No. 893,640. PATENTED JULY 21, 1908.

E. A. MOCCETTI.

REINFORCED GIRDER.

APPLICATION FILED APR. 18, 1905.

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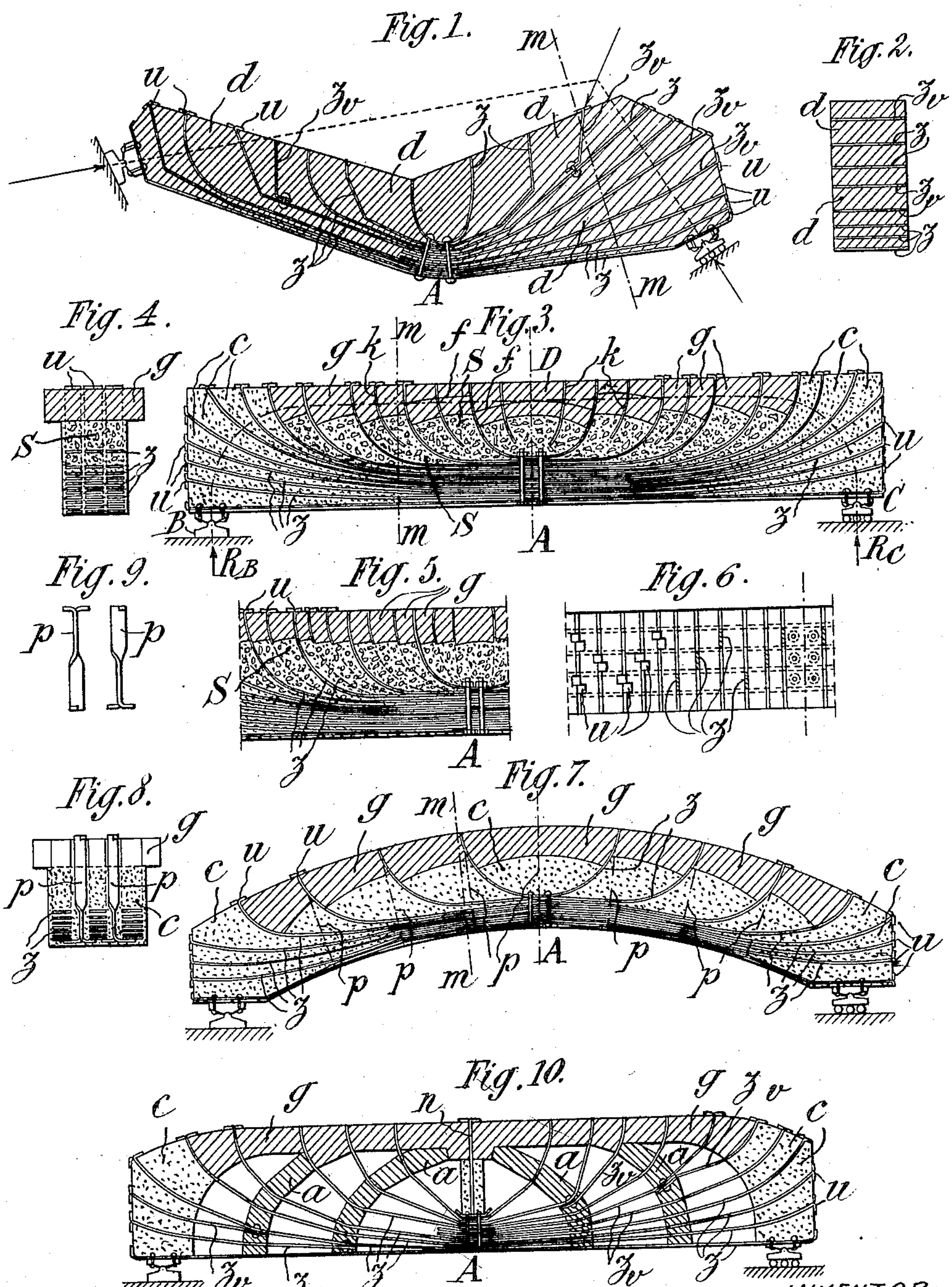

WITNESSES:

Fred White

René Bruine

INVENTOR:

Ernst Arnold Moccetti,

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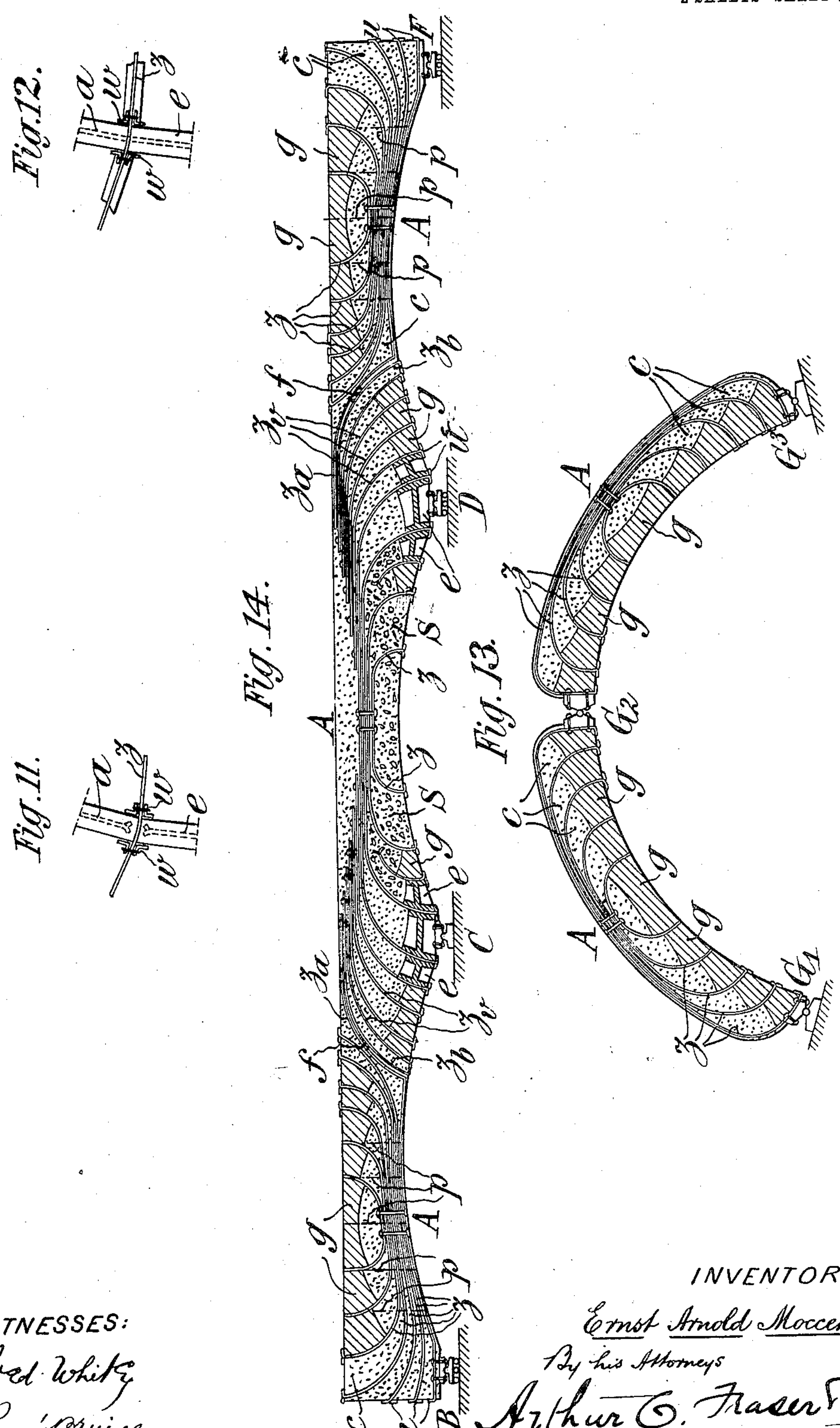

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UNITED STATES PATENT OFFICE.

ERNST ARNOLD MOCCETTI, OF PARIS, FRANCE.

REINFORCED GIRDER.

No. 893,640. Specification of Letters Patent. Patented July 21, 1908.

Application filed April 18, 1905. Serial No. 256,253.

To all whom it may concern:

Be it known that I, ERNST ARNOLD MOCCETTI, a citizen of the Republic of France, residing at Paris, France, have invented new and useful Improvements in Reinforced Girders, of which the following is a specification.

This invention relates to compound girders which, from their nature and the arrangement of the materials forming them, are in most cases better suited than the majority of girders as heretofore made for the efficient bridging of large spans and the support of heavy loads.

In Figure 1 a girder made according to the invention is shown in its general form. Figs. 3 to 14 illustrate the application of the principle employed in the construction of the girder to a number of different types of girder work. Figs. 2, 4 and 8 are cross sections on the lines *m*—*m* of Figs. 1, 3 and 7 respectively.

The girder illustrated in Figs. 1 and 2 consists simply of a number of tension members *z* for taking up the tensile forces and a number of compression bodies or members *d* which are introduced between the tension members. The tension members are connected together at a point A and extend from this point in both directions towards the compression zones of the girder. They are bent polygonally or in continuous curves and, if necessary, are provided with branches such as Z_v (Fig. 1) for increasing the tensile strength. The ends of the tension members are bent around and on to the free surfaces of the compression body as at *u* (Fig. 1). The compression members are either inserted between the tension members or are poured or cast therein according to their nature; each body can be composed of one or more materials. Furthermore, each of the compression members can wholly occupy the space between two tension members or may only partially occupy such a space. In the latter case the compression bodies between the tension members are arranged as rods; the girder is, in this case, a lattice or framework girder (Fig. 10). The various structures, therefore, are built up girders, the resistance of which varies with the nature of the materials employed. The latter do not need to possess any adhesion between themselves; the load capacity of the girder is not injuriously affected if care be taken that the compression bodies are always maintained compressed against the tension members.

By the combination of two or more girders constructed as above described, structures as usually employed for building purposes are obtained.

The rivets or bolts which effect the connection of the tension members at the point A do work only under a one-sided load or with the unsymmetrical arrangement of the tension members, and prevent the said members from sliding apart from one another at the said point, which would otherwise be the case. When, therefore, the tension members are arranged symmetrically and the load is symmetrical, or approximately symmetrical, which would be the case, for example, with girders the weight of which is large compared with the load, then the connection at the point A may be dispensed with.

The bending of the ends of the tension members, as above remarked, gives rise to a greater effect the less the friction or adhesion existing between the tension members and the compression bodies. According to the importance of these factors with respect to the stresses in the tension members the said bends can be partially or wholly dispensed with. Adhesion between the compression members and the tension members also results in the removal of load from the rivets or bolts at the point A. The latter are, therefore, in many cases, unnecessary.

In connection with the construction of the different beam elements I proceed as follows. For the tension members, iron or steel lamellæ are best adapted. Each tension member can consist of a single iron bar (Fig. 2) the width of which is equal to the thickness of the girder, or it may be composed of a number of adjacent flat bars (Fig. 4). The latter arrangement is to be preferred in bridge construction and permits of the employment of verticals between the separate bars of the individual tension members for connection to the road beam.

For the compression members freestone, artificial stone, concrete, reinforced concrete, cast iron or steel, that is to say, materials having a high compressive strength, are advantageously chosen. In cases where a number of different materials are present in the same compression body or member the strongest material is used at the points which are subjected to the heaviest stresses.

The structures shown in Figs. 3 to 14 respectively are built upon the foregoing general principles. The said structures all possess the characteristics referred to, so that they are all of a species of which the girder shown in Fig. 1 may be taken as a type.

The structure illustrated in Fig. 3 is a simple beam mounted upon two supports. Each of the tension members *z* consists of a number of adjacent flat iron bars. They are so curved or bent that they intersect the compressive forces in the compression bodies or members approximately at right angles at all points. The tension members are, in the neighborhood of the supports, made only of cement concrete C; towards the center they consist of slag concrete S and granite blocks *g*. The latter are also used at the upper part of the beam, where the compressive stresses are the greatest. The surfaces of the stone blocks which are in contact with the tension members, are carefully prepared and are curved similarly to the iron bars; the lower surfaces or faces are also made with a slight curvature in the direction of the compressive forces, so that no strain is set up between the concrete and stone. The joints through which the tension members pass are provided with a paper or asbestos insertion for the better transmission of the compressive stress, but they can be filled also with a substance of greater strength, such for example, as lead or cement without an addition of sand. At the points at which the distance between the tension members is too great to be spanned by a single block, the compression bodies are each provided with a number of stone blocks. The new joints are also curved and, as before, are provided with an insertion or the filling; they can, however, be made similarly to the others by means of shorter iron bars *k* (Fig. 3) which pass through the joints and are anchored in the lower concrete so that the different elements of the same pressure member are rigidly connected together.

Another method of obtaining shorter stone blocks is shown in Figs. 5 and 6. The iron bars *z* of each tension member are no longer arranged in the same plane, but are displaced with respect to one another. The principle of construction remains the same, since the new beam can be regarded as the combination of three separate adjacent beams the thickness of which is approximately equal to the width of the iron bar and wherein each of the tension members consists of a single iron bar. At those points at which the strength of the compressive forces in the girder requires a thick layer of granite, then, in lieu of a single block, a number of superposed blocks may be employed. The joints *f* (Fig. 3) are also so curved that no strains are set up between the stone blocks.

Fig. 7 illustrates a structure or beam of a curved form. The tension members *z* are curved and arranged as in the preceding case. The compression members consist of cement concrete *c* and stone blocks *g*. As in this case the tension members at their central parts possess a tendency to straighten, they are retained in their proper positions by means of iron supports *p* (Figs. 7 and 8). The tension members run in straight lines between the lower ends of the supports. The function of the metal supports is thus to take up special tensile stresses which are set up in consequence of the shape of the tension members. Their lower ends are formed as shown in Figs. 8 and 9 for practical reasons, and can be connected to the tension members in any suitable manner. The supports are thus in effect not new elements or members of the beam but are rather to be regarded as branches of the tension members. The structure illustrated in Fig. 7, therefore, can be considered a beam with branched tension members which are bent partially in curves and partially polygonally.

Fig. 10 represents a simple beam with rod-like compression members. The tension members, which are assumed to be branched in order to show the girder in its general form, consist, as in the two preceding constructions, of flat iron bars arranged adjacent to one another. For the compression members cement concrete C, reinforced concrete *a* and granite *g* are chosen. The separated rods *g*, *c* and *a* serve the same function as the blocks *g* and concrete S of the previously described figures. The girder forms an open-work structure which may be regarded theoretically as follows:—

Figs. 11 and 12 are details of connections between the tension and compression members of Fig. 10. At the angular points a slight curvature is given to the tension members for more equable transmission of the compressive stresses. Furthermore, at these points angle irons *w* are arranged in order to prevent the compression members from sliding. As the compression members are applied directly at the angles (Fig. 11) for the better transmission of forces they must not be subjected to the action of tensile forces; where this condition cannot be fulfilled by reason of the varying load the iron insertion at the aforesaid angle extends through the iron bar forming each tension member (Fig. 12) so that the pressure rods are rigidly secured at the angles. In the same manner the tension members which, under certain circumstances, may be subjected to compressive forces must be stiffened with angle irons or with concrete jackets (Fig. 12). The tension members, in case they are not stiffened in any way must obviously run in straight lines between the joints. In cases where, as in Fig. 10, the tension members are made with special branches Z_v the latter must be fitted to the joints; fastening is effected by means of simple rivets or bolts. The connection of the tension members at the point A is, in this case, of still greater importance than in the case of beams with solid compression members. It is, in practice, always necessary, even in the case where no tension member extends from the point in question and can only be dispensed with in the case of the quite symmetrical arrangement of the tension members in combination with symmetrical loads.

Fig. 13 illustrates an arch structure. It consists of two girders connected together by a link G^2. The tension members are curved and finished as in the case of the girder shown in Fig. 3. Cement-concrete C and stone blocks *g* are used for the compression members. Further details are obvious from the drawing without further explanation. In order that compressive forces shall always exist in the compression members the arch is provided with links G^1, G^2, and G^3 and its curvature is so chosen that the neutral axis is always outside the pressure lines corresponding to the varying loads.

Fig. 14 illustrates a girder beam which is made of three separate girders connected together. The projecting central beam is supported upon two metal supports C and D and the end girders rest upon the ends of the central girder and upon the outer supports B and F respectively. The tension members *z* of the end girders are curved and arranged as in the case of the structure shown in Fig. 7 and are provided with iron supports *p* on account of their curvature as before. The compression members consist of cement-concrete C and granite blocks *g*. In the case of the central girder the tension members are also so curved that they intersect the direction of the compressive stresses practically at right angles and consist of adjacent flat iron bars. For the compression members on the other hand, I can use: (1) Cement-concrete C, granite blocks *g* and cast iron *e* for the overhanging portions of the structure. (2) For the central parts of the central girder slag concrete S granite blocks *g* and cast iron *e*. For downwardly directed forces the suspended end girders are only subjected to positive bending moments. The ends of the tension members must in this case and for this reason be arranged at the upper edge of the beam. In those parts of the overhanging girder adjacent to the lateral openings the moments are always negative for the above load; the tension members must also consequently in this case be directed downwards. In the middle parts of the central girder the moments may be positive or negative according as to whether the influence of the load is greater or smaller than of the dead weight of the structure. As the tension members are similarly arranged throughout the whole of the central girder care must be taken that the bending moments at the central arch always remain negative. On this account only slag concrete is utilized at this part, the specific gravity of which is about half as great as that of the cement concrete employed for the side openings. This structure further offers at the central openings an example of branched tension members as have also occurred in the structures illustrated in Figs. 1 and 10. As the bending moments are considerably greater above the middle supports C and D than in the middle of the central girder, the number of the tension members at the last named points may be less than over the supports. The outer tension members are for this reason made of short lengths z_v and are connected together by rivets or bolts in the manner indicated in Fig. 14. By reason of the high value of the bending moments above the supports the compression members are made of cast iron *e* at these points.

The connection of the end girders to the central structure is, in the arrangement in Fig. 14, effected simply by the connection (by riveting as shown or otherwise) of the outermost tension members z^a z^b. The tension members of the suspended beams can be therefore regarded as branches of those of the central girder or, more generally stated, the tension members of any two single girders can be regarded as branches of the tension members of the third girder. The structure illustrated in Fig. 14 is very nearly related to that illustrated in Fig. 1. It is a girder with partially polygonal and partially curved and specially branched tension members. Between the tension members z^a z^b a short flat iron bar *f* is introduced in order that the floating parts may be actually linked above the central overhanging girder. If the iron bar *f* be dispensed with, the girder in Fig. 14 becomes a continuous beam upon four supports.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by compression members of varied degrees of strength in positions corresponding to the varied compressive stresses in the girder.

2. A girder composed of tension and compression members, the tension members be-

ing brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by compression members of varied degrees of strength in positions corresponding to the varied compressive stresses in the girder, and said tension members being bent in a direction to intersect the compressive stresses at approximately right angles throughout the whole of the compression members.

3. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by material adapted to resist compression, the compression members being composed of concrete S and blocks of hard material *g*, the latter being arranged at the points where the greatest compressive stresses exist.

4. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by material adapted to resist compression, the compression members being composed of concrete S and blocks of hard material *g*, the latter being arranged at the points where the greatest compressive stresses exist, and said tension members being bent in a direction to intersect the compressive stresses at approximately right angles throughout the whole of the compression members.

5. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by material adapted to resist compression, the compression members being composed of concrete S and blocks of hard material *g*, the latter being arranged at the points where the greatest compressive strains exist, and said blocks being connected with the concrete by means of metal bars *k*.

6. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by material adapted to resist compression, the compression members being composed of concrete S and blocks of hard material *g*, the latter being arranged at the points where the greatest compressive strains exist, and said blocks having their lower faces so curved that no strain exists longitudinally of them.

7. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by material adapted to resist compression, the compression members being composed of concrete S and blocks of hard material *g*, the latter being arranged at the points where the greatest compressive strains exist, and said blocks having their lower faces so curved that no strain exists longitudinally of them, and said tension members being bent in a direction to intersect the compressive stresses at approximately right angles throughout the whole of the compression members.

8. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their extremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by material adapted to resist compression, the compression members being composed of concrete S and blocks of hard material *g*, the latter being arranged at the points where the greatest compressive strains exist, and the tension members being arranged in a plurality of adjacent planes.

9. A girder composed of tension and compression members, the tension members being brought close to each other at the point where the tension is greatest, and being extended in diverging lines from this point to the portions of the girder in which the compression is greatest and in which their ex-

tremities lie, so as to divide the girder into pressure zones, the spaces between the tension members being occupied by compression members of varied degrees of strength in positions corresponding to the varied compressive stresses in the girder, and metal supports *p* connecting said tension members to the upper part of the girder.

In witness whereof, I have hereunto signed my name in the presence of two subscribing witnesses.

ERNST ARNOLD MOCCETTI.

Witnesses:
MARCEL ARMENGAUD, Jeune.,
HANSON C. COXE.