No. 840,053. PATENTED JAN. 1, 1907.

H. L. DUNN.

METALLIC STRUCTURAL ELEMENT FOR BUILDINGS.

APPLICATION FILED JULY 31, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

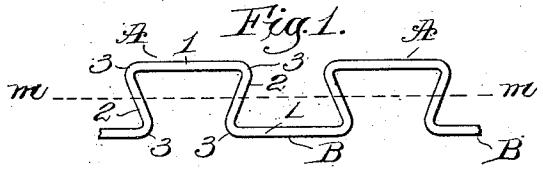


Fig. 2.



Fig. 13.

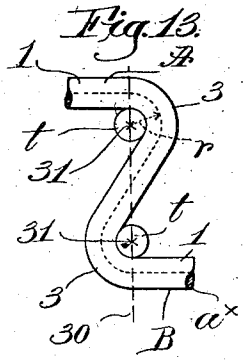


Fig. 3.

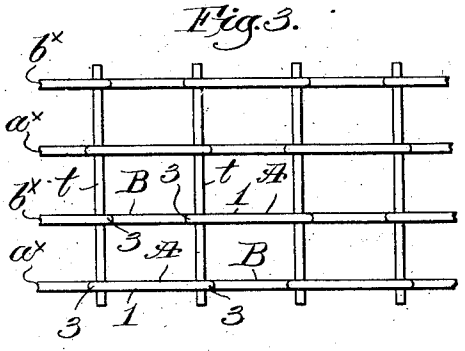


Fig. 4.

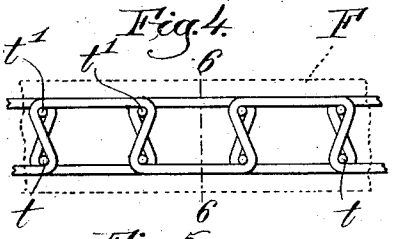


Fig. 6.

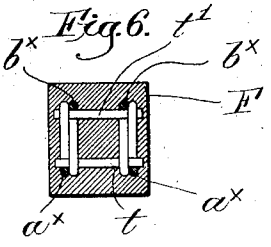
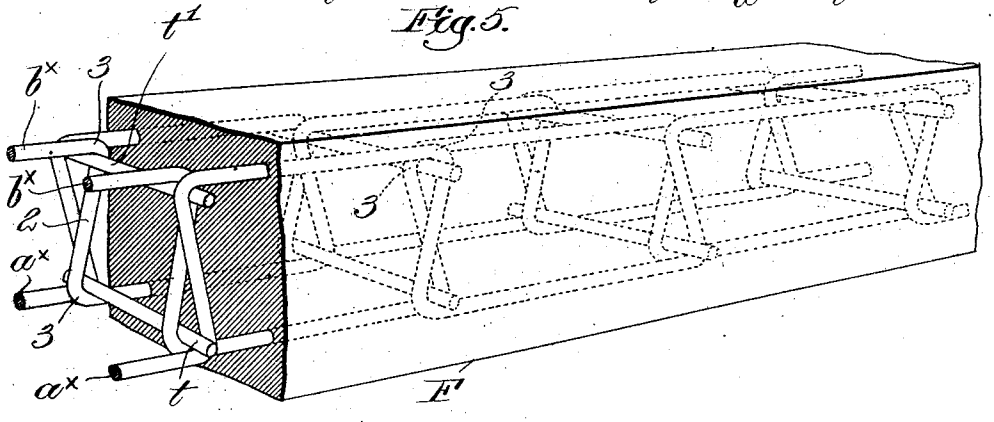


Fig. 5.



Witnesses.

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S. Wm. Lutton.

Inventor:

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3 SHEETS—SHEET 2.

Fig. 7.

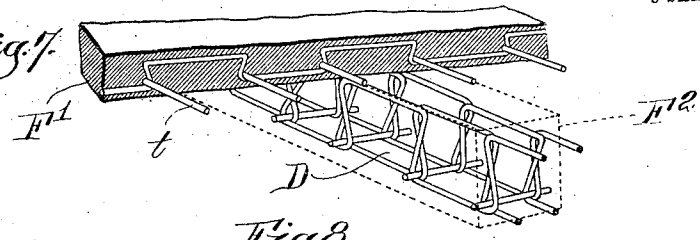


Fig. 8.

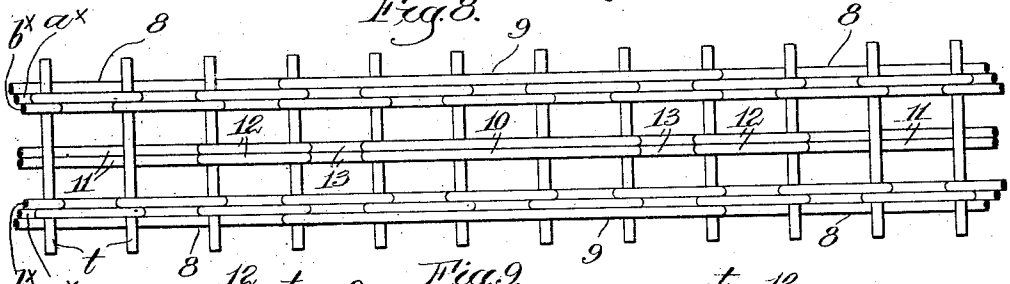


Fig. 9.

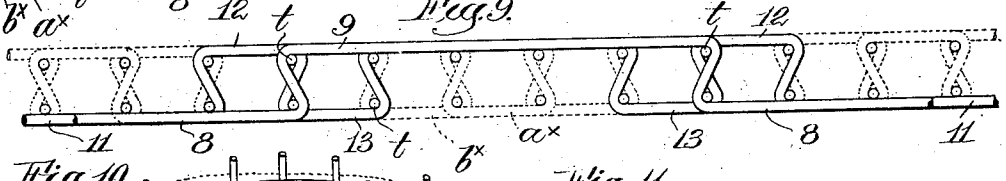


Fig. 10.

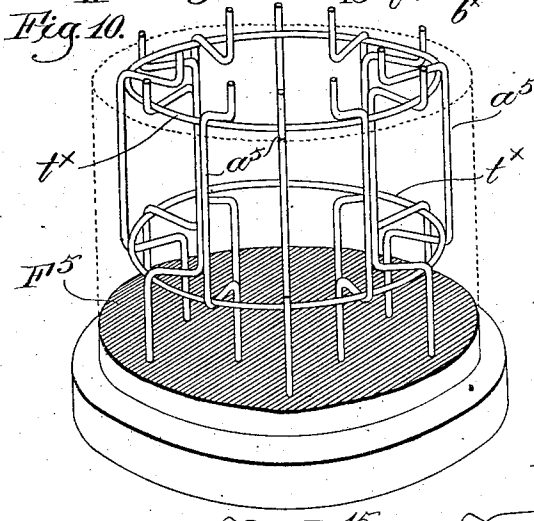


Fig. 11.

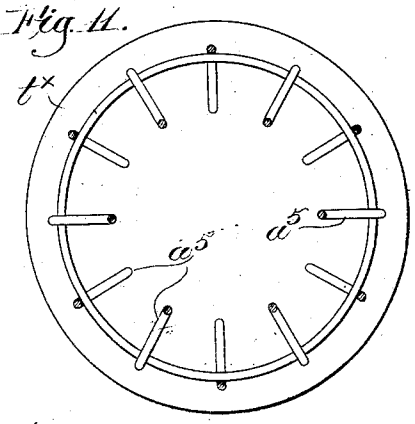
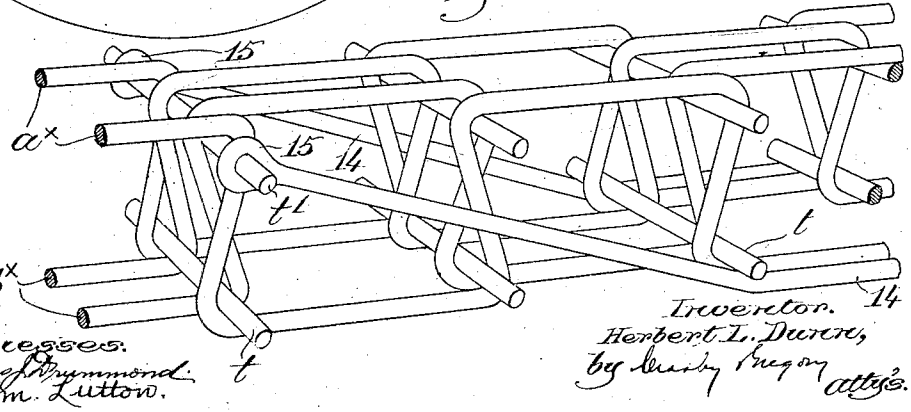


Fig. 12.



Witnesses:
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APPLICATION FILED JULY 31, 1905.

3 SHEETS—SHEET 3.

Fig. 14.

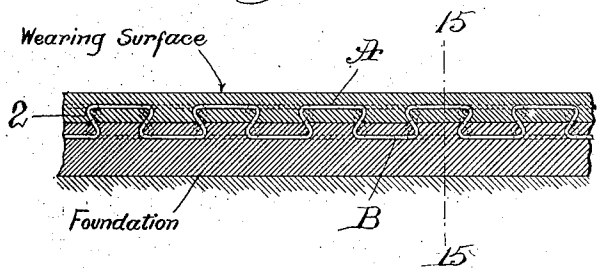


Fig. 15.

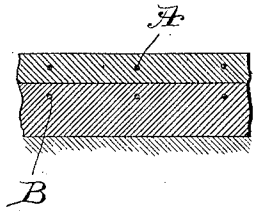


Fig. 16.

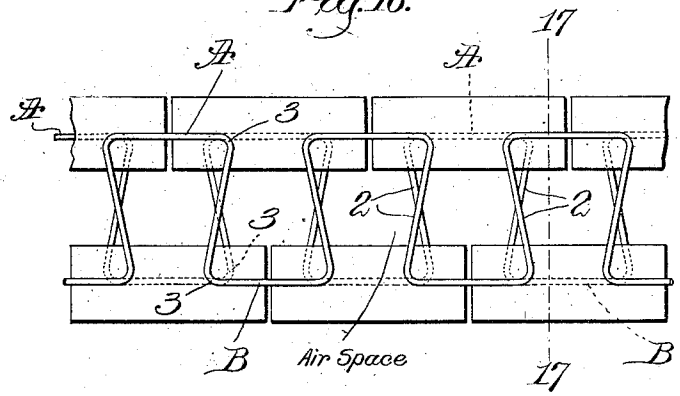


Fig. 17.

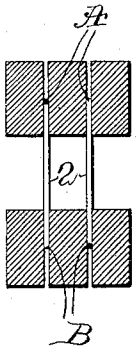
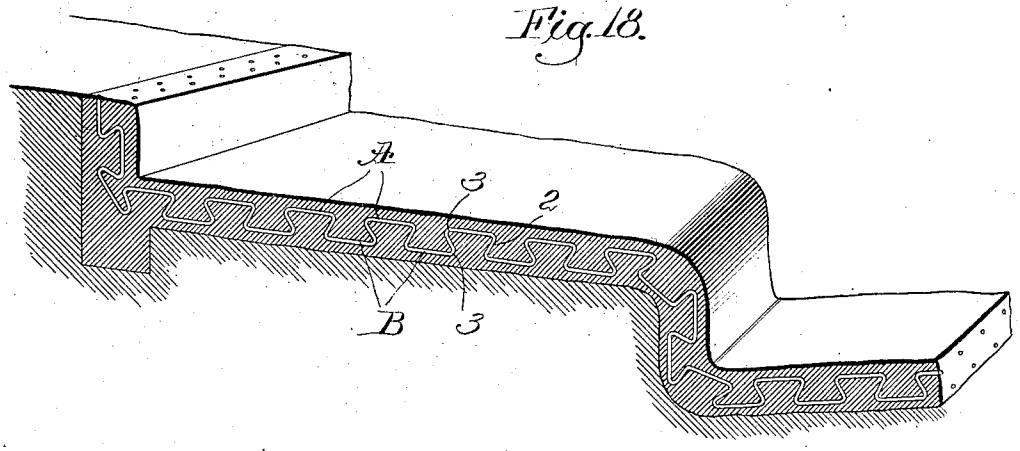


Fig. 18.



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Walter R. Trott

Inventor.
Herbert L. Dunn,
by Glenny & Gregory Attys.

UNITED STATES PATENT OFFICE.

HERBERT L. DUNN, OF HOPEDALE, MASSACHUSETTS.

METALLIC STRUCTURAL ELEMENT FOR BUILDINGS.

No. 840,053. Specification of Letters Patent. Patented Jan. 1, 1907.

Application filed July 31, 1905. Serial No. 272,029.

To all whom it may concern:

Be it known that I, HERBERT L. DUNN, a citizen of the United States, and a resident of Hopedale, county of Worcester, State of Massachusetts, have invented an Improvement in Metallic Structural Elements for Buildings, &c., of which the following description, in connection with the accompanying drawings, is a specification, like characters on the drawings representing like parts.

This invention relates to the so-called "composite" construction for buildings, columns, and various structures in which a metallic skeleton framework is used in combination with a concrete or similar filling; and it has for its object the production of a novel, simple, and efficient structural element for use in connection with such structures. These elements assembled in various forms, a vast number of which are possible, are used as a reinforcement for the concrete or other filling material in constructing foundations, walls, columns, beams, floors, &c.

The structural element embodying my invention consists of a metallic bar or rod of suitable dimensions bent or deformed to present substantially trapezoidal convolutions, the bases of adjacent convolutions being located in and forming the upper and lower chords of a truss-like structure when used with tie-rods, the inwardly-converging sides of the convolutions connecting the chord portions and forming the diagonals of the structure. Such formation of the structural element provides, when a number of such elements are assembled, locking-openings through which tie-rods are passed, tying the whole into a strong rigid skeleton frame self-sustaining and capable of imparting to the filling great resistance to tensile strains.

In assembling the elements they are arranged in couples, as it were, the convolutions of one being opposed to or the reverse of the convolutions of the other, so that the bends connecting the base and sides of a convolution in one element overlap bends in the coupled element. Through these overlapped bends the tie-rods are passed and resist extension longitudinally in either or both chords, as the case may be.

The convolutions of an element are preferably symmetrical with relation to the median line of the element, so that the elements are reversible and interchangeable for a given size.

A combination of a plurality of longitudinal elements with the transverse tie-rods produces a firm species of netting having length, breadth, and thickness or depth, tied securely together without the use of wire wrappings, clips, or welds, self locking and sustaining, and possessing great firmness and stiffness.

The varous novel features of my invention will be fully described in the subjoined specification and particularly pointed out in the following claims.

Figure 1 is a side elevation of a portion of a structural element embodying my invention. Fig. 2 is a similar view showing a plurality of elements coupled together with tie-rods in the lower chord only of the truss formation. Fig. 3 is a top plan view thereof. Fig. 4 is a view similar to Fig. 2, but showing tie-rods in both chords, the filling of concrete or other suitable material being indicated by dotted lines. Fig. 5 is a perspective view of a concrete beam reinforced by a skeleton frame made up of structural elements embodying my invention. Fig. 6 is a transverse section of such a composite beam on the line 6 6, Fig. 4, looking toward the right. Fig. 7 is a perspective view illustrating a beam and floor structure embodying the novel structural elements. Fig. 8 is a top plan view of a skeleton frame suitable for a floor, wall, or partition, showing stiffening-binders. Fig. 9 is a side elevation thereof, but with the longitudinal elements in dotted lines and the binders in full lines. Fig. 10 is a perspective view of a composite column structure, showing the manner in which the structural elements can be arranged to stiffen and effect lateral bracing of the filling. Fig. 11 is a transverse sectional view thereof through the framework. Fig. 12 is an enlarged perspective view of a skeleton frame assembled and made up of the structural elements and tie-rods, with an eyebar form of stiffening-binder; and Fig. 13 is an enlarged detail of the opposite bends at the ends of one of the sides common to two adjacent convolutions of the structural element. Fig. 14 is a sectional view of a concrete floor, showing the use of the elements without tie-rods, serving to bond together the foundation or bottom and the top or wearing surface. Fig. 15 is a transverse section on line 15 15, Fig. 14. Fig. 16 is a plan view of a brick wall with an air-space, showing the use of the elements to tie the two parts of the wall together. Fig.

17 is a transverse section on line 17 17, Fig. 16. Fig. 18 is a partly-perspective view showing the use of the elements by themselves acting as binders in a pavement structure of concrete.

In making up the structural element in accordance with my invention I take a metal bar or rod, preferably cylindrical and of proper diameter—say about two inches, more or less—and deform or bend the same to form substantially trapezoidal convolutions A B, the former being reversely arranged with relation to the latter. Each convolution comprises a base portion 1 and sides 2, shown herein as inwardly convergent, connected with the ends of the base by circular bends 3. I prefer to make these bends with a radius equal to one-half the diameter of the element plus one-half the diameter of the transverse tie bar or rod *t*, to be referred to, and, viewing Fig. 13, the radius *r* of curvature of the bend 3 is equal to one-half the diameter of the bar $a^{\times}$ (the element) plus one-half the diameter of the tie-rod *t*. This provides for a snug fit of the tie-rod in the bend when the elements are assembled. With reference to the median line of the element, which may be made of any convenient length, (said line being indicated at *m m*, Fig. 1,) the convolutions A may be considered to be one series above the line and the convolutions B a second series, alternating with series A and below the median line, the inclined sides of a convolution in one series merging into or being common with a side of each of two convolutions in the other series. A truss-like structure is thus formed when used with tie-rods, the bases 1 of series A forming one chord and the bases of the other series B forming the other chord, the inclined sides 2 of the trapezoidal convolutions connecting the chords and constituting diagonals of the truss. In assembling these elements there is almost an infinite number of ways in which they can be arranged, and I have shown herein but a few examples of the skeleton frame or structure which can be made, sufficient, however, to demonstrate the character and utility of the invention. I have also shown some examples in which the elements are used without tie-rods.

Referring to Figs. 2 and 3, a plurality of the structural elements made as described are arranged in parallel planes, laterally separated and so placed that the convolutions of one element break joints, as it were, with the convolutions of adjacent elements. The elements $a^{\times}$, Fig. 3, alternate with elements $b^{\times}$, and the bases 1 of the convolutions of the former are located opposite the spaces between the bases of the convolutions of the elements $b^{\times}$, the bends 3 at the ends of the bases overlapping or extending past each other. By this arrangement openings are formed through which transverse tie-rods *t* are passed from one to the other side of the frame, and in Fig. 2 the tie-rods are passed through the openings in the lower chords only, though it will be seen that the openings 4, formed in the upper chords, could be utilized in a similar manner. Such an arrangement is shown in Figs. 4, 5, and 6, the tie-rods *t* being located in the lower chord-openings and the tie-rods *t'* in the upper chord-openings.

In Fig. 3 the elements are shown as equidistant from each other laterally, and adjacent elements may be said to be coupled together by the tie-rods, the elements of a couple being reversed as to the location of their convolutions, as explained. If desired, however, two or more elements placed side by side may make one member of a couple, and a like number of reversed elements may make the other member, as will be manifest.

Referring to Figs. 5 and 6, it will be noted that the coupled members are placed close together and one of the couples is separated laterally from the other couple, the similarly-disposed members $a^{\times}$ being arranged on the outside, with the corresponding members $b^{\times}$ inside.

A strong, rigid, yet light, skeleton frame is thus provided, self-locking and self-sustaining and adapted to form the framework or reinforce for the concrete or other filling F, herein shown as molded about the metallic frame to form a composite beam.

When the elements are thus formed into a self-sustaining structure by the tie-rods, which latter lock the elements together, so rigid a truss structure is presented that the molds for the filling can be attached directly thereto, greatly reducing the cost of building and supporting the forms or boxes in which the concrete is molded.

A strong and rigid reinforce for the concrete is provided without the weight and expense of the regular structural sections, such as I-beams, &c., and a most thorough and complete mechanical bond between the filling and the reinforcing-frame is assured by the form of the latter and the parts composing the same. It will also be seen from an inspection of Fig. 5 that the reinforce is well distributed throughout the cross-section of the filling instead of being concentrated in heavy sections at widely-distributed points. Consequently there are no planes of weakness, as the frame reinforces the entire section.

The skeleton frame or reinforce resulting from the combination of the structural elements with the transverse locking or tie rods has two parallel surfaces strongly supported and firmly held together without the use of any additional members, as will be manifest. One of these surfaces affords suitable reinforcement for the floor when used in a building, while the other surface may be used for the ceiling, and by the use of a proper mold

an air-space may be formed between such surfaces.

The general object in reinforcing concrete with relatively small steel or iron framing is to provide the necessary tensile resistance in a beam, slab, &c. Concrete is weak in tensile strength, especially in small sections, and this weakness is overcome to a greater or less extent by embedding a metallic reinforce in the concrete, making a composite structure. The peculiar truss formation or arrangement of the reinforce produced by the peculiar deformation or bending of the rods or bars to form the structural elements in my invention not only gives a rigid reinforcement to the filling, with a perfect mechanical bond, well distributed and adapted to many uses, but it places the metal where it is most necessary to overcome tensile stresses by giving a continuous tension member throughout the structure.

When a block of concrete is subjected to a compression test, it fails by the sides spalling off, as there is nothing to hold the sides from bulging. The inclosing jacket formed by the elements in accordance with my invention gives a lateral support to the filling, which greatly increases the resistance thereof to compression.

In Fig. 7 I have shown at D a reinforce or skeleton frame embodying my invention for use as a floor-beam and supporting a composite flooring comprising filling F' and a skeleton frame or reinforce such as has been described, the filling for the beam being indicated by dotted lines at F^2. The reinforce D in the beam is substantially the same as shown in Fig. 5; but the upper tie-rods are omitted, as the tie-rods in the lower chords resist the tensile strain on the beam.

In Figs. 8 and 9 I have shown a skeleton reinforce or frame substantially such as illustrated in Fig. 5 so far as relates to the coupled structural elements $a^\times$ $b^\times$, arranged in pairs; but I have provided stiffening-binders which partake of the general characteristics of the structural elements; but they are made with larger convolutions. The outside binders are made with alternating convolutions 8 9 of such length that they correspond to a number of the smaller convolutions of the regular elements $a^\times$ $b^\times$—that is, as shown, one of the binder convolutions will span six of the tie-rods in a chord, while the ordinary convolutions span but two tie-rods. Intermediate stiffening-binders are also shown, a pair of them being illustrated in Fig. 8 side by side and between the two pairs of coupled elements, and the convolutions here are a combination of small and large ones—that is, the convolutions 10 11 are large enough to span, say, four of the tie-rods and the intervening smaller convolutions 12 13 span but two of the tie-rods.

The stiffening-binders serve to strengthen and stiffen the frame as a whole, and they may be shaped differently and applied in different ways—as, for instance, they may be made as eyebars (see Fig. 12)—the binders 14 having eyes 15 to receive the tie-rods t' in the upper chord, and in this illustration the binders strengthen the lower chord of the truss-frame by passing beneath tie-rods t in such lower chord.

My invention is readily adaptable to various uses—as, for example, the same general form of structural element such as shown in Figs. 1, 2, 5, and 7 may be used in a foundation, column, beam, or floor, but the combining or assembling would be varied to suit the conditions in each case. For instance, in Figs. 10 and 11 an arrangement is shown suitable for a column, the several elements, deformed or bent as hereinbefore described, being set upright in a series of radial planes, but reversely, as before explained, in order that the tie-rods may lock them together. The tie-rods $t^\times$ in this instance are bent into circular form and lie in horizontal planes, and while I have shown them only at the outer edges of the elements it will be obvious that other tie-rods curved on a smaller radius can be used on the inner edges. The filling is indicated at F^5 and the elements as a whole at a^5.

In general the convolutions in the elements are made symmetrical, with the bases of the convolutions forming one series alined and parallel to the bases of the other series of convolutions, and then the oppositely-turned bends 3 at the ends of a common side member 2 will be struck from centers which lie in a line normal to the chords of the structure, as shown in Fig. 13, the line 30 passing through the centers 31 of the upper and lower bends shown and being normal to the upper and lower chords. This line 30 also intersects the common side member 2 at its center. The deformation or bending of the element may be varied somewhat, however, for particular cases, and the disposition of the reinforcement is at the will of the designer to suit the conditions of the case.

When the elements are assembled to form a reinforce or frame for concrete-steel construction, as in columns, beams, &c., short lengths only are exposed to the heat in case of fire, and consequently there is no chipping or spalling off of the concrete, as is the case when continuous rods or bars are used, due to the expansion of the same practically as a unit.

My invention results in great economy of construction, as the deforming or bending of the bars or rods to form the elements can be effected at a very slight increase over the cost of the steel, and the assembling into the desired frame is easily accomplished. There is also a saving of cost on the forms requisite to mold the filling, and the latter can be easily placed about the reinforce without

danger of voids. A very simple and effective method of composite construction is thus provided, giving maximum strength for the minimum reinforcement.

Among the many structural works for which my invention is adapted I may mention concrete piles, sheet-piling, and cap grillage, spreading footings in concrete foundations, concrete basement-floors to prevent cracks in waterproofing, armoring canal-walls, retaining-walls, dams, conduits and culverts, chimneys, stand-pipes, arches, columns, girders, beams, floors, roofs, stairs, pressure-pipes, penstocks, flumes, concrete building-blocks, &c.

Referring to Figs. 14 to 18, inclusive, I have illustrated a few of the ways in which the structural element may be used without tie-rods to tie or bond different parts together. In the construction of a concrete floor it is often desirable to make the upper or wearing surface of a richer mixture than the bottom or foundation; but it has been difficult to make a satisfactory bond between the two layers. I have found, however, that by using my structural elements in the manner shown in Figs. 14 and 15 a most perfect and thoroughly satisfactory bond is provided. The elements are placed in parallel vertical planes, but preferably with openings in one opposite closed portion of the next element, the lower portion of each element being embedded in the foundation layer. The wearing-surface or top layer is then applied and embeds the upstanding portions of the elements.

In Figs. 16 and 17 I have shown the use of the elements to tie the two portions of a brick wall built with an air-space, the elements being laid between courses in parallel horizontal planes and breaking joints, as shown. A very simple, cheap, and strong tie is thus provided. Another use is shown in Fig. 18, the elements being embedded in the concrete-pavement structure and set in parallel upright planes, the elements being capable of bending to conform to the general conformation of the concrete. The convolutions of the elements act in such a structure to securely bind and hold together the various portions of the concrete, giving a very strong and wear-resisting body.

Having fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A reversible structural element for building purposes, consisting of a metallic rod or bar deformed or bent to present two alternating series of convolutions having straight base portions and inwardly-convergent sides, the centers of curvature of corresponding apex bends of two adjacent convolutions lying in a line perpendicular to the base portions and intersecting the common side of said convolutions at its center, said bends being adapted to receive tie-rods, pairs of the latter being thereby located one above the other in lines perpendicular to the base portions.

2. A structural element for building purposes consisting of a metallic rod or bar deformed or bent to present substantially trapezoidal convolutions lying in the same plane, the diagonal side common to adjacent convolutions being joined to their bases by circular bends the centers whereof are in a line intersecting the side at its center, the circular bends being adapted to receive cylindrical tie-rods of substantially the same curvature.

3. In building construction, a plurality of elements located in parallel planes and each consisting of a metallic rod or bar bent to present substantially trapezoidal convolutions having inwardly-converging sides, the convolutions of adjacent elements being reversed to cause the bends at the ends of their bases to overlap, and a filling in which the said elements are embedded, the elements reinforcing and bonding the filling.

4. A skeleton frame for composite structures, comprising a plurality of elements each consisting of a metallic rod or bar bent to present two alternating series of convolutions having straight base portions and sides joining the bases by circularly-curved bends, the convolutions of coupled elements being reversely positioned to cause the bends at the ends of their bases to overlap, and cylindrical tie-rods passed through the pairs of overlapped bends and being seated therein, to unite the elements into a rigid frame.

5. A skeleton frame for composite structures, comprising a plurality of elements each consisting of a metallic rod or bar bent to present substantially trapezoidal convolutions having inwardly-converging sides, the convolutions of coupled elements being reversely positioned to cause the bends at the ends of their bases to overlap, and tie-rods passed through the pairs of overlapped bends to unite the elements into a rigid truss-like frame.

6. A skeleton frame for composite structures, comprising a plurality of elements each consisting of a metallic rod or bar bent to present substantially trapezoidal convolutions having inwardly-converging sides, the convolutions of coupled elements being reversely positioned to cause the bends at the ends of their bases to overlap, and tie-rods passed through the pairs of overlapped bends to unite the elements into a rigid frame, combined with stiffening-binders bent to present elongated trapezoidal convolutions equal to two or more convolutions of one of said elements and coöperating with predetermined tie-rods.

7. A skeleton frame comprising a plurality of metallic rods or bars each bent to present substantially trapezoidal convolutions hav-

ing inwardly-converging sides, the convolutions of coupled elements being reversely positioned to cause the bends at the ends of their bases to overlap, and tie-rods passed through the overlapped bends transversely of the elements, to unite the same into a rigid structure, and a filling of plastic or cementitious material.

8. In building construction, a composite structure comprising a skeleton frame consisting of coupled elements, each element consisting of a metallic rod or bar bent to present substantially trapezoidal convolutions having inwardly-converging sides and their bases forming upper and lower chords, the two elements constituting a couple being reversely positioned to cause the bends at the ends of the bases of the convolutions to overlap, and tie-rods passed through the pairs of overlapped bends in both chords of the elements forming a couple, to thereby form a rigid frame, and a filling.

9. A skeleton frame comprising a plurality of metallic bars or rods each bent to present substantially trapezoidal convolutions having straight base portions constituting upper and lower chords, and inwardly-converging sides connecting them, the convolutions of adjacent elements being reversed to cause the bends at the ends of their bases to overlap, and tie-rods passed through the overlapped bends, to tie or bind the elements into a rigid structure, and a filling in which the said elements and tie-rods are embedded.

10. A self-sustaining skeleton framework for composite structures, comprising a plurality of elements located in different planes and each consisting of a metallic rod or bar bent to present substantially trapezoidal convolutions having straight bases and inwardly-converging sides, the bases in one chord of the element being alined and in parallelism with the bases in the other chord, adjacent elements being reversely positioned to cause the bends at the ends of the bases of alternating convolutions to overlap, and tie-rods extended through the overlapped bends, to unite the elements into a rigid, unitary truss-like frame.

11. A self-sustaining skeleton framework for composite structures, comprising a plurality of elements located in different planes and each consisting of a metallic rod or bar bent to present substantially trapezoidal convolutions having straight bases and inwardly-converging sides, the bases in one chord of the element being alined and in parallelism with the bases in the other chord, adjacent elements being reversely positioned to cause the bends at the ends of the bases of alternating convolutions to overlap, and two sets of tie-rods, the tie-rods of each set passing through the overlapped bends in one of the chords, to thereby unite the elements at both chords and resist flexure transverse to the depth of the elements.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

HERBERT L. DUNN.

Witnesses:
WALTER F. ROPER,
CLARE H. DRAPER.