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FABRICATED TRUSS

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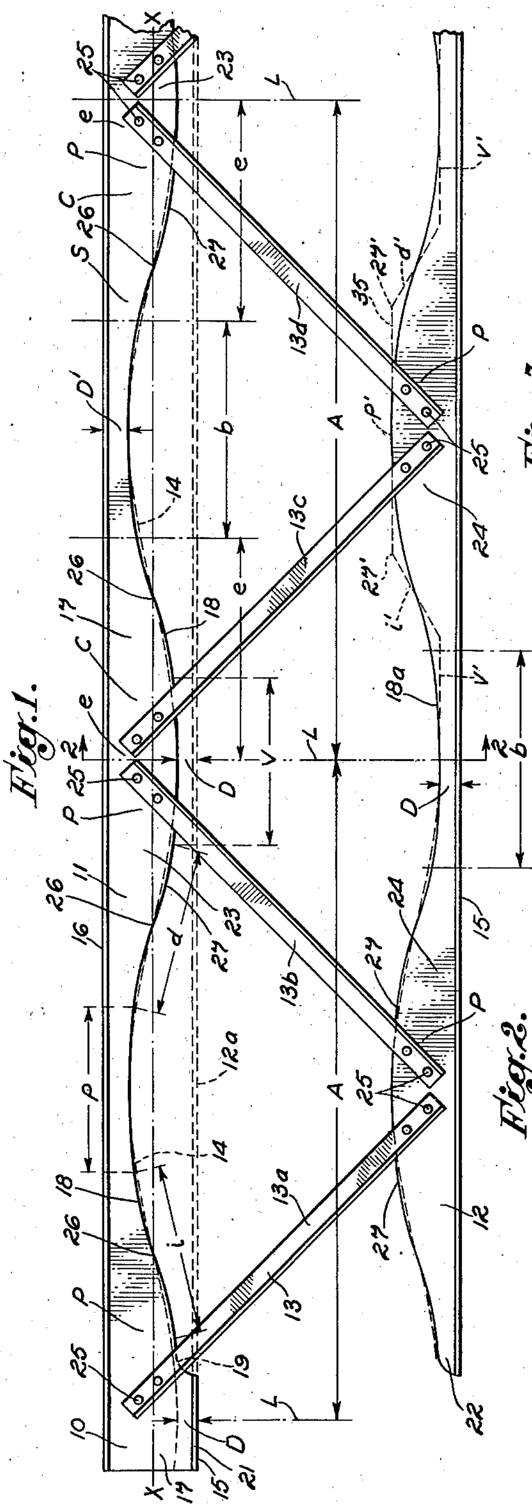

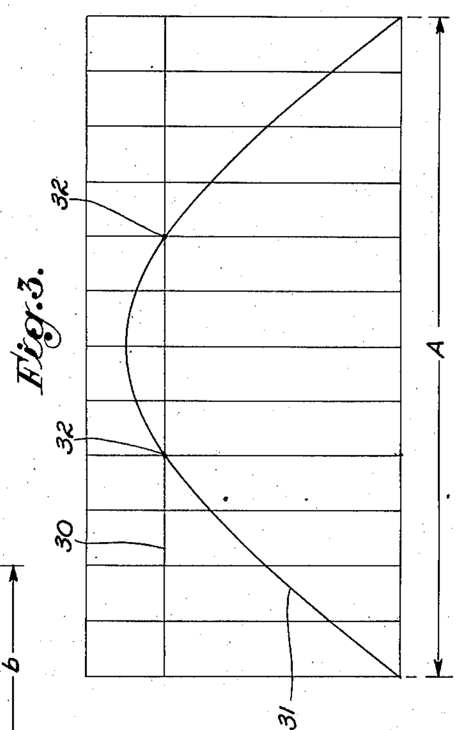

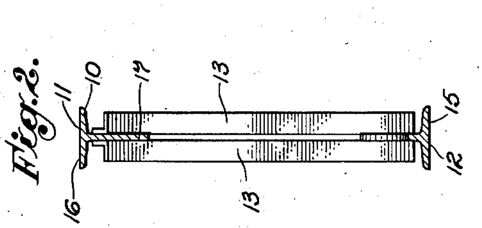

INVENTOR
FRANKLIN N. ROPP
BY
Fred [signature]
ATTORNEY.

UNITED STATES PATENT OFFICE

2,156,818

FABRICATED TRUSS

Franklin N. Ropp, Los Angeles, Calif., assignor to Soule Steel Company, Los Angeles, Calif., a corporation of California

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8 Claims. (Cl. 189—37)

My invention relates to the fabrication of steel structures for buildings, bridges, and the like, with particular reference to trusses.

For the purpose of illustrating the principles of the invention, the present disclosure will be devoted to a truss in which the top chord supports a substantially uniformly distributed load, such as a roof structure, and the bottom chord also supports a uniformly distributed load, such as a ceiling. It will be understood, however, that the principles so illustrated apply to any type of truss, and that the configurations of the chords and the relative dimensions of the elements of the truss may be widely varied to meet the requirements of particular installations.

The total or combined stress through a section of the upper chord of such a truss is the sum of a compression stress caused by truss action and a bending stress attributable to loading between panel points; the total or combined stress through a section of the lower chord is the sum of a tension stress caused by truss action and a bending stress caused by the ceiling load between the panel points; and the combined unit stress through any section of either chord is the combined stress divided by the area of the section. Because the top chord is in compression, the allowable unit stress is less for the top chord than for the bottom chord.

An important object of my invention is to provide a novel truss construction whereby the value of the combined unit stress in either chord taken through consecutive sections throughout the length of the chord will have a minimum variation from a given value, preferably approximately the allowable unit stress for each chord. In such a construction the cross-section of a chord will be non-uniform, varying substantially with the combined stress through the section. Since the maximum combined unit stress in such a series determines the allowable load of the truss, and since any understress with respect to such maximum value represents excess material, in achieving this object I approach a maximum value for the ratio of allowable load to weight of material in the truss, thus providing an efficiently designed, light, and economical structure.

The preferred form of my invention is characterized by the conception that the two chords of a truss may be shaped and dimensioned in a complementary manner to each other in the sense that corresponding sections of the two chords will vary inversely to each other. In achieving this inverse relationship, I attain one of the most important objects of my invention, namely, the provision of a truss structure in which the combined corresponding sections of the two chords throughout their lengths will be constant in total cross-sectional area and in the pattern of that area.

While it will be apparent, in the detailed description to follow, that my truss, considered as a finished product without consideration for the problems of manufacture, is, in itself, novel and represents a substantial advance in the art, a great part of the value of my invention resides in the simplification and economy of manufacture made possible by the novel design. The requirements for economical manufacture of steel members conflict directly with the requirements of chord members in an ideal truss, since only members of uniform cross-section may be produced by steel mills at less than prohibitive costs, whereas variation in cross-section is required for the chords of an ideal truss. The importance of the complementary relationship between the two chords provided by my invention may be understood when it is pointed out that a pair of such complementary chords may be readily cut from a single uniform member without waste of material. A feature of my invention, then, is that I offer a complete solution for the aforementioned conflict between the requirements for economical manufacture of steel and the requirements for efficient distribution of metal in a truss structure.

More specifically, it is an object of my invention to provide a truss having upper and lower chord members interjoined by diagonal struts, which chord members may be formed by the cutting of a uniform structural member along an undulating line of such character that the metal in the resulting complementary portions will be disposed to carry the various stresses with maximum efficiency. At this point a further feature of my invention becomes apparent. The steel shapes may be carried in stock in standard sizes and specialized only as used. Thus, a standard six inch I-beam in stock may be converted by my process of fabrication into chord members specialized for any number of particular installations.

In a preferred form of my invention it is my object to sever the uniform structural member along a longitudinal path that is essentially sinusoidal. Also, in the preferred form of my invention it is my object to cut the two complementary chord members from a uniform member having a bottom flange, such as an I-beam, and to cut one of the chords shorter than the other chord so that said bottom flange will remain a part of the longer chord at each end thereof to serve as supporting surfaces at each end of the truss. By such a procedure I eliminate the necessity for end detail in the construction of the truss.

Further objects and advantages of the invention will be made evident throughout the following part of the specification.

Referring to the drawing, which is for illustrative purposes only,

Fig. 1 is an elevational view of a portion of a truss made in accordance with my present invention.

Fig. 2 is a cross section on a plane represented by the line 2—2 of Fig. 1.

Fig. 3 is a graph of moments of one panel of the upper chord member.

In Fig. 1 I show a structural I-beam 10 comprising an upper chord member 11 and a lower chord member 12 severed from the upper chord member 11, moved down in spaced relation thereto, and connected to the upper chord member by diagonal struts 13, individually indicated as 13*a*, 13*b*, 13*c*, and 13*d*. Prior to being severed from the upper chord member 11, the lower chord member 12 existed as a unitary part of the I-beam 10, as indicated by dotted lines 12*a*. The fabricated beam shown in Fig. 1 is divided longitudinally into panels A, and extending longitudinally of the web 17 of the I-beam 10 I have shown a sinuous path indicated by a dotted line 14 which undulates from a distance D from the lower face 15 of the beam 10 to a distance D′ from the upper face 16 of the beam 10, the valleys of this sinuous path 14 being centralized on the line L of division of the panels A. The undulating curve or path 14 is an elongated sine curve wherein one panel A represents a revolution of 360°, the curve being of shallow character as shown and being formed in centralized relation to an axis X—X which is closer to the lower edge of the I-beam 10 with the result that the dimension D′ is greater than the dimension D. Following and approximating the sine curve 14, I show a line or path of cut 18 on which the beam 10 is actually severed by suitable means such as an oxyacetylene cutting torch. It will be noted that the line of cut 18 does not follow the sine curve 14 to the extreme ends of the beams 10 but swerves downwardly at 19 so that the cut will run out the lower edge or face 15 of the beam 10, thereby leaving a flange portion 21 at each end of the upper portion or chord member 11, and at the same time producing a lower chord member 12 having its ends 22 foreshortened with respect to the ends of the upper chord member 11. It will be perceived that the cutting of the I-beam 10 in the manner shown produces therefrom two members 11 and 12 which have T cross section, but which members 11 and 12 respectively have webs 23 and 24 which are complementary in character in that the cutting line 18 which defines the lower edge of the web 23 of the upper chord member 11 matches or is complementary to the upper undulating edge 18*a* of the web 24 of the lower chord member 12. By severing the beam 10 along the undulating path described, I have provided in the web 23 of the upper chord member 11 a plurality of widened portions P forming plates to which the upper ends of the diagonal struts 13 may be secured as by use of rivets 25, and at the same time I have produced in the web 24 of the lower chord member 12 widened portions P disposed in vertical planes intermediate planes indicated by the lines L to which the lower ends of the struts 13 may be connected by means of rivets 25. It will be noted that the line of cut 18 crosses the sine curve 14 at points 26 so that the line of cut, instead of being a true sine curve, merely follows the sine curve and deviates therefrom in a manner to produce shoulders 27 on the plate portions P of the webs 23 and 24.

In a chord of uniform section the combined unit stresses would be widely divergent and the sections at the panel points would control, leaving much understressed portions between panel points. At the panel points, which correspond to reactions in a continuous beam, the moments produced by the loading between panel points are greater than the moments produced at the centers of the panels. By increasing the section of the chord at each panel point, as taught by my invention, the combined unit stress is reduced by virtue of the increased area and the unit stress at the center of the panel is increased relatively by virtue of its lesser area. Increasing the section at the panel point by deepening it, very materially increases its moment of inertia, and, furthermore, reduces the unit stress in bending, since the unit stress is an inverse function of the moment of the inertia. The reverse holds for the center or reduced section, except that the increase of the moment of inertia for the increased section is much greater relatively than the reduction of the moment of inertia for the reduced section. By properly varying the sections of the top chord and the bottom chord, I achieve in each chord member substantially uniform combined stress throughout each panel of the finished truss, and, by forming the two chord members by a cut that favors the upper member, I approach relatively closely the maximum allowable unit stress in each chord without exceeding said allowable stress.

By staggering the upper and lower panel points, it is possible to choose a beam section such that the depth of the beam is equal to the required depth for the top chord section between upper panel points, plus the required depth for the lower chord section at the lower panel points, or the required depth for the upper chord section at the upper panel points, plus the required depth for the lower chord section between lower panel points, whichever may control.

In Fig. 3 I show a graph of moments in one of the panels A of the upper chord member 11, specifically the rightward panel A of Fig. 1, which is representative of the remaining panels formed throughout the length of the truss. In that portion of the chord member 11 lying in the panel A or intersected by two vertical planes indicated by adjacent lines L, there exists a structural member S having fixed ends *e* owing to the fact that these ends *e* are connected rigidly to the adjacent portions of the upper chord member 11. The section S is subject to bending stresses due to a load superimposed thereon and is likewise subject to column or compressive stresses due to the tendency for the loads on the truss to deflect the truss downwardly from end to end thereof. The structural member S, owing to its having fixed ends, resists the superimposed forces applied thereto in the manner of a pair of cantilevers *c* facing inwardly from the ends *e* and being joined by a central beam section *b*. In Fig. 3 I have shown a graph of moments from superimposed loads applied to the structural member S, wherein the base of moments 30 is moved up relative to the moment curve 31 in accordance with the character of stresses to which the structural member

S is subjected by reason of the fixed connection of its ends *e*. The moment changes from positive to negative at the points **32**, showing that the lower portions of the plates P of the upper chord member **11** are in compression owing to the cantilever effect therein; whereas, the intermediate section *b* is subject to restrained flexure.

I have shown the diagonal struts **13** secured by rivets **25**. Since these rivets require holes for their accommodation in the plates P, there is a slight reduction in cross section in the plates P due to the formation of the rivet holes therein, and to compensate for the reduction in section modulus in the plates P, I prefer to deviate the line of cutting **18** from the sine curve **14** so as to provide the shoulders **27** or additional metal in the manner previously described. In instances where the struts **13** are secured in a manner not requiring removal of metal from the plates P, for example by welding the ends of the struts **13** to the plates P, the line of cut **18** would preferably follow the sine curve **14**, with the exception of the end portions **19** where the cut is caused to run out the lower edge of the beam **10**.

An essential characteristic of the present invention is that the undulating path or line of cut **18** has peaks *p* which may be somewhat flattened in character, which are led to by sloping inclines *i*, and which are joined with adjacent valleys *v* through sloping declines *d*. This condition or essential characteristic is found where the line of cut coincides with the sine curve **14**, where the line of cut deviates or is exaggerated from the sine curve **14** as shown by the actual line of cut **18**, or further as indicated by the dotted line **35** shown in the lower right-hand corner of Fig. 1, which dotted line **35** indicates an indulating line of cut having essentially flat peaks *p'* and complementary valleys *v'* connected by approximately straight inclines and declines *i'* and *d'* with shoulders **27'** which are comparatively sharp.

Owing to the fact that the axis X—X is located below the longitudinal axis of the I-beam **10**, the width D' of the sections *b* of the upper chord member **11** is greater than the width D of the sections *b* of the lower chord member **12**. This is another characteristic of the preferred practice of my invention contributing toward maximum economy in a fabricated truss of this character. By following this procedure, the upper sections *b* are given a greater section modulus than the lower sections *b*, which is in agreement with the requirement that a larger section is required in the upper chord elements in view of the fact that they are subjected both to flexure and compression stresses, whereas the lower chord elements are subjected principally to tension, although they may be required to carry a ceiling load.

It will be noted that the two points **26** in a panel are 180° apart as measured in the revolution of the curve between panel points, each of the points **26** being at a quarter point or 90° from the nearest panel point. It will be apparent that each point **26** is approximately at the middle of the transition from the heavy section required at the panel point to the lighter section in the middle of the panel, the transition being smooth and gradual by virtue of the inclination of the cut. Since the quarter point transition is approximately at the intersection of the undulating line with its own longitudinal axis, whether the cut is a sine curve, a modified sine curve, or is angular in configuration, it may be regarded as characteristic of the preferred forms of my invention.

Although I have herein shown and described my invention in simple and practical form, it is recognized that certain parts or elements thereof are representative of other parts, elements, or mechanisms which may be used in substantially the same manner to accomplish substantially the same results; therefore, it is to be understood that the invention is not to be limited to the details set forth herein but is to be accorded the full scope of the following claims.

I claim as my invention:

1. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member in spaced relation thereto, said chord members being complementary in form as by the cutting of a plate along a wavy or undulating line extending longitudinally thereof so as to form alternate enlarged portions and narrow portions on said chord members while retaining substantially all of the original metal of said web in said chord members, said lower chord member being disposed with its enlarged portions staggered with respect to the enlarged portions of the upper chord member; and diagonal struts connecting the enlarged portions of the upper chord member with the wide portions of the lower chord member.

2. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member in spaced relation thereto, said chord members being complementary in form as by the cutting of a plate along an undulating line of a substantially sinusoidal character extending longitudinally thereof so as to form alternate enlarged portions and narrow portions on said chord members while retaining substantially all of the original metal of said plate in said chord members, said lower chord member being disposed with its enlarged portions staggered with respect to the enlarged portions of the upper chord member; and diagonal struts connecting the enlarged portions of the upper chord member with the enlarged portions of the lower chord member.

3. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member in spaced relation thereto, said chord members being formed by cutting the web of a structural shape longitudinally along an undulating line to form wide portions and narrow portions on said chord members connected by gradual lines of transition and whereby substantially all of the original metal of said web is retained in said chord members, said lower chord member being shorter than the upper chord member and being disposed with its wide portions staggered with respect to the wide portions of the upper chord member; and diagonal struts connecting the wide portions of the web of said upper chord member with the wide portions of the web of the lower chord member.

4. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member in spaced relation thereto, said members having webs facing each other, the web of said upper chord member having a lower edge defined by a wavy or undulating line extending longitudinally of said upper chord member forming peaks and valleys connected by sloping inclines and declines, said web of said lower chord member having its upper edge defined by an unlulating line comple-

mentary to that of said upper chord member forming spaced peaks and vallays connected by sloping inclines and declines, the wide portions of the web of the lower chord member being staggered with the wide portions of the web of the upper chord member; and a single zigzag series of diagonal struts interconnecting the wide portions of the web of the upper chord member with the wide portions of the web of the lower chord member.

5. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member in spaced relation thereto, said chord members being formed by cutting the body of a structural I-beam longitudinally along a single wavy or undulating line, to thereby form T-shaped chord members having webs of varying width facing each other while at the same time retaining substantially all of the original metal of the body of said I-beam in the webs of said chord members and disposed with the wide portions of the web of one member staggered with the wide portions of the web of the other member; and diagonal struts extending from the middle of the wide portions of the web of one chord member to the middle of the wide portions of the web of the other chord member.

6. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member in spaced relation thereto, said chord members being formed by cutting the web of a structural shape longitudinally along a single wavy or undulating line centralized on a longitudinal axis disposed closer to the lower edge of the structural shape than to the upper edge thereof, thereby forming wide and narrow portions on said chord members and retaining substantially all of the original metal of said web in said chord members; and diagonal struts connecting the wide portions of the web of said upper chord member with the wide portions of the web of the lower chord member.

7. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member in spaced relation thereto, said chord members being formed by cutting a web of structural shape longitudinally along a single undulating line centralized on a longitudinal axis disposed closer to the lower edge of the structural shape than to the upper edge thereof, said line being substantially sinusoidal in character, thereby forming wide and narrow portions on said chord members and retaining substantially all the original metal of said web in said chord members the wide portions of the web of the upper chord member being staggered with the wide portions of the lower chord member; and diagonal struts connecting the wide portions of the web of the upper chord member with the wide portions of the web of the lower chord member.

8. In a fabricated truss of the character described, the combination of: an upper chord member; a lower chord member of shorter length than said upper chord member arranged in spaced relation thereto, said chord members being formed from an I-beam by cutting the web thereof longitudinally along an undulating line and terminating said line by extending it downwardly through a lower flange adjacent at least one end of said I-beam, whereby a portion of said flange remains as a footing; and diagonal struts connecting said chord members together in said spaced relation.

FRANKLIN N. ROPP.