flange modification is shown in FIG. 14 wherein the flange 32 is formed with an enlarged central portion 34 having a lacing surface and shoulder 36 and 37, respectively. The distinction between this flange and that of FIGS. 7-9 lies in the location of surfaces 16 and 36 in a common plane whereby only one length of lacing strut is required. It will be understood that the flange 32 may be used in the same manner as flange 10 to form "I" sections, box and double box beams as in FIGS. 1-9.

The enlarged sections 12 and 20 form an important feature of the aluminum components of the invention in that the use of such bulbous portions prevents the aluminum from weakening due to exposure to excessive heat during welding of the lacing to the flanges. By increasing the mass of the material adjacent the welded joint the heat necessary to effect the weld may be rapidly carried away from the point of application thereby preventing excessive localized hot spots from forming which would burn and weaken the flange or joint. Thus a flange construction is provided which permits the use of minimum cross sectional area to obtain the desired strength yet permits the lacing to be welded to the flanges without heat damage to these elements.

A box beam of somewhat different construction is shown in FIGS. 15-17 wherein the flanges are replaced by chord angle members 38 interconnected by lacing 24. The angles 38 include leg portions 40 and 42 disposed at right angles to each other and are formed at the edges with an inwardly disposed portion 44 of increased thickness having a lip 46 defining a surface and shoulder 48 which receives the lacing edge 26 which is welded thereto as in FIG. 17. As is apparent from FIG. 16 a box beam 50 is composed of four angle members maintained in spaced parallel rectangular relation by lacing 24. The leg portions 40 and 42 define an elongated pocket which opens

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toward the interior of the beam 50 and four plates 52 are interposed between the angle members 38 and welded within the shoulders 48 adjacent the ends of the beam and are provided with holes whereby the end of the beam 50 may be affixed to supporting structure.

FIG. 15 illustrates how three beams 50 may be employed to form a structure consisting of an elevated cross member supported at each end by a vertical column. By forming holes in the leg portions of the chord angles at equal distances, for instance on 3 inch centers, the horizontal cross member may be affixed to the columns simply by the use of overlapping perforated aluminum strips 54 which are bolted to the column and the cross member as illustrated and by the angles 56 which are bolted to the chord angles of the columns and the plates 52 of the cross beam.

The use of holes at equidistant intervals on the chord angles is the preferred construction in that by dimensioning all beam sizes and similar components such that all the holes within the components are based on a unit dimension, construction and design are simplified and material costs reduced.

A slightly different modification in chord angle construction is shown in FIG. 18 wherein a section is taken through holes 58 formed in the leg portions 40 and 42 of a chord angle 38'. This embodiment shapes the portion 44' with a rounded configuration, rather than angular, however the extra mass of material is present to prevent overheating during welding of the lacings.

Preferably the holes 58 which are formed in the chord angles and other components of the invention are not merely punched or drilled out in the usual fashion. As it is a prime object of the invention to provide as strong a structure as possible with the least weight, removal of all the material displaced by the holes 58 substantially reduces the cross sectional area of the member containing the hole and hence the stress capacity of the member. According to the invention the reduction in cross sectional area caused by the holes is minimized by displacing, rather than removing, the material at the hole location. Such displacement may take the form shown in FIGS. 18-20 wherein by placing the chord angle in a press and properly shaped die the hole material may be caused to flow out of the plane of the leg portion to form a pair of ridges 60 adjacent the periphery of the hole. Rather than displacing the hole material equally from the center of the hole to form a continuous annular ridge, the material is displaced from a diameter A-A of the hole which is parallel to the longitudinal axis of chord angles and hence parallel to the direction of the forces within the chord angle as the angle will be primarily subjected to either tension or compression. Thus the hole material is in effect pushed to the sides of the hole in a direction at right angles to the direction of the forces within the chord angles which employs a majority of the hole material to increase the section area of the chord angle at right angles to the forces within the angle. Thus as the strength of the chord angle member is proportionate to the sectional area through which the stress forces are transmitted a hole may be formed in the angles without material loss of strength in the chord angle member.

As the bending, tension or compression forces within a beam or column vary throughout the length of the member according to the location of the point or points of support and the distribution of weight on the beam, certain portions of the beam are subject to greater forces than other sections and the common practice is to utilize a beam or column of heavy uniform cross sectional area whereby sufficient strength is provided at the areas of maximum stress to prevent failure at that point. Such a design is wasteful and unnecessarily heavy as the maximum cross section is only required at localized beam areas, however, the use of such beam construction is conventional. The ideal design is to uniformly vary

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the beam sectional area according to the load capacity required, however, such a design is very expensive and is used only where cost is not a factor. The invention contemplates forming the chord angles 38 and 38' of a cross sectional area sufficient to withstand normal loads with a reasonable safety factor, however should heavy loads be imposed on the beams or columns 50 at localized points the chord angles may be easily reinforced by inserting an elongated insert 62 inside the angles. Such an insert consists merely of an angle member which engages the inner sides of leg portions 40 and 42 and the ends of the legs of the insert engage the inner edge 64 of the portions 44 and is inserted into the chord angle from the end and located as desired. The insert is positioned at those points subjected to the maximum stresses, for instance the insert 62 would be located in the center of the horizontal beam 50 of FIG. 15 as indicated by the dotted lines and be located adjacent the lower ends of the vertical columns 50.

In most beam constructions the chord angles and the insert will be provided with holes whereby the insert may be bolted in place. In those constructions where the versatility of bolt holes is not desired and no holes are formed in the chord angles the insert may be welded in place. It will be appreciated that as the ridges 60 of the holes 58 would interfere with the insert, chord angles employing such holes will require inserts having clearance grooves 66 formed therein as shown in FIG. 18, while inserts which are welded or provided with conventional drilled or punched holes would use an insert as shown in FIG. 17. The use of the insert 62 permits a beam to be strengthened in accordance with the specific use of the beam and is important in providing adequate strength with a low weight ratio as reinforcement may be located only where needed. It is also within the scope of the invention to employ a plurality of overlapping inserts of different length for extreme load reinforcement.

Another modification of a box beam is shown in FIG. 21 wherein a pair of channels 68 are maintained in spaced relation by lacing 24 welded to shoulders formed in the enlarged portions 70 as described in previously discussed embodiments. The channels 68 are formed such that the leg portions 72 are of a greater thickness than the base portions 74 adjacent the angle bend of the channels. The central base portion 76 is thinner than portion 74 and hence it will be seen that the channels are formed with three thicknesses becoming larger as the distance from the Y axis increases. In a typical example of a channel employed in a 12" x 12" beam the leg portion 72 would be $\frac{1}{4}$ ", portion 74 $\frac{3}{16}$ " thick and central portion 76 $\frac{1}{8}$ " in thickness. The advantage of the embodiment of FIG. 21 is achieved by the elimination of half of the lacing when compared with the beam of FIG. 16 and permits the portion 76 to be used in computing the section modulus of the beam whereby lacing cannot be included in such computation. By utilizing central portion 76 such that this portion of the beam is included in determining the sectional modulus the cross sectional area of a single channel 68 is less than that of the two chord angles 38 or 38' that it replaces yet has the same strength characteristics, thus a weight reduction is achieved with no sacrifice of strength.

Holes may also be formed or drilled adjacent the right angle portions of the channels 68 and reinforcing inserts 62 employed as described above if desired.

It will thus be understood that the construction described above permits aluminum or other light weight material to be fabricated in a manner to provide beams, trusses and columns of comparable strength and size to similar steel construction members with significant advantages over steel due to reduction of weight and increased corrosion resistance. Electric substations constructed of aluminum components may be erected much quicker and will require less manpower than heretofore possible with steel components due to the weight differ-

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ential and by employing standard parts such as the flanges 10 and chord angles 38 to construct several types of beams reductions in assembly and inventory costs are realized. The use of the positionable inserts 62 permits standard beams to be used in many applications where extra strength and reinforcement is required and the forming of the holes 58 by displacing, rather than removing metal, prevents substantial loss of cross sectional area and strength due to the holes. Uniform welding is achieved by employing enough metal adjacent the welded joint to carry away excessive heat yet this extra metal is located at only those points where heat is applied. It will be appreciated that by using longer or shorter lacing the shapes of the beams may be widely varied and that beams suitable for most purposes may be easily fabricated from the use of flanges 10 or chord angles 38—38'.

I claim:

1. A fabricated beam construction comprising, in combination, a pair of parallel, spaced, generally planar, elongated aluminum flanges, a planar lacing abutting surface defined on each of said flanges in opposed relation, said lacing abutting surface extending substantially the length of and parallel to the associated flange, a plurality of aluminum lacing members interposed between said flanges and having ends affixed to said flanges maintaining the spacing between said flanges, said lacing ends including a planar surface parallel to and abuttingly engaging a flange lacing abutting surface, a longitudinal shoulder surface defined on each of said flanges adjacent and perpendicularly intersecting the lacing abutting surface thereof of defining a right angle intersection upon said flanges, said lacing ends being of a transverse width less than the transverse width of said lacing abutting surfaces and coplanarly engaging said abutting surfaces whereby a lacing lateral side engages said shoulder surface, a weld fillet welding said lacing ends to said flanges at the intersection of the lacing and lacing abutting surfaces on the opposite lateral side of said lacing with respect to said shoulder surface and an elongated flange portion of substantially enlarged cross section adjacent said shoulder surface and lacing abutting surface intersection adapted to carry away welding heat during welding of said lacing to said flanges.

2. In a fabricated beam construction as in claim 1 wherein said lacing abutting surface, shoulder surface and enlarged flange portion are centrally located with respect to the longitudinal edges of the flange.

3. In a fabricated beam construction as in claim 1 wherein the longitudinal edges and central portions of said flanges are each formed with lacing abutting surfaces, shoulder surfaces and enlarged cross sectional portion.

4. In a structural aluminum beam, a pair of elongated flanges maintained in spaced opposed relation by lacing members welded thereto having ends which abut against said flanges, a plurality of planar parallel lacing engaging first surfaces longitudinally extending the length of the flanges and transversely spaced thereon, said surfaces being disposed parallel to the general plane of the flange to abuttingly receive the ends of the lacing, lacing members having planar ends interposed between said flanges wherein said planar ends abut said first surfaces in coplanar relationship a single longitudinally extending shoulder defined on said flange adjacent each surface and extending therefrom having a planar second surface parallel to the plane of the lacing intersecting said first surface at a right angle whereby the lacing may laterally engage said second surface, the transverse width of said lacing being less than the transverse width of said first surfaces, said lacing being welded to said flanges by a bead at the intersection of the lacing and first surface on the opposite lateral side of said lacing with respect to said second surface.

5. A structural beam flange as in claim 4 wherein said flange includes a pair of longitudinal parallel edges and lacing engaging first and second surfaces are defined adjacent each of said edges.

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6. In a structural beam flange as in claim 5 wherein a third lacing engaging first and second surfaces is formed on said flange intermediate said edges and parallel thereto.

7. In a fabricated aluminum box beam construction comprising a plurality of elongated rigid chord angle members, lacing having planar end surfaces interposed between adjacent angle members and welded thereto, said chord angles consisting of a pair of leg portions having longitudinal edge portions and disposed at right angles intersecting at an apex which defines the corners of the beam, the longitudinal leg edge portions consisting of a first portion deflected inwardly with respect to the included angle defined by the leg portions, said first portion being disposed at right angles to the associated leg portion and defining an open exteriorly accessible planar lacing abutting surface of a transverse width greater than the transverse width of the lacing end, the end of said first portion formed to constitute a second portion extending at right angles to said first portion parallel to and inwardly from the associated leg portion, said second portion defining a planar shoulder surface perpendicularly intersecting and extending from said lacing abutting surface serving to locate and laterally engage the lacing end coplanarly abutting said lacing abutting surface, said first and second portions having a wall thickness greater than that of the remainder of the leg portions to facilitate the dissipation of welding heat and a weld fillet welding said lacing to said lacing abutting surface at the intersection of the lacing and lacing abutting surface on the opposite lateral lacing side with respect to said shoulder surface.

8. In a fabricated box beam construction as in claim 7 wherein planar end plates are interposed between adjacent chord angles adjacent the ends thereof, said plates abutting said lacing abutting surface and contiguous with said shoulder surface and being welded to said leg portions.

9. In a fabricated box beam construction as in claim 7 wherein an elongated angle member insert is inserted within an uninterrupted length of said chord angles contiguous with said leg portions and is affixed thereto to strengthen the chord angle.

10. In a fabricated aluminum box beam as in claim 9 wherein said insert consists of a right angle member having leg portions terminating in longitudinal edges and interconnected to define an apex, said insert longitudinal edges closely engaging said first leg edge portions in opposed relation to said lacing abutting surface and the apex of said insert located adjacent to the inside of the apex of said chord angle members.

11. In a fabricated aluminum beam construction utilizing an angle member as an integral force transmitting component thereof, said angle member comprising a pair of longitudinal leg portions intersecting at right angles, a longitudinally extending shoulder defined on each leg portion extending substantially parallel to and in the

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direction of the other leg portion being located within the included angle defined by said leg portions, a reinforcing insert comprising a pair of longitudinal leg portions intersecting at right angles and affixed together at the intersection thereof, each insert leg portion being defined by a longitudinally terminating edge transversely disposed to the associated insert leg portion, said insert being received within the included angle of said angle member so that an insert leg portion is disposed parallel and contiguous with an angle member leg portion, and each of said insert terminating edges abuttingly engaging an angle member shoulder.

12. In a beam construction as in claim 11, wherein fastening means affix said insert to said angle member.

13. A method of forming a relatively small circular hole in a substantially planar member of relatively thick material comprising the steps of displacing the material of the hole location in opposite directions from a diameter of the hole to be formed by a flowing of the material to define the hole and a pair of arcuate ridges of displaced material adjacent the periphery of the hole projecting from the plane of the member on a common side thereof to thicken said planar member adjacent the hole in a direction transverse to said diameter and sizing and trimming said hole upon displacing of the hole material.

14. The method of forming a hole in a metallic structural element adapted to transmit a primary force there-through comprising displacing the material from the hole location from a diameter thereof parallel to said primary force by a molecular flowing of the material to form a pair of separated arcuate ridges integrally formed from the material of said structural element on opposite sides of said diameter, said ridges being formed on a common side of said element thickening the cross section of said element adjacent the hole in the direction transverse to said primary force.

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