July 1, 1930. J. H. EDWARDS ET AL 1,768,833

STRUCTURAL MEMBER

Original Filed May 15, 1925 4 Sheets-Sheet 1

Fig. 1.

12 Inch Group			14 Inch Group		
Weight per Ft.	Depth in Inches	Width in Inches	Weight per Ft.	Depth in Inches	Width in Inches
100	12.348	14.000			
110	12.516	14.048	115	14.154	15.145
120	12.680	14.097	125	14.304	15.191
130	12.846	14.144	135	14.452	15.239
140	13.010	14.192	145	14.602	15.284
150	13.172	14.241	155	14.750	15.330
160	13.334	14.288	165	14.896	15.377
170	13.496	14.335	175	15.042	15.424
180	13.654	14.383	185	15.188	15.469
190	13.814	14.431	195	15.334	15.513
200	13.974	14.476	205	15.478	15.559
210	14.132	14.522	215	15.622	15.604
220	14.290	14.567	225	15.764	15.650
230	14.446	14.614	235	15.908	15.693
240	14.602	14.659	245	16.050	15.738
250	14.756	14.705	255	16.192	15.781
			265	16.332	15.826
			275	16.472	15.870
			285	16.614	15.912
			295	16.752	15.956
			305	16.890	16.000

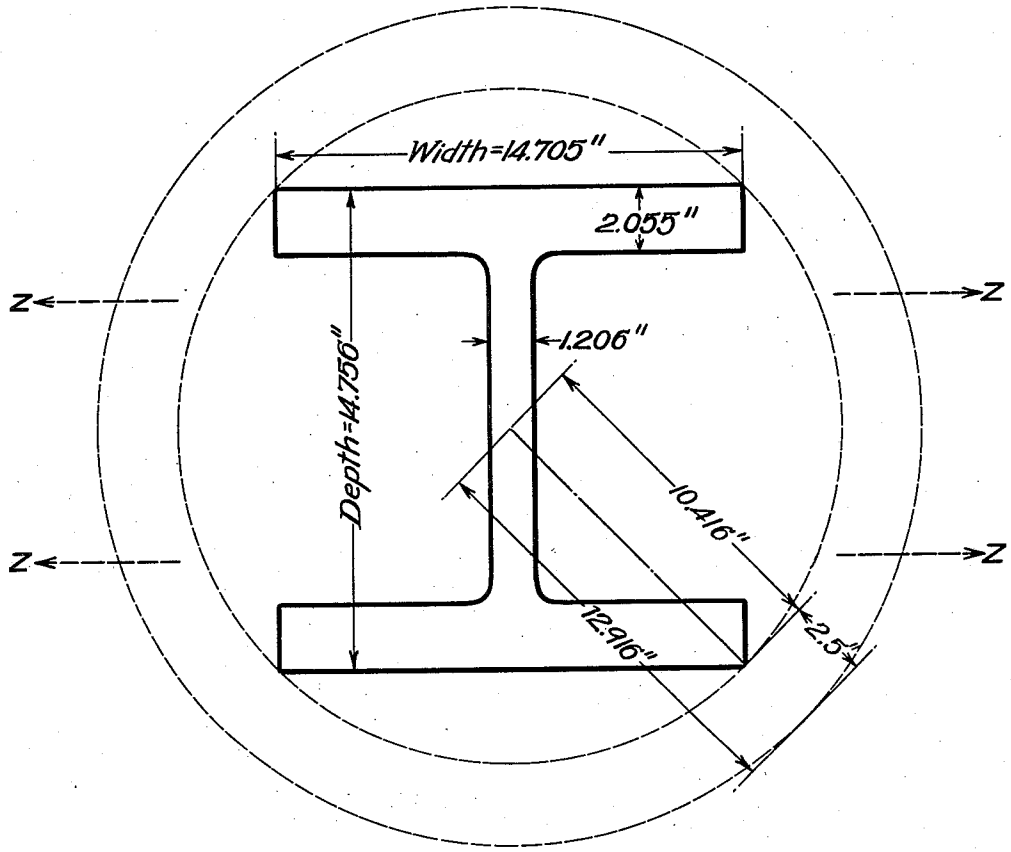
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STRUCTURAL MEMBER

Original Filed May 15, 1925 4 Sheets-Sheet 2

Fig. 2.



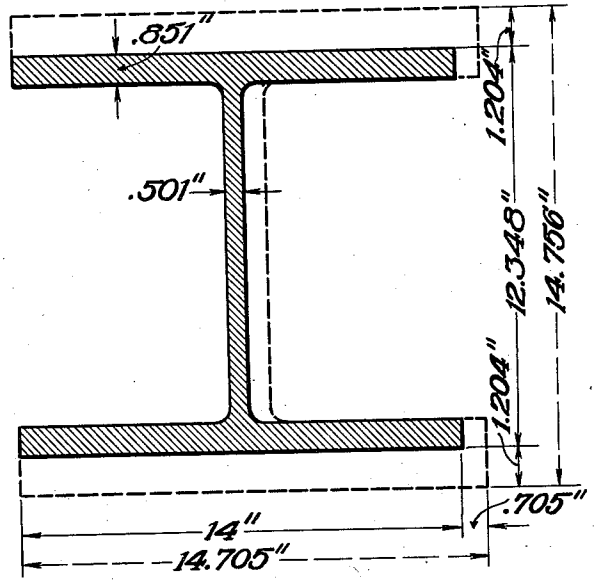
Weight of "H" Section = 250 pounds per linear foot.
Area " " " (incl. Fillets) = 73.517 sq. inches.
Radius of Gyration in direction Z-Z = 3.85 inches.
Traverse Area to outside of Circular Covering 524.09 sq. in.

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STRUCTURAL MEMBER

Original Filed May 15, 1925 4 Sheets-Sheet 3

Fig. 3.



Ratio of twice mean flange thickness to web thickness in minimum weight section $= \frac{2 \times .851}{.501} = 3.4$

Ratio of increment in depth to increment in width of heavier section $= \frac{2 \times 1.204}{.705} = 3.4$

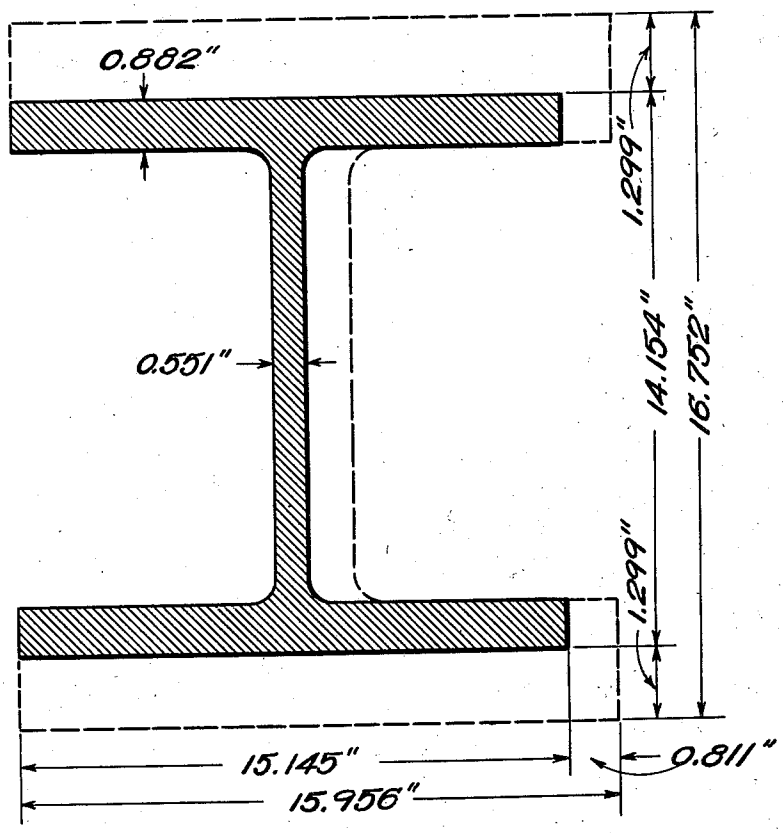
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July 1, 1930. J. H. EDWARDS ET AL 1,768,833

STRUCTURAL MEMBER

Original Filed May 15, 1925 4 Sheets-Sheet 4

Fig. 4.



Ratio of Twice Mean Flange Thickness to Web Thickness in Minimum Weight Section $= \frac{2 \times .882}{.551} = 3.2$ Approx.

Ratio of Increment in Depth to Increment in Width of Heavier Section $= \frac{2 \times 1.299}{.811} = 3.2$ Approximately.

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1,768,833

UNITED STATES PATENT OFFICE

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STRUCTURAL MEMBER

Application filed May 15, 1925, Serial No. 30,494. Renewed September 26, 1929.

This invention relates to improvements in structural members and aims to provide groups of rolled sections whose weights per unit of length vary at a determined rate.

While not limited thereto, we propose to group together for use as columns various sections of the shape roughly denominated H-sections, which are proportioned so that the minimum weight section of each group is wider in cross-section than its depth and to proportion the other sections of a given group so that their weights increase by substantially uniform increments.

It is well known in the structural art that a variety of weights of sections is required to meet the varying loads they have to carry and to satisfy requirements due to their varying unsupported lengths. It is also recognized by those skilled in the art that the expense and loss of time that would result if each of these weights were produced by means of a different set of rolls would be prohibitive, and it is therefore the practice to group these weights in such manner that each group is producible from one set of rolls by a proper spacing of the rolls. It is customary and desirable that, starting with the minimum weight section of each group, the depth and width of each of the other section weights in that group shall increase from the dimensions of the minimum weight section by additions to the mean flange thickness and the web thickness of the minimum weight section.

It has hitherto been the practice in the production of H-sections to dimension the minimum weight section of each group with depth and width substantially equal. Considerations of efficiency of section make it desirable that the mean flange thickness be considerably greater than the web thickness and this condition combined with the fact that there are two flanges and only one web, causes the depth of the heavier sections in each group to increase more rapidly than their width with the result that the heavier section weights heretofore produced in each group are substantially deeper than they are wide.

The invention will be understood from the following specification when read in connection with the accompanying drawings in which—

Fig. 1 is a table showing dimensions and weights of two groups of sections embodying features of our invention;

Fig. 2 is a sectional view of one of our improved sections illustrating in dotted lines an enclosure for fireproofing the same;

Fig. 3 is a diagram illustrating the ratio of the mean flange thickness to the web thickness of the twelve inch group of sections tabulated in Fig. 1;

Fig. 4 is a diagram illustrating the derivation of the ratio expressed in claim 8.

It can be shown as has been done in our co-pending application Serial No. 30,493 that the use of sections whose width is only equal to their depth results in less strength and greater occupancy of floor space than are securable under that invention. Evidently, the respective strength and occupancy of floor space will be still less favorable in the heavier section weights of a group whose depths are substantially or much greater than their width.

This excessive occupation of floor space, however, when applied to a group of such sections becomes augmented still further for the reason that it is architectural practice to adopt standard dimensions for the covering of columns for a series of stories and the dimensions required by the lowest and consequently the heaviest column in that series fixes the dimensions of covering throughout all the stories in question.

One object of our present invention is to so proportion the dimensions of each group of section weights that the depth and width will be substantially equal in a heavier rather than in the minimum weight section. This we accomplish by making the width of the minimum weight section of a given group substantially greater than its depth and then produce the heavier section weights in that group by additions which have the same respective ratio as the mean flange thickness bears to the web thickness in the minimum weight section.

To illustrate, a popular section in the nominally 14 inch group of H-column sections heretofore proposed and now on the market, and one that is frequently used in the lower stories of a building, is that weighing approximately 254 pounds per linear foot. It is 16.375 inches deep, 14.74 inches wide and its least radius of gyration is 3.76. If fireproofed by a square enclosure it occupies 457 square inches of floor area; if a circular enclosure is used it involves a loss of floor area of 574 square inches.

The nearest section weight in our corresponding group is shown in Fig. 2. This section is a heavier weight of the 12 inch group tabulated in Fig. 1, and Fig. 3 shows how it is produced by spreading the rolls required for the minimum weight section so that the depth and width increase by increments that have the same ratio as twice the mean flange thickness bears to the web thickness in the minimum weight section. In Fig. 3 the cross-hatched portion depicts the minimum weight section, 12.348 inches deep, 14 inches wide, and having a ratio between twice its mean flange thickness and its web thickness of substantially 3.4. We have shown a section with no flange slope, but the same method is, of course, applicable with any flange slope.

The dotted lines show the contour and dimensions of a heavier section forming part of the same group, its depth increment being 2.408 inches, and its width increment .705 inch. It will be noted that the ratio between depth increment and width increment is substantially 3.4, that is to say, it is the same ratio that twice the flange thickness bears to the web thickness in the minimum weight section. This ratio is expressed in the equations shown below the section in Fig. 3. As a result of starting the group with a minimum weight section substantially wider than its depth this section which weighs 250 pounds per linear foot is 14.756 inches deep, 14.705 inches wide and its least radius of gyration is 3.85 which is 2.4 percent stronger per pound than the old section above referred to. If fireproofed square it occupies 390 square inches of floor area which is 14.6 percent less than the area required by the popular 14 inch H-section above referred to. If circular, it occupies 524 square inches, which is 8.7 percent less than the prior form mentioned.

In the same manner, but not necessarily in the same proportion, the other section weights in the groups covered by our invention show a greater strength combined with less occupancy of floor space than the corresponding section weights now on the market.

A further purpose of our invention is to meet the demand for a variety of section weights by means of a smaller number of sections than has hitherto been used. At present there are rolled sections on the market in the range of weights from 110 to 190 pounds per linear foot which are most in demand, a nominally 12 inch group which comprises 12 weights ranging from 113 to 190 pounds, with increments averaging 7 pounds; and a nominally 14 inch group which comprises 10 weights ranging from 115.5 to 187.5 pounds with increments averaging 8 pounds. This makes a total of 22 section weights but it should be noted that the weight of many sections in one group varies by less than one pound from that of certain sections in the other group. This is an unnecessary duplication which under our invention is avoided. Furthermore, we achieve greater selectivity by making the weights of one group stagger or alternate with those of the other group.

For example, as examination of our table in Fig. 1 will show, our 12 inch group consists of sections whose weights per foot end in zero while in our 14 inch group the weights end in five. Such a series will comprise within the range mentioned above only 9 weights in the 12 inch group and only 8 in the 14 inch group making a total of only 17 which is a saving of nearly 23 percent in number of section weights. Combined with this saving we afford better selectivity for in our two groups a weight can always be found that is not over 5 pounds above any requirement, whereas, under present practice many requirements cannot be met within 7 pounds and in such cases this permits a saving of two pounds per linear foot under our invention.

The 295 pound section listed in Fig. 1 is a heavier weight section of the 14 inch group. Fig. 4 illustrates diagrammatically how it is produced by spreading the rolls required for the production of the minimum weight section so that the depth and width increase by increments that have the same ratio as twice the mean flange thickness bears to the web thickness in the minimum weight section. In Fig. 4 the cross-hatched portion depicts the minimum weight section, 14.154 inches deep, 15.145 inches wide and having a ratio between twice its mean flange thickness and its web thickness of substantially 3.2. We have shown a section with no flange slope, but the same method is, of course, applicable with any flange slope.

The dotted lines show the contour and dimensions of a heavier section forming part of the same group, its depth increment being 2.598 inches, and its width increment 0.811 inch. It will be noted that the ratio between depth increment and width increment is substantially 3.2, that is to say, it is the same ratio that twice the flange thickness bears to the web thickness in the minimum weight section. This ratio is expresed in the equations shown below the section illustrated in Fig. 4.

Our invention contemplates the provision

of a series of structural members whose section weights are both more accurate and more convenient than present practice. The weight of sections per unit of length, usually expressed in pounds per linear foot, is of first importance and is most frequently repeated in general plans, estimates, detail drawings, requisitions, purchasing orders, specifications, mill orders, shipping papers, invoices, and other documents. Sales are usually based on published catalog weights and it is therefore most desirable that these weights be both simple and accurate.

At present the increments between the successive weights in each group of H-sections are determined by successive increases in flange thickness. When the product of the cross-sectional dimensions that vary with this increase are multiplied by the unit weight of steel the resulting weight per linear foot usually works out to a number with a fraction that frequently extends to six decimal places. If this weight is used in the catalogs it entails the encumbrance of all documents with annoying and error-inviting fractions. If, on the other hand, this weight is listed in approximate numbers as is done in the present catalogs this rounded weight in many cases varies from the true weight by percentages large enough to substantially affect invoiced amounts.

These conditions or deficiencies of prior practice are improved under our invention by making the weight per linear foot as distinguished from the thickness of each section, the starting point in the design of a group of sections to which corresponding dimensions are then determined. This permits the selection of any convenient non-fractional weight combined with dimensions of the section adjusted to any desired degree of accuracy.

For example, as tabulated in Fig. 1, in our 12 inch group of H-sections we make all the weights exact multiples of 10 pounds ending in zero and make all the weights in our 14 inch group end in 5 whereby they alternate or stagger with the 12 inch group. Thus we combine accuracy in the basis of sale with convenience and less chance of error in the preparation of all the many documents and calculations in which the weight appears or is a factor.

By making the weight per linear foot the basis or starting point in the design of a group of sections, it will be apparent that we are enabled to group them in such a way that the weights of different sections in a group vary from one another by uniform increments expressed in whole pounds. That is to say, weights per linear foot will be expressed in non-fractional units. While in practice the sections will be rolled to accurate dimensions and the aim will be to have the weights of sections such that they will be expressed in whole pounds some error may creep into the rolling operations but we calculate that the sections can be rolled to such a degree of accuracy that the error will not vary over a multiple of one pound by more than 5/100 of a pound per linear foot of section. Our calculations for computing the weight of section are based on the fact that one square inch of steel one foot in length has a weight of 3.4 pounds.

While the weights per foot of the sections in the groups listed progress from a minimum to a maximum by ten pound increments we are not limited to such increments. It will be observed that the increments as expressed in pound numbers in Fig. 1 are not greater than the inch numbers which designate the depth of the group. This relationship of pound increment to inch depth is desirable because in the heavier groups of sections of considerable depth one can progress by greater increments whilst in the shallower sections the pound increments can progress by smaller uniform amounts.

This application covers groups of sections certain of which are referred to individually in our co-pending application Serial No. 30,493 filed May 15, 1925.

While we have described our invention by reference to structural shapes of specific dimensions, it is to be understood that we are not limited to these proportions as various modifications may be made by those skilled in the art without departing from the invention as defined in the appended claims.

What we claim is:—

1. A group of rolled metal sections progressing in weight per linear foot from a minimum to a maximum weight by uniform increments which do not vary from a multiple of one pound by more than five one hundredths of a pound.

2. A group of rolled steel sections progressing in weight per linear foot from a minimum to a maximum weight by uniform increments each section being substantially H-shape in cross-section and being so proportioned that its sectional area when multiplied by 3.4 pounds per square inch gives a weight per linear foot that does not vary from a multiple of one pound by more than five one hundredths of a pound.

3. A series of at least two groups of rolled metal sections, each group comprising a plurality of sections whose weights per linear foot progress from a minimum to a maximum weight by uniform increments, the proportions of the sections of one group bearing such a relation to these of another group that the weights per foot of sections in one group stagger or alternate symmetrically with those of another group.

4. A group of solid rolled steel sections substantially H-shaped in cross-section having a mean flange thickness greater than the

web thickness, whose minimum weight section has a width substantially greater than its depth and whose heavier weight sections have depth and width increasing from those of the minimum weight section by increments that have substantially the same ratio as twice the mean flange thickness bears to the web thickness in the aforesaid minimum weight sections.

5. A group of sections according to claim 1 in which the weights vary by ten pound increments.

6. A series of steel sections as defined in claim 3 in which the weights vary by ten pound increments, the numbers representing weights per foot in one group ending in zero while those of the other group end in five.

7. A group of solid rolled steel H-sections including a minimum weight section which weighs 100 pounds per linear foot and a heavier weight section which weighs 250 pounds per linear foot, the depths and widths increasing from 12.348 inches and 14 inches respectively by increments that are substantially in the ratio 3.4 to 1.0, the weights of said sections varying by ten pound increments.

8. A group of solid rolled steel H-sections including a minimum weight section which weighs 115 pounds per linear foot and a heavier section which weighs 305 pounds per linear foot, said sections varying in weight per foot by ten pound increments and having depths and widths increasing from 14.154 inches and 15.145 inches respectively by increments which are substantially in the ratio of 3.2 to 1.0.

9. A group of metal sections progressing in weight per linear foot from a minimum to a maximum weight by uniform increments which do not vary from a multiple of one pound by more than five one hundredths of a pound, said increments being pound-numbers which are less than the inch-numbers which designate the depth of the group.

10. A group of metal sections progressing in weight per linear foot from a minimum to a maximum weight by uniform increments measured substantially in whole pounds expressed in numbers not greater than the inch numbers which designate the depth of the group.

In witness whereof, we have hereunto signed our names.

JAMES H. EDWARDS.
ROBERT A. MARBLE.