

May 20, 1930.

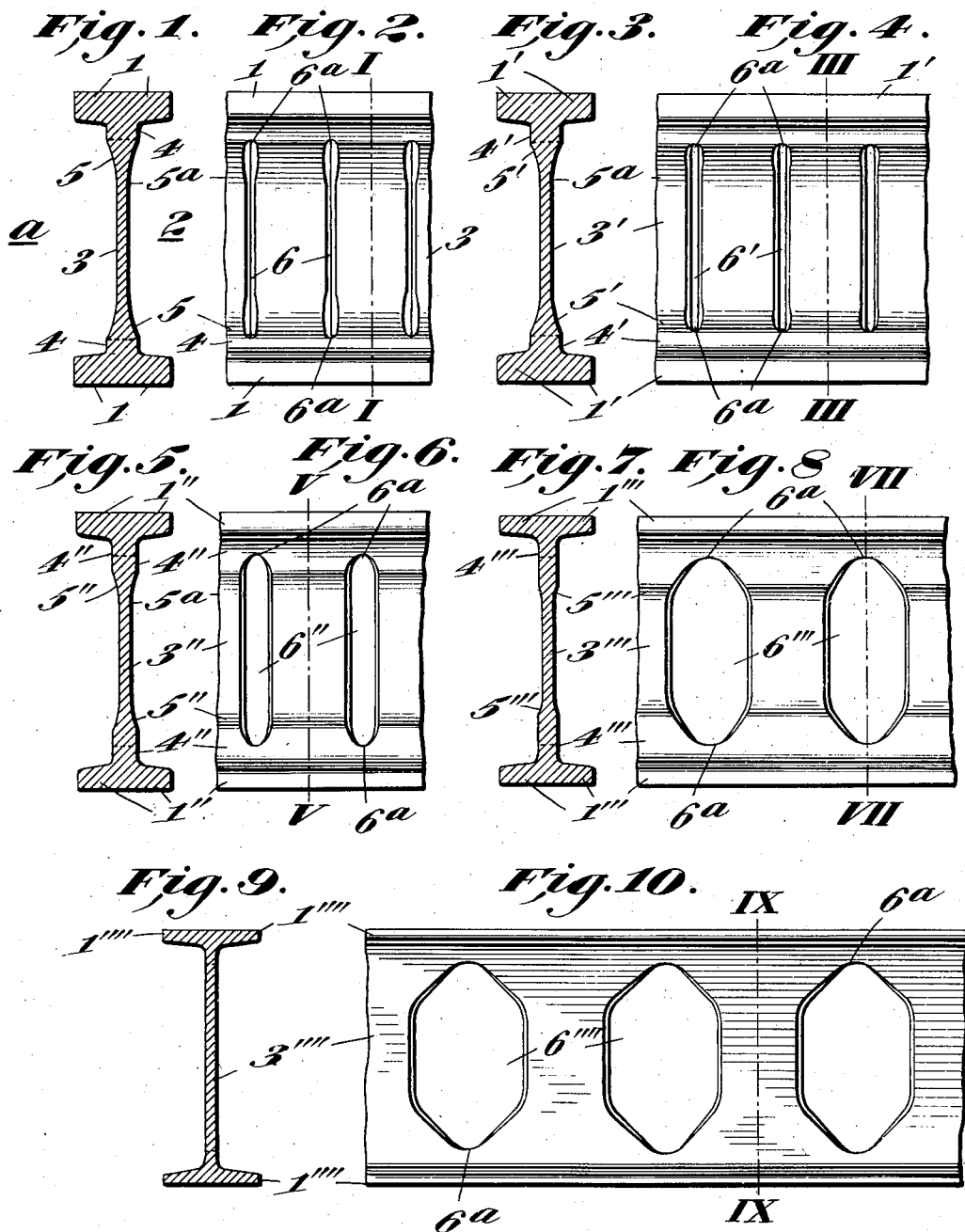
R. S. A. DOUGHERTY ET AL

1,759,481

METAL ROLLING

Filed May 7, 1927

4 Sheets-Sheet 1



INVENTORS
Robert S. A. Dougherty
and *Nevil Greenwell*
BY *R. S. A. Dougherty*
ATTORNEY

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Fig. 11.

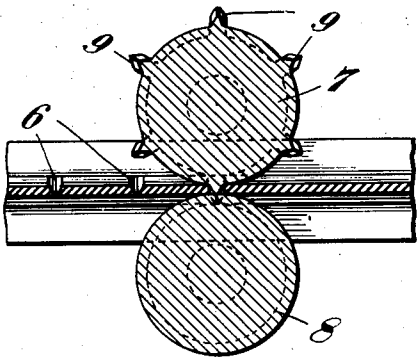


Fig. 12.

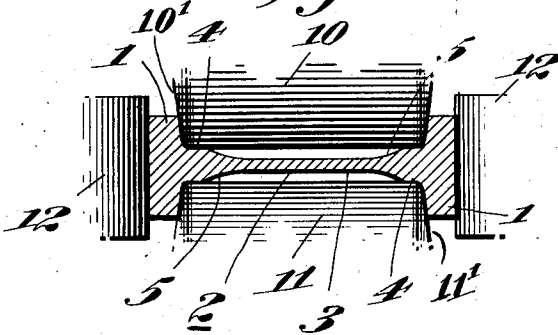


Fig. 13.

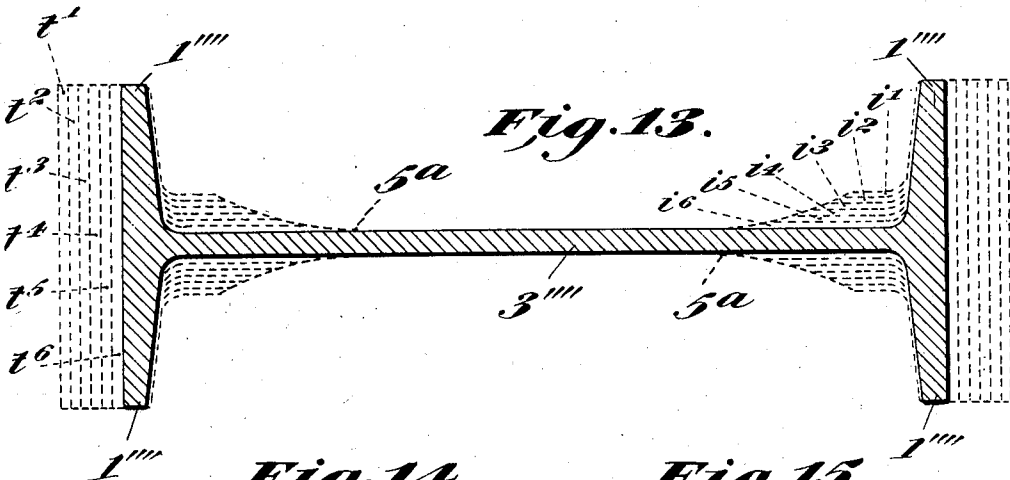


Fig. 14.

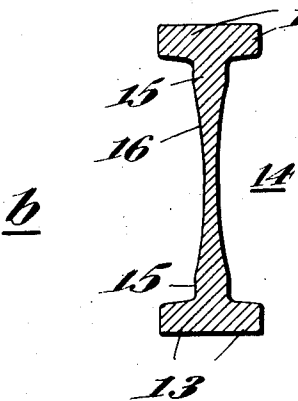
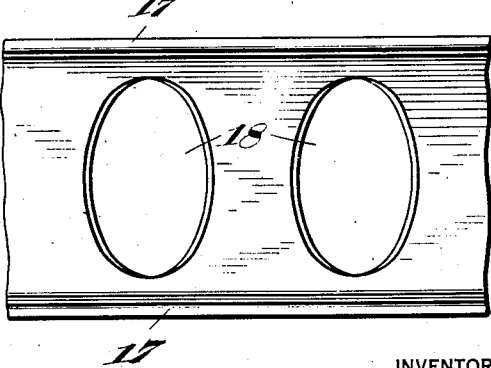


Fig. 15.



INVENTORS
and Robert S. A. Dougherty
Nevil Greenwell

BY

R. S. A. Dougherty
ATTORNEY

May 20, 1930.

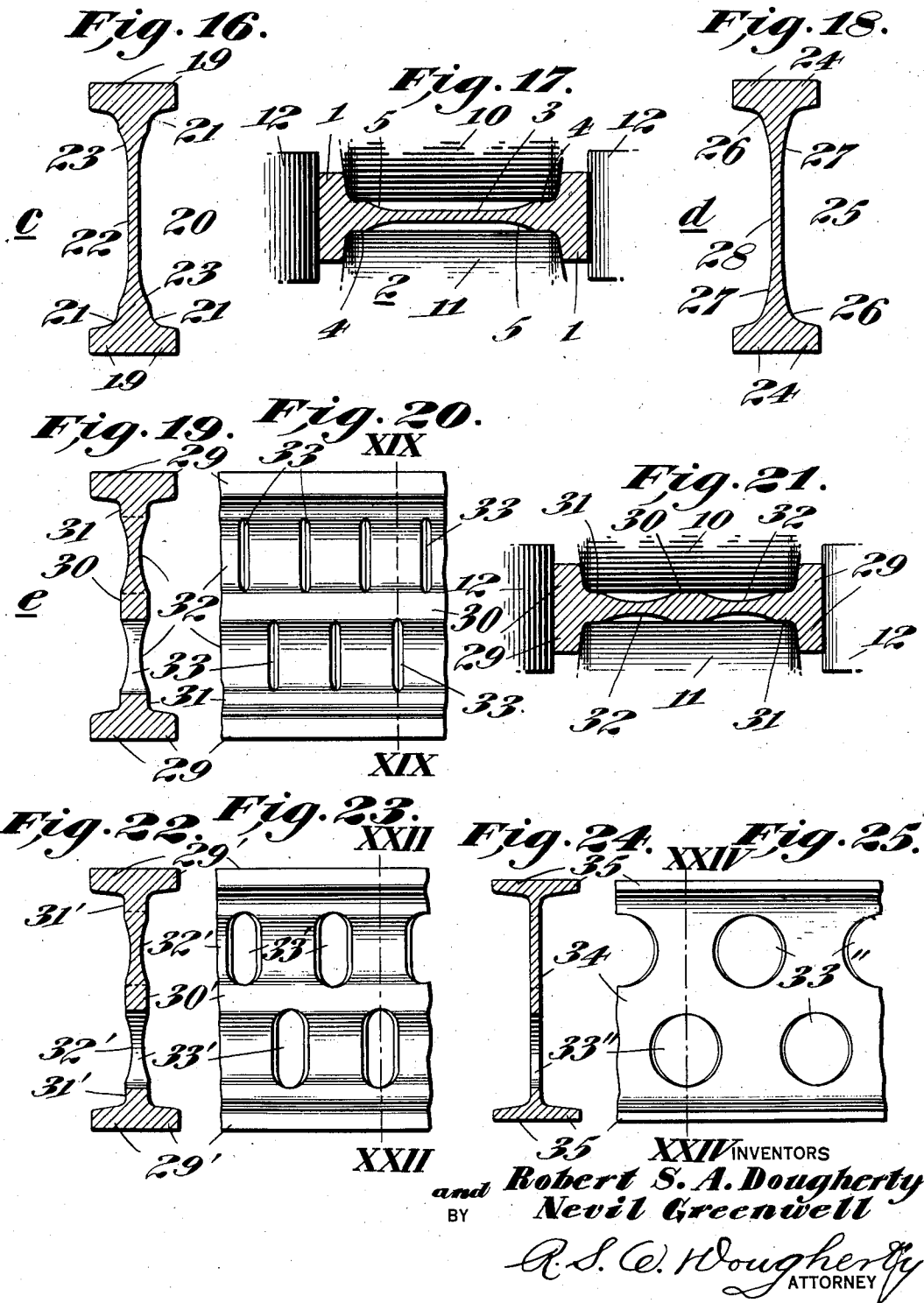
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METAL ROLLING

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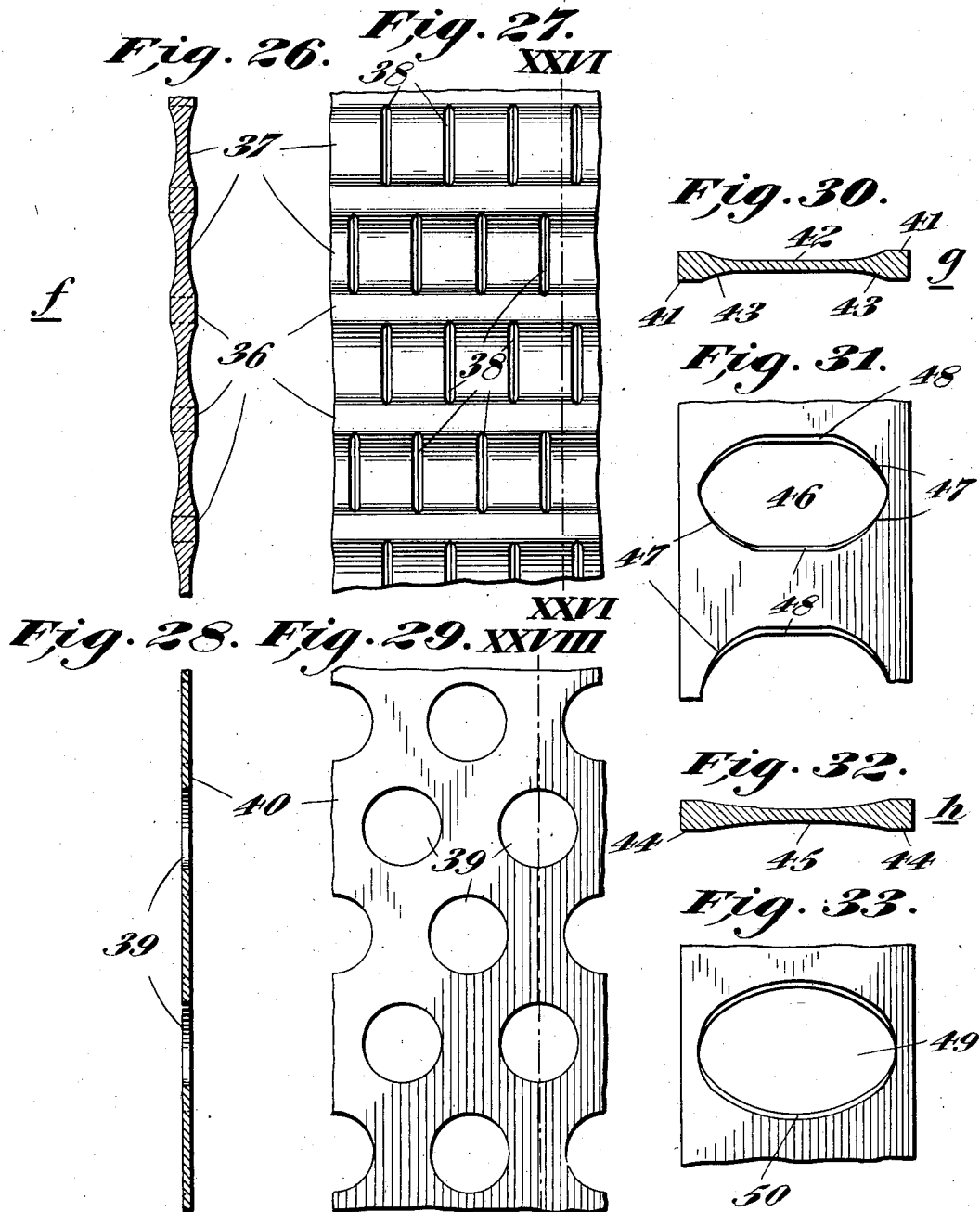
R. S. A. DOUGHERTY ET AL

1,759,481

METAL ROLLING

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4 Sheets-Sheet 4



XXVIII
INVENTORS
Robert S. A. Dougherty
and *Nevit Greenwell*
BY
R. S. A. Dougherty
ATTORNEY

UNITED STATES PATENT OFFICE

ROBERT S. A. DOUGHERTY AND NEVIL GREENWELL, OF BETHLEHEM, PENNSYLVANIA

METAL ROLLING

Application filed May 7, 1927. Serial No. 130,360.

This application is a continuation in part of application, Serial No. 171,108, filed Feb. 26, 1927.

Our invention relates to the production of open-work in metal by providing slits or other restricted openings in the metal and then so mechanically working the metal between the slits as to open up or develop the openings.

A primary purpose of our invention is to produce open-work in metals concurrently with the rolling thereof and directly in consequence of the reduction in thickness incidental to such rolling.

The principal object of the invention is to obtain openings in metal without producing the undesirable stresses and strains resulting from processes heretofore proposed. This we secure by developing openings in metal during mechanical working thereof. As a consequence, we not only avoid the disadvantage of the prior art methods, but we obtain the beneficial influences of mechanical working, as also the economic advantage of obtaining the openings at the same time as the metal is worked and from the same operation.

It is already well known to make open-work metal sheets by slitting the metal and then opening up the slits by stretching the sheet in a direction at an angle to the direction of the slits. This, of course, is a common mode of preparing the so-called expanded metal. The same general method has been applied to the preparation of such flanged structural elements as beams or columns, the web being provided with a multiplicity of longitudinal slits and then separating the flanges to produce an open-work or lattice-like structure. In processes of this type the step of elongating the metal to produce the open-work purposely utilizes stretching with the inevitable consequence that strains and weaknesses are given to the metal.

It is also old to prepare beams with open-work webs by first slitting the metal so as to produce a plurality of strands extending lengthwise of the beam, then rolling the web but not the flanges, to lengthen the strands, and finally separating the flanges to produce the lattice-like web. In this type of process

also, stretch strains and weaknesses are unavoidable. Because of the lengthening of the strands to a greater extent than the other metal of the beam there is produced in them a wavy or undulating character and because the metal of the strands has a considerable degree of rigidity, the final step of flange separation to open up the web must entail a substantial degree of stretching.

In these processes of the prior art, it will be further noted, there is a positive separation or widening of the structural element as a whole to open up the slits or to part the strands. The opening up of the metal is not accomplished as a result of the rolling but because of a more or less independent separating and stretching operation.

It is further old to provide a sheet of metal with transverse slits arranged in a plurality of zones, these slits being separated by zones of imperforate metal. The sheet is subjected to a rolling operation along the imperforate portions but not in the slitted zones, whereby the imperforate metal is reduced and thereby somewhat lengthened, with the consequence that the sides of the slits are separated to a certain extent to produce more or less restricted openings.

It has still further been proposed as a step in the development of an open-work web in an I-beam that the flanges be rolled without rolling the web to effect the initial separation of strands arranged more or less diagonally of the web.

In these methods of the prior art, no considerable opening up of the metal can be produced without parts of the metal being subjected to considerable stretching.

All of these methods of the prior art are essentially different from that of our invention, not only in the mechanical and physical manipulation of the metal worked upon but also in the effects produced.

We also provide slits or openings, or weakened portions in the metal, but instead of pulling or stretching the metal to open up the slits we so work the metal, including those portions thereof within which the slits actually lie, as to develop them directly as a result of the mechanical working. Instead

of so treating the metal as to subject the slitted portions to stretching tension to open up the slits, as in the prior art, we apply compressive forces directly to the metal of the slitted portions to develop the openings. As a consequence we avoid the weakening influences of a stretching operation and at the same time we obtain the well known ameliorating effects of mechanical working. In contrast-

ing our process with those of the prior art it is realized that in practically all forms of mechanical working, tensional forces are to a greater or lesser extent involved but in such operations as rolling such forces are accompanied by compressive forces which nullify the deleterious influence of stretching.

By mechanically working we mean rolling, forging, pressing, or any equivalent kneading-like manipulation to reduce and lengthen the metal.

Our invention consists in providing slits, openings, scorings, or weakened places in a portion of a metal blank and then so mechanically working the blank or parts thereof, including at least a substantial fraction of the portion containing the openings, as to elongate the metal of said portion to different degrees whereby the open-work is developed.

Stating the invention somewhat differently, it consists in rolling the metal which actually contains the slits or openings in such a way as to reduce the thickness of the metal to different degrees progressively along the slits or openings to develop them and thereby produce the open-work.

Furthermore, in its preferred forms, our invention comprises metal bodies having open-work, the metal of which is substantially free from stretch strains and deformations.

Several illustrated embodiments of our invention will now be described:

Figs. 1 to 10, inclusive, are alternately cross sections and plan views representative of different stages in the formation of an open-work beam, by our process;

Fig. 11 is a longitudinal section through the web of a blank, showing the scoring rolls in elevation;

Fig. 12 is a cross section of a blank like that in Fig. 1, showing the application of the horizontal and vertical rolls during the first pass;

Fig. 13 is a diagrammatic representation in cross section of the several stages of reduction to which the blank of Fig. 1 is subjected.

Fig. 14 gives a cross section of a blank similar to that of Fig. 1 but in which the web decreases in thickness practically to the longitudinal median line of the web;

Fig. 15 is a plan of a beam produced by rolling the blank of Fig. 14;

Fig. 16 shows in cross section a modification of the blank of Fig. 1, there being a

greater degree of curvature between the web and the flanges;

Fig. 17 is similar to Fig. 16, showing the same beam, but indicating the rolls in application thereto;

Fig. 18 is a cross section of a beam, also similar to Fig. 9, but different therefrom in there being a continuous curve from the flanges to the flatter, interior portion of the web;

Fig. 19 gives a cross section of a flanged blank, the web of which is divided into two similar longitudinal portions separated by a median, longitudinal thickened portion;

Fig. 20 is a plan view of the same, slitted preliminary to the rolling operation;

Fig. 21 is a cross sectional view of the blank given in Figs. 19 and 20 showing the application of the horizontal and vertical rolls;

Figs. 22 and 23 give cross sectional and plan views respectively of the same beam at an intermediate stage of rolling;

Figs. 24 and 25 are cross sectional and plan views respectively of the finished beam;

Fig. 26 is a cross section of a blank having a plurality of longitudinal, thickened portions with the regions therebetween of varying thickness;

Fig. 27 is a plan view of the same, the regions between the thickened, longitudinal portions being provided with slits in staggered arrangement;

Figs. 28 and 29 are cross sectional and plan views respectively of an openwork sheet produced by rolling this blank;

Fig. 30 is a cross section of a plate-like blank, having thickened side portions, tapering off in thickness inwardly of the blank, the more central portions of the blank being practically uniform in thickness;

Fig. 31 is a plan view of a sheet or plate rolled from such a blank, indicating the form of the openings produced by this type of cross sectional contour;

Fig. 32 is a cross section of a blank similar to that of Fig. 30 but with the thickness varying throughout the space between the thickened side portions; and,

Fig. 33 is a plan of the product obtained from rolling the blank given in the preceding figure, indicating how the alteration of the cross sectional contour alters the form of the opening.

Describing the invention as applied to the production of the beam shown in Figs. 9 and 10 having flanges 1''' and web 3''', provided with openings 6'''. Representative stages in the manufacture of this beam are indicated in Figs. 1 to 8, inclusive, and diagrammatically represented in Fig. 13.

Metal is rolled to produce blank *a* having the cross sectional contour indicated in Figs. 1 and 12 and in the outside dotted lines of Fig. 13. The flanges 1 of this blank are of considerable greater thickness than are the

flanges 1'''' of the finished beam. The web 2 comprises flat portions or regions 4, adjacent to the flanges, substantially greater in thickness than are the corresponding regions of web 3'''' in the finished beam and thicker than the remaining portions of the web in the blank. The thickness of the web gradually diminishes through portion 5 to the flat inner zone 3, which is of substantially the same thickness as the web 3'''' of the finished beam.

Blank *a* is passed through a splitting or scoring device, presented conventionally in Fig. 11, to make the slits or scorings 6 in the web.

These cuts 6, as here shown, do not completely pass through the metal of the web, being more truly scorings than actual slitted openings. Although these scorings, particularly when the cut is V-shaped as indicated in the drawings and nearly cutting through the web, are especially effective, developing well into the desired openings during the rolling operation which follows, it is obvious that other scorings or actual slitting may be employed with success.

The splitting machine may be of any desired construction. It is here shown as comprising two opposed rolls 7 and 8, the surface of the upper of which carries a plurality of extended cutting ridges 9, parallelly disposed to each other and to the axis of the roll. The cuts or scorings 6 of the web extend transversely thereof, the ends reaching quite up to, or even slightly penetrating the thick portions 4.

Following the scoring operation the blank is preferably rolled in a universal mill of the Grey type. As is well known, this comprises a main reducing mill and a supplemental, flange edging mill. So far as this invention is concerned, attention need be paid only to the main reducing mill. This comprises horizontal rolls 10 and 11 and vertical rolls 12, upper roll 10 being adjustable toward and from the lower roll 11 and vertical rolls 12 being laterally adjustable toward and from each other.

Blank *a* is repeatedly passed through this reducing mill, first in one direction through the mill and then in the other direction, back and forth, as in the ordinary Grey mill practice, rolls 12 being adjusted toward each other after each pass so that the flanges will be effectively reduced between these vertical rolls and the somewhat beveled side surfaces 10' and 11' of the horizontal rolls. Also, after each pass upper roll 10 is adjusted toward the lower roll 11, portions 4 and 5 of the web being thereby gradually reduced in thickness and the metal thereof gradually lengthened.

Attention is called to the sequence of changes in the web during its rolling, particularly as indicated by the changes in the

cross sectional contour and in the development of the openings. During the first pass of the blank through the rolls only those portions of the web near the flanges and between the ends of the slits will be subjected to any rolling action with consequent metal reduction and elongation; but, pass by pass, more and more of the web surface will come within the action of these rolls. During the first pass, flat portions or regions 4 and parts of the tapered portions 5, those parts adjacent to 4 and lying between the ends 6^a of the slits 6, will be reduced in thickness and elongated, but, pass by pass, more and more of the tapered portions 5 will come within the action of the rolls, until, during the last pass, the entire web surface will be engaged thereby. Obviously this means that the total amounts of reduction in thickness and the total amounts of elongation of the metal between the slits due to the action of all of the passes are progressively greater from the line of juncture 5^a outwardly to the region between the ends of the slits. It is obvious too, that the percentage of reduction in thickness and of the consequent elongation are likewise progressively greater; that is to say, the reduction in thickness and the elongation are progressively greater in degree. The result of this differential reduction and elongation of the metal between the slits is that such slits are developed into the openings 6'''' in the finished beam.

To make clearer just what occurs during the rolling, an attempt will now be made to point out in greater detail than in the preceding outline, the sequence of changes in the web, also indicating the accompanying changes in the flanges. See particularly Figs. 1 to 10, inclusive.

During the first pass the surfaces of horizontal rolls 10 and 11 engage the flat surfaces of regions 4 of the web, compressing and elongating the metal and reducing the thickness. As is obvious this reduction in thickness occurs not only in regions 4 but takes place also in the adjacent parts of portions 5, this effect diminishing inwardly because of their tapered formation. This reduction is represented by *i'* in Fig. 13. Evidently the amount of reduction in thickness at each edge of the web during this pass will be twice that of *i'*, there being similar reductions on both sides of the web.

During this same pass each flange is reduced in thickness by an amount represented by *i'* in Fig. 13, proportional to the amount of reduction at each end of the web, that is, those portions adjacent the flanges. Of course, in actual rolling there is a slight reduction in addition to *i'*, that reduction upon the inner sides of the flanges, but this is relatively so small as to be negligible so far as the exposition of this invention is concerned.

As a result of this first pass the width of

the flat region 4 is increased to that of 4' in Figs. 3 and 4; the tapered portion 5 is narrowed to 5'; the distance between the ends 6^a of the slits is slightly increased and as a consequence the sides of the slits 6 are somewhat separated to form openings 6'.

The succeeding passes of the blank through the rolls, the horizontal rolls being adjusted toward each other after each pass, as also the vertical, produced similar, cumulative effects. Pass by pass, the horizontal rolls engage wider flat regions 4', 4'', and 4''' of the web, each time the rolls encroaching upon the gradually narrowing tapered portions 5', 5'', 5''', until in the final pass the last difference in thickness of web is eliminated and the surfaces of the horizontal roll engage the entire web surfaces 3'''. Step by step the thickness of the web is reduced over a wider and wider area; at first the narrow strip i^1 , then i^2 , i^3 , i^4 , i^5 , and finally i^6 . Consequent upon these reductions the metal between the original slits 6 and in region 4 is elongated in proportion to the degree of reduction, the greater elongation of metal between the slits occurring between the ends 6^a of the openings, gradually diminishing inwardly of the beam to line 5^a where the tapered portion joins the inner flat portion of the web. This differential elongation of the metal between the slits results in their being gradually opened up, as indicated in the representative stages of Figs. 1 to 10, through 6', 6'', 6''' to the finished openings 6'''' of Fig. 10.

Simultaneously the flanges are passing through the stages 1', 1'', 1''', reaching finally the finished stage 1'''. At each pass they undergo substantially uniform reductions in thickness t^1 , t^2 , . . . t^6 , each reduction substantially proportional in amount to the simultaneous reduction in web thickness in the region between the ends 6^a of slits 6 and the flange. By saying that the reduction of the flanges is proportional to the corresponding reduction of the adjacent parts of the web it is meant that, for any particular pass, the ratio of reduction in flange thickness to its thickness before that pass is equal to the ratio of reduction in the adjacent web portion to its thickness before the pass. Consequently the flanges and thickest portions of the web are being substantially equally elongated during the rolling operation. Stating it somewhat differently, the flanges and adjacent regions of the web are reduced to substantially the same degree.

Special note should be taken of the gradual reduction of the web. Because of the tapering character of portion 5 of the web, the reduction at each pass of the blank through the rolls merges imperceptibly into the adjacent unreduced portion of the metal. For example, in the first pass the metal is represented in Fig. 13 as being reduced in thickness, on each side of the web, by the section i^1 . The

section tapers off gradually at its inner side, becoming less and less until it merges into the unreduced metal. The same is true with the succeeding reductions i^2 , i^3 , . . . i^6 . Corresponding to these reductions and, in consequence thereof, the elongations of the metal between the slits, through the several passes through the rolls, are similarly gradual in character. Just as the reduction in thickness merges into the unreduced portion so also the lengthening of the metal between the slits or openings at each pass shade off imperceptibly where the lengthened adjoins the unlengthened portion.

It is to be noted also that, not only do the reductions due to the individual passes taper off but also that the sum of such reductions likewise taper off, that is the reduction as a whole is differential.

A highly important advantage accrues from these conditions. If the metal were so reduced that there were an abrupt plane of demarcation between the reduced and unreduced portions, weakness, and in some cases, even disruptive stresses would be introduced. Particularly would this be true if there were an abrupt plane of separation between the metal of the reduced portion due to all of the passes and the unreduced portion. The unreduced metal would always be subjected to a greater or lesser degree of stretching, the amount depending upon the degree of elongation in the reduced portions. Moreover, shearing stresses would be present, especially in the plane of demarcation between the reduced and unreduced portions. These inimical conditions are avoided by this feature of our invention, there being no abrupt transition between the regions of reduced and unreduced metal. Because of the gradual tapering off of reduction, elongation of metal between the openings at any particular part thereof is substantially proportional to the amount of reduction at that part. Necessarily, this means that the disposition of metal in the spaces between the openings in the finished product is entirely dependent upon the rolling conditions.

Obviously, during the several passes the beam is lengthened, the flanges as a result of the reduction which its metal undergoes, and the web both from the reduction and from the developing of the openings therein. Preferably, as above indicated, the elongation of the flanges and the adjoining portions of the web as far inwardly of the web as the beginning of the space between the ends of the slits 6^a should be substantially equal to avoid strains being introduced.

It is obvious that not only in this example of the invention, as well as in those which follow, the drawings are not to be taken as restrictive of the protection sought. Relative dimensions of parts, numbers of passes, shapes of openings and the like are purely il-

illustrative and may be departed from greatly in actual practice without avoiding the spirit of the invention.

It should be further noted that in the example just given more or less ideal conditions are represented. For example, Fig. 13 shows reductions $t^1, t^2, \dots, t^6$ to be substantially equal as also reductions $i^1, i^2, \dots, i^6$, but obviously in actual practice the rolling man may reduce to a greater degree at one pass than at another, depending upon conditions. Then also it has been stated that the reductions of flange and web are preferably proportional, yet in rolling a practical beam it may be advantageous at times to depart somewhat from this principle. It is well however, to avoid such variations as would bring into play excessive stresses.

While the illustration just given sets forth the essential principles of our invention, there are many possible variations thereof. For example, the cross sectional contour may be changed in different ways to vary the form of the openings.

The beam blank *b* of Fig. 14 is a modification of blank *a* of Fig. 1. It possesses the thickened flanges 13 and shelf-like regions 15 similar in every respect to the corresponding parts 1 and 4 of blank *a*. The tapered portions 16 differ from the tapered portions 5 of the blank *a*, however, in that the taper continues to practically the median, longitudinal line of the web instead of terminating considerably short thereof as in blank *a*. It is rolled in the same manner and under the same conditions as blank *a* but because of the continuous variation in thickness of the web between portions 15, it is necessary to roll so as to reduce the thickness of the web practically to the median line thereof. Naturally the result will be that the flanges 17 of the finished product will be similar to flanges 1''' of Fig. 9 and the openings 18 will differ from the openings produced from blank *a* in that they will be continuously curved instead of having more or less straight edges transversely of the web as in the first described form.

Blank *c* of Fig. 16 likewise is similar in most respects to Fig. 1. Flanges 19 are practically identical with flanges 1 of blank *a*; web 20 likewise is very much like that of web 2 having the flattened portion 22 corresponding to the flattened portion 3 of blank *a* and tapered portions 23 like tapered portions 5 of that blank, the only difference being that instead of the regions of the web adjacent the flanges being flat as in blank *a*, they are curved as indicated at 21. For certain purposes, such a curvature seems to have some advantage over the flattened portions. Fig. 17 shows this blank in position at an initial stage between the rolls of a universal mill. Obviously, after the first pass the cross sec-

tional contour will be almost identical with that of the corresponding stage of blank *a*.

Blank *d*, having flanges 24, is provided with a web 25 the inner portions 28 of which are flat like the corresponding portions of blank *a*, and also having a tapered portion 27 like portion 5 of the earlier described form, but differing from that blank in that there is no shelf-like portion 4 but the curve of the tapered portion merges into the curve of the inner faces of the flanges and the web as indicated at 26. While this form of blank is not preferred, it is somewhat simple to roll and under some circumstances may be advantageous.

In Figs. 19 to 25, inclusive, we show our invention applied to the production of a beam or girder having a multiplicity of approximately circular openings disposed in staggered relation to each side of the median line of the web. Blank *e* of Figs. 19 and 20, having the thickened flanges 29, is provided with a thickened region 30 disposed in the longitudinal median line of the web, and corresponding thickened regions 31 adjacent the flanges. The thickness of the web in each of the zones 32 between the thickened regions 30 and 31 diminishes gradually, as a curved taper from both regions 30 and 31 to practically the central lines of such zones 32. These intervening zones are provided with slits 33 transversely disposed and in staggered relation. Fig. 21 represents this blank in the process of rolling during the first pass. Obviously the horizontal rolls 10 and 11 will first engage the thickened regions 30 and 31, reducing the thickness thereof and also the adjacent portions of the tapered zones 32. As in the first example above outlined, the reduction in thickness will result in corresponding elongation of the metal; the lengthening of the metal between the slits corresponding to the degree of reduction. Obviously, as in the first example, the degree of elongation of metal between the slits will diminish gradually inwardly thereof, so as to avoid substantial stretching and straining in the unreduced portions.

Figs. 22 and 23 indicate an intermediate stage in the rolling of this blank. Flanges 29' are considerably thinner than original flanges 29; thickened regions 30' and 31' have likewise been considerably thinned and widened; region 32 has been substantially narrowed to 32'. The differential reduction of the metal between the slits has opened them up as indicated by 33'.

The rolling is continued until the web has been reduced to uniform thickness, indicated at 34 in the finished product. The openings are developed until they are in the form represented at 33''. The form of these openings is approximately circular because of the continuous variation in thickness of region 32 in the original blank.

In Figs. 26 to 29, inclusive, we show our in-

vention applied to the production of an open-work sheet of metal. Blank *f* is provided with a plurality of longitudinally disposed thickened regions 36 with zones 37 therebetween of gradually varying thickness, similar to zones 32 between the thickened regions in blank *e* of Figs. 19 and 20. Blank *f* is provided with plurality of staggered slits 38 transversely arranged between the thickened regions 36. Upon rolling this blank in a direction longitudinally of the thickened portions until a flat sheet of uniform thickness has been obtained, there will result the sheet 40 provided with openings of nearly circular formation 39. Obviously the same conditions of development of openings prevails here as in the preceding example.

Figs. 30 to 33, inclusive, give representations of the application of our invention to the formation of non-flanged bodies, Figs. 30 and 31 showing the production of a plate-like body with straight sided openings while Figs. 32 and 33 show a modification thereof applied to the production of curved openings.

Blank *g* of Fig. 30 has thickened side regions 41 extending longitudinally of the blank and between them a region having a central flat portion 42 and portions 43, tapering off in thickness from regions 41 to 42. When slitted transversely and rolled longitudinally to uniform thickness the resulting plate-like body will have openings 46 with curved end portions 47 and straight transverse edges 48. It will be noted that practically the same conditions are involved here as in the rolling of the web of blank *a* in Fig. 1, the only difference between blank *g* and blank *a* being that blank *g* has no flanges.

In comparison with the preceding example, blank *h* with thickened regions 44 diminishes continuously in region 45 to the central median line thereof. When this is slitted transversely and rolled until a body of uniform thickness is formed, the openings 49 resulting will be curved continuously as indicated at 50 instead of having the straight side edges 48 as of the preceding example. That this will be so is evident in view of there being a differential reduction and elongation of metal between the slits practically throughout the region containing the slits.

As produced by the particular embodiments illustrated, the openings are symmetrical, although it is evident that it would be possible to obtain non-symmetrical openings, if desired.

Attention should be given to certain other aspects of the products of our process. Evidently, the very fact of the openings being produced during the mechanical working contributes special characteristics to the finished bodies. The metal throughout the bodies possesses substantially the same qualities that it would have had if no openings had been made therein. The metal is substantially un-

altered by the fact that openings are produced during the rolling operation. In contrast to this, the metal of open-work bodies produced by the processes of the prior art suffers some ill effects from the more or less independent operations used for producing the openings; the metal of such bodies is invariably weakened, bent or otherwise distorted to a greater or lesser extent.

The distinction of the bodies of our invention over those of the prior art is evident not only from the mechanical superiority in properties of the metal, but also in the differences in metal structure. As a result of rolling action, or other mechanical working, metal acquires an elongated crystalline structure the general distribution of elongation being determined by the direction of the mechanical working. For example, as a result of rolling an I-beam, the metal of the web will have its crystalline structure elongated in the general longitudinal direction of the beam. Now, as effects of making openings in rolled metal by the processes of the prior art, as by punching, by slitting the metal longitudinally and then separating laterally, and by allied operations, this metal structure is altered in various ways, the most obvious being a bending or distortion of the metal with corresponding changes in the metal structure. In our products, on the contrary, there being no substantial amount of bending, or other distortions, and the openings being produced simultaneously with the regular rolling, no such changes in structure are produced. The metal possesses a longitudinal disposition of structure to the edges of the openings. Unlike the products of the prior art the structure of the metal in our bodies is substantially the same near the edges of the openings as it is elsewhere in the body. For example, an open-work, flanged beam, made in accordance with our invention, will have the elongated crystalline structure of the web longitudinally disposed thereof throughout, even in that metal at the very edges of the openings.

Obviously, in the production of bodies not having flanges, appropriate rolling mills will be employed, the simple plate rolling type being suitable.

In the illustrative embodiments given, the portion of the blanks containing the slits or restricted openings have been shown as having thicknesses progressively different along such slits or openings, whereby, when subjected to rolling with "flat" rolls, in a series of passes, the thickness of the metal is reduced to different degrees and correspondingly differently elongated, with the resultant opening or developing effect upon the slits or restricted openings. Clearly, the significant thing is the differential reduction along the slits of the metal between them.

To obtain different degrees of elongation of the metal between slits in a body, for the

purpose of opening them up, it is not dependent upon such metal being of different thicknesses, nor is it essential that the blank be subjected to several passes through the rolls, nor that this product be of uniform thickness. The important condition is that there be a differential reduction. Clearly, if a slitted blank or metal, even if of uniform thickness, be so rolled across the slits as to reduce the thickness therebetween differently, producing a product of varying thickness, the slits will be developed into openings. This would be true even if but one pass were made through the rolls, providing the rolls were so shaped as to effect the differential reduction.

While each of the forms of the invention illustrated in the drawings indicate initial, transverse slits or scorings, it is obvious that any openings or scorings or weakened places of an extended character are equivalents. It is obvious too, that in its broader phases, openings or weakenings of any character may be increased or developed by utilizing the principles of our invention.

The invention is applicable to different metals, although of course steel is of the greatest economic importance.

In rolling to develop the open-work, steel structure, the ordinary practice may be followed. The metal should be rolled hot, as usual, and, preferably, the slitting and rolling to open up the slits should immediately follow the rolling of the blank from the ingot, thus making one continuous process.

While the specific description has been limited to rolling, as the most commonly practical, it will be clear that other modes of mechanical reduction may be employed.

The advantages of our invention will be apparent. It permits of a direct production of open-work in metal incidentally to the usual mechanical reduction. Only the common rolling and scoring machinery is necessary. In opening up the metal simultaneously with the rolling operation it is possible to avoid excessive weakening stresses upon the metal, and to produce a finished product having much greater strength and more uniform properties, than in those products of the prior art where the metal is subjected to various stresses such as stretching, bending and the like.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. In a process of making open-work metal bodies, the steps of preparing a blank provided with a plurality of slits, rolling across the slits to reduce the thickness of the metal in different degrees lengthwise of the slits to elongate the metal in different degrees and thereby to open up the slits.

2. In a process of making open-work metal bodies, the steps of preparing a blank having a portion of varying thickness, with slits

transverse of said portion, rolling at least a fraction of this portion of variable thickness across the slits to reduce the thicker parts along the slits to a greater degree than the thinner, thereby to elongate the metal of the thicker parts to a greater degree than the thinner, and thus to open up the slits.

3. In a process of manufacturing an open-work metal body, the steps of making a blank having a portion of varying thickness, with slits transverse of said portion, rolling at least a part of said portion across the slits to substantial flatness, to elongate the metal to different degrees and thereby open up the slits.

4. In a process of making an opening in metal, the step of mechanically working the metal to reduce the thickness along one portion of a slit to a greater degree than along another portion thereof, to elongate the metal of the former portion in a direction transversely of the slit to a degree greater than the latter portion, thereby to open up the slit.

5. In a process of making open-work metal bodies, the steps of preparing a blank having a portion of gradually varying thickness, with slits transverse of said portion, rolling at least a fraction of this portion of variable thickness across the slits to reduce the thicker parts of said portion along the slits to a greater degree than the thinner, thereby to elongate the metal in gradually varying degrees, and thus opening up the slits.

6. In a process of making open-work metal bodies, the steps of preparing a blank having a portion thereof provided with a plurality of slits, rolling at least a fraction of said portion across the slits to reduce the thickness thereof in gradually varying degrees, thereby to elongate the metal between the slits in gradually varying degrees, and thus to produce substantially symmetrical openings in the metal.

7. In a process of manufacturing open-work metal bodies, the steps of preparing a blank having a portion thereof of gradually varying thickness, provided with slits transverse of said portion, rolling at least a fraction of said portion across the slits to reduce to substantially uniform thickness, thereby to elongate at least a part of the metal between the slits in gradually varying degrees, and thus to produce substantially symmetrical openings.

8. A process for producing open-work in metals, including the steps of providing a plurality of openings in a blank, mechanically working the metal between the openings to reduce the thickness of metal to different degrees transversely of the direction of lengthening, thereby to elongate the metal to different degrees and thus to develop the openings.

9. In a process for making an opening in

metal, the steps of slitting the metal, rolling the metal across the slit to reduce the thickness of the metal in gradually varying degrees along the slit, thereby to open up the slit.

10. In a process for manufacturing an open-work metal body, the steps of providing a plurality of slits in a blank, subjecting the blank to a series of passes through a rolling mill transversely of the slits, the rolls upon each pass engaging more of the surface of the metal between the slits than upon the preceding pass, to reduce the thickness of the metal between the slits as a result of all the passes in gradually lessening degrees along the slits, thereby elongating the metal between the slits in gradually lessening degrees, and thus to open up the slits.

11. In a process for manufacturing open-work metal bodies, the steps of providing a plurality of slits in a blank, subjecting the blank to a series of passes through a mill to roll transversely of the slits, the rolls upon each pass engaging more of the surface of the metal between the slits than upon the preceding pass, to reduce the thickness of the metal between the slits differentially as a result of all the passes, and thereby elongating the metal between the slits differentially, whereby the slits are opened up, the reduction in thickness effected by each pass merging gradually into the unreduced metal.

12. In a process of manufacturing open-work metal bodies, the steps of preparing a blank having a portion thereof of gradually varying thickness, providing said portion with parallel slits transversely thereof, rolling at least a fraction of said portion across the slits to reduce to substantially uniform thickness, thereby to elongate at least a part of the metal between the slits in gradually varying degrees, and thus to produce substantially symmetrical openings.

13. In a process of manufacturing open-work metal bodies, the steps of preparing a blank having a portion thereof of gradually varying thickness, providing said portion with a plurality of parallel slits at right angles to the direction of said portion, rolling at least a fraction of said portion across the slits to reduce to substantially uniform thickness, thereby to elongate at least a part of the metal between the slits in gradually varying degrees, and thus to produce substantially symmetrical openings.

14. In a process for manufacturing open-work metal bodies, the steps of providing a plurality of slits in a zone between imperforate regions of the blank, rolling at least a part of the metal of said zone transversely of the slits, to reduce the thickness thereof in gradually lessening degrees inwardly from said imperforate regions, thereby to elongate the metal between the slits in gradually lessening degrees inwardly from the imper-

forate regions, and simultaneously rolling the imperforate regions to reduce their thickness to such a degree that the resulting elongation thereof does not differ greatly from the adjacent portions of the slitted zone.

15. In a process of manufacturing an open-work body, the steps of making a blank having spaced, imperforate regions and an intervening zone provided with a plurality of transverse slits, rolling at least a portion of said zone across the slits to reduce the thickness of a part of said portion to a greater degree than another part, to elongate one part to a greater degree than the other part, thereby to open up the slits, and simultaneously rolling the imperforate regions longitudinally thereof to reduce their thickness to such a degree that the resulting elongation thereof does not differ greatly from the elongation of the adjacent portions of the slitted zone.

16. In a process for producing an open-work metal body, the steps of providing a blank having spaced, imperforate regions, and intervening zones provided with a plurality of transverse slits, rolling the blank longitudinally of the imperforate regions to reduce the thickness thereof and also to reduce the thickness of the intervening zones in gradually diminishing degrees inwardly from the imperforate portions to intermediate portions of the intervening zones, thereby to elongate the metal of the intervening zones in gradually diminishing degrees between the slits, and thus to produce substantially symmetrical openings.

17. In a process for manufacturing open-work metal bodies, the steps of preparing a blank having spaced imperforate regions and intervening zones progressively diminishing in thickness from the imperforate portions to intermediate portions of the intervening zones, providing a plurality of slits transversely of said zones, and rolling the blank longitudinally of the imperforate portions to reduce the thickness thereof and also to reduce the thickness of the intervening zones to substantially uniform thickness, thereby to elongate at least a part of the metal between the slits in progressively diminishing degrees and thus to produce substantially symmetrical openings.

18. In a process for manufacturing a flanged beam with an open-work web, the steps of making a flanged blank, slitting the web transversely thereof, rolling the web to reduce the thickness thereof in progressively less degree inwardly from the regions containing the ends of the slits, to an intermediate portion of the web, thereby to elongate the metal between the slits in progressively less degrees inwardly from the ends of the slits, and rolling the flanges to reduce their thickness and to elongate them to a degree not greatly different from the web regions containing the ends of the slits.

19. In a process for manufacturing a flanged beam with an open-work web, the steps of making a blank having flanges and a web diminishing gradually in thickness from regions adjacent the flanges to an intermediate portion of the web, slitting the web transversely to cut the parts of varying thickness, rolling the web to lessen the differences in thickness thereof, thereby to elongate at least part of the metal between the slits in gradually diminishing degrees inwardly from the ends of the slits, thus to open up the slits, and simultaneously rolling the flanges to reduce their thickness to a degree not greatly different from that of the thickest parts of the web, thereby to lengthen the flanges in a degree not greatly different from the thickest parts of the web.

20. In a process for manufacturing a flanged beam with an open-work web, the steps of making a blank having flanges and a web diminishing gradually in thickness from regions adjacent the flanges to an intermediate portion of the web, slitting the web transversely to cut the parts of varying thickness, passing the blank repeatedly through a universal mill to progressively lessen the differences in thickness of the web, and simultaneously reducing progressively the thickness of the flanges, the total reduction in thickness of the flanges not being substantially different in degree than the reduction in thickness of the thickest parts of the web, whereby the flanges are lengthened in amount not greatly differing from the amount of lengthening of the thickest parts of the web.

21. In a process for manufacturing a flanged beam with an open-work web, the steps of making a blank having flanges, and a web having thickened regions adjacent the flanges, the web gradually diminishing in thickness from such thickened regions inwardly to an intermediate portion of the web, slitting the web completely across the portions of varying thickness, rolling the web to substantially uniform thickness and simultaneously rolling the flanges to reduce their thickness to a degree approximately equal to that of the thickened regions of the web adjacent the flanges, thereby to lengthen the flanges in amount substantially equal to the lengthening of the thickened regions of the web.

22. A process for making a flanged beam, comprising the steps of preparing a flanged beam blank having a web, a portion at least of which is of gradually varying thickness transversely of the web, slitting the web across the portion of varying thickness and rolling the beam so as to reduce the web portion of varying thickness to a state of uniform thickness, whereby the slits are opened up and simultaneously rolling the flanges to reduce their thickness in a degree substan-

tially proportional to the degree of reduction of the thickest portions of the web.

23. In a process of manufacturing a flanged beam with an open-work web, the steps of preparing a blank having flanges and a web with thickened longitudinal regions adjacent the flanges and also at an intermediate portion of the web, the flanges and the thickened longitudinal web regions being thicker than the corresponding parts of the finished beam in substantially the same proportion, the thickness of each of the web zones between said longitudinal regions diminishing gradually in thickness from the longitudinal regions to an intermediate portion of the zone, providing a plurality of slits transversely of said zones, rolling the web to substantially uniform thickness, thereby opening up the slits, and simultaneously rolling the flanges to reduce their thickness and elongate them in substantially the same degree as the longitudinal regions of the web.

24. In a process for manufacturing a flanged beam with an open-work web, the steps of providing the web of a beam blank with a plurality of transverse slits, passing the blank a series of times through a universal mill, the horizontal rolls being adjusted between passes to engage successively more and more of the surface of the metal between the slits thereby reducing the thickness of the metal between the slits differentially as a result of all the passes, whereby the slits are opened up, and adjusting the vertical rolls toward each other between passes to reduce successively the thickness of the flanges.

25. In a process for manufacturing a flanged beam with an open-work web, the steps of providing the web of a beam blank with a plurality of transverse slits, rolling the blank between horizontal rolls to successively engage more and more of the surface of the metal between the slits thereby reducing the thickness of the metal between the slits differentially, whereby the slits are opened up, and rolling the flanges between vertical rolls to reduce successively the thickness thereof.

26. In a process for manufacturing a flanged beam with an open-work web, the steps of providing the web of a beam blank with a plurality of transverse slits, rolling the blank between web engaging rolls to successively engage more and more of the surface of the metal between the slits thereby reducing the thickness of the metal between the slits differentially, whereby the slits are opened up, and rolling the flanges between flange engaging rolls to reduce successively the thickness thereof.

27. A process for producing open-work in metals including the steps of providing a plurality of scored, weakened places in a blank, mechanically working the metal between weakened places to reduce the thick-

ness of the metal to different degrees transversely of the direction of lengthening, thereby to elongate the metal between the weakened places to different degrees and thus develop the weakened places into openings.

In testimony whereof we hereunto affix our signatures.

ROBERT S. A. DOUGHERTY.
NEVIL GREENWELL.