No. 769,941. PATENTED SEPT. 13, 1904.

H. A. CRANE.

COMPOSITE STRUCTURE.

APPLICATION FILED FEB. 27, 1904.

NO MODEL.

Fig. 1.

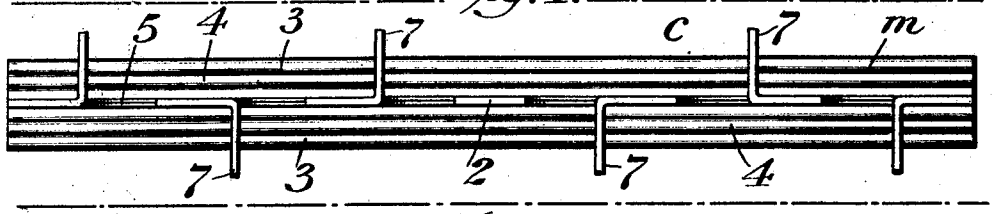



Fig. 2.

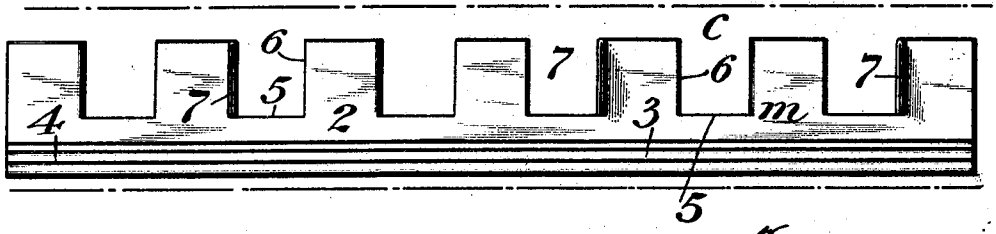



Fig. 3.

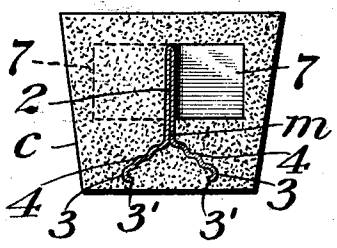



Fig. 6.

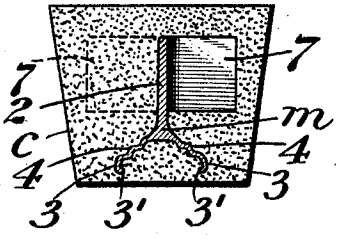
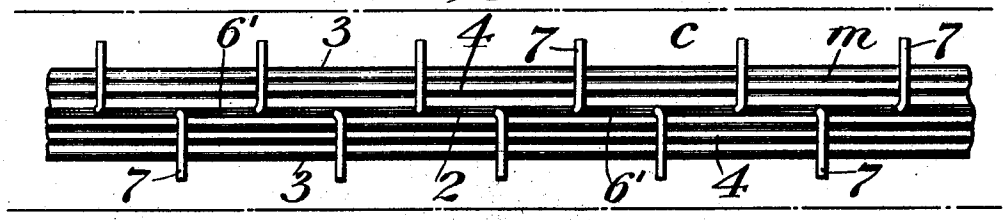



Fig. 4.



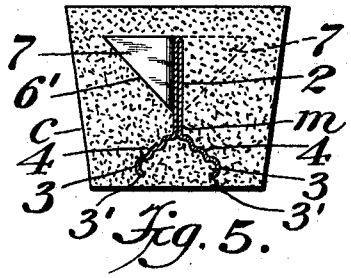




Fig. 5.

Witnesses
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No. 769,941. Patented September 13, 1904.

# UNITED STATES PATENT OFFICE.

HARRY A. CRANE, OF JERSEY CITY, NEW JERSEY.

## COMPOSITE STRUCTURE.

SPECIFICATION forming part of Letters Patent No. 769,941, dated September 13, 1904.

Application filed February 27, 1904. Serial No. 195,527. (No model.)

*To all whom it may concern:*

Be it known that I, HARRY A. CRANE, a citizen of the United States, and a resident of Jersey City, in the county of Hudson and State of New Jersey, have invented certain new and useful Improvements in Composite Structures, of which the following is a specification.

This invention relates to improvements in composite structures of that class in which a cementitious body—such, for example, as concrete—is stiffened and strengthened by a metallic member embedded therein; and the principal object of this invention is to provide an improved structure of this type having great stiffness and strength as compared with similar composite structures as heretofore made.

It is well known that the greatest strength with a given weight of metal is obtained by shaping the metal into bar or sheet form—that is, to such a form as will be of slight thickness as compared with its width—and so disposing the bar or sheet that it will receive strains and thrusts edgewise. This principle is applied in the present case to composite structures, and the concrete or other cementitious body is stiffened and strengthened by a metallic beam embedded therein and made up of a web and flanges which run lengthwise of the beam and lie in different planes, the principal element of the beam—viz., the web—being disposed, preferably, in a vertical plane, so as to give the maximum strength to the composite structure. The metallic beam is also shaped to provide holding members adapted to interlock with the cementitious body, and the particular construction of these members and the mode of disposing the same for increasing the stiffness and strength of the composite structure constitute an important feature of the invention.

In the drawings accompanying this specification and forming part of the present application, Figure 1 is a plan of a composite structure in the form of a beam made in accordance with the present invention. Fig. 2 is a side elevation of the same. Fig. 3 is a cross-section of the same. Fig. 4 is a plan of a composite structure in the form of a beam, illustrating a modification of the invention. Fig. 5 is a transverse section of the same; and Fig. 6 is a transverse section of a composite beam, illustrating a further modification of the invention.

Similar characters designate like parts in all the figures of the drawings.

Referring first to Figs. 1 to 3, inclusive, *c* designates the concrete or other cementitious body constituting one of the two main elements of the composite structure, and *m* designates generally a metallic beam embedded in such concrete or other cementitious body. The metal beam illustrated at *m* is of the improved type hereinbefore specified—that is to say, it is a beam having a web of slight thickness as compared with its width, and this web is placed edgewise to the direction of greatest strain—that is to say, it will usually be placed in a vertical position and will therefore be of maximum strength in a vertical direction. In order to obtain a firm hold on the body *c* in all directions, a metallic beam is preferably employed which has flanges extending therefrom at suitable angles and also running lengthwise of the beam, the preferred construction being that in which the flanges and the web are substantially equidistant from one another. When so disposed, these members of the beam coöperate with the cementitious body *c* to the best advantage and stiffen the structure in all directions. The web and the flanges of such a metallic beam may be formed in one piece from sheet metal, such as sheet-steel, and when so formed the web may be of double thickness and the flanges of single thickness, thereby assuring the greatest strength in the direction of the greatest strain. When so formed, the flanges are disposed at a considerable angle to the horizontal, and therefore oppose great resistance to vertical strains tending to crush the same. Moreover, the two flanges meet at the line of union with the web and form both of the diagonal members of a metallic truss. The web is designated generally by 2 and the flanges by 3, and the manner in which this complete metallic strengthening-truss is formed by the flanges will be evident from an inspection of Fig. 3. In the construction shown these flanges, and hence the complete metallic truss formed thereby, are still further

strengthened by longitudinal corrugations or arches 4, the convex portions of which face upward and greatly stiffen the flanges in a transverse or vertical direction, so that the tendency of vertical strains to crush or buckle the flanges 3 is greatly reduced. A further advantage resulting from the use of these corrugations or arches is the fact that they greatly increase the adhesion between the concrete and the beam.

In composite structures as heretofore made a large body of metal of slight thickness in a vertical direction has usually been separated from the under surface of the composite structure by a thin layer of cement imperfectly interlocked with the adjacent metallic portion of the structure, and this thin layer of cement has frequently cracked and scaled off under the action of the sustained load. In the present invention this is prevented partly by the construction of the metallic beam proper and partly by turning over the edges of the flanges 3, as shown at 3′, so as to interlock these edges securely with the cement or other body *c* and at the same time form a stiffening-arch at the edges of the flanges, which also tends to resist vertical strains.

In order to obtain the best results, it is necessary to provide one of the members of the metallic beam with projecting members adapted to interlock with the cement or other body *c*. These interlocking members are preferably struck from the metal of the web itself and in the construction shown in Figs. 1, 2, and 3 are formed by cutting the metal of the web on the horizontal and vertical lines 5 and 6, respectively, and bending the rectangular members included between these lines on the lines constituting the opposite vertical sides of the respective rectangles, these members being bent out until they are at right angles to the web 2. The members so formed are designated by 7 and project from opposite sides of the web, there being in the construction shown two series of such projecting members, one series at each side of the web and the members of the two series alternating with one another. It will be noticed that these projecting members, which are adapted to interlock with the cement or other body *c*, are disposed in vertical planes, so as to oppose the edges thereof to vertical strains and the sides thereof to horizontal strains, and by maintaining perfect adhesion with the concrete prevent displacement of the metallic beam endwise thereof.

In Figs. 4 and 5 a modification of the invention is illustrated in which the web and flanges are identical in construction with the corresponding parts just described and are designated by corresponding reference characters. The members of the web which project laterally therefrom to interlock with the cement or other body *c* are, however, somewhat different in construction from those shown at 7. Here these projections are formed by slitting the web diagonally along the lines 6′ and bending the triangular portions formed by these cuts about the vertical lines constituting one side of each triangular piece until such triangular portions are at right angles to the web. By cutting and bending the web in this manner two series of projections are formed which are also perpendicular to the web, as are the projections 7 shown in Figs. 1, 2, and 3, and are also disposed vertically, so as to oppose their edges to vertical strains.

It will be evident that the construction of the projecting members for interlocking with the cement or other body *c* may be varied within wide limits; but it is preferable in all cases to shape these members so that they will lie in vertical planes in order to increase the stiffness of the metallic beam and the strength of the individual projections in a vertical direction. Moreover, by disposing the projections in this manner the concrete or other cementitious body in a plastic state may be filled in and around the various projections readily and the entire space in the vicinity of the web completely filled, even when the plastic cement is handled carelessly. Where composite structures are provided with interlocking projections placed at an oblique angle to a vertical plane, voids frequently are left in the composite structure and materially weaken the same. By placing the interlocking members vertically the maintenance of their positions under great vertical strains is assured, and this is not the case with the interlocking projections which are struck up diagonally from the main beam in other types of composite structures. Instead the oblique or diagonally-disposed members of such composite structure frequently slip or draw through the concrete under extreme strain or loads instead of supporting the same. In the present construction, however, such slipping or drawing out of the interlocking projections through the concrete is impossible, as all vertical strains are sustained by the web and projections edgewise. Moreover, by making the metallic beam in girder form, with thin webs and flanges extending in different directions, the minimum amount of metal required for stiffness and strength is distributed most perfectly throughout the cement body of the structure, and the most complete adhesion and union of the two main elements are obtained. By this construction great strength in the metal beam and capacity for resisting both vertical and horizontal strains are combined with the compressive strength of the concrete or other cementitious body, and a superior type of composite structure results therefrom.

Because of the great strength of this composite structure as compared with other types, it is especially adapted for use on long span-work, it being sufficiently rigid to permit the

use of very long metal beams without sagging at the center. Moreover, in structural work its use as floor-supports permits the erection and inclosing of upper stories of a building without waiting for the construction of each floor to be completed before the walls are carried higher, these metal beams serving to stiffen and anchor in all walls as they are erected and permitting the concreting of the different floors to follow at leisure. It will be evident also that the construction of the web and flanges of each metal beam is such as to facilitate the coupling of beams end to end and that at the points of connection the strength of the united beams will be as great as at any other point. This is a very great advantage in erecting additions to buildings, as it permits the reinforced concrete system of the main building to be securely connected with any desired addition.

In Fig. 6 a modification of the invention is illustrated in which the vertical web is made of single thickness instead of double thickness, as shown in the other views.

What I claim is—

1. A composite structure consisting of a cementitious body, in combination with a sheet-metal beam made up of a web and flanges running lengthwise of the beam and lying in intersecting planes substantially equidistant from one another, said flanges being each of a single thickness of metal and said web being of double thickness and having members projecting therefrom into interlocking engagement with the cementitious body.

2. A composite structure consisting of a cementitious body, in combination with a metallic beam made up of a web and flanges running lengthwise of the beam and lying in intersecting planes substantially equidistant from one another, said flanges being each of a single thickness of metal and said web being of double thickness and having members projecting depthwise thereof at right angles thereto from opposite sides of the web into interlocking engagement with the cementitious body.

3. A composite structure consisting of a cementitious body, in combination with a metallic beam made up of a web and flanges running lengthwise of the beam and lying in intersecting planes substantially equidistant from one another, said web having members projecting therefrom into interlocking engagement with the cementitious body and said flanges having their edges turned over into interlocking engagement with said cementitious body.

4. A composite structure consisting of a cementitious body, in combination with a metallic beam made up of a web and flanges running lengthwise of the beam and lying in intersecting planes substantially equidistant from one another, said web having members projecting therefrom into interlocking engagement with the cementitious body and said flanges having their edges turned over substantially into a common plane for interlocking engagement with said cementitious body.

5. A composite structure consisting of a cementitious body, in combination with a metallic beam made up of a web and flanges running lengthwise of the beam and lying in different planes, said web having members projecting therefrom into interlocking engagement with the cementitious body, and said flanges being disposed obliquely to a vertical plane and having longitudinal corrugations or ribs.

6. A composite structure consisting of a cementitious body, in combination with a metallic beam made up of a web and flanges running lengthwise of the beam and lying in different planes, said web having members projecting therefrom into interlocking engagement with the cementitious body and said flanges being continuous and disposed obliquely to a vertical plane at opposite sides of the web.

7. A composite structure consisting of a cementitious body, in combination with a metallic beam made up of a web and flanges running lengthwise of the beam and lying in different planes, said web having members projecting therefrom into interlocking engagement with the cementitious body and said flanges having their edges turned over into interlocking engagement with said cementitious body.

Signed at New York, in the county of New York and State of New York, this 23d day of February, A. D. 1904.

HARRY A. CRANE.

Witnesses:
CHAS. F. DANE,
E. M. FAITH.