May 28, 1968 H. M. HADLEY 3,385,015

BUILT-UP GIRDER HAVING METAL SHELL AND PRESTRESSED CONCRETE TENSION FLANGE AND METHOD OF MAKING THE SAME

Filed April 20, 1966 3 Sheets-Sheet 1

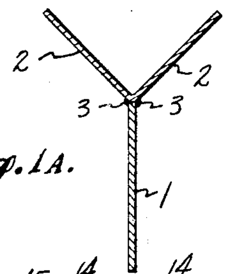

Fig. 1A.

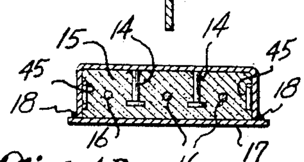

Fig. 1B.

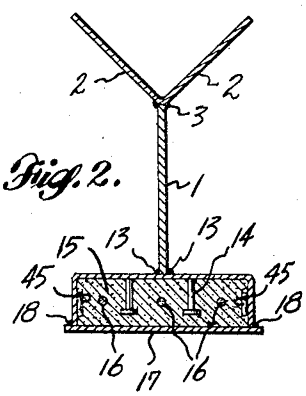

Fig. 2.

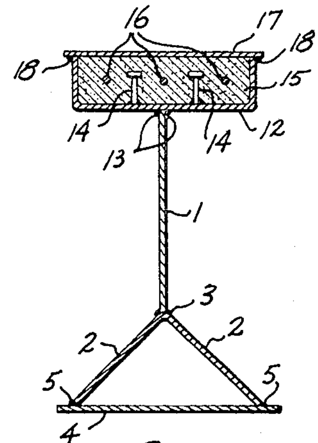

Fig. 3.

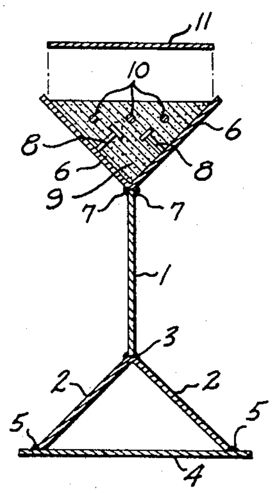

Fig. 4.

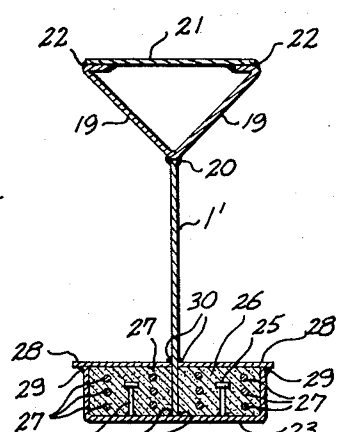

Fig. 5.

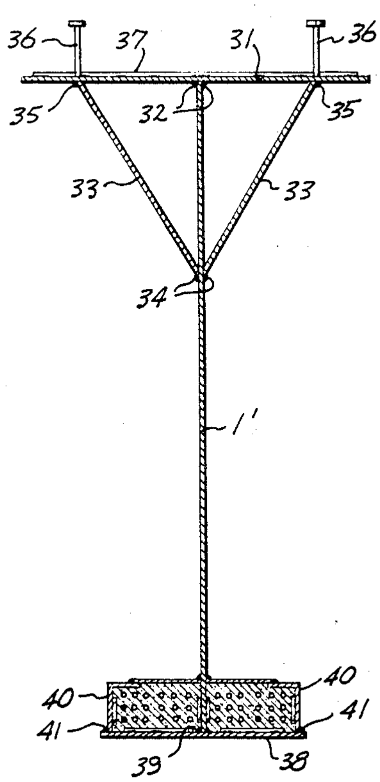

Fig. 6.

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BUILT-UP GIRDER HAVING METAL SHELL AND PRESTRESSED CONCRETE TENSION FLANGE AND METHOD OF MAKING THE SAME

Filed April 20, 1966 3 Sheets-Sheet 2

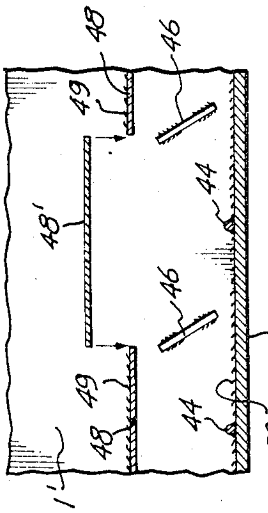

Fig. 8.

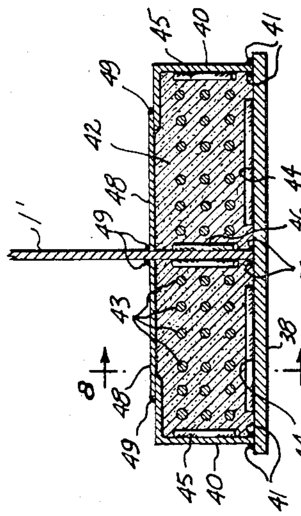

Fig. 7.

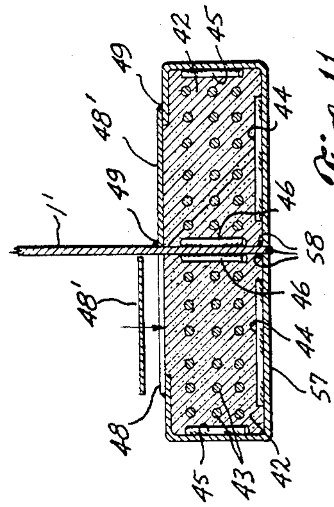

Fig. 11.

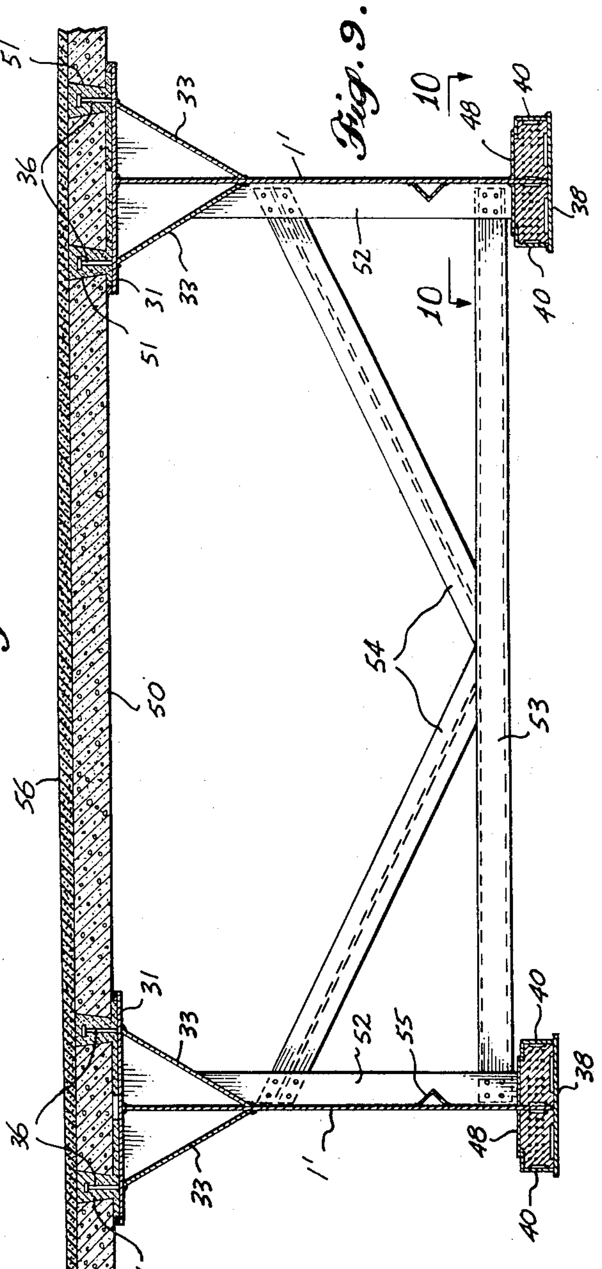

Fig. 9.

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BUILT-UP GIRDER HAVING METAL SHELL AND PRESTRESSED CONCRETE TENSION FLANGE AND METHOD OF MAKING THE SAME

Filed April 20, 1966 3 Sheets-Sheet 3

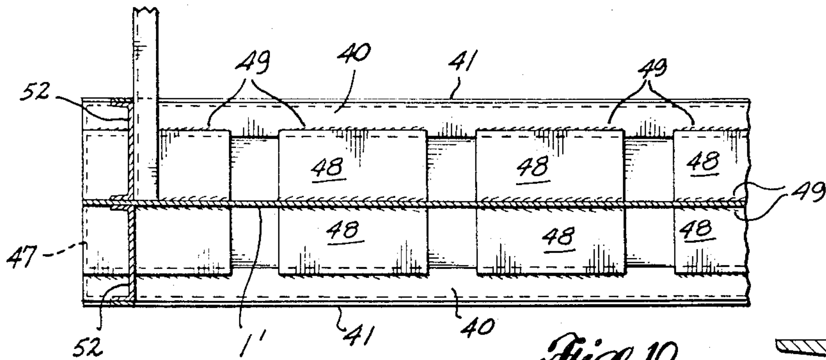

Fig. 10.

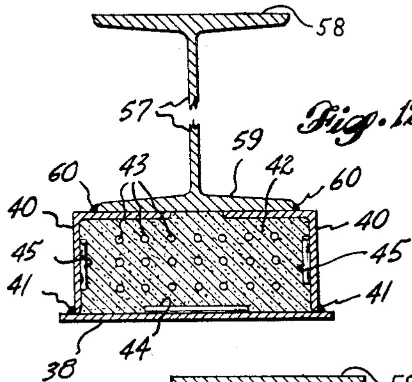

Fig. 12.

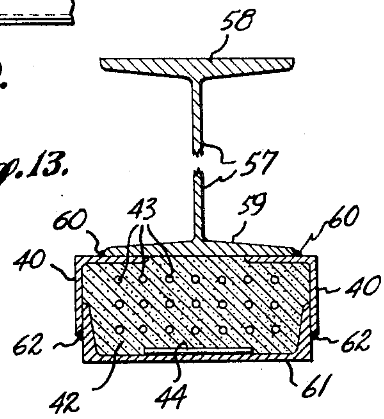

Fig. 13.

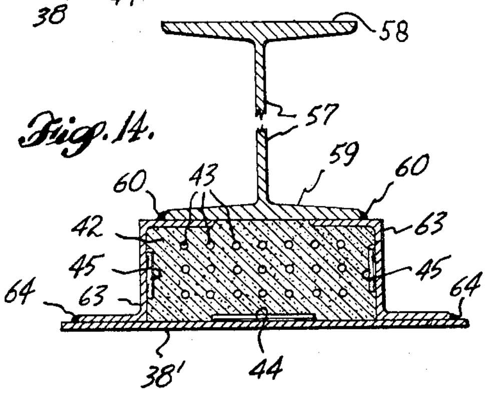

Fig. 14.

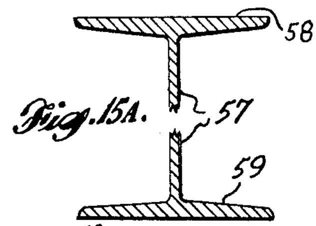

Fig. 15A.

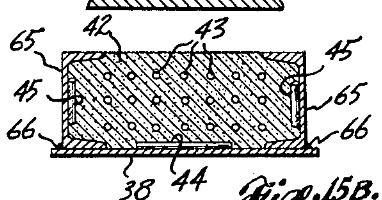

Fig. 15B.

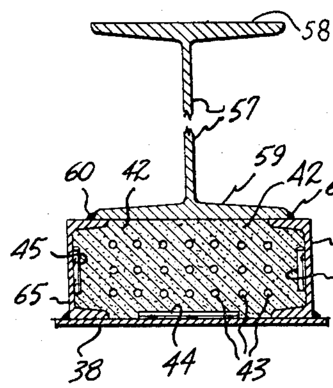

Fig. 16.

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United States Patent Office

3,385,015

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BUILT-UP GIRDER HAVING METAL SHELL AND PRESTRESSED CONCRETE TENSION FLANGE AND METHOD OF MAKING THE SAME

Homer M. Hadley, Seattle, Wash., assignor by community property survivorship agreement to Margaret S. Hadley

Continuation-in-part of application Ser. No. 501,589, Oct. 22, 1965. This application Apr. 20, 1966, Ser. No. 544,001

12 Claims. (Cl. 52—223)

This application is a continuation-in-part of my application Ser. No. 294,931, filed July 15, 1963, for Prestressed Steel and Concrete Beam, now abandoned, and of my application Ser. No. 501,589, filed Oct. 22, 1965, and now abandoned, for Fabricated Steel and Concrete Composite Prestressed Girder and Method of Making the Same.

This invention relates to a built-up girder fabricated from metal plate and/or structural shapes which provide a metal web integral with a unitary tension flange metal shell or casing for prestressed concrete substantially filling the tension flange shell and particularly to such a girder which can be made in a wide variety of sizes and designs and which provides exceptional strength.

It has been proposed heretofore to provide a composite girder having both fabricated steel portions and concrete portions, but great difficulty has been experienced in fabricating a strong and true beam or girder of such character. Normally steel is considered to be a material most suitable for carrying tensile stresses, while concrete has been considered to be most useful for carrying compression loads.

A principal object of the present invention is to provide a built-up steel and concrete composite girder of high strength for its weight in which the flange portion of the girder which is normally subjected to compressive stresses is made of steel and the flange portion of the girder which is normally subjected to tension stresses is constructed of prestressed concrete encased in metal. Especially it is an object to construct such a beam which will maintain an accurate cross section throughout its length despite the stress imposed on the beam by prestressing forces, and which will not be appreciably distorted or twisted throughout its length.

It is also an object to provide a process for manufacturing composite steel and concrete girders which will facilitate such manufacture and by which girders can be produced in which the steel in the tension flange is prevented from warping or buckling and the prestressed concrete in the tension flange is adequately supported and prevented from being ruptured by either prestressing forces or working loads.

Another object is to provide a composite steel and concrete girder construction in which the concrete is structurally integrated with the steel and is confined by the steel to prevent normal shrinkage of the concrete.

In the process of making such a composite steel and concrete beam, it is an object to form as a part of the beam a unitary hollow metal flange shell constituting a receptacle for the prestressed concrete which is readily accessible so that the concrete can be placed in it easily. More specifically it is an object to provide a construction in which the concrete can be covered completely with metal after the receptacle or cavity of the girder has been filled with concrete.

A further object is to provide a hollow metal flange shell receptacle for the concrete in the girder construction which will enable a large number of prestressing strands to be embedded in the concrete.

It is an additional object to provide a composite steel and concrete girder construction in which the proportions and shapes of the steel and concrete parts can be altered

as may be desired for the design of a beam or girder which will have the desired strength and weight characteristics.

Another object is to provide a girder construction in which the tension flange can be manufactured as one component and a plate web and compression flange can be manufactured as a second component and such components can then be joined to form an integral metal structure to complete the girder.

In the manufacture of such a built-up girder it is also an object to utilize metal structural shapes for most or all of the metal girder elements which can be joined by welding into an integral structure in an economical fashion. The use of such metal structural shapes produces a girder of greater rigidity, more accurate and consistent shape and design, more economical because of the elimination of shaping operations and stronger for a given weight because of the design of the metal structural shapes to provide the most effective structure.

A girder construction which will accomplish the foregoing objects can include a metal plate web, a metal upper compression flange, which may be of substantially delta cross-sectional shape or may be flat, and a lower tension flange structure composed of a metal shell encasing set concrete reinforced and preferably prestressed by a multiplicity of prestressing strands embedded in it and extending lengthwise of the tension flange. Such prestressed concrete is encased by a unitary metal shell which may be of triangular shape, but preferably is of rectangular cross-section, and may have an open bottom, but the remainder of which, constituting the major portion of its periphery, is unitary and continuous. In either case the set concrete will extend from side to side of the tension flange formed by metal plate elements so that the concrete will be confined and protected and the concrete and metal shell will cooperate in carrying the stress to which such flange is subjected by prestressing stress and by working loads imposed on the girder. The metal web of the girder may extend from top to bottom through the concrete-filled flange and be attached to both the top and bottom metal walls of the flange shell. The opposite sides of the tension flange shell may be formed by plates but preferably are formed of metal structural shapes, such as angles, Z bars or channels. The upper and/or lower sides of the tension flange unitary shell can be composed of plates or the upper side of the tension flange can be formed by the lower flat flange of an H beam or an I beam.

FIGURE 1A is a cross section of a metal compression flange and plate web component and FIGURE 1B is a cross section of a box tension girder flange filled with prestressed concrete adapted to be joined to the compression flange and web component of FIGURE 1A.

FIGURE 2 is a cross section of a girder composed of the components of FIGURES 1A and 1B in assembled relationship, and FIGURE 3 is a cross section of the same girder in inverted position.

FIGURE 4 is a cross section of another type of girder in inverted position with a part in exploded relationship.

FIGURE 5 is a cross section through a further type of girder.

FIGURE 6 is a cross section through still another type of girder and FIGURE 7 is an enlarged cross section through the lower portion of such girder.

FIGURE 8 is a fragmentary longitudinal section through a portion of the girder taken on line 8—8 of FIGURE 7.

FIGURE 9 is a cross section through a bridge structure utilizing girders of the type shown in FIGURE 6, and FIGURE 10 is a fragmentary horizontal section through one of the girders of such structure taken on line 10—10 of FIGURE 9.

FIGURE 11 is a fragmentary cross section through the lower portion of a slightly modified type of girder with a part being shown in exploded relationship.

FIGURES 12, 13 and 14 are cross sections through alternative types of girders including an H beam or an I beam forming the web component.

FIGURE 15A is a cross section of an H beam web component of a girder prior to assembly and FIGURE 15B is a cross section through a tension flange component of a girder including a metal shell encasing prestressed concrete.

FIGURE 16 is a cross section of a completed girder composed of the components shown in FIGURES 15A and 15B in assembled relationship.

My previous patent application Ser. No. 294,931, and now abandoned, mentioned above, proposed a girder generally like those shown in FIGURES 3 and 4 in inverted condition. That application described the method of producing such a girder as including manufacturing the concrete-filled flange portion of the girder of FIGURE 4 as a separate element and attaching its apex subsequently to the web by welding. Such a procedure is very difficult to accomplish without creating unrelieved stresses in the girder which tend to cause it to warp or buckle and generally to reduce its mechanical effectiveness. Such disadvantages have been overcome in the present invention.

The girder of FIGURE 4 is shown in the inverted condition in which it is placed during construction. First, the steel portion of the girder is fabricated by securing one edge of the plate web **1** to the edges of plates **2** by fillet welds **3**. The plates **2** diverge away from the web and a cover plate **4** is secured to the edge of plates **2** remote from the web by fillet welds **5**. The two plates **2** and the cover plate **4** thus form a hollow compression flange of delta or triangular shape.

To the other edge of web **1** are secured plates **6** by fillet welds **7**. These plates also diverge away from the web, preferably at approximately the same dihedral angle as that between the plates **2**, such as approximately 90°. These plates constitute part of the unitary metal shell of the tension flange of the girder which is peripherally continuous over a major portion of the periphery of the tension flange, and which plates form a trough to be filled with concrete. Headed studs **8** can be secured at intervals to the plates **6** for embedment in the concrete **9** so as to integrate such concrete with the steel structure of the girder. In order to facilitate placing concrete in the tension flange portion of the structure, the girder can be inverted, as shown in FIGURE 4, and supported on the cover plate **4** so that the plates **6** form an upwardly-opening trough.

It is desirable for the concrete **9** to be prestressed by embedding in the concrete a plurality of prestressing strands **10** even though the concrete is bonded to the plates **6** by studs **8**, when this flange is to be used for carrying tension stresses. Before the concrete is set in the trough formed by the plates **6**, therefore, the strands **10** are highly tensioned in accordance with known prestressing procedure. After the concrete has set, the tension on the strands **10** is released so that the strands will exert a substantial compression load lengthwise of the girder on the concrete **9**. After the concrete has thus been placed under compression, the upper side of the trough can be closed by a cover plate **11**, opposite edges of which can be welded respectively to the edges of the two plates **6** located remote from the web **1**, so that the unitary shell encases the concrete completely. The girder can then be inverted from the position shown in FIGURE 4 and installed in the position in which it is to be used.

The girder of FIGURES 1B, 2 and 3 differs from that of FIGURE 4 in that the tension flange portion of the girder is of rectangular box cross section instead of being of delta cross section. In FIGURE 3 the compression flange unitary metal shell structure including plates **2** and **4** secured to the web **1** by fillet welds **3** and **5** is the same as described in connection with FIGURE 4. In this instance, however, the edge of web plate **1** remote from the compression flange is secured to the exterior of a channel **12** forming part of the tension flange metal shell approximately at the center of its web by fillet welds **13**. The girder can, therefore, be supported in inverted position with the tension flange channel **12** opening upward and resting on the cover plate **4** of the compression flange.

Any number of headed studs **14** can be secured in positions distributed within the channel **12** by their ends opposite their heads being welded to the inner side of the flange channel's web. These studs will then be embedded in concrete **15** poured into the open upper side of the channel. Before such concrete has set a plurality of prestressing strands **16** are placed under tension and held in this condition until the concrete has set. The stress applied to the prestressing strands can be relieved after the concrete has acquired adequate strength. The prestressing force imposed on the strands will then be applied to the concrete to place and maintain it under compression when the girder is subjected to working loads.

The opposite flanges of the trough or channel **12** constitute a convenient reference gauge for leveling the upper side of the concrete **15** by use of a screed. The concrete can then be encased completely by the unitary metal shell so as to be confined within the channel by securing the cover plate **17** to the flanges of channel **12** by fillet welds **18**. Alternatively the open side of the unitary tension flange hollow shell can be covered by a layer of sealant, such as mastic or resin material, to protect the concrete from moisture and air so as to deter deterioration of the concrete. The girder has thus been completed, ready to be inverted and put into use.

As an alternate to fabricating the entire metal portion of the girder first and filling its tension flange unitary metal shell when the girder is in the inverted position of FIGURE 3, the web and compression flange elements of the girder can be formed as one component and the prestressed concrete-filled tension flange shell can be formed as a second component, as shown in FIGURES 1A and 1B. The shell of the tension flange should be of quite rigid material and should be integrated with the concrete, not only by studs **14** projecting from the web for embedment in the concrete, but also by shear bars **45** welded to the inner sides of the flanges of the tension flange shell. The shell trough will, of course, be inverted from the position shown in FIGURE 1B so that it can be filled with concrete **15**. The prestressing strands **16** preferably will be mounted so that the concrete-filled shell can then be inverted into the position shown in FIGURE 1B and the cover plate **17** secured in place by fillet welds **18** before the stress on the prestressing strands is relieved. Moreover, it is very desirable for the girder web and compression flange component to be secured to the web of the shell by the fillet welds **13** before the stress on the prestressing strands is relieved.

Like the girder of FIGURES 2 and 3, the girder of FIGURE 5 has a hollow compression flange of delta-shaped cross section and a tension flange of rectangular box shape. The compression flange is composed of two plates **19** diverging upwardly, the lower edge of which can be secured by fillet welds **20** to the upper edge of the girder web **1'**. While reference has been made to the elements **19** as being two plates, as the elements **2** of the girder tension flanges in FIGURES 1A to 4 were designated, it should be understood that such plate elements can be formed as two sides of an angle member which is bent to form an apex joining such sides. In this instance the edge portions of the plates **19** remote from the girder web **1'** have been bent inward toward each other at acute angles to the plates proper into coplanar relationship. The upper side of the girder compression flange can be closed by a cover plate **21** which is secured to such inturned flanges by fillet welds **22**.

The girder of the type shown in FIGURE 5 is manufactured in its normal position rather than in inverted position. The lower flange of box section includes the steel channel **23**, on the inner side of which rests the lower edge of the web **1'**. Preferably such web is located midway between the opposite flanges of the channel **23** and the edge of the girder web is secured to the central portion of the channel web by fillet welds **24**. Headed studs **25** are secured to the inner side of the web of channel **23** with their heads up so as to be embedded in the concrete **26** which is poured to fill the channel **23**.

The web **1'** serves as a divider or partition for the channel **23** so that the concrete **26** is divided and poured into the two channel sections at opposite sides of the web **1'**. To place such concrete under compression, a plurality of rows of prestressing strands **27** may be received in the channel **23**. While the number of prestressing strands is a matter of choice to a considerable extent, depending upon the degree of compression to which the concrete **26** is to be subjected, twelve prestressing strands are shown in FIGURE 5 arranged in four columns with three strands in each column. Again such prestressing strands will be held under tension during setting of the concrete and then such tension will be released so as to place the concrete under compression.

After the concrete has set, the upper sides of the two sections of channel **23** can be closed by cover plates **28**. The edge of each such cover plate adjacent to a flange of channel **23** can be secured to such channel by a fillet weld **29** and the opposite edge of each plate disposed adjacent to the web **1'** can be secured to such web by a fillet weld **30**. Such cover plates thus serve to brace the girder web **1'** relative to the channel **23** because the edge portion of such web will be secured to the channel, not only by welds **24**, but the cover plates will bridge between the edges of the channel flanges and a portion of the girder web spaced from the web edge a distance equal to the width of each channel flange.

The girder construction shown in FIGURES 6 to 10 inclusive is generally of the same character as the construction of the girder shown in FIGURE 5, except on a larger scale. In this instance the girder's upper flange of delta-shaped cross section should not be made of an angle member because the upper edge portion of the girder web **1'** extends through the compression flange structure to bisect it. Thus the top plate **31** of the compression flange is secured to the upper edge of the girder web by fillet welds **32**. Hypotenuse brace plates **33** are located at opposite sides of the upper portion of the girder's web and their lower edges are secured to opposite sides of the girder web by fillet welds **34**. The upper edges of such plates spaced from the girder web are joined to the top plate **31** of the girder flange by fillet welds **35**.

A girder of this type can be used to support reinforced concrete structure above it and, consequently, rows of studs **36** can be provided on the top plate **31** extending parallel to the length of the girder with the ends of such studs opposite their heads welded to the upper side of the girder top plate. In order to integrate such concrete to a greater extent with the top plate of the girder, rods **37** lying on such top plate with their lengths extending transversely of the length of the girder can be welded in place to provide upstanding ribs on the upper side of the top plate. Such rods can be ¼" in diameter, for example, and be spaced apart not more than about 2 feet. Such rods are shown in FIGURE 6.

The construction of the tension flange of the girder shown in FIGURES 6 and 9 is illustrated in greater detail in FIGURES 7, 8 and 10. In this instance, instead of the unitary rectangular box section flange being formed of a single-piece channel member, such as shown in FIGURE 5, the unitary box flange shell itself is fabricated from a greater number of structural shapes joined into a unit such as by welding to provide a continuous and unbroken periphery for the shell. This expedient en-

ables stock of different thickness to be utilized for different portions of the box section flange shell, if desired.

Thus in the construction shown principally in FIGURES 7 and 8, the bottom plate **38** of the unitary tension flange shell is made of metal which is considerably thicker than other portions of the shell. Such bottom plate may, for example, be made of plate 1" thick. The central portion of such plate is secured to the lower edge of the girder web **1'** by fillet welds **39**. The opposite sides of the box-section flange can be made of angles **40** which may be of stock ⅜" thick. The lower edges of the upright flanges of such angle members are secured to the marginal portions of bottom plate **38** by fillet welds **41**. Concrete **42** can then be poured into the open upper sides of the box section flange sections at opposite sides of the web **1'**. In each of such sections the concrete can be heavily prestressed by placing in each section of the box-shaped flange a multiplicity of prestressing strands **43**. Preferably such strands are arranged in a symmetrical pattern of rows and columns. In the particular arrangement illustrated in FIGURES 6 and 7, six columns of such strands are provided at each side of the girder web **1'** with each column including three strands so as to make a total of 36 prestressing strands in the tension flange of the girder.

As explained in connection with the production of the other girders, all of the prestressing strands are tensioned prior to placing of the concrete and the tension of such strands is released to be transmitted to the concrete after it has acquired adequate strength. Intimate contact of the concrete with all of the strands can be assured by vibrating the concrete as it is being put in place or after it has been placed in the channel of the beam flange shell but before it has set. Such vibration can be accomplished by vibrating the girder itself, but preferably is effected by inserting a vibrating instrument into the concrete through the open upper sides of the flange shell sections.

Integration of the concrete with the unitary metal shell of the girder's tension flange can be assured by welding onto the upper side of the bottom plate **38** elongated rods **44** arranged at intervals along the length of the beam and which rods form ribs outstanding from the plate surface and embedded in the concrete the lengths of which ribs or rods are disposed parallel to such surface and extend transversely of the length of the beam or girder either perpendicular to the web **1'** or at a different angle to it. Such rods can be ½" in diameter. In addition, short sections **45** of rod stock can be welded to the inner walls of the upright flanges of angles **40** with their lengths upright, being either vertical or inclined somewhat relative to vertical. Similar rod sections **46** can be welded to opposite sides of the lower portion of the web plate **1'** which is received within the cavity of the box-section girder flange, as shown in FIGURES 7 and 8.

The ends of the box section unitary tension flange shell of the girder are closed by suitable end plates **47**, as indicated in FIGURE 10. These end plates are apertured for passage of the prestressing strands. At least near the opposite ends of the girder, because the stress exerted on the concrete increases progressively toward the girder ends, it may be desirable to reinforce the angles **40** forming the shell sides by top plates **48** spanning between the horizonal upper flanges of such angles and the girder web **1'**. Such plates may be installed before or after the prestressing strands **43** have been placed in the tension flange shell. Such spanning plates are held in place by fillet welds **49**, securing to the girder web **1'** the edges of such plates adjacent to such web and securing to the horizontal flanges of angles **40** the edges of such plates overlying and supported on such flanges. The spanning plates **48** should be made in short sections, as shown in FIGURE 10, so that concrete can be inserted into the tension flange shell through the openings between such plates.

After pouring of the concrete **42** into the hollow flange shell has been completed, the gaps between the plates 48 can be filled by filler spanning plate sections 48' indicated in FIGURES 8 and 11, or by a sealant such as mastic or resinous material which will seal the concrete from exposure to water and air. The spacing between the initial plate sections 48 can be greater toward the central portion of the girder and, in fact, for a considerable span at the central portion of the girder, few or no spanning plates are required.

After fabrication of the girders has been completed to the form shown in FIGURE 6, such girders can be installed in a bridge structure of the type shown in FIGURES 9 and 10, for example. Such bridge construction shows two of such girders disposed in spaced parallel relationship to support a reinforced-concrete roadway 50 spanning between and projecting beyond such girders. The studs 36 can be embedded in concrete portions 51 of the supported structure. The two girders can be tied together by trusswork including frames spaced lengthwise of the girders. Each frame can include upright plates 52 secured to the sides of the girders, a connecting channel 53 having its opposite ends secured to the plates 52, and inclined braces 54 connecting the central portion of the member 53 and portions of the upright plates 52 spaced from the member 53. The members 54 may be of T-bar cross section. Also, if desired, the girder webs 1' can be stiffened longitudinally by welding to their sides horizontal longitudinal stiffeners 55 which may be of angle cross section. The roadway can be surfaced with a layer of asphaltic concrete 56, if desired.

As an alternative construction for the unitary box-section tension flange metal shell of the girder, a two-part box 57, as shown in FIGURE 11, can be formed having a cross-sectional shape similar to the unitary fabricated box shown in FIGURE 7. Thus the box 57 will have a bottom, upright sides and inturned flanges all formed of only two bent sheet shapes. Such a box element can be bent up from plate material or could be extruded, particularly if made of metal other than steel, such as aluminum for example. Especially if such special box part is bent up from steel plate, the concrete-integrating rod sections 44 and 45 can be welded to it as well as rod sections 46 being welded to the edge portion of the girder web 1' received in the shell 57. The edge of such girder web and the abutting edges of the two half-channel shapes meeting at the web can be secured together by upper and lower fillet welds 58.

After the unitary flange shell has been attached to the lower edge of the girder web, as described, the prestressing strands can be placed in the shell and the shell filled with concrete 42 in the manner described in connection with the girder of FIGURES 6 and 7. After the flange shell has thus been filled with concrete, any portions of the opening in the upper side of the shell not previously closed by bridging plates 48 can be closed by bridging plates 48', in the manner described. The completed girder can then be used for installations similar to that shown in FIGURES 9 and 10. The upper compression flange of this girder can be constructed like the compression flange shown in any of FIGURES 2, 5 and 6.

As has been discussed above in connection with FIGURE 7, the unitary tension flange metal shell of the girder advantageously can be made from, or at least include, metal structural shapes, in that instance the shapes used being angle irons. The girder of FIGURE 12 shows opposite sides of the unitary tension box flange being made of angle irons 40, as discussed in connection with FIGURE 7, but in this instance the web does not extend down to the central portion of the box or shell. The tension flange structure of the girder is, however, made of the same general type of construction as that shown in FIGURE 7, including the opposite angles 40 forming the opposite sides of the flange shell and a substantial portion of the upper side of such shell.

It will be understood that the dimensions and proportions of the girder tension flange can be varied in accordance with design requirements. Thus angles having flanges of different widths can be selected, the thickness of the metal forming the angle iron can differ, and the angles can be placed farther apart or closer together. By such variations wide latitude of design is possible. Also, of course, the number, size and arrangement of the prestressing strands 43 extending through the channel formed by the flange shell, can be selected or altered as may be desired to comply with various design requirements. The width of the bottom plate 38 will be selected in accordance with the desired spacing of the angles 40, but this plate should always be wide enough so that it can be joined to the downwardly directed edges of the upright flanges of angle irons 40 by fillet welds 41 to produce a unitary shell structure. To the upper side of this plate will be welded shear bars 44 and to the inner sides of the upright flanges of angles 40 will be welded shear bars 45 for integrating the metal shell with the concrete as explained in connection with FIGURE 7.

In this girder of FIGURE 12 the web-forming component is a conventional structural shape preferably of H beam or I beam type. Such a beam includes the web 57 rolled integral with the flat upper flange 58 and the flat lower flange 59. The upper inturned flanges of the angles 40 are located closer together than the width of the lower web component flat flange. The opposite edges of such flange may consequently be bonded to the upper horizontal flanges of the angles 40 by fillet welds 60 after the metal tension flange shell has been filled with concrete 42 and it has been allowed to set. Preferably the I beam or H beam bottom flange is welded to the angle iron upper flanges while the prestressing strands 43 are maintained under tension so that they have not exerted a stress on the concrete 42 at the time that the web component and the lower tension flange component of the beam are joined.

While the composite girder shown in FIGURE 12 has been illustrated as using angle structural members for forming opposite sides of the girder's unitary tension flange metal shell, other types of structural shapes can be used for the flange shell sides or for the flange shell bottom. In FIGURE 13 the bottom of the girder's tension flange shell is shown as being closed by a structural channel 61 instead of by a plate. The opposite flanges of such channel are directed upwardly and are bonded to the downwardly directed flanges of the angle bars 40 by fillet welds 62 to form a unitary structure. The web component of the girder would be secured to the inwardly directed angle flanges as described in connection with FIGURE 12.

In FIGURE 14 Z bars 63 form the opposite sides of the girder's tension flange shell and the bottom of such flange shell is closed by a wide plate 38' which is bonded by fillet welds 64 to the edges of the outwardly directed lower flanges of the Z bars. The webs of the Z bars have shear bars 45 welded to them and the upper side of the plate 38' has shear bars 44 welded to it.

FIGURES 15A and 15B illustrate the girder's web component and the girder's unitary tension flange shell component shown in assembled condition in FIGURE 16. In this instance, the opposite sides of the girder's tension flange shell are formed by channels 65 the flanges of which are directed inward. The bottom of the girder's tension flange shell is again closed by a plate 38 which is bonded to the lower corners of the channels 65 by fillet welds 66. The lower flat flange 59 of the H beam or I beam is bonded to the upper flanges of the channels 65 by fillet welds 60 in the same manner as explained in connection with FIGURES 12, 13 and 14.

In fabricating the girder of FIGURE 16, again the concrete 42 will be supplied to the channel formed by the shell through its open upper side and the concrete will be vibrated while the strands 43 are held under tension. The girder web component will then be assembled with the girder tension flange component in the relationship shown in FIGURE 16 before the tension on the prestressing strands **43** is relieved.

I claim as my invention:

1. A built-up girder comprising a rolled metal structural shape including a plate web having substantially flat flanges on opposite edges thereof, the girder tension flange including a unitary metal shell defining a peripherally continuous hollow and having one of said structural shapes's flat flanges forming a wall portion of said shell, prestressing strands extending along such hollow with their lengths substantially parallel to the length of the girder, and concrete in the hollow of said shell engaged with said shell and prestressed by said strands.

2. The girder defined in claim **1**, in which the shell is of substantially rectangular cross section and includes additional metal structural shapes having substantially flat elements projecting in substantially parallel relationship edgewise from the shell flat flange of the structural shape including the web, and forming opposite sides of the shell.

3. The girder defined in claim **2**, in which the additional shell structural shapes are angles.

4. The girder defined in claim **2**, in which the additional shell structural shapes are channels.

5. The girder defined in claim **2**, in which the additional shell structural shapes are Z bars.

6. In a fabricated girder, a metal plate web, and a flange including a metal shell secured to said web, said metal shell defining a peripherally continuous hollow, concrete filling the hollow of said shell and being confined by said shell and prestressed strands having their lengths extending lengthwise of said flange embedded in and prestressing said concrete in compression.

7. In a fabricated girder defined in claim **6**, the metal shell including a channel having side flanges and a web joining said side flanges, an edge of the metal plate web being bonded to the inner side of the channel web, the side flanges of said channel extending generally parallel to the metal plate web and located at opposite sides thereof, forming troughs between the channel side flanges and the metal plate web filled with concrete, and plate means extending between and bonded to the metal plate web and the edges of said channel side flanges remote from said channel web.

8. In the fabricated girder defined in claim **7**, the edge portions of the channel flanges remote from the channel web being inturned and bonded to the plate means.

9. In the fabricated girder defined in claim **7**, the edge portions of the channel flanges remote from the channel web being turned outwardly and bonded to the plate means.

10. In the process of constructing a composite metal and concrete girder having an integral metal structure including a metal plate web and a concrete-filled, peripherally continuous metal shell flange, the steps of placing prestressing strands in an open-topped trough portion of the metal shell flange with their lengths extending lengthwise of such flange, tensioning the strands, pouring sufficient concrete into the open top of such trough portion to fill it from side to side and embed therein such prestressing strands, covering the concrete-filled trough portion with metal plate and bonding such metal plate to opposite edges of the trough portion to close the metal shell of the girder flange joining the metal plate web to said metal shell flange and, after the concrete has acquired sufficient strength, relieving the tension on the prestressing strands and thereby exerting a compression load on the concrete.

11. The process of constructing a girder defined in claim **10**, including forming the metal plate web as an element separate from the metal shell and joining such web and such shell to form an integral structure after the concrete has been placed in the shell.

12. The process of constructing a girder defined in claim **10**, including forming the metal plate web as an element separate from the metal shell and joining such web and such shell to form an integral structure before the concrete is placed in the shell.

References Cited

UNITED STATES PATENTS

1,546,118	7/1925	Chubbuck	52—174 X
3,140,764	7/1964	Cheskin	52—223
3,166,830	1/1965	Greulich	52—723 X

FOREIGN PATENTS

1,295,131	4/1962	France.
740,121	11/1955	Great Britain.
1,048,852	8/1953	France.
784,383	10/1957	Great Britain.
842,739	7/1960	Great Britain.
538,402	1/1956	Italy.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,385,015 May 28, 1968

Homer M. Hadley

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 9, line 32, "prestressed" should read -- prestressing --; line 35, "a" should read -- the --. Column 10, line 17, insert a comma after "flange".

Signed and sealed this 18th day of November 1969.

(SEAL)

Attest:

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Attesting Officer

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Commissioner of Patents