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TRUSSED STRUCTURAL MEMBER AND METHOD OF AND MEANS FOR ITS MANUFACTURE

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Fig. 1

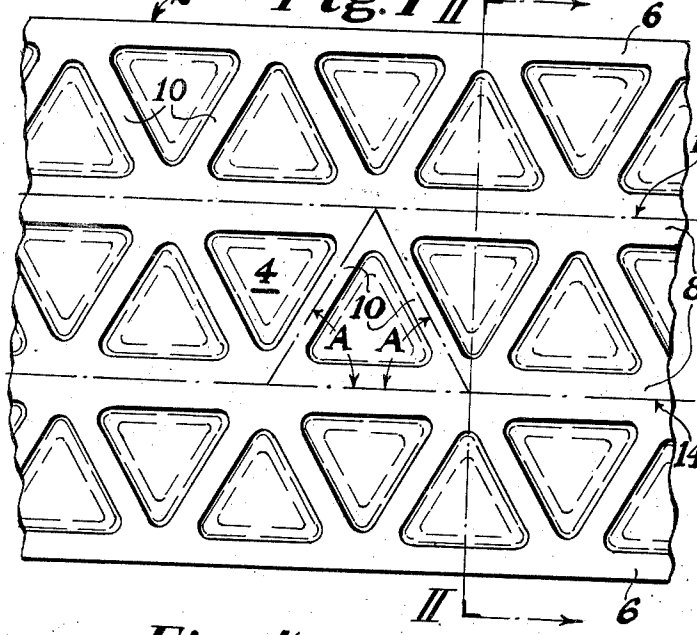


Fig. 2

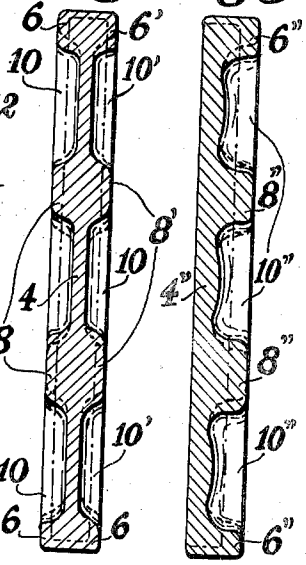


Fig. 3

Fig. 5

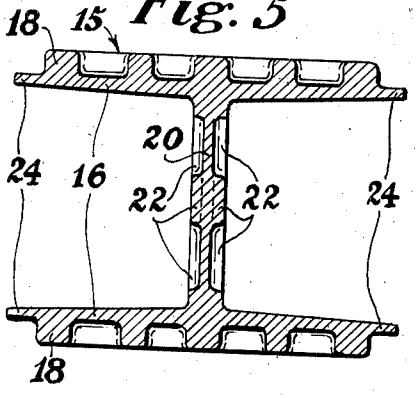


Fig. 4

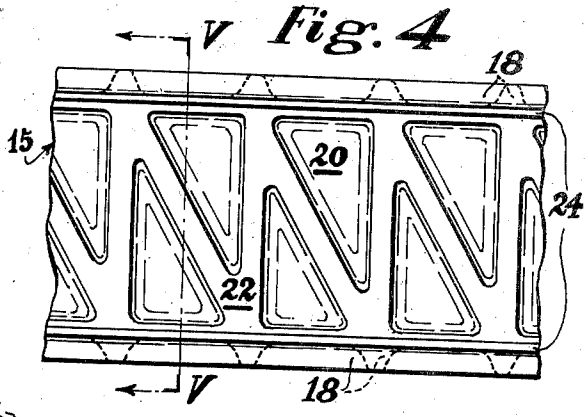


Fig. 6

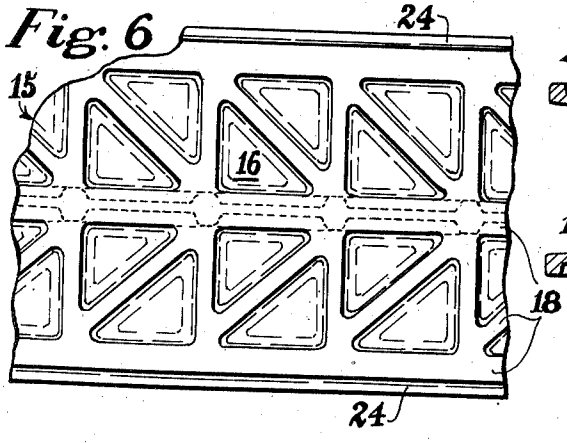


Fig. 8

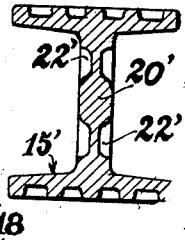
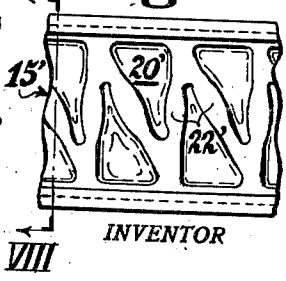


Fig. 7



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Fig. 11

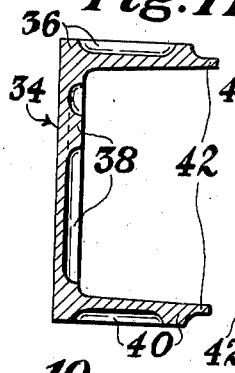


Fig. 12

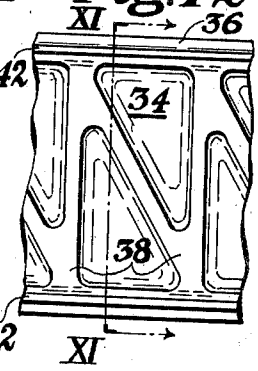


Fig. 9

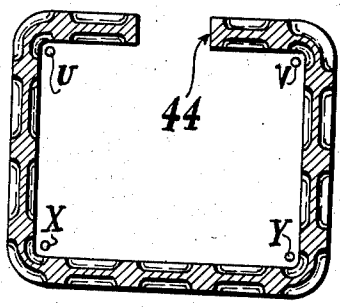


Fig. 10

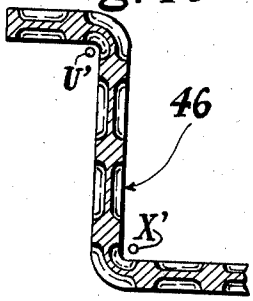


Fig. 13

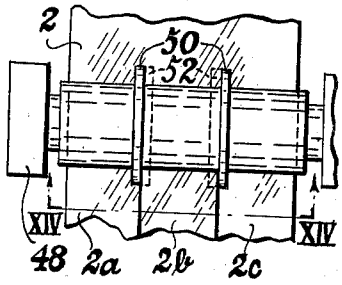


Fig. 14

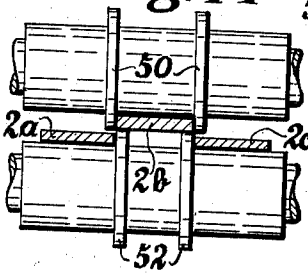


Fig. 15

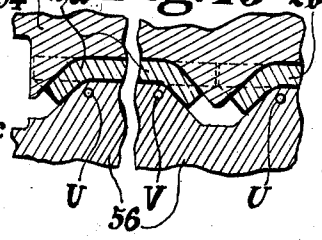


Fig. 16

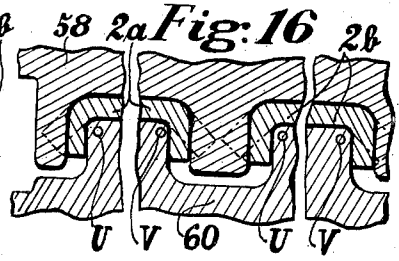


Fig. 17

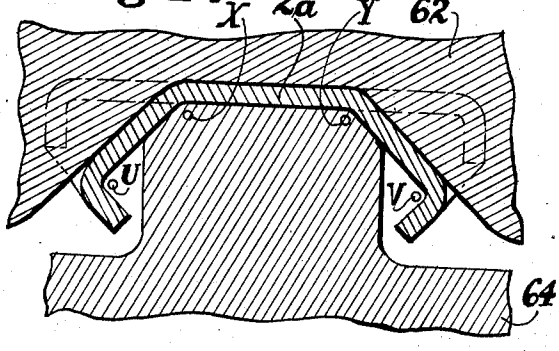
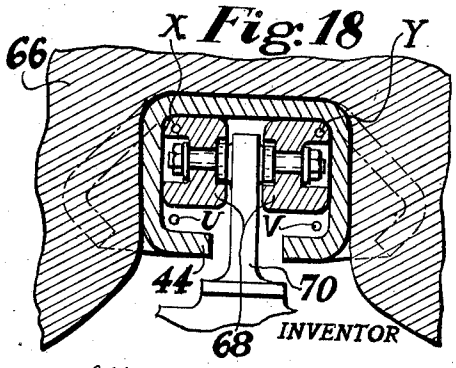


Fig. 18



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Fig. 21

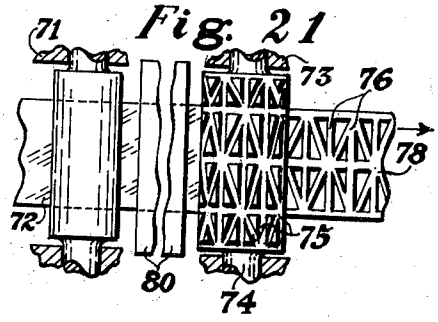


Fig. 22

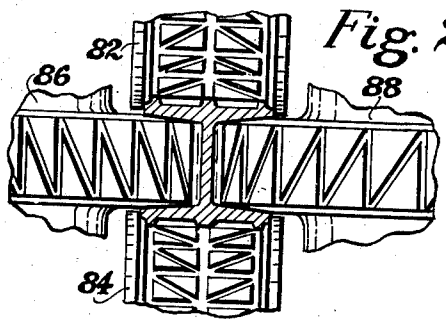


Fig. 23

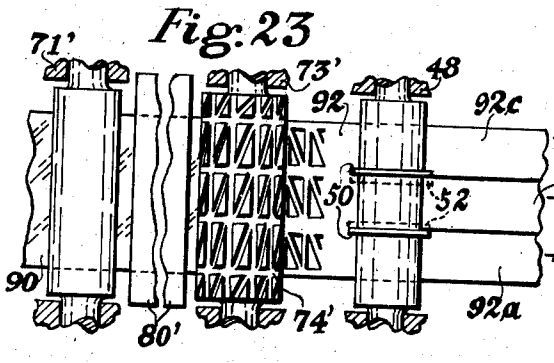


Fig. 24

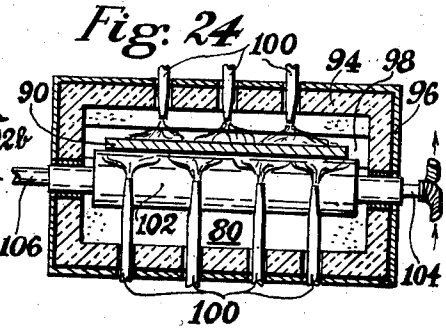


Fig. 25

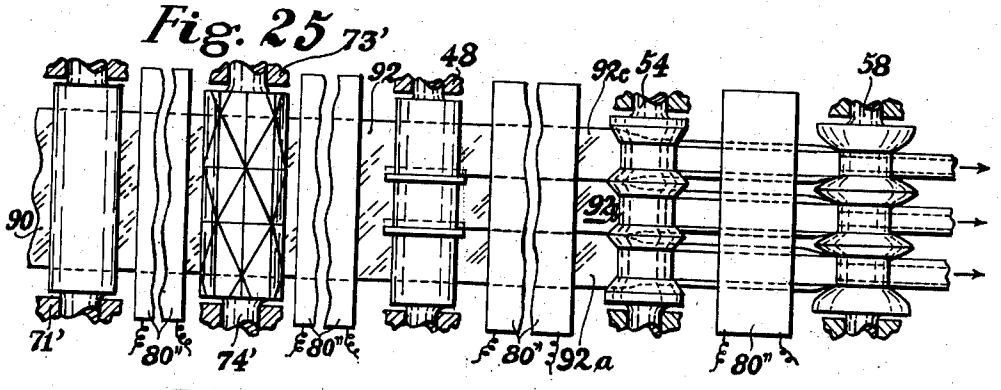


Fig. 19

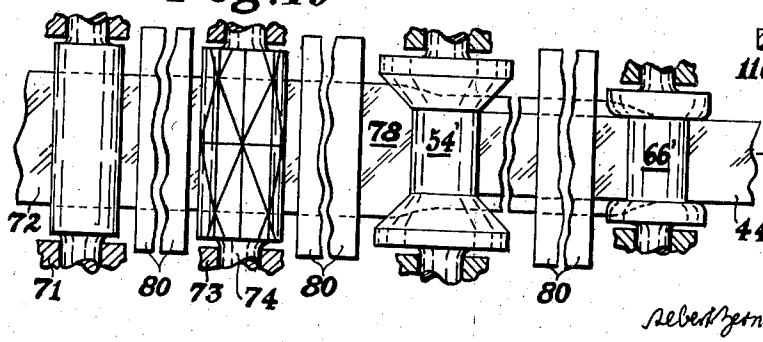
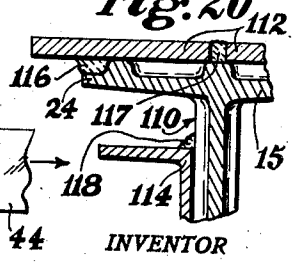


Fig. 20



INVENTOR

Albert Bernhard de Salardi

Patented June 24, 1941 2,246,578

UNITED STATES PATENT OFFICE

2,246,578

TRUSSED STRUCTURAL MEMBER AND METHOD OF AND MEANS FOR ITS MANUFACTURE

Albert Bernhard De Salardi, Wilkinsburg, Pa.

Application February 24, 1939, Serial No. 258,260

22 Claims. (Cl. 29—34)

My invention relates to structural members such as plates, I-beams, channels, T's, angles and the like composed of substantially prismatic bars integral with each other and to the methods of and means for their manufacture.

The structural members of the present art (hereinafter called "conventional") consist of one or more bars (hereinafter called "parent bars") of substantially uniform cross sections thruout their length integral and forming certain angles with each other and distinguished, according to location, by such names as: "flange," "web," "leg," etc.

Subjected to bending forces the conventional structural members do not utilize their material in the most efficient way because the material toward the neutral axis participate only to a relatively small extent in the development of the stresses which are needed to balance the acting forces while in the same time the fibres remotest from the neutral axis may be stressed beyond their elastic limits. This unequal distribution of the stresses necessitates an increase of the cross sectional area hence the use of a heavier member for supporting a certain load.

My invention does away with above and other drawbacks by providing an improved distribution of the material bounded by the cross sections so that the stresses are more evenly developed thruout the cross sections, the buckling effects in the web portions are reduced, the strength and rigidity of the member substantially increased and approximately the maximum economy in material can be achieved under the given circumstances. I achieve these purposes by providing parent bars of the member with pockets or indentions bounded by derivative bars (these bars derive their material from that replaced by the pockets) protruding from the parent bar, integral therewith and forming triangles constituting at least one rigid (non-collapsing) truss embossed upon the surface thereof.

Hence, the objects of my invention are: first, to provide structural members parent bars of which having sunk-in pockets or indentions bounded by derivative bars arranged in a network of triangles integral with and protruding substantially from the parent bar; second, to provide structural members having the parent bars with a network of derivative bars embossed thereon, said derivative bars forming rigid trusses; third, to provide structural members in which portions at varying distances from the neutral axis are rigidly connected by derivative bars protruding from the parent bar; fourth, to provide structural members having relatively thin and wide indented parent bars carrying a network of integral derivative bars protruding therefrom with a height that is greater than the minimum thickness of the indented parent bar for increasing the strength, stiffness and economy of the member; fifth, to provide structural members having cross sections of greater momenta of inertia and radii of gyration, respectively, than those of the conventional members of equal cross sectional areas; sixth, to provide fabricated structural members composed of at least one member having derivative bars facilitating rigid attachment by welding; seventh, to provide structural members having an increased bond with concrete by virtue of sunk-in pockets and protruding derivative bars; eighth, to provide a method of producing improved structural members by rolling conventional structural members and subsequently producing on its parent bars indentions or sunk-in pockets and protruding derivative bars by die rolling; ninth, to provide a method of producing improved structural members adding to the rolling die rolling of the member, respectively, some or all of the steps of longitudinal cutting, bending and partial or total progressive reheating thereof; tenth, to provide means for manufacturing the improved structural members comprising a rolling mill having flat-rolling and one die-rolling passes the latter being formed by rolls at least one of which is provided with a network of connected grooves arranged in a triangular pattern; eleventh, to provide means for manufacturing the improved structural members comprising a rolling mill having flat-rolling, die-rolling and bending passes and some or all of the following means acting upon the work piece: a rotary slitter for dividing the work piece longitudinally and reheating means for keeping the temperature of the work piece within desired limits during the shaping operations.

These and other ancillary objects as well as the various improvements and advantages of my invention will be best understood by reading the following specification in conjunction with the accompanying drawings in which:

Fig. 1 is the plan view of one embodiment of the invented structural member: a trussed plate;

Fig. 2 is a cross sectional view on the line II—II of Fig. 1;

Fig. 3 is the sectional view of an one side trussed plate;

Fig. 4 is the side elevational view of another embodiment showing a trussed I-beam having

sunk-in pockets and derivative bars on both flanges and the web;

Fig. 5 is a sectional view taken on the line V—V of Fig. 4;

Fig. 6 is the top plan view of the trussed I-beam shown in Fig. 4;

Fig. 7 is the side elevational view of another trussed I-beam in which the thickness of the web and the width of its derivative bars are increasing toward the neutral axis;

Fig. 8 is a sectional view taken on the line VIII—VIII of Fig. 7;

Fig. 9 is a cross sectional view of a trussed structural member having a partially closed or semi-closed box shape obtained from a trussed plate by bending;

Fig. 10 is a partial cross sectional view of an exemplary embodiment having an open channel shape obtained from a trussed plate by bending;

Fig. 11 is a sectional view of a trussed channel taken on the line XI—XI of Fig. 12;

Fig. 12 is the side elevational view of a trussed channel;

Fig. 13 shows in diagrammatic plan view the apparatus for slitting a trussed plate longitudinally into several narrower strips;

Fig. 14 is a partly sectional view taken on the line XIV—XIV of Fig. 13;

Figs. 15, 16, 17 and 18 show diagrammatically the apparatuses and operational steps necessary to produce from a trussed plate a semi-closed box shaped member by bending;

Fig. 19 is the diagrammatic plan view of the apparatus for producing semi-closed box shaped trussed structural members by flat rolling and die rolling and bending;

Fig. 20 is a fragmental cross sectional view of a composite structure obtained by welding to a trussed structural member other members, conventional or trussed;

Fig. 21 illustrates diagrammatically the apparatus producing trussed structural members;

Fig. 22 shows diagrammatically the die rolls of a die rolling pass producing trussed I-beams;

Fig. 23 is the diagrammatic plan view of the apparatus producing trussed strips by cutting longitudinally a wide trussed plate;

Fig. 24 is a diagrammatic partial sectional view of the reheating apparatus for reheating portions of the structural member during the rolling operations;

Fig. 25 is the diagrammatic plan view of the apparatus for rolling and die rolling a wide trussed plate and cutting and bending it for producing simultaneously several trussed structural members.

Referring closer to the drawings by the characters of reference in Figs. 1 and 2 the shown embodiment of my invention is a trussed plate designated generally by **2**. It comprises the web or the indented parent bar **4** and the derivative bars **6**, **8** and **10** raised on one side of the web and **6'**, **8'** and **10'** on its other side. The derivative bars are integral with the indented parent bar and with each other, **6**, **8**, **6'** and **8'** running longitudinally (referred to as the bases), **10** and **10'** running diagonally (referred to as the struts) of the member. The network of the derivative bars shows equilateral triangles raised on the surface of the indented parent bar **4** constituting a number of connected Warren type trusses. Though the type of the truss in the pattern of which the derivative bars are arranged is optional I prefer the Warren type truss pattern in which the struts form equal angles A with the bases and I also prefer to choose A so that it satisfies the following equation:

$$\tan. A = \sqrt{\frac{C+T}{T}}$$

where C is the crushing strength and T is the tensile strength of the material of the structural member. In case of commercial low carbon steel the approximate value of A in degrees will be 52°.

It was shown by calculus that an equilateral triangular frame having two base-angles A satisfying above equation will need to have the least weight to support a certain load, hence this construction will lead to the greatest economy when incorporated into my trussed structural members.

In case the trussed plate is intended to be cut or bent along the middle of a longitudinally running derivative bar, I prefer to make some of such bars twice as wide than the others along which such operation is not intended.

The original cross sectional dimensions of the conventional parent bar are shown in Fig. 2 by dot and dash lines illustrating the reduction of the thickness to that of web **4** by the indentions and the protrusion of the derivative bars from the indented web to a height which is preferably greater than the minimum thickness of the indented web. With other words, in all embodiments of the invented trussed structural members I segregate the material, displaced in the parent-bars by indentions, into derivative bars, which protrude therefrom above the original surface of the parent-bar, the latter being shown in Figs. 2 and 3 in dot and dash-lines.

Fig. 3 is a cross sectional view of a similar embodiment representing a one side trussed plate, the derivative bars **6''**, **8''** and **10''** being raised only on one side of the web **4''** which is shown to be flat on one face and convex between the derivative bars. The cross sectional dimensions of the original conventional plate are shown in dot and dash lines.

Generally, the thickness of the bars at the indentions is kept at a minimum determined by the necessary strength and limitations imposed by the manufacturing process and by the physical properties of the material while the derivative bars are preferably made to have proportionate but substantial cross sections for substantial increase of the rigidity and economy of the member.

As the trussed members are preferably shaped by rolling, the profiles of all derivative bars and those of the corresponding grooves in the die rolls will consist of suitably curved surfaces—some of them similar to gear-teeth flanks—merging through fillets of proper radii into the surfaces of the indented parent bar. As the determination of such curved surfaces is a matter of skill only, I do not describe or show them more particularly.

Figs. 4, 5 and 6 illustrate another embodiment of my invention, a trussed I-beam **15** upon the indented parent bars of which integral derivative bars are raised arranged in networks of triangles forming rigid (non-collapsing) trusses. In the exemplary embodiment shown each flange **16** of the I-beam **15** is provided with outwardly protruding trusses **18** and the web **20** with trusses **22** raised thereon on both sides, each truss being formed by derivative bars. The trusses shown are substantially of the Howe type, but any other type of rigid network of tri-

angles will be satisfactory. I recommend also in this embodiment the employment of the Warren trusses with base angles satisfying the aforementioned equation for increased economy. As this pattern is illustrated in Fig. 1 it is not necessary to repeat it.

In the embodiment shown the parent flanges are wider than the trusses formed thereon so that protruding lips 24 remain which due to their smaller mass are especially suited for quick welding to other members forming fabricated structures; they have also a value as convenient support of added members before welding. An exemplary embodiment of such composite welded structure is shown in Fig. 20.

Figs. 7 and 8 illustrate a trussed I-beam 15' which differs from that shown in Figs. 4 to 6 in so far only that the thickness of the web 20' and the width of the derivative bars forming trusses 22' are increasing toward the plane of the neutral axes of the cross-sections and that the flanges and their trusses are shown to be coextensive and no lateral lip is formed. It is obvious that the lips may be added to this or any other embodiment of trussed structural members and also, that the width and the height of the derivative bars as well as the thickness of the indented bar may be varying instead of being substantially constant, as shown in the majority of the illustrated embodiments.

Fig. 9 is the cross sectional view of a semi-closed box-shaped trussed structural member 44 made from a trussed plate of sufficient width by bending it about four axes X, Y, U, and V running in the longitudinal direction of the member.

Fig. 10 is a partial cross-sectional view of an open channel-shaped trussed structural member 46 obtained from a trussed plate of sufficient width by bending said plate about four axes, running in the longitudinal direction of the member. Of these four axes only two, X' and U' are shown. The embodiments shown in Figs. 9 and 10 are especially adapted for reinforcing concrete structures cast about them.

Figs. 11 and 12 illustrate a trussed channel 34 the flanges and the web of which being provided with indentions and derivative bars forming trusses 36, 38 and 40. The trusses are narrower than their flanges leaving laterally protruding lips 42 in the preferred embodiment.

Figs. 13 and 14 illustrate diagrammatically the apparatus for dividing a trussed plate such as 2 in Fig. 1 into a number of strips. The plate 2 is led onto rotary slitting shear 48 of any approved design having cooperating shear disks 50 and 52 that cut the plate 2 into strips 2a, 2b and 2c. Adjusting laterally the positions of the disks by known means (not shown) the width of the strips are controlled.

Figs. 15 to 18 illustrate the apparatus for and method of, respectively, bending a trussed plate by rolling it through suitable roll-passes into different shapes such as angles, channels, semi-closed box, etc.

Fig. 15 shows the bending of the cut strips (only 2a and 2b are shown) by a roll-pass formed by suitably profiled rolls 54 and 56 shown broken away. The bending of the strips is effected at an acute angle, preferably about 45° around longitudinal axes U and Y corresponding to those shown in Fig. 9.

Fig. 16 illustrates the completion of the bending of the same strips around the same axes to 90° in a succeeding roll-pass formed by suitably grooved rolls 58 and 60 shown broken away. The resulting shape is a U channel.

Fig. 17 shows the bending of the channel formed of strip 2a about longitudinal axes X and Y in a third roll-pass constituted by suitably profiled rolls 62 and 64 shown broken away. The bending is effected at an acute angle, preferably 45°.

Fig. 18 shows the last bending operation for obtaining the semi-closed box shape 44 (shown to a larger scale in Fig. 9) completing the bending about axes X and Y to 90°. This final bending is effected by a suitably grooved roll 66 of relatively large diameter (shown broken away) and two or more cooperating mandrel-rollers 68 rotatably mounted on a stationary bracket 70 accommodated in the groove of the large roll.

In Figs. 13 to 18 conventional (solid) plates are shown for simplicity but it will be understood that they may also represent trussed plates. Full lines illustrate the obtained shapes after they leave the respective roll-pass, dot and dash lines the previous shapes, before entering the respective pass.

Fig. 19 illustrates diagrammatically the apparatus for producing semi-closed box-shaped trussed structural members 44 (shown in Fig. 9) by rolling. The trussed plate 78 is led onto four consecutive bending passes, corresponding to those shown in Figs. 15 to 18, of which passes only the first and the last ones are indicated by rolls 54' and 66' respectively, the second and third passes being broken away in the drawings. 71 is the last finishing stand of a hot-strip or plate-mill delivering the parent-bar or plate 72 onto the die-rolling stand 73 having a roll pass formed by a set of rolls at least one of which is a die-roll 74 producing from the parent-plate the trussed plate 78. Between the roll passes reheating devices 80 are installed for continuous and progressive reheating of the work-piece which travels through them. The die-roll 74 and the reheating device 80 will be described in more detail in conjunction with subsequent figures.

Fig. 20 shows a fragmental cross sectional view of a composite structure 110 fabricated from trussed I-beam 15 and other shapes, such as plates 112, angle 114, etc. by welding. Welds 116, 117 and 118 attach the added members to the stiff derivative bars of the trussed I-beam forming a rigid, strong and economical unit. The effectiveness of weld 116 is increased by lip 24. Though the plates 112 and angle 114 are shown to be conventional shapes, it will be understood that some or all of them may be of the invented trussed type.

Fig. 21 is the diagrammatic plan view of the apparatus producing trussed plates. The last finishing stand 71 represents a hot strip mill delivering the parent bar or plate 72 onto the die-rolling stand 73 having a pass formed by a set of rolls at least one of which is a die roll 74 provided with suitable grooves 75 corresponding to the desired derivative bars 76 to be raised on the parent plate for producing the trussed plate 78 delivered from the die rolling stand in the direction of the arrow. 80 is a suitable heating device of any approved design located between the finishing pass and the die rolling pass for reheating the moving plate to the desired temperature previous to die rolling. The reheating device 80 is shown broken away; its design, dimensions and control are such that the plate, traversing it with the speed of the mill, is kept

automatically within the desired temperature limits.

Fig. 22 shows diagrammatically the die-roll pass and the die-rolls (broken away) for producing trussed I-beams such as illustrated in Figs. 4 to 8. The die-roll pass is formed by two horizontal die-rolls **82** and **84** and two vertical die-rolls **86** and **88** the axes of which are preferably in the same vertical plane. In case any of the trusses should be omitted the respective die-roll would have to be replaced by a smooth surfaced roll. I am using the expression "die-roll" to designate a roll carrying on its body die-blocks having the shape of substantially truncated pyramids, with curved side surfaces protruding from the cylindrical base of the roll-body and forming peripherally widening grooves between the dies which grooves are the molds of the derivative bars into which the displaced material is squeezed during die-rolling.

By substituting in Fig. 21 in place of stand **71** a universal mill stand and for the die-rolling pass that illustrated in Fig. 22 we obtain the apparatus for rolling trussed I-beams.

Fig. 23 illustrates diagrammatically the apparatus for producing wide trussed plates and subsequently cutting them into narrower strips. It is a combination of the apparatus shown in Fig. 21 and the rotary slitting shear illustrated in Figs. 13 and 14. The conventional solid rolled plate **90** enters the die-rolling stand **73'** having sufficiently wide die rolls **74'** and is shaped into trussed plate **92** which is then delivered onto rotary slitting shear **48** to be divided into strips **92*a***, **92*b*** and **92*c*** by the action of the shear disks **50** and **52**. Finishing stand **71'** represents a hot plate mill and **80'** a suitable reheating device.

Fig. 24 is the cross sectional view of a heating device **80** represented in a semi-diagrammatic manner. It comprises a chamber **94** of heat insulating material enclosed preferably in a metallic shell **96** and having suitable openings **98** for receiving and delivering the workpiece and admitting burners **100** which eject blasts of combustion gases impinging upon the workpiece **90** moving through the chamber and supported by rollers **102** rotatably mounted and preferably water cooled. **104** is the piping for the cooling water and **106** the driving connection of the rollers. The burners **100** are arranged in sufficient number at proper locations to elevate the temperature of the workpiece and keep it between desired limits.

The mixture of the combustion gases and the intensity of the blasts ejected by burners **100** are automatically regulated by known means (not shown) for conveying sufficient heat to the moving workpiece the mass and the speed of which being varied between predetermined limits according to need. The control means may enable the uniform heating of the whole plate or selectively intensified heating of certain strips only, according to need for cutting or bending the workpiece along certain lines.

The reheating devices may also be electrical ones such as shown diagrammatically in Fig. 25 which is a schematic plan view of the apparatus for producing simultaneously a number of trussed channels, formed from strips **92*a***, **92*b*** and **92*c*** by bending. The bending roll passes are indicated by rolls **54** and **58** already described in Figs. 15 and 16. The reheating devices **80''** are shown to use electrical energy for heating, the transformation of the energy being effected by known means of electric resistance or electromagnetic induction, not shown.

In Figs. 19 and 25 the network of grooves of the die rolls **73'** and **73** are indicated schematically by a network of lines.

Having fully described my invention and illustrated certain preferred embodiments thereof, it will be understood that various changes and alterations may be made by those skilled in the art in practicing my invention without departing from the spirit and the scope thereof, hence I do not wish to be limited by the shown illustrative embodiments, but what I claim as new and desire to protect by Letters Patent is:

1. Trussed structural member comprising a plurality of substantially prismatic parent bars united longitudinally throughout their length forming predetermined angles with each other and derivative integral bars embossed upon said parent bars in patterns of composite triangles, said derivative bars constituting in themselves a plurality of rigid trusses arranged to each other at the same angle as said parent bars.

2. Trussed structural member comprising a plurality of substantially prismatic parent bars united longitudinally throughout their length forming predetermined angles with each other and integral derivative bars embossed upon said parent bars in patterns of composite isoceles triangles the equal legs of which form an angle of A° with their respective bases, said derivative bars constituting in themselves a plurality of rigid Warren type trusses arranged to each other at the same angle as said parent bars, said angle A satisfying the equation

$$\tan A = \sqrt{\frac{C+T}{T}}$$

where C denotes the crushing strength and T denotes the tensile strength of the material of said member at ordinary temperature to which it is subjected during use.

3. Trussed structural member comprising a plurality of substantially prismatic parent bars united longitudinally throughout their length forming predetermined angles with each other and derivative integral bars embossed upon said parent bars in patterns of composite triangles, said derivative bars constituting in themselves a plurality of rigid trusses arranged to each other at the same angle as said parent bars, the width of some of said trusses being less than that of the respective parent bar having lateral strips free from said derivative bars.

4. Trussed structural member according to claim 1 in which said parent bars form an angle of 180° with each other constituting a plate.

5. Trussed structural member according to claim 1 in which three parent bars are arranged in an I shape, two of said parent bars forming the flanges and the third being the web of said I shape.

6. Trussed structural member according to claim 3 in which three parent bars are arranged in an I shape, two of said parent bars forming the flanges and having lateral strips free from said derivative bars and the third of said parent bars forming the web provided with derivative bars extending all over its width.

7. The method of producing trussed structural members consisting in the steps of hot rolling the work piece into a shape composed of prismatic parent bars of suitable dimensions and being united longitudinally throughout their

length forming predetermined angles with each other, and subsequently die-rolling the obtained shape in a manner that substantially triangular indentions are obtained in said parent bars, segregating the squeezed-away material into derivative bars surrounding said indentions and arranged in patterns of composite triangles forming in themselves a plurality of rigid trusses arranged to each other at the same angle as said parent bars.

8. The method of producing trussed structural plates consisting in the steps of hot rolling the work piece into a plate of suitable dimensions and subsequently die-rolling it in a manner that substantially triangular indentions are obtained therein and the squeezed-away material is segregated into derivative bars surrounding said indentions and arranged in patterns of composite triangles forming in themselves a plurality of annexed rigid trusses.

9. The method of producing trussed structural members consisting in the steps of hot rolling the work piece into a plate of sufficient dimensions, afterwards die-rolling it in a manner that substantially triangular indentions are obtained therein and the squeezed-away material is segregated into derivative bars surrounding said indentions and arranged in patterns of composite triangles forming in themselves a plurality of annexed rigid trusses and subsequently subjecting the die-rolled plate to permanent deformation chiefly by bending, preserving substantially the values of the areas of the cross sections obtained by die-rolling.

10. The method of producing trussed structural plates consisting in the steps of hot rolling the work piece into a plate of sufficient dimensions and simultaneously progressively reheating and die-rolling it in a manner that substantially triangular indentions are obtained thereon and the squeezed-away material is segregated into derivative bars surrounding said indentions and arranged in patterns of composite triangles forming in themselves a plurality of annexed rigid trusses.

11. The method of producing trussed structural members consisting in the steps of hot rolling the work piece into a plate of suitable dimensions and simultaneously progressively reheating and die-rolling it in a manner that substantially triangular indentions are obtained thereon and the squeezed-away material is segregated into derivative bars surrounding said indentions and arranged in patterns of composite triangles forming in themselves a plurality of annexed rigid trusses and subsequently subjecting the die-rolled plate to progressive permanent deformation chiefly by bending, preserving substantially the values of the areas of the cross sections obtained by die-rolling.

12. A rolling mill comprising a finishing roll pass containing at least one roll having on its body portion a network of communicating peripherally widening grooves arranged in a pattern of composite triangles constituting the negative imprint of the bars of a rigid truss bent about a cylindrical surface and adjacent to said die roll pass a reheating device through which the workpiece passes on its way toward said die roll pass for progressive increase of its temperature and plasticity to facilitate the die-rolling.

13. A hotplate mill comprising a die roll pass containing at least one roll having on its body portion a network of communicating peripherally widening grooves arranged in a pattern of composite triangles constituting the negative imprint of the bars of a rigid truss bent about a cylindrical surface, adjacent to said die roll pass a reheating device through which the workpiece passes on its way toward said die roll pass for progressive increase of its temperature and plasticity to facilitate the die-rolling, and bending roll passes following said die roll pass for progressive permanent deformation of the die-rolled plate by bending.

14. For deforming material in plastic state, a die-roll having neck- and body portions, the latter consisting of a substantially cylindrical base and a plurality of die-blocks integral with and protruding radially from said base in such a shape that the plan-projection of the sectional areas of each with said base and also with other coaxial cylindrical surfaces within the periphery of said body-portion are substantially triangular with rounded-off corners, the dimensions of said sectional areas decreasing with the increase of the diameters of said cylindrical surfaces.

15. A rolling mill comprising a die roll pass containing at least one die-roll having a body portion consisting of a substantially cylindrical base and a plurality of die-blocks integral with and protruding radially from said base in such a shape that the plan projection of the sectional areas of each with said base and also with other coaxial cylindrical surfaces within the periphery of said body portion are substantially triangular with rounded off corners, the dimensions of said sectional areas decreasing with the increase of the diameter of said cylindrical surfaces, and adjacent to said die roll-pass a reheating device through which the workpiece passes on its way toward said die roll-pass for progressive increase of its temperature and plasticity to facilitate the die rolling.

16. A hotplate mill comprising a die roll pass containing at least one die-roll having a body portion consisting of a substantially cylindrical base and a plurality of die-blocks integral with and protruding radially from said base in such a shape that the plan projection of the sectional areas of each with said base and also with other coaxial cylindrical surfaces within the periphery of said body portion are substantially triangular with rounded off corners, the dimensions of said sectional areas decreasing with the increase of the diameter of said cylindrical surfaces, adjacent to said die roll pass a reheating device through which the workpiece passes on its way toward said die roll pass for progressive increase of its temperature and plasticity to facilitate the die-rolling and bending roll-passes succeeding said die roll-pass for progressive permanent deformation of the finished plate by bending.

17. For deforming material in plastic state, a die-roll having neck and body portions, the latter consisting of a substantially cylindrical base and a plurality of die-blocks protruding radially from said base, said die-blocks forming substantially truncated pyramids with curved side-surfaces having finit radii of curvature.

18. A rolling mill comprising a die-roll-pass containing at least one die-roll having a body portion consisting of a substantially cylindrical base and a plurality of die-blocks protruding radially from said base, said die-blocks forming substantially truncated pyramids with curved side-surfaces having finit radii of curvature.

19. A hot-plate-mill comprising a die-rolling

pass containing at least one die-roll having a body portion consisting of a substantially cylindrical base and a plurality of die-blocks protruding radially from said base, said die-blocks forming substantially truncated pyramids with curved side-surfaces having finit radii of curvature and at least one bending roll pass for progressive permanent deformation of the die-rolled plate by bending.

20. The method of producing structural members having semi-closed box-shape consisting of the steps of rolling plates and progressively subjecting said plates to permanent deformation by bending without substantially altering the cross sectional areas of the work-piece.

21. Bending roll-pass consisting of two substantially parallel mounted rolls, means to rotate at least one of said rolls, a groove on the working surface of the one roll serving as a female bending-die and a cylindrical protrusion on the other roll serving as male-die and cooperating with said groove.

22. Bending roll-pass comprising a relatively large roll, a groove on its working surface acting as a female bending-die, and two relatively small rolls mounted rotatably upon a stationary stand accommodated within said groove, said small rolls acting as male-dies.

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