Nov. 10, 1964 F. A. GRUETJEN 3,156,034

METHOD OF FORMING CURVED AND FLANGED METAL MEMBERS

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Fig. 1.

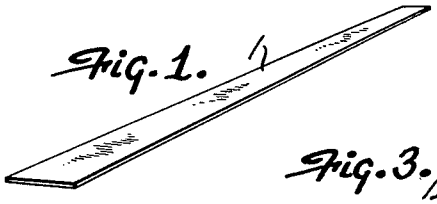


Fig. 3.

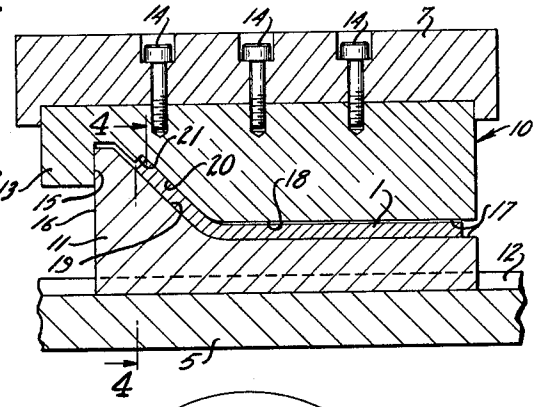


Fig. 2.

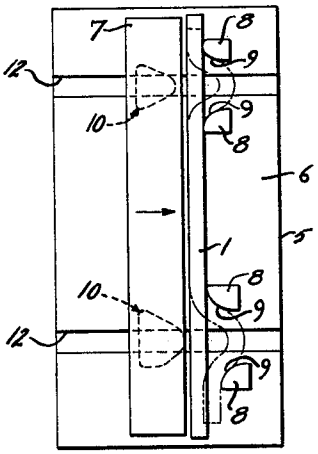


Fig. 5.

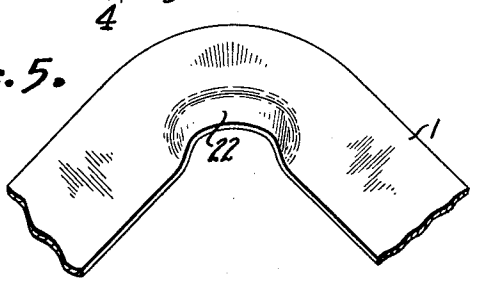


Fig. 6.

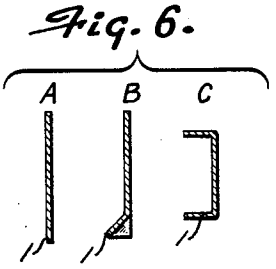


Fig. 7.

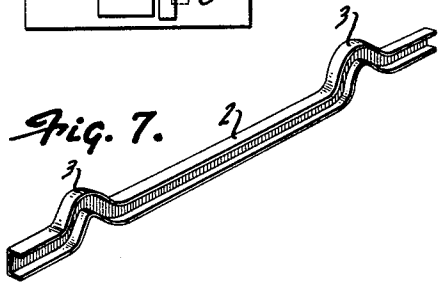


Fig. 8.

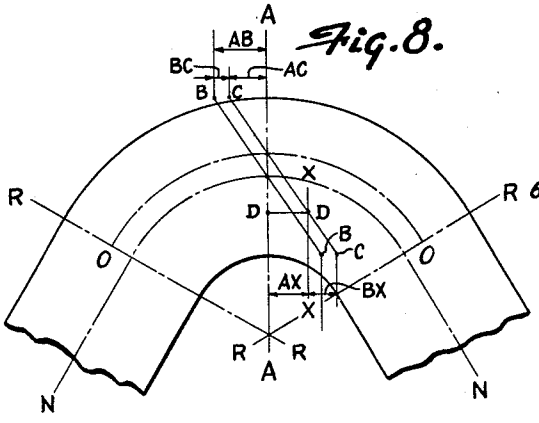
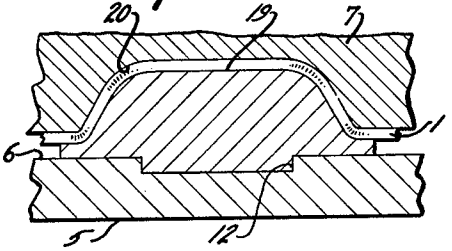


Fig. 4.



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Fig. 9.

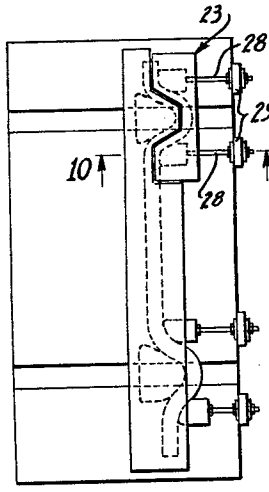
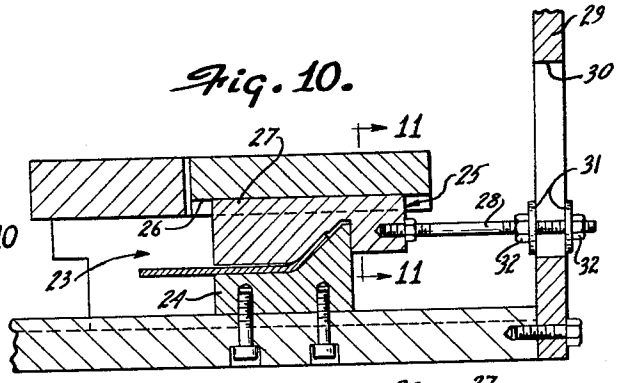


Fig. 10.



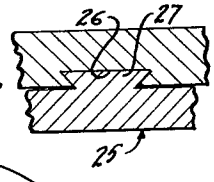


Fig. 11.

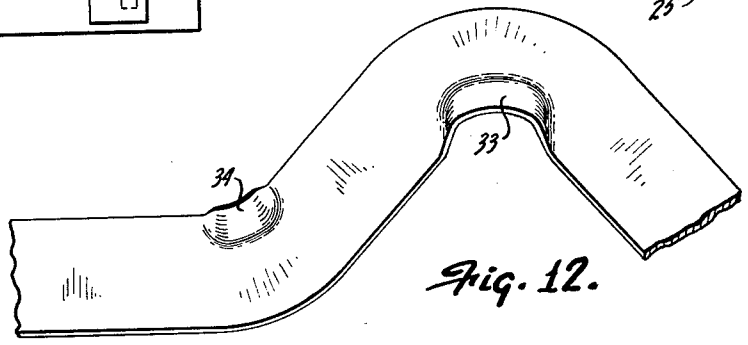


Fig. 12.

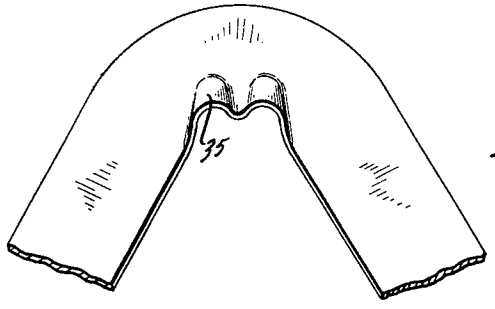


Fig. 13.

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METHOD OF FORMING CURVED AND FLANGED METAL MEMBERS

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6 Claims. (Cl. 29—155)

The present invention relates generally to the forming of metal members and particularly relates to an improved method of forming curved and flanged metal members such as automotive frame side rails.

In the automotive industry, the trend has been towards even lower vehicle silhouettes with the frame at or near the level of minimum ground clearance. As a result of this trend, it has been necessary to form the side rail frame members with fore and aft kicked-up portions of ever increasing depth and bidirectional angularity in order to maintain the required clearance between the frame and the front and rear wheel assemblies and suspension members.

Ordinarily in the past, the frame side rails were formed by initially offsetting a blank of the required length and width in the direction of its width in each of the areas requiring kick-up by applying local bending force to opposed edges of the blank with the latter being maintained in a flat condition. Following offsetting, the blank was then flanged longitudinally along the edges to thereby provide a channel section member capable of use by itself as a side rail or with a mating channel member welded thereto to form a composite, box section side rail.

In this process, the blank was subjected to fairly severe stress and deformation both in upset and in stretch and it was the experience that with the need for a deeper and sharper kick-up in the rail the resultant deformation frequently reached critical values as a result of which the blanks frequently cracked, split, buckled or otherwise failed during forming. As a consequence, scrap losses were inevitably quite high as were the per unit production costs of the members.

In order to reduce the incidence of blank failure, it was proposed to use blanks of higher grade steel and/or to subject the critical areas of the blanks to local annealing. These added measures increased production time and costs and, up to now, have been only partially effective in reducing scrap losses.

The present invention is directed to a method of forming flanged and locally curved or kicked-up metal members of the type mentioned with substantially less overall deformation during both the offsetting and channelling operations than heretofore under given conditions and which enables the forming of fairly deep and sharply angled kicked-up portions in these members with little accompanying scrap loss.

According to the invention, the blanks as they are offset are simultaneously bent progressively upwardly in the approximate center of the area being offset and along the edge thereof under compression in a controlled manner with such bending being confined transversely of the blank to the proportionate width thereof taken-up in flanging. Insofar as the compression side of the blank is concerned, the aforesaid bending of the blank results in the extreme compression fibers yielding upwardly to a predetermined extent with the offsetting of the blank to thereby reduce proportionately the compressive stress and the resultant upset in these fibers during offsetting. It will be appreciated that the upset in these fibers may be readily controlled by varying the amount of bending imported to the blank so that irrespective of the severity of offset the deformation of the compression fibers may be kept relatively low.

With regard to the tension side of the blank, the upward forming of the compression edge of the blank results in the neutral fiber axis of the blank shifting from the approximate center of the blank relatively towards the tension edge thereof. As the deformation of any particular fiber is a direct function of its distance from the neutral fiber, it follows then that in the invention the tension fibers are subjected to a reduced amount of stretch as compared to the conventional forming method. While the potential reduction in fiber stretching is somewhat limited due to the restricted transverse extent of the bending, in actual practice sufficient reduction has been realized to effectively preclude the blank from failing in tension during offsetting.

The upwardly formed edge of the blank is flattened out during the flanging of the blank so that in the completed side rail the flanges are perfectly smooth and concentric. However, additional benefits are derived from the invention in the channelling operation as in this phase of forming the edges of the blank previously subjected to tension and compression are subjected to compression and tension respectively. Due to the reduced amount of deformation in the blank sides in offsetting, it will be appreciated that in channelling the resultant deformation in the blank sides will be reduced commensurately over that using conventional methods, as a result of which the tendency of the blank to rupture, buckle or otherwise produce an imperfect flange upon channelling is reduced.

The method of the invention may be applied also to the blank immediately to either or both sides of the area which is to be offset and kicked-up where the required kick-up is particularly severe in order to control the metal deformation to a safe level in these areas. In this instance, the edge of the blank being contoured would be on the reverse side of the blank from that described as the compression and tension sides of the blank in these areas are opposite of that in the center of the offset curve.

The accompanying drawings illustrate the best mode presently contemplated of carrying out the invention.

In the drawings:

FIG. 1 is a perspective view of a metal blank used in the present method in the forming of an automotive frame side rail;

FIG. 2 is a plan view of an offset press with the blank positioned therein and with the phantom lines indicating the blank following offsetting;

FIG. 3 is a transverse section of the die inserts used in the method of the invention for forming the blank edge and with the blank shown fully in the insert;

FIG. 4 is a longitudinal section of the die insert and blank taken along the lines 4—4 of FIG. 3;

FIG. 5 is a fragmentary plan view of the blank following offsetting and illustrating the condition of the compression edge of the blank upon removal from the die inserts;

FIG. 6 is a cross-section of the blank through the center of the offset portion thereof illustrating successive forms of the blank in going from an initial flat position in FIG. 6A to an intermediate offset condition in FIG. 6B and finally to a channel shape shown in FIG. 6C;

FIG. 7 is a perspective view of the blank following completion of the channelling operation;

FIG. 8 is a diagrammatic illustration of the portion of the blank shown in FIG. 5 with reference lines imposed thereon for comparing the normal fiber deformation with that obtained in the method of the invention;

FIG. 9 is a schematic plan view of the offset press as modified for performing an alternate form of the invention and showing the blank in offset condition;

FIG. 10 is a transverse section of one of the die inserts used in the press of FIG. 9 with the blank disposed fully

therein and which is taken along the lines 10—10 of FIG. 9;

FIG. 11 is a longitudinal section of the die insert illustrating the manner in which it is carried within the platen of the press and which is taken along the lines 11—11 of FIG. 10;

FIG. 12 is a fragmentary plan view of the offset portion of the blank shown in FIG. 9 with the blank being broken off to one side of center; and

FIG. 13 is a fragmentary plan view of the offset portion of the blank illustrating a still further alternative form of the invention.

Referring to the drawings and to FIGS. 1–8 in particular, the method of the invention is illustrated in connection with the forming of an elongated sheet metal blank 1 into a channel section member 2 of the type suited for use as an automotive side rail as is or welded to a companion member to provide a boxed rail construction. Channel member 2 is formed fore and aft with the kicked-up portions 3 in what corresponds to the front and rear wheel receiving areas of the frame which portions frequently are of substantial depth and bidirectional angularity to enable dropping of the frame to or near the level of minimum ground clearance to afford a low silhouette in the assembled vehicle.

The initial step in forming member 2 consists in offsetting blank 1 in the direction of its width in each of the areas requiring kick-up. To this end, a suitable hydraulic or mechanical press 4 is provided, consisting of a stationary bed 5 having an upper, flat work surface 6 and a platen 7 supported for horizontal and vertical movement relatively of bed 5 by any suitable means. Work surface 6 supports a number of block-like nubs 8 each of which has a generally convexly curved shaping edge 9 and these nubs are secured rigidly to bed surface 6 in sets of two each to engage the blank through their edges 9 immediately to either side of each of the areas to be kicked up.

Cooperating with the nubs 8 to offset the blank is a pair of die inserts 10 movable with platen 7 and adapted to engage the blank in the approximate center of each of the areas to be kicked-up. Inserts 10 are of identical construction and each comprises a lower die plate 11 slidably supported on bed surface 6 within one of a pair of transversely spaced grooves 12 extending longitudinally of the bed surface and a cooperating upper die plate 13 secured to the underside of platen 7 in general longitudinal alignment with one of the corresponding plates 11 by the fastening studs 14. Upper plates 13 are formed with a depending abutment surface 15 engageable with the end wall 16 of plates 11 upon platen 7 being lowered and advanced over bed 5 whereby the plates 11 and 13 of each insert 10 are movable as a unit with platen 7.

In accordance with the invention, die inserts 10 are designed to effect simultaneously with the offsetting of the blank a predetermined upward contouring of the edge of the blank subject to compression during offsetting for the purpose of reducing and controlling the deformation of the blank in being formed to the completed member 2. To this end, the horizontally extending, facing surfaces 17 of each set of plates 11 and 13 are formed with mutually complementing surface contours and the plates 11 and 13 constructed such that when juxtaposed on one another their surfaces 17 form therebetween a substantially vertically extending die cavity 18 of sufficient vertical clearance to receive blank 1 edgewise therein while providing a nominal allowance with the blank.

The die plate surfaces 17 are flat and coplanar for the most part and form an elongated forwardly extending throat in cavity 18 for indexing the blank in the insert and restraining the latter against vertical movement during the offsetting operation. Rearwardly, and referring to lower die plate 11, surface 17 is formed with an outwardly curved, rearwardly upwardly sloping portion 19 having practically no intermediate curvature and dropping off fairly gently along the sides as shown in FIG. 4. The corresponding area of the surface 17 of upper die plate 13 is provided with a complementary contoured, inwardly dished portion 20 adjacent the rear of which is formed a perpendicularly inwardly extending, transverse end wall 21 serving to close off the rear end of cavity 18 and providing a limit position for relative moment of blank 1 between die plates 11 and 13. The overall width of cavity 18 exceeds the width of blank 1 and of this total the width of portions 19 and 20 as limited by end wall 21 is approximately equal to the proportionate width of the blank which is taken up in forming one of the flanges, it being understood, however, that this is not a requirement of the invention and that the width of the portions 19 and 20 may be greater or less than the flange width as desired.

In carrying out the offsetting operation, blank 1 is laid flatwise on bed work surface 6 adjacent nubs 8 and with the areas of the blank requiring offsetting in properly oriented relation thereto. Although not shown, indexing means may be provided along the sides of bed 5 to aid in initially locating the blank in press 4 and to fix the blank against laterally shifting movement during offsetting. With blank 1 in the press, platen 7 is lowered and advanced over bed surfaces 6 to move upper die plate 13 over lower plate 11 to thereby move abutment surfaces 15 against end wall 16 whereby the plates move forwardly as a unit with platen 7, it being noted that grooves 12 are of a depth such that lower die plates 11 ride therein with their forward ends flush with bed surface 6. Upon the inserts reaching the blank, the individual die plates 11 and 13 move relatively over the opposed sides of blank 1 by reason of cavity 18 and upon the plates being moved sufficiently relatively of the blank to bring portions 19 and 20 of die plate surfaces 17 against the blank, the blank is caused to initiate offsetting between nubs 8 simultaneously while the rear edge portion of the blank starts to assume the contour of portions 19 and 20. As platen 7 continues to advance, die inserts 10 force the blank further between nubs 8 simultaneously while the plates 11 and 13 move further over the blank whereby the latter is progressively bent in the direction of its width concurrently while being progressively and increasingly contoured upwardly along its rear edge portion.

The advance of the platen is continued until blank 1 has obtained the desired amount of offset at which time the blank will be fully within die cavity 18 and against end wall 21 to complete the contouring of the rear edge portion of the blank. Inserts 10 are then opened to allow removal of the blank whereupon the inserts are closed and platen 7 backed off to ready the press for another cycle.

The configuration of blank 1 in the offset area following removal from press 4 is shown best in FIG. 5, and, as can be seen therein, the edge of blank 1 subjected to die inserts 10 is formed with an upwardly sloping, curved projection or wave 22. Wave 22 extends lengthwise of the blank to either side of the centerline of the offset area while laterally it dies out at what coresponds to the line along which the coresponding edge of the blank is to be flanged as illustrated by FIGS. 6B and 6C of the drawings.

The influence of wave 22 on the magnitude of the deformation developed within the blank may be explained best in connection with FIG. 8 which illustrates diagrammatically the fiber deformation pattern within the offset position of the blank following conventional offsetting procedures and the procedure of the present invention. With conventional techniques, the fibers along the opposite edges of the blank are stretched in one case and upset in the other an amount AB, disregarding any distortion in geometry in the cross-section of the blank due to plastic flow and assuming that the neutral fiber axis of the blank indicated by line NN coincides with the longitudinal centerline of the blank.

In the present method and taking the condition of the blank following the completion of the offsetting operation, the provision of wave 22 has the effect of shifting the neutral fiber axis from line NN to line OO; it being understood that this new position of the neutral fibers axis is exemplary of only one of many possible, and is for purposes of discussion only. The fiber stretch at the edge of the blank is now an amount AC an amount BC less than that stretch experienced in this same fiber in the conventional offsetting operation.

The maximum reduction in the amount of stretching in the tension fibers is more or less fixed due to the necessity of restricting the bending of the blank to the proportionate width thereof taken-up in forming a flange. Even so, however, the reduction obtainable following the proposed method is sufficient to enable the forming of substantial offsets in the blanks without the latter failing in tension. In an actual instance, it was found that the upset in the tension fibers along the edge of the blank was reduced by 15% following the present method.

In the case of the fibers along the opposite or compression side of blank 1, the base of the controlled wave in the ultimate condition of the blank is indicated by the line DD which is extended to line CC to indicate the amount of upset in the metal fiber at DD and a line XX is drawn through the point where these lines intersect and parallel to the line AA. In this illustration, it will be assumed that the wave shape is such that each of the fibers outwardly of line DD is uniform in length at the completion of the offset operation, this length being taken between the radial reference lines RR. Under the above assumed conditions then the upset of the extreme compression fibers will be an amount AX, as will the upset of all the fibers in the area of wave under the conditions assumed, to decrease the upset by an amount BX in the extreme edge fiber.

It is to be understood, however, that the above illustration is exemplary only of the results attainable following the present method and the actual upset in any fiber in the affected area could be varied from fiber to fiber and made greater or less than that of the example simply by varying the shape of wave 22. It would be possible for example to reduce the upset in particular fibers to near zero value and in fact upset could be eliminated altogether and the fibers subjected to stretching if it were deemed desirable by using a wave of suitable shape.

The forming of the blank to the channel member is completed by a channelling operation which may be performed in any suitable press (not shown) in the course of which operation wave 22 is completely smoothed out. Where the blank has been offset in a conventional manner, the channelling operation often resulted in the blank tearing, wrinkling or buckling along the edges as the edge fibers having been severely deformed in one direction during offsetting, that is in stretch or upset, were then subjected to a reverse deformation in channelling. In the invention, however, since the edge fibers experience considerably reduced stretching and upsetting as the case may be, the corresponding reverse deformation which they are required to undergo in providing the flanges is thereby reduced commensurately over these prior art methods. Up to a 50% reduction in fiber deformation during the channelling operation has been obtained in the edges of the blank by following the instant invention. As a result, the present invention substantially reduces the likelihood of the blank failing during the channelling operation and thus is of further advantage over previous forming practices.

Where desired, the method of the invention may also be applied to one or both of the areas of the blank immediately to either side of the center of each of the areas to be offset in order to provide additional relief against deformation in these areas of the blank.

To carry out this form of the invention, each of the previously referred to stationary nubs 8 is replaced by one of the die inserts 23 which may be substantially the same construction as die inserts 10 with respect to the shape and form of their die cavity forming surfaces. The lower die plate 24 of each of inserts 23 is secured rigidly to the work surface 6 of bed 5 to engage the blank 1 along a corresponding side of each of the portions to be offset. The upper die plates 25 of the inserts are in this instance supported in platen 7 for horizontally slidable movement relatively thereto and for vertical movement therewith. This is accomplished by providing the underside of platen 7 with a laterally extending slideway 26 for each upper die plate 25 with the sides of the slideway being tapered inwardly in a direction proceeding to the underside of the platen as shown in FIG. 11. The upper surface of each die plate 25 is formed with a beveled projection 27 interfitting within corresponding slideways 26 to thereby hold die plates 25 in platen 7 while accommodating horizontal sliding movement relatively therebetween. Die plates 25 are fixed against horizontal movement with platen 7 by means of the linkage rods 28 and the cooperating upright posts 29 which are bolted along the end of the bed 5 in line with each of the inserts 23. One end of each of rods 28 is threaded to each of the upper die plates 25 while the other is received within a vertically extending slot 30 provided in each of posts 29. Rods 28 project through slot 30 as shown and are provided with a washer 31 and nut 32 on either side of the posts to fix the rods horizontally against the dies while permitting vertical movement relatively of the posts. Platen 7 and upper die plates 25 are movable together as a unit upon the platen being raised or lowered and, at the same time, the platen may be moved horizontally independently of movement of die plates 25 by reason of slideway 26 and linkage rods 28 and posts 29.

The blank is offset in exactly the same manner as before only in this instance the blank simultaneously while being offset and contoured along its rear edge and in the center portion of the area being offset is additionally contoured along its forward edge immediately to each side of the offset area by inserts 23. The condition of the blank following offsetting is shown in FIG. 12 of the drawings and, as illustrated, the rear edge of the blank is formed with a wave 33 identical to wave 22 previously described while the forward edge of the blank is provided with a pair of similar waves 34 one immediately to each side of the offset area (only one of which is shown).

The provision of waves 34 has the same effect as described previously in connection with the first form of the invention and results in corresponding reductions in stretching and upsetting of the fibers in the areas on either side of the offset portion both in the offsetting and channelling steps.

In the embodiment of the invention shown in FIG. 13, the blank 1 is shown following offsetting as being formed with a double wave or wrinkle 35 along the compressions side of the blank and in the center of the offset area. As compared to the previously described waves 22, 33 and 34, wrinkle 35 permits a somewhat increased amount of upward forming or physical displacement of the compression fibers from the plane of the blank for any given wave slope and height. This construction is of advantage where the bidirectional angularity of the side rail kick-up is particularly severe and where it would be difficult or impractical to provide the desired reduction in fiber deformation through the provision of a single wave because of the abruptness and height which would be needed therefor.

The proposed invention is particularly well suited for use with presently employed side bar forming operations and equipment and constitutes a relatively inexpensive mean for producing automotive side bars and other flanged members requiring substantially curved portions without incurring heavy scrap losses.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. In the method of forming a flanged, curved metal member from a metal blank by initially offsetting the blank in the direction of its width to stress one side of the blank in tension and the other in compression in the center of the area being offset and subsequently flanging the blank longitudinally along each side, the step consisting of controllably pressing the side of the blank under compression during offsetting progressively upwardly from the plane of the blank along the edge thereof simultaneously during the offsetting of the blank whereby the fibers under compression are permitted to yield upwardly to a predetermined extent with the offsetting of the blank to thereby reduce the total upset in said fibers while at the same time shifting the neutral fiber axis of the blank relatively toward the tension edge of the blank to thereby reduce the stretching of the fibers under tension during the offsetting operation.

2. The method of claim 1 wherein the controlled upward pressing of the blank is effected by a set of complementary contoured die plates engageable with the opposed faces of said blank.

3. In the method of forming a flanged and curved metal member from a metal blank by initially offsetting the blank in the direction of its width to the approximate curvature desired in said member to place one side of the blank under compression and the other under tension in the center of the area being offset, and subsequently flanging the blank longitudinally along its sides, the step consisting of concurrently with the offsetting of the blank controllably and progressively forming the portion of the blank in the aproximate center of the area being offset and along the edge under compression upwardly from the plane of the blank to a progressively increasing extent in proceeding toward the compression edge of the blank from a base line coincident with the line on which the corresponding side of the blank is subsequently flanged to allow the compression fiber to yield upwardly to a predetermined extent with the offsetting of the blank to thereby reduce the resultant upset therein while simultaneously shifting the neutral fiber axis of the blank relatively toward the tension side of the blank during the offsetting of the blank to thereby reduce the resultant stretch in the tension fibers, the metal thus pressed upwardly being smoothed out and taken up in the subsequent flanging of the blank.

4. In the method of forming a channel section metal member curved relatively of its longitudinal axis by initially offsetting a sheet metal blank in the direction of its width to the approximate curvature of the metal member to thereby place one edge of the blank under compression and the other under tension in the center of the area being offset and similarly immediately to each side of the area being offset and thereafter flanging the blank along its longitudinal edges, the step consisting of concurrently with the offsetting of the blank providing each of the portions of the blank under compression with an upwardly curved wave-like portion sloping downwardly from the edge of the blank in a direction relatively toward the opposite edge of the blank and dying out along the line along which the corresponding side of the blank is subsequently flanged whereby said wave like portions are taken out in the flanging of the blank to provide uniformly smooth flanges in the finished metal member, the provision of the wave-like portions serving to reduce metal fiber deformation in the offset portion of the blank along the sides of the blank during the offsetting and flanging of the blank by allowing the fibers under compression to yield upwardly to a predetermined extent with the offsetting of the blank to thereby reduce the upset therein and to thereby shift the neutral fiber axis relatively toward the tension side of the blank in each of the areas of said wave-like portion to in turn reduce the stretching or the tension fibers, said reduced upsetting and stretching resulting in commensurate reduction in stretching and upsetting respectively in opposite sides of the blank upon the latter being flanged.

5. In the method of forming a flanged and a locally curved metal member from a sheet metal blank including the steps of initially offsetting the blank in the direction of its width in each of the areas requiring curvature to thereby subject one side of the blank to compression in the portion thereof in the approximate center of the area being offset and the opposite side of the blank to compression in the portions thereof immediately to each side of the area being offset with the opposed side of the blank in each of the said portions of the blank being subjected to tension and thereafter flanging the blank longitudinally on each side, the step which consists of simultaneously with the offsetting of the blank controllably bending each of the portions subjected to compression upwardly toward the adjoining edge of the blank from a base line adjacent to the said edge whereby the fibers under compression and adjacent the edge of the blank are permitted to yield upwardly to a predetermined extent with the offsetting of the blank to thereby reduce the resulting upset in such fibers while at the same time causing the neutral fiber axis of the blank to be shifted in each of the portions subjected to the controlled bending from the approximate longitudinal centerline of the blank relatively toward the edge of the blank subjected to tension to thereby reduce the resulting stretch in the fibers in each of said portions, the controlled bending of the said portions of the blank being conducted progressively with the offsetting of the blank and upon the completion of the offsetting of the blank being limited to the proportionate width of the blank taken-up in forming a flange in the direction of the width of the blank whereby all vestige of the bending of said portions is removed in flanging the blank so that the resultant flanges are perfectly smooth and concentric with one another in the finished member.

6. The method of claim 5 wherein the controlled bending of the said portions of the blank is effected by sets of cooperating die plates engageable with the opposed faces of the blank in each of the said portions, said die plates on one side of the blank being movable with respect to the corresponding die plates on the opposed side of the blank in the plane of the blank and adapted to also effect the offsetting of the blank.

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