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[54] APPARATUS FOR FORMING CURVED METAL BARS SUCH AS AUTOMOBILE BUMPERS
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[51] Int. Cl. B21d 5/02
[50] Field of Search 72/381, 383, 321, 319, 387, 388, 394, 400, 411, 379

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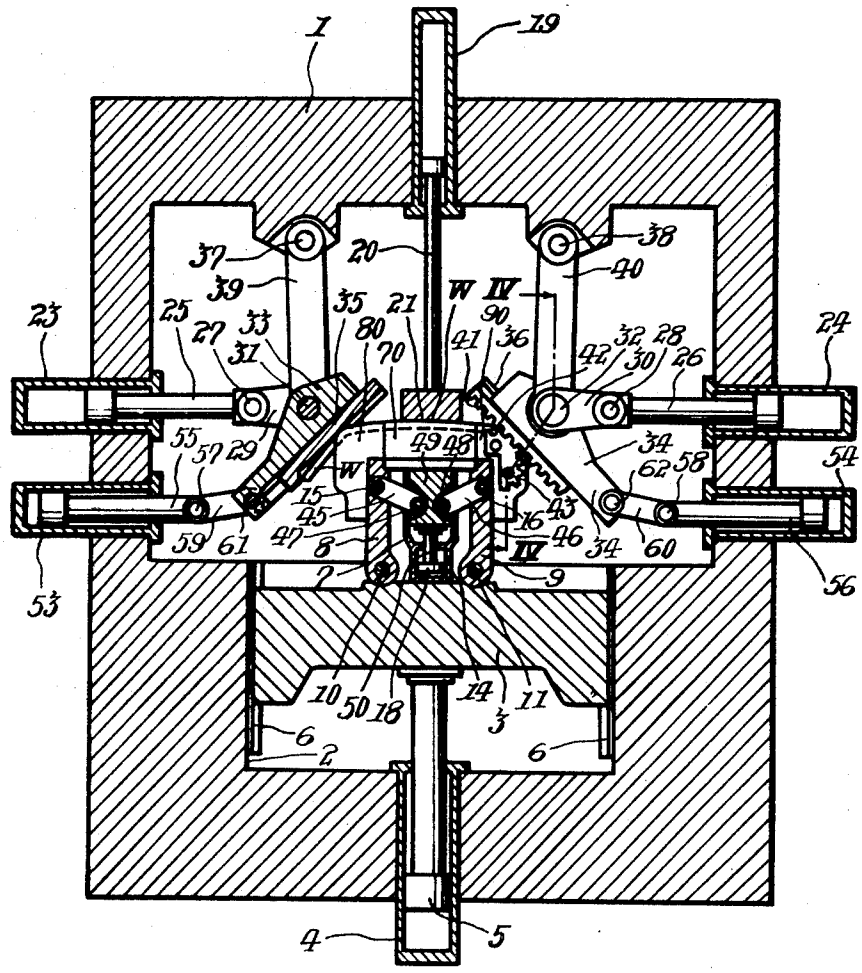
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Assistant Examiner—Michael J. Keenan
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ABSTRACT: In forming apparatus of the type having a split-type male die assembly and a pair of female die members rockable to roll-bend the opposite end portions of the blank in cooperation with the male die assembly, a pair of auxiliary hydraulic assemblies are provided to drive the bottom portions of the respective female die members toward each other thereby to make the rolling action of the female members on the associated male members more accurate and stable irrespective of of the curvature required of the bumper end portions.

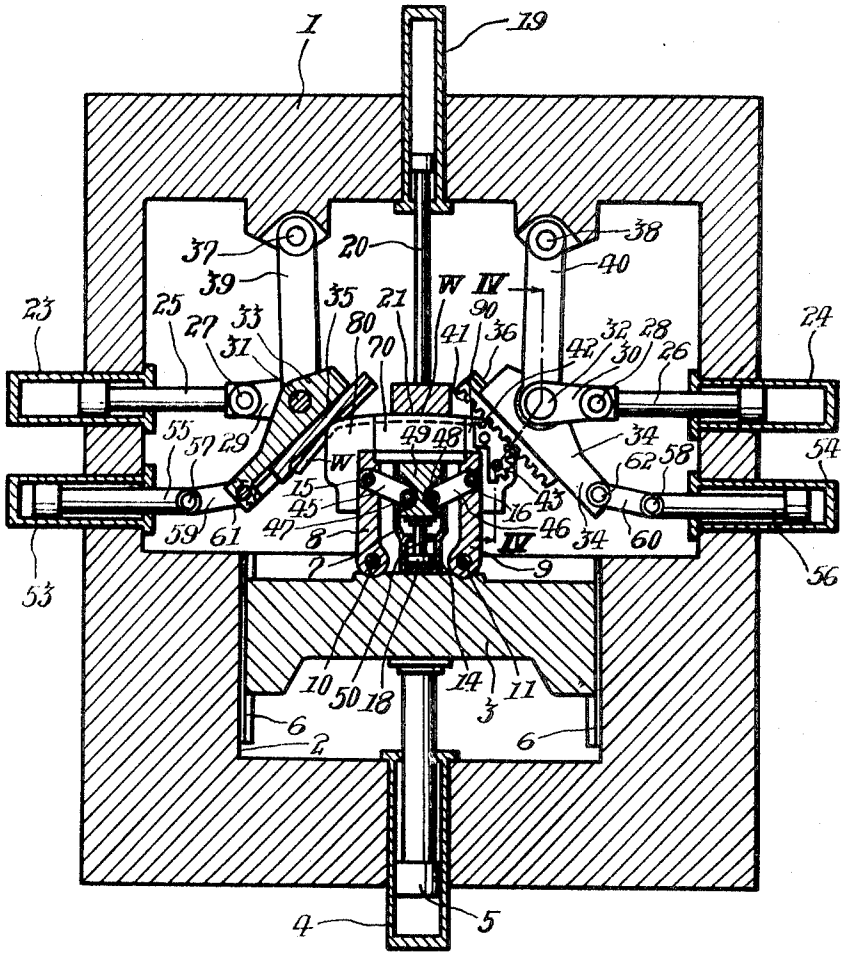


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Fig. 1



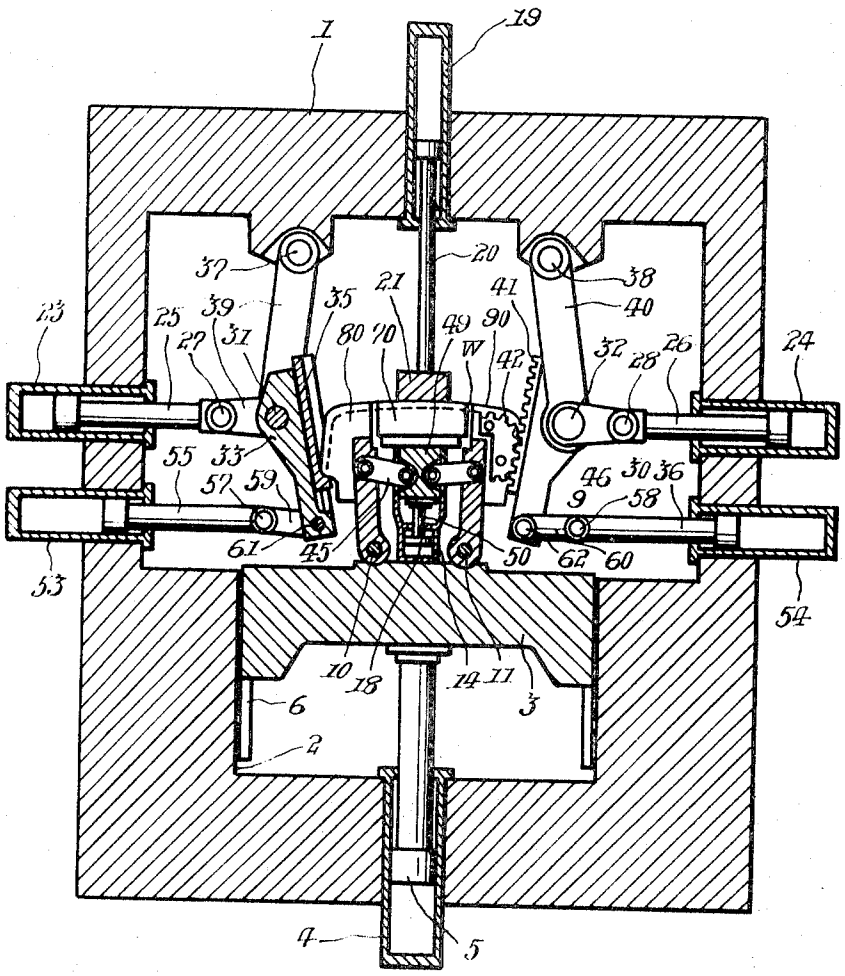
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Fig. 2



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Fig. 3.

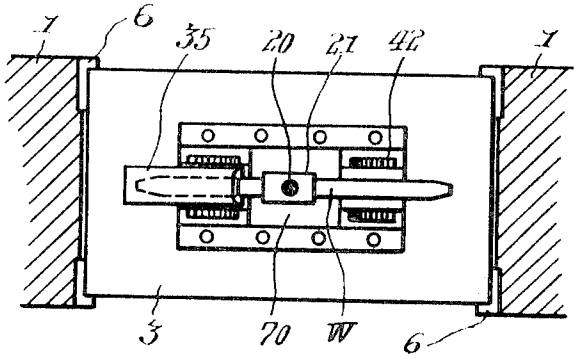
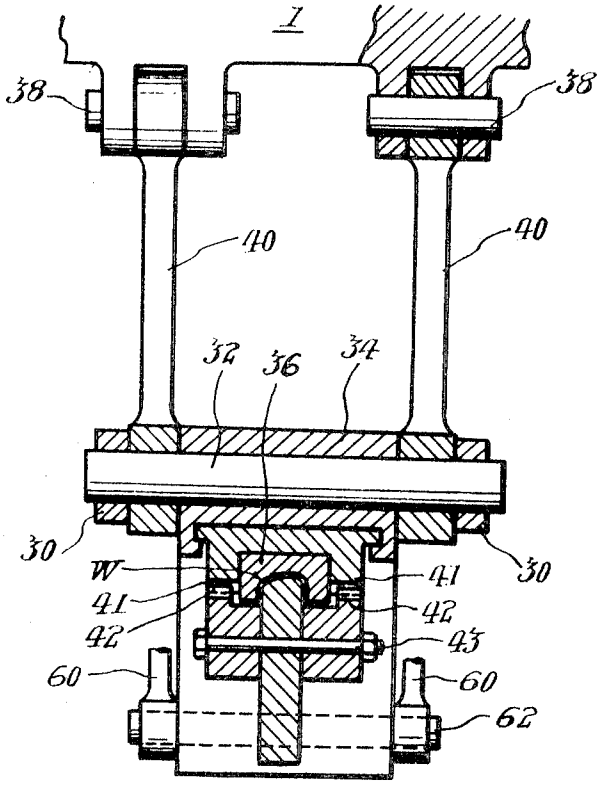


Fig. 4.



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APPARATUS FOR FORMING CURVED METAL BARS SUCH AS AUTOMOBILE BUMPERS

This invention relates to improvements in apparatus for forming curved metal bars such as automobile bumpers.

A type of bumper forming apparatus has previously been known which includes a metal die rotatable about a rotative shaft and a roller assembly operable by pressure means to press the blank against the metal die.

One improvement over such bumper forming apparatus is the one previously proposed by the inventor and which employs in place of the conventional roller assembly a pair of rockable female die members operable in association with the linear movement of a reciprocable male die to shape the opposite end portions of the bumper blank positioned on the male die into the desired curved form by rolling over the curved end portions of the male die, which is made split including an intermediate or central die member and a pair of longitudinally spaced side die members movable apart therefrom to stretch form the intermediate portion of the blank into the desired configuration of limited curvature through plastic deformation of the blank material.

The present invention relates particularly to improvements in or relating to this type of forming apparatus and and has for its object to provide a forming apparatus of the type described which includes a pair of auxiliary side pressure means arranged to act inwardly upon the bottom portions of the respective rockable female die members, in addition to a pair of principal side pressure means substantially the same in structure and function as the side hydraulic assemblies previously used to press the female die members inwardly against the male die assembly and arranged to act upon the female die members through their points of pivotal connection with the respective hanging levers, for the purpose of promoting the rocking movement of the female die members when the latter are forced to roll over the contoured surface of the male die assembly.

Another object of the present invention is to provide a forming apparatus of the type described which is designed to ensure highly accurate and stable rolling movement of the female die members relative to the male die assembly.

A further object of the present invention is to reduce the length of stroke of the reciprocating male die assembly used in the described type of forming apparatus.

Yet another object of the present invention is to provide a forming apparatus of the type described which is capable of accurately forming a bumper or the like curved metal bar which includes opposite end portions of relatively limited curvature and varying in cross-sectional configuration lengthwise thereof.

These and other objects, features and advantages of the present invention will be made more apparent as the specification proceeds.

Attention now is particularly directed to the accompanying drawings, which illustrate one preferred embodiment of the present invention and in which:

FIG. 1 is a vertical cross-sectional view of the essential part of a bumper forming apparatus embodying the principles of the invention, showing the machine in the state it assumes for forming the opposite curved end portions of the bumper;

FIG. 2 is a view similar to FIG. 1, showing the machine in the state it assumes when the forming operation is completed;

FIG. 3 is a fragmentary cross-sectional plan view showing the relative position of the male die, male die supporting table or platen, female die members and the bumper blank on the machine; and

FIG. 4 is an enlarged cross-sectional view taken along the lines IV–IV in FIG. 1.

Referring now to the drawings, the bumper forming machine illustrated includes a machine frame or housing 1 having four vertically extending parallel guide members 6 secured on the inside 2 of the frame and a male die supporting

table or platen 3 arranged for vertical sliding movement along said guide members 6 (FIG. 3). As shown in FIG. 1, a piston 5 secured to the bottom of the supporting table 3 is received in a hydraulic cylinder 4 provided in the bottom of the frame 1 and is operable under the hydraulic pressure as supplied to the cylinder 4. Mounted on the supporting table 3 is a male die assembly of the split type which includes a plurality of separable die members arranged longitudinally of the bumper blank W as loaded on the machine. The male die supporting table 3 carries on its top male die mounting means which includes a central fixed mount 7 and a pair of rockable side mounts 8 and 9, which are pivotally secured to the supporting table 3 by pivot pins 10 and 11, respectively, and rockable to open and close relative to the central fixed mount 7. Male die members 70, 80 and 90, all made of hard steel, are removably secured to the fixed and rockable mounts 7, 8 and 9, respectively by appropriate means. Formed within a part of the fixed mount 7 is a space in which is accommodated a hydraulic piston and cylinder assembly including a cylinder body 14 and a piston 18 slidably received therein and connected with a piston rod 50, which in turn is connected with a crosshead 49 vertically movable within the fixed mount 7. Pivoted to the crosshead 49 at 47 and 48 are links 45 and 46 which are pivotably secured to the rockable side mounts 8 and 9, respectively, by means of respective pivot pins 15 and 16. It will be apparent that upon energization of the hydraulic assembly provided within the central fixed mount 7, the crosshead 49 is caused to slide upwardly together with the rising piston 18 of the hydraulic assembly and thus acts, by way of the links 45 and 46, to rock the respective side mounts 8 and 9 outwardly in opposite directions about the axes of respective pivot pins 10 and 11 until the state shown in FIG. 2 is attained.

Two pairs of female die hanging levers 39 and 40 are suspended from the top of the machine frame 1 by means of respective pivotal pins 37 and 38 and extend into the top portion of the space defined within the machine frame 1. The hanging levers 39 and 40 are pivotally connected at their respective free or bottom ends with female die support blocks 33 and 34, respectively, by means of pivot pins 31 and 32. Mounted on the underside of these support blocks 33 and 34 are a pair of left and right female die members 35 and 36 which are shaped symmetrical to each other. These die members 35 and 36 are removable from the underside of the respective female die support blocks 33 and 34 and adjustable in position thereon.

Connecting rods 29 and 30 are pivoted at one end to the respective hanging levers 39 and 40 by means of pivot pins 31 and 32 which are used in pivotal connection between the hanging levers and the respective female die support blocks 33 and 34, as described above. The connecting rods 29 and 30 are pivotally connected at the other end with respective piston rods 25 and 26 by means of pivot pins 27 and 28. Piston rods 25 and 26 are formed integral with respective pistons received in side hydraulic cylinders 23 and 24, which are symmetrically arranged on the opposite sides of the machine frame 1. With this arrangement, female die members 35 and 36 and their support blocks 33 and 34 are rockable to the connecting rods 29 and 30 respectively. It will be readily understood that the hydraulic assemblies arranged in this manner together form principal side pressure means of the machine which are hydraulically operable to press the female die members 35 and 36 against the respective male die members 80 and 90, clamping a blank W between the cooperating male and female die members. The above hydraulic pressure means and associated construction are similar to those employed in the aforesaid forming apparatus previously proposed by the inventor.

According to the present invention, auxiliary side pressure means are employed for the female die members in addition to the principal side pressure means described above.

As illustrated, the female die support blocks 33 and 34 carry at their respective bottom ends pivot pins 61 and 62, on which respective connecting rods 59 and 60 are mounted. These connecting rods are pivotally connected at the other end with

respective piston rods 55 and 56 by means of pivot pins 57 and 58. Piston rods 55 and 56 are formed integral with respective pistons received in a pair of hydraulic cylinders 53 and 54 arranged symmetrically on the machine frame 1 on the left and right side walls thereof.

In operation, when hydraulic pressure is introduced simultaneously into the first pair of left and right hydraulic cylinders 23 and 24 and the second pair of left and right hydraulic cylinders 53 and 54, the respective associated piston rods 25, 26, 55 and 56 are moved inwardly toward the center of the machine so that the female die support blocks 33 and 34 and female die members 35 and 36 thereon are rocked about the respective points 37 an 38 of pivotal connection with the hanging levers 39 and 40 and at the same time caused to roll along the curved profile surfaces of the respective side male die members 80 and 90 by meshing engagement of toothed racks 41 and arcuate segments 42, which will be described hereinafter in detail. Also, mounted on the top of the machine frame 1 is a hydraulic piston and cylinder assembly which includes a vertically arranged cylinder body 19 and a piston received therein and formed integral with a rod 20, which extends vertically downward and carries an enlarged bottom end 21 for engagement with a blank W as positioned on the male die assembly 70, 80 and 90. The enlargement 21 serves to press and hold the intermediate region of the blank W against the male die and particularly against the central fixed member 70 thereof upon energization of the piston an cylinder assembly 19–20.

The forming machine described above is operated as follows.

At the start, a number of preparations are made according to the configuration of the product bumper and particularly of its opposite wing portions and to the entire length of the bumper. Firstly, side male die members 80 and 90 are selected according to the particular length and curved formation of the bumper and secured to the respective rockable mounts 8 and 9 mounted on the platen 3. Then, female die members 35 and 36 are selected and secured to the respective female die support blocks 33 and 34 for cooperation with the selected male die members 80 and 90, respectively. It will be readily understood that the configuration of the opposite wing portions of the bumper as formed by the forming machine is determined by the selection of the male die members 80 and 90 and the female die members 35 and 36 cooperable therewith.

In order to load the machine with a blank W to be worked, the cylinder and piston assembly 4–5 is first energized so as to lower the male die supporting table 3. It is to be noted that at this moment the piston 18 in the hydraulic cylinder 14 and the crosshead 49 connected integral with the piston 18 are in their bottom position psotopm in the central fixed die mount 7 as viewed in FIG. 1 under the hydraulic pressure fed to that cylinder space lying on the top side of the piston 18 and thus the male die is in its closed state with the rockable side die members 80 and 90 held in close contact with the respective outer end surfaces of the central fixed male die member 70.

Subsequently, after a blank W has been positioned on top of such closed male die assembly 70, 80 and 90, the piston and cylinder assembly 19–20 at the top of the machine is energized by supplying hydraulic pressure into the top space in cylinder 19 in order to drive piston rod 20 downwardly until the blank W is firmly clamped against the top surface of the male die member 70 by the enlarged bottom end 21 of the piston rod 20.

After such preliminary and loading procedures, hydraulic pressure is introduced into the first and second side cylinders 23–24 and 53–54. Accordingly, the piston rods 25 and 26 associated with the respective first cylinders 23 and 24 are actuated toward each other to swing the female die hanging levers 39 and 40 inwardly about the axes of the respective pivotal pins 37 and 38 through the intermediary of connecting rods 29 and 30. In this manner, hanging levers 39 and 40 are moved toward each other, carrying respective female die support blocks 33 and 34 to their position closest to the center of the machine frame and the female die members 35 and 36 are both brought into a substantially horizontal position. Then, the bottom hydraulic piston and cylinder assembly 4–5 is so energized as to cause the piston 5 to rise together with the male die supporting table 3 until the male die assembly 70, 80 and 90 thereon comes into engagement with the now nearly horizontal female die members 35 and 36. In this manner, the blank W is pressed against the female die members 35 and 36 and thus forced to assume a cross-sectional configuration complemental to that of the latter and now preparation for forming work is completed.

Subsequently, the bottom hydraulic cylinder 4 for actuating the male die supporting table 3 is fed with hydraulic pressure to override the top cylinder 19 and side cylinders 23 and 24 and the piston 5 acts to raise the male die mounts 7, 8 and 9 together with the respective male die members 70, 80 and 90. As the result, piston rods 25 and 26 are forced to retract through the medium of the respective female die members 35 and 36 while at the same time swinging the hanging levers 39 and 40 outwardly about their respective fulcrum points 37 and 38. On this occasion, it will be readily appreciated that the female die support blocks 33 and 34 are forced up by the respective side male die members 80 and 90 to move away from each other while rocking about the respective axes of pivot pins 31 and 32 in such a manner that the female die members 35 and 36 secured to the respective support blocks 33 and 34 are displaced outwardly progressively to roll along the curved outer end surfaces of the respective adjacent male die members 80 and 90 while maintaining pressure contact therewith to roll-bend the blank W. It is to be noted that such rolling action of the female die members 35 and 36 along the curved outer end surfaces of the side male die members 80 and 90 is forcefully effected with the aid of the additional or auxiliary side pressure means, which include side cylinders 53 and 54 and respective piston rods 55 and 56 associated therewith and act, by way of connecting rods 59 and 60, upon the respective female die support blocks 33 and 34 to drive the latter inwardly toward each other at their respective points of pivotal connection 61 and 62 with the connecting rods 59 and 60.

The rocking movement of the female die support blocks 33 and 34 as caused by the auxiliary pressure means is highly effective to form the blank with precision and efficiency and particularly advantageous when the bumper to be formed has especially long and large curved end portions.

Moreover, in order to secure the rolling contact of the female die members 35 and 36 with the outer curved end surfaces of the respective male die members 80 and 90 without any sliding action therebetween, toothed interengaging means are employed which include, as shown in the right-hand half portions of FIGS. 1, 2 and 4, straight toothed rocks 41 formed on the opposite edges of each of the female die members 35 and 36 longitudinally thereof and arcuate toothed rack members 42 fixedly mounted on the opposite sides of each of the side male die members 80 and 90. As shown the arcuate racks 42 are curved along the adjacent outer end surface of the associated side male die member 80 and 90 and held in mesh with the straight racks 41 on the adjacent female die member 35 or 36. With this arrangement, it will be apparent that the female die members 35 and 36 are constrained to roll along the arcuate profile of the fixed racks 42 and thus without any sliding movement relative to the respective side male die members 80 and 90.

Upon continued rising movement of the male die supporting table 3, the piston rods 25 and 26 are further forced to retract, allowing the female die members 35 and 36 to assume respective substantially vertical positions. On the other hand, the inward advancing movement of the piston rods 55 and 56 associated with the respective second side cylinders 53 and 54 continues to cause the female die members 35 and 36 to tilt outwardly, as shown in FIG. 2.

In this manner, the lower portions of the female die members act to bend the opposite end portions of the blank W

further along the curved outer end portions of the respective side male die members 80 and 90 while forming the blank end portions into the desired cross-sectional shape and thus the forming of the opposite wing portions of the bumper is completed. The timing control of supplying hydraulic pressure to the two pairs of side hydraulic cylinders 23–24 and 53–54 and to the bottom cylinder 4 provided for vertical movement of the male die supporting table 3 can be effected automatically, for example, by electromagnetic valves arranged in the respective hydraulic pressure supply lines.

After formation of the bumper wing portions has been completed, the control slightly curved portion of blank W is subjected to required formation or plastic deformation in the same manner as with the case of the machine previously proposed by the inventor. In other words, after the opposite wing portions have been completely formed in the manner described above, hydraulic pressure is introduced into the bottom of the cylinder 14 provided in the fixed male die mount 7 to rock the side die mounts 8 and 9 outwardly about the axes of respective pivot pins 10 and 11 thereby to expand the distance between the side male die members 80 and 90, mounted on respective side mounts 8 and 9, as shown in FIG. 2. By this expanding action, the blank W will be subjected to a large pulling force, which acts upon the blank longitudinally thereof along the slightly curved top surfaces of the male die members 70, 80 and 90. In this manner, the blank W is stretched longitudinally thereof with an elongation far exceeding the elastic limit of the blank material and, under such plastic deformation, efficiently formed into the same slightly curved configuration as that defined by the top surfaces of the spaced male die members 70, 80 and 90 in combination and thus the bumper forming operation is completed.

To summarize the forming apparatus according to the present invention includes auxiliary pressure means in the form of a pair of left and right hydraulic cylinders 53 and 54 and piston rods 55 and 56 received therein to act upon the bottom portions of a pair of female die support blocks 33 and 34, in addition to the principal pressure means including a pair of left and right hydraulic cylinders 23 and 24 and piston rods 25 and 26 received therein to act upon the respective support blocks 33 and 34 at their points of pivotal hanging connection 31 and 32 as in the forming apparatus previously proposed by the inventor, and in operation the female die members 35 and 36, mounted on the respective support blocks 33 34, are caused to roll over the contoured surfaces of the side male die members 80 and 90 in a highly accurate and stabilized manner with the aid of the positive drive of the auxiliary pressure means, which act, as described above, upon the bottom end portions of the left and right female die assemblies. It will also be appreciated that the provision of such auxiliary pressure means enables reduction in distance of rising movement required of the male die members 70, 80 and 90, that is in length of stroke of vertical reciprocation of the male die assembly.

Other modes of applying the principles of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

What I claim is:

1. An apparatus for forming curved metal bars such as automobile bumpers, comprising a machine frame (1), a male die supporting table (3) mounted on said machine frame for vertical reciprocating movement, a male die assembly mounted on said male die supporting table and including a pair of side male die members (80, 90) having curved surfaces corresponding to the cross-sectional configuration required of the product, a pair of two rockable hanging levers (39, 40) pivotally hung from the top of the machine frame, a pair of movable female die members (35, 36) pivotally connected with said respective hanging levers and having curved surfaces corresponding to those of said side male die members, a pair of principal side pressure means arranged respectively on the left and right sides of the machine frame and hydraulically operable to act inwardly upon said respective female die members through the points of pivotal connection (31, 32) with said respective hanging levers, and a pair of auxiliary side pressure means arranged to act inwardly upon the bottom end portions of said respective female die members.

2. An apparatus a set forth in claim 1 in which said auxiliary side pressure means each include a hydraulic cylinder (53 or 54), a piston rod (55 or 56) associated therewith and a connecting rod (59 or 60) pivotally connected at one end with said piston rod and at the other end with the bottom end portion of the associated one of female die support blocks (33, 34) carrying said respective female die members.

2. An apparatus as set forth in claim 1 in which said auxiliary side pressure means each include a hydrauliic cylinder (53 or 54), a piston rod (55 or 56) associated therth and a cpmmectomg rpd (59 or 60) pivotally connected at one end with said piston rod and at the other end with the bottom end portion of the associated one of female die support blocks (33, 34) carrying said respective female die members.