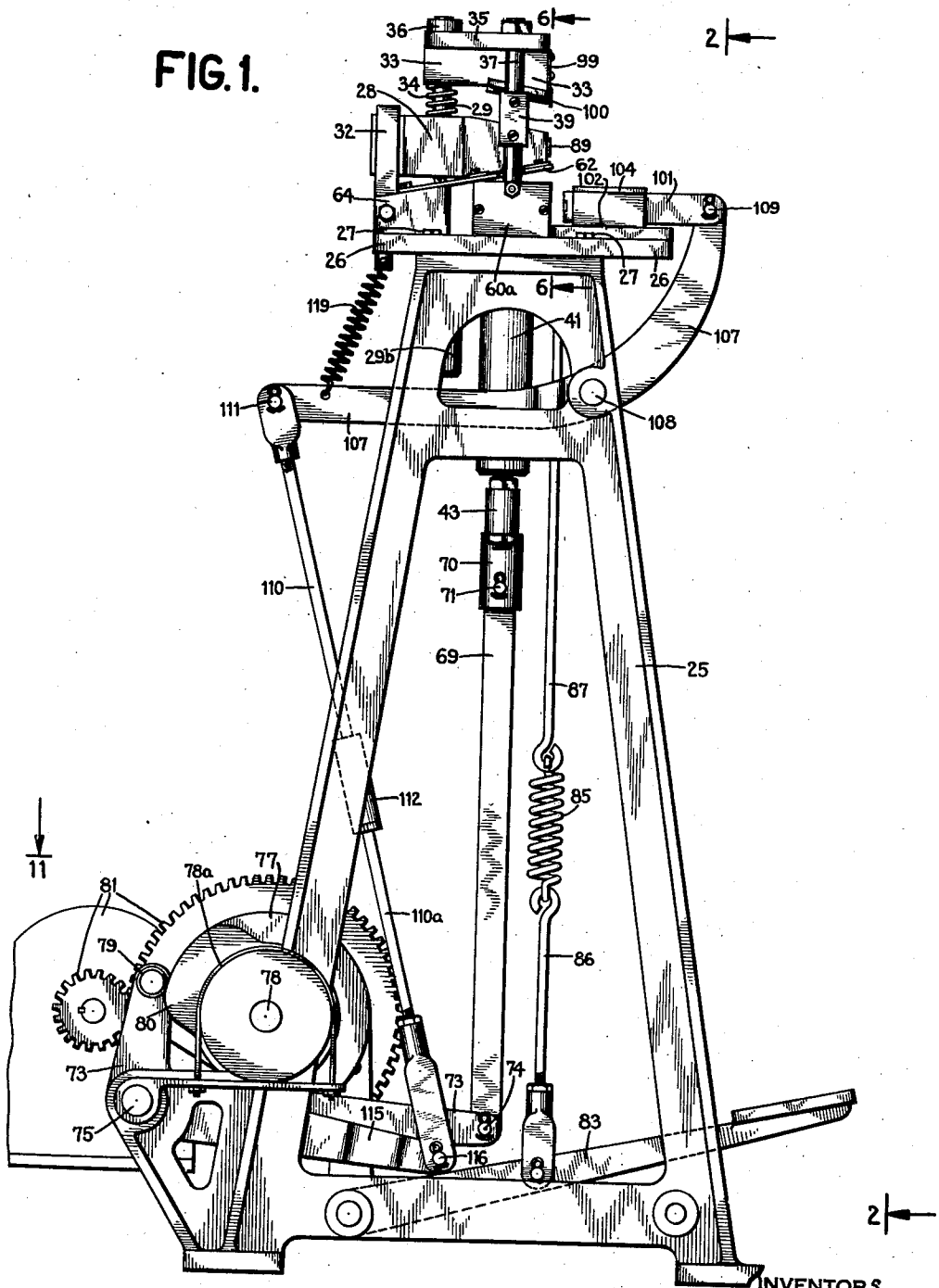
Jan. 11, 1938. M. M. BALSAM ET AL 2,104,727

METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

Filed May 20, 1936 9 Sheets-Sheet 1

FIG. 1.



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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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FIG. 2.

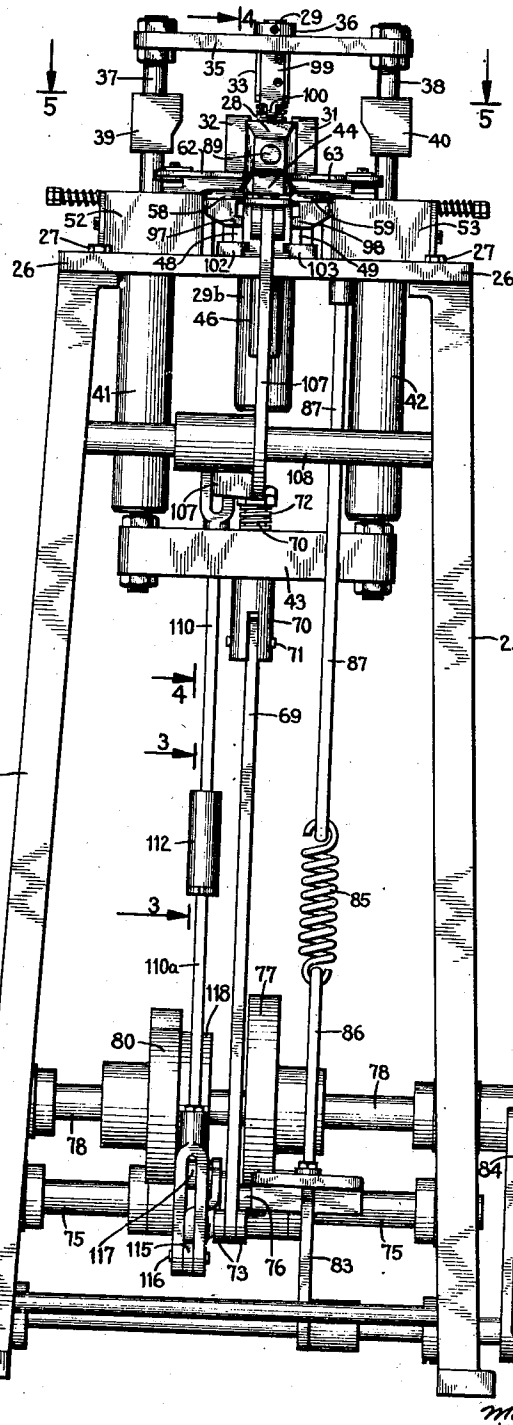
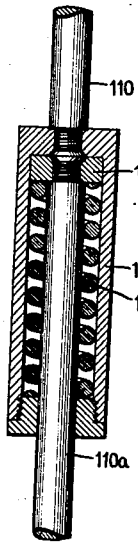


FIG. 3.



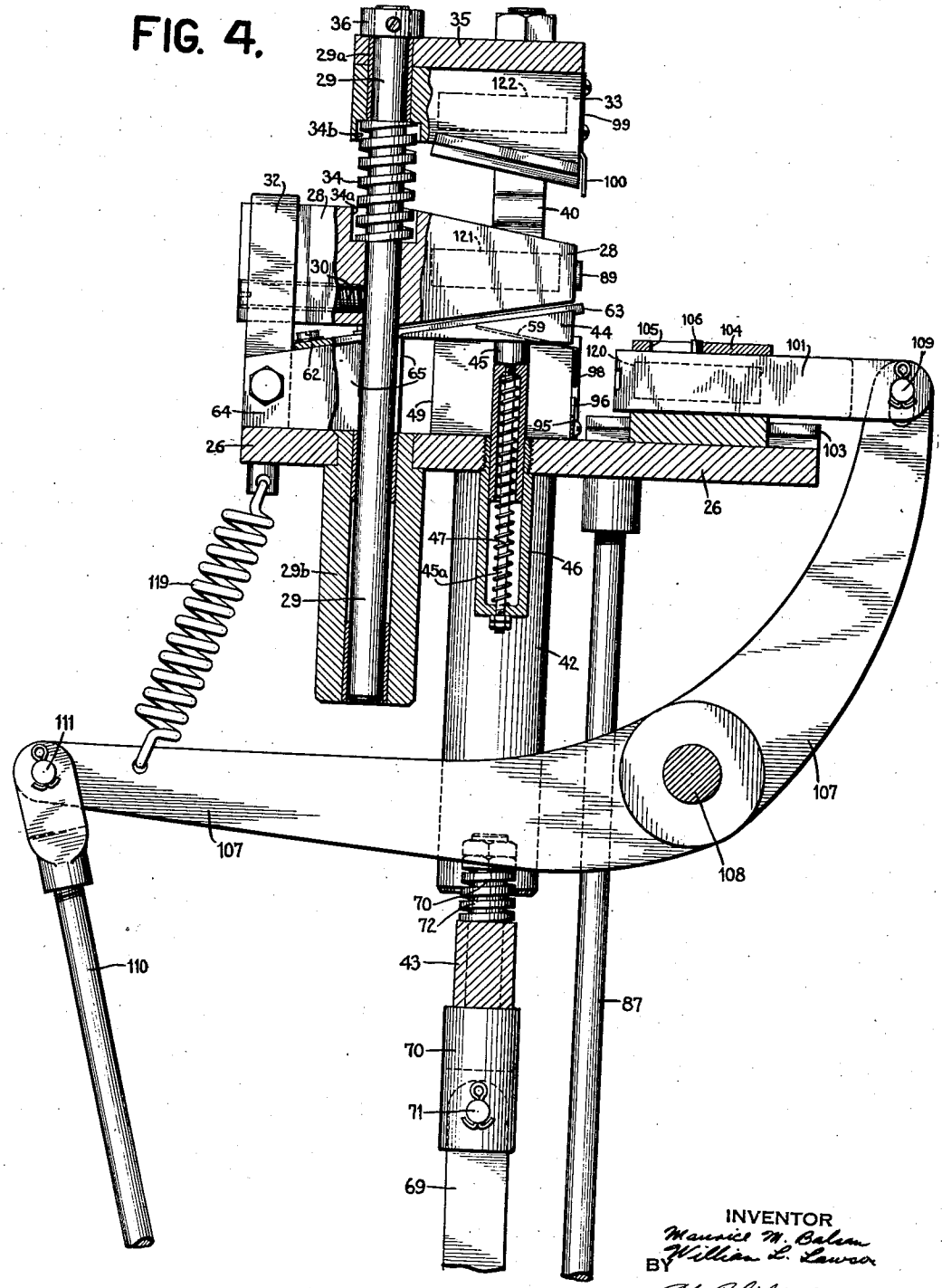
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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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FIG. 4.



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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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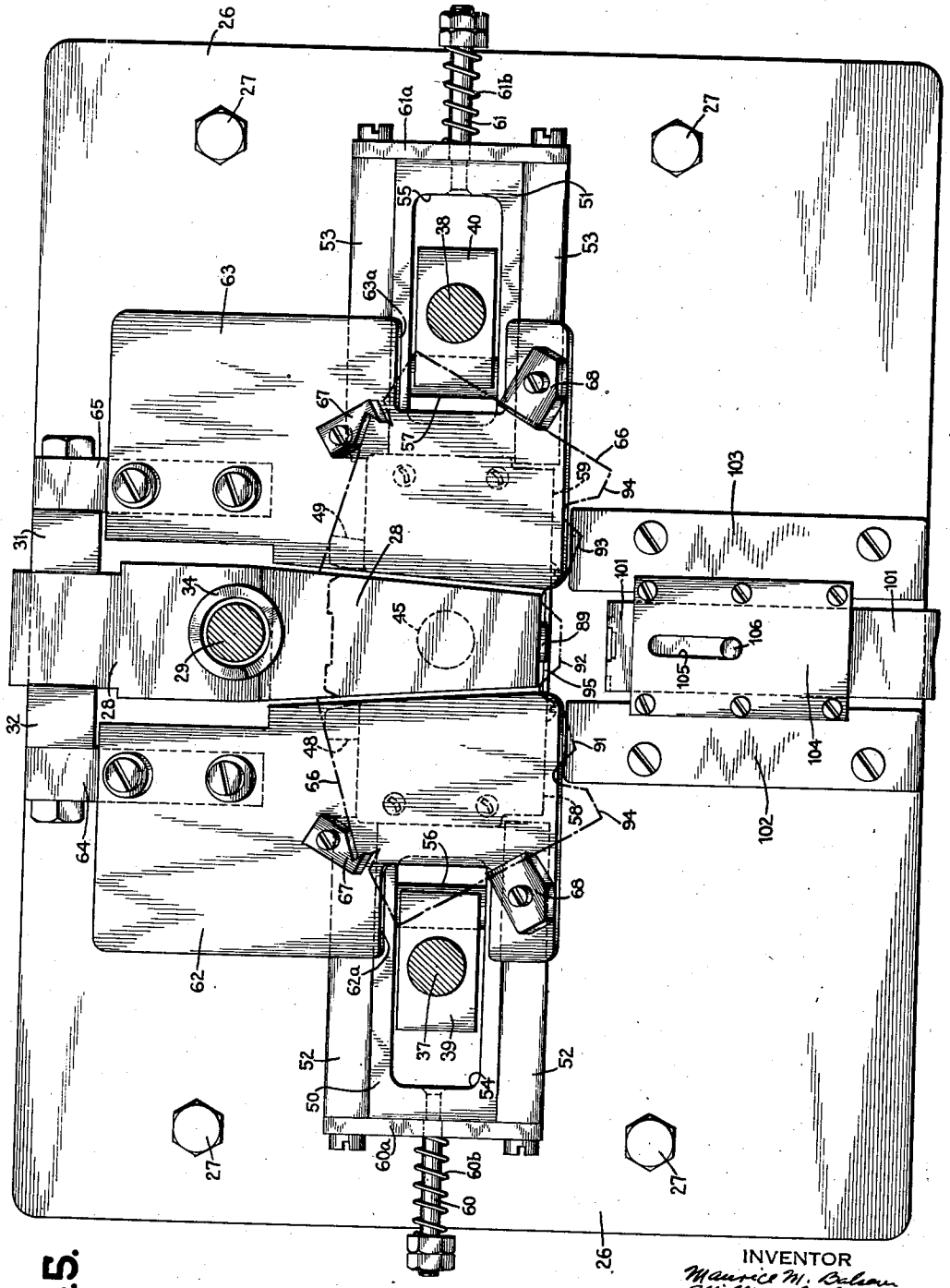


FIG.5.

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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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FIG. 6.

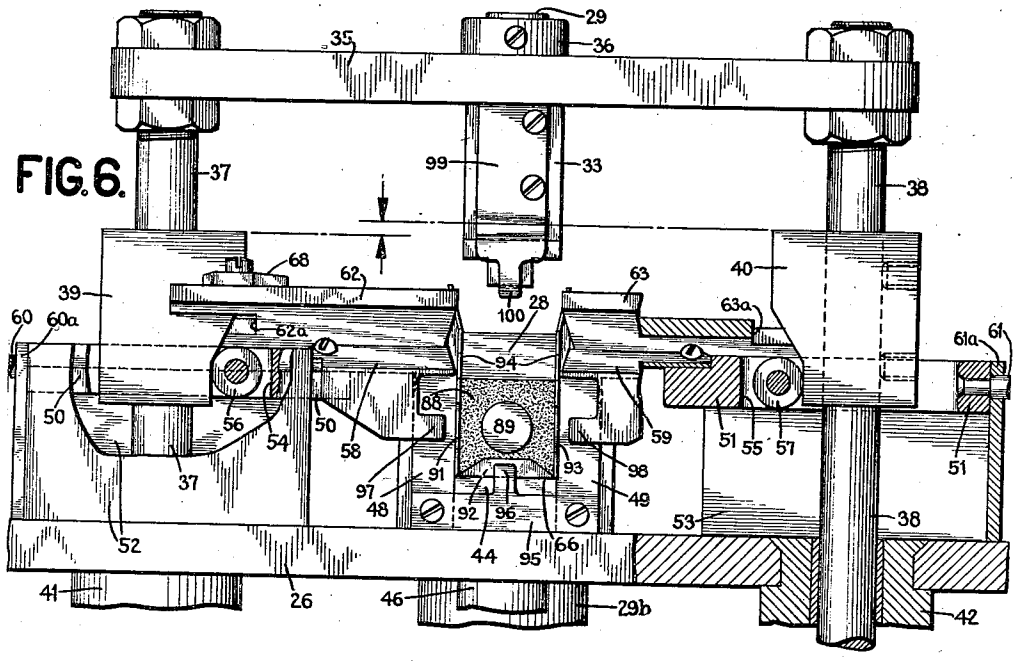
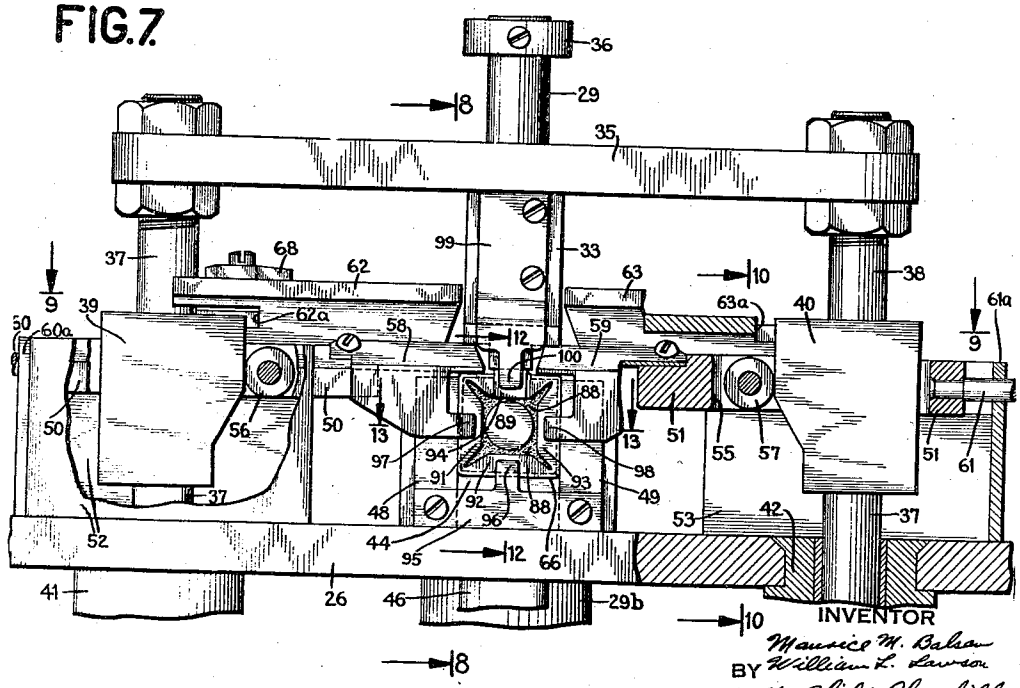


FIG. 7.



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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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FIG. 8.

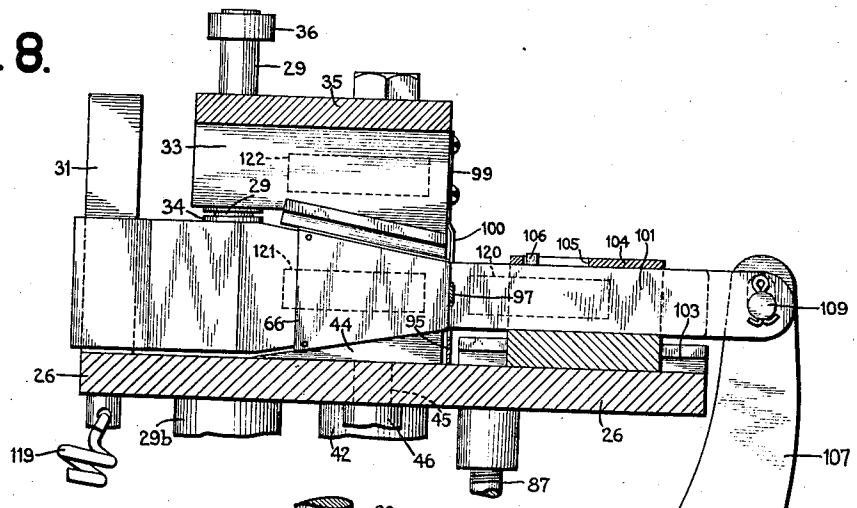


FIG. 10.

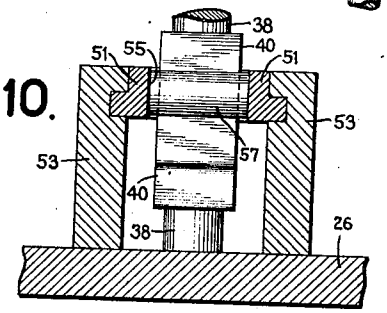
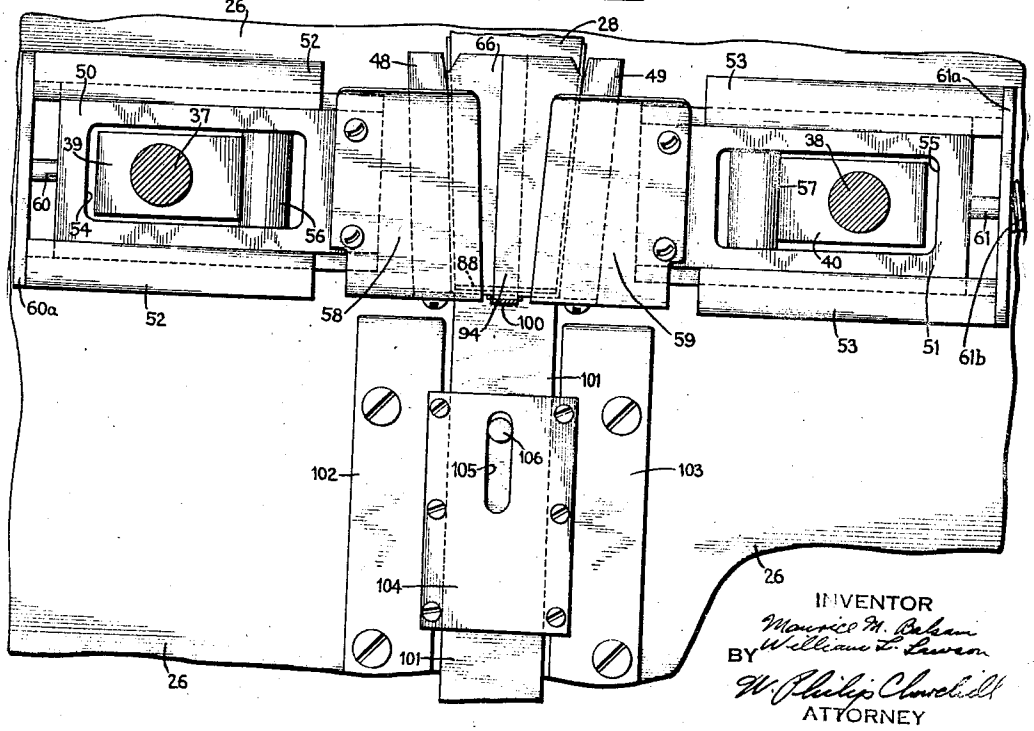


FIG. 9.



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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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FIG. 11.

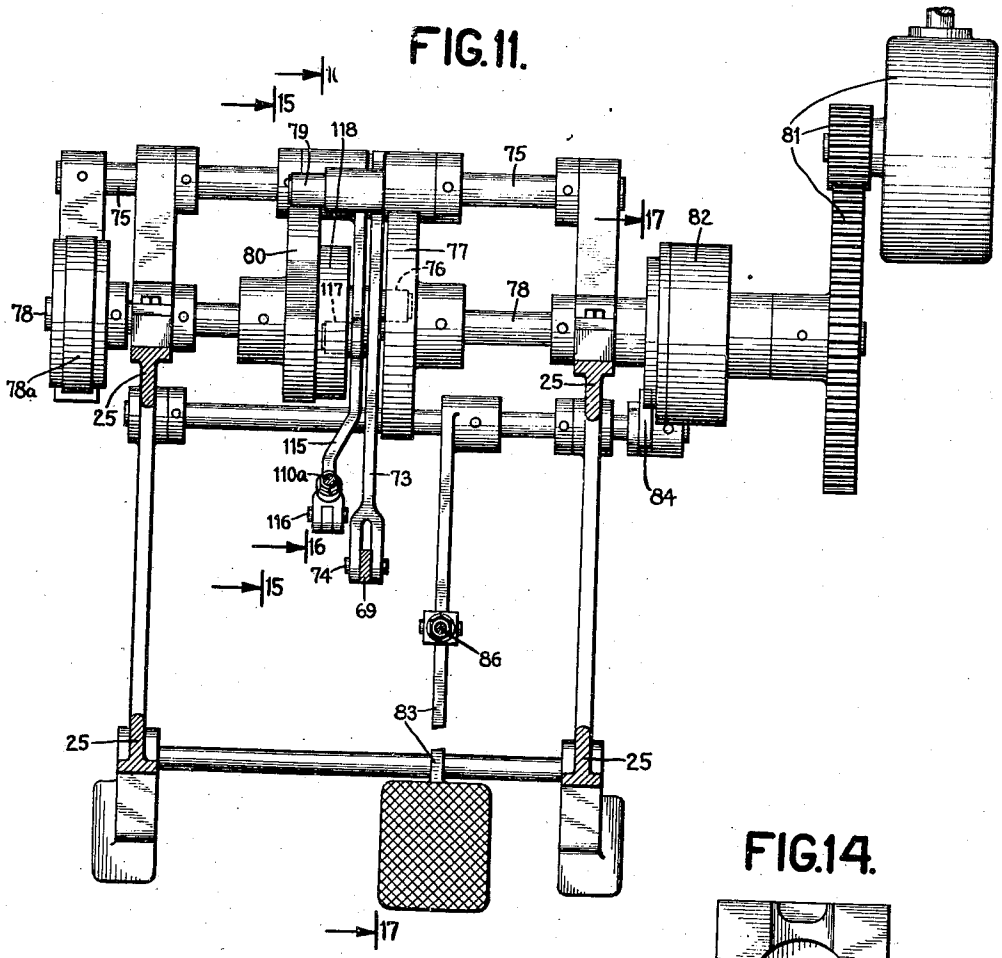


FIG. 12.

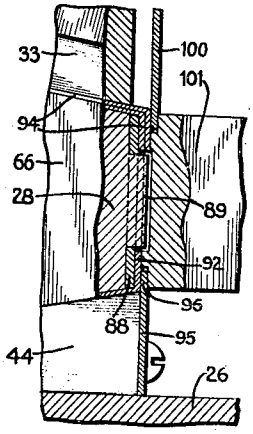


FIG. 13.

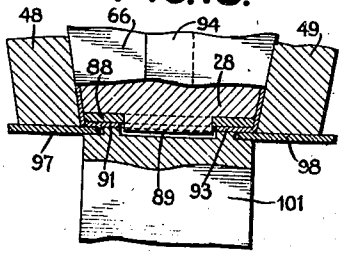
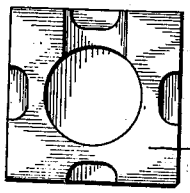


FIG. 14.



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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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FIG. 15.

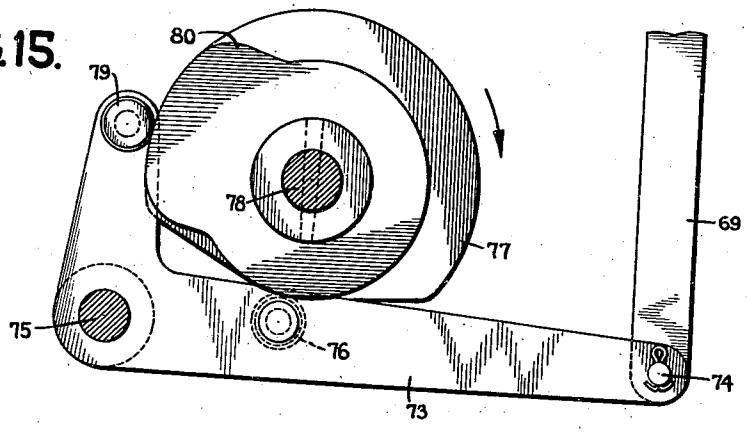


FIG. 16.

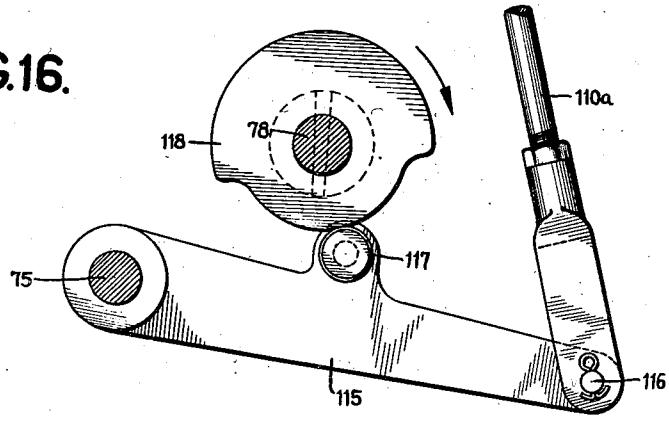
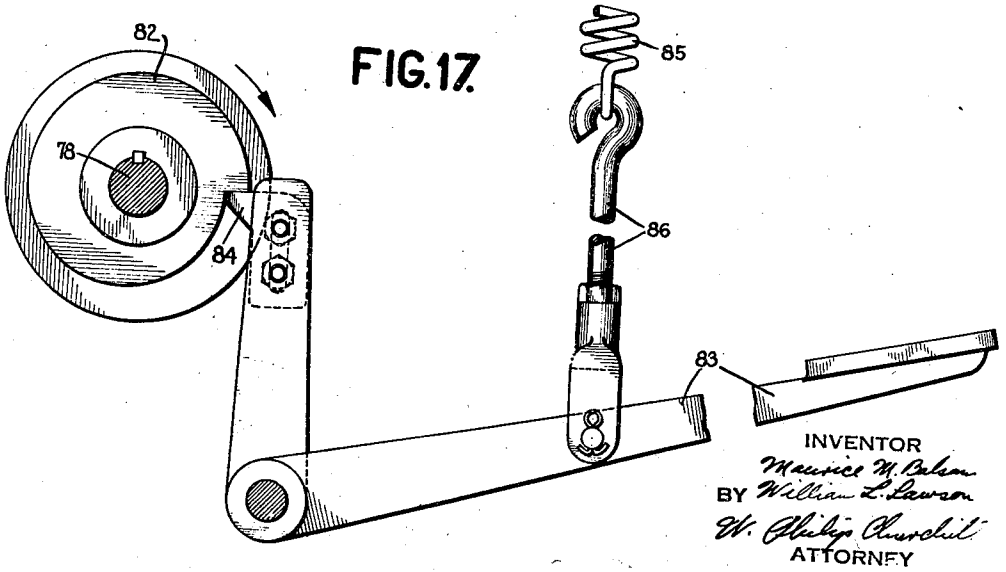


FIG. 17.



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METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

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FIG. 18.

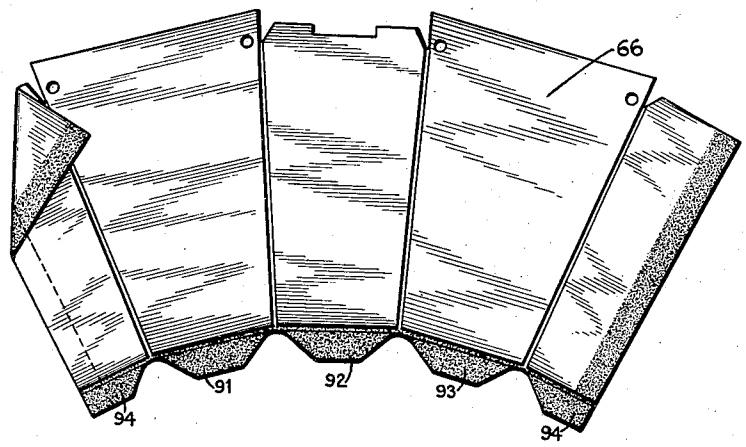


FIG. 20.

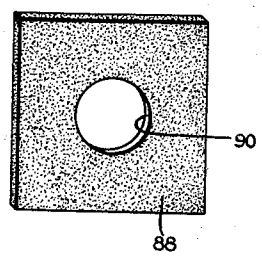


FIG. 19.

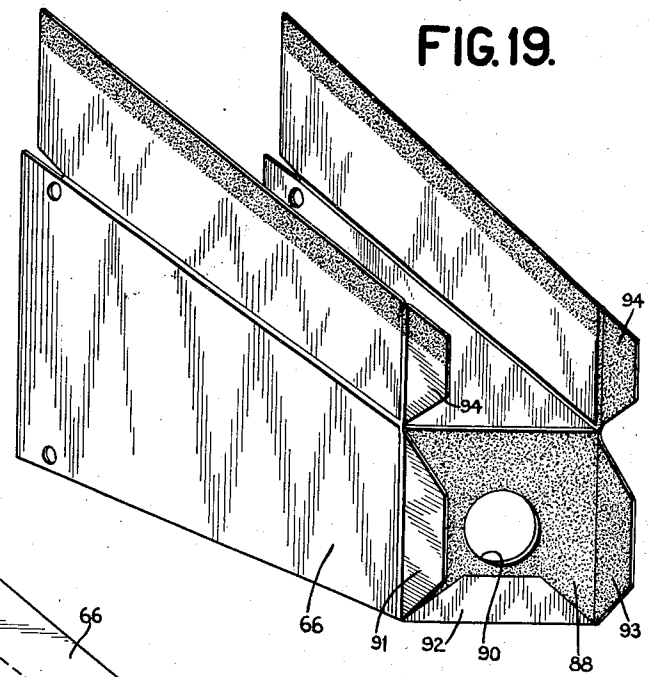
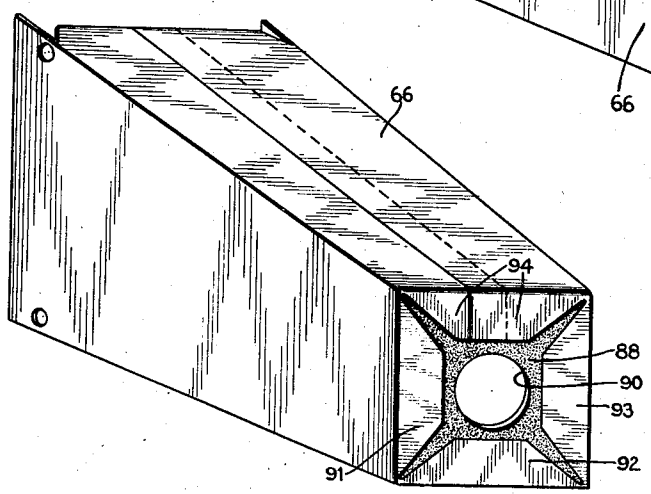


FIG. 21.



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Patented Jan. 11, 1938 2,104,727

UNITED STATES PATENT OFFICE

2,104,727

METHOD OF AND APPARATUS FOR FOLDING SHEET MATERIAL

Maurice M. Balsam and William L. Lawson, New York, N. Y.; said Balsam assignor to said Lawson

Application May 20, 1936, Serial No. 80,682

25 Claims. (Cl. 93—39.1)

This invention relates to an apparatus and a method for folding sheet material and more particularly for performing a plurality of folding operations in rapid sequence.

One object of the invention is to provide an apparatus and method whereby a series of folding and forming actions may be carried out rapidly and precisely. A further object of the invention is to provide apparatus for accomplishing these results, which is simple, compact, easy to operate, and provided with relatively few moving parts.

A further object of the invention is to provide apparatus and method for folding a blank of sheet material into a hollow form suitable for making a bellows. A hollow blank formed in accordance with our invention may be subsequently folded to form a bellows as described in the copending application of Maurice M. Balsam, Serial No. 80,683, filed May 20, 1936.

Further objects and advantages of the invention will be more apparent from the detailed description of the embodiment thereof illustrated in the drawings, in which

Figure 1 is a side elevation of a folding machine embodying the invention.

Figure 2 is a front elevation of this machine.

Figure 3 is a section of one detail thereof, taken on about the line 3—3 of Figure 2.

Figure 4 is a vertical section on an enlarged scale, with parts of the machine shown in side elevation and taken on the line 4—4 of Figure 2.

Figure 5 is a horizontal section illustrating the folding mechanism in plan and taken on the line 5—5 of Figure 2.

Figure 6 is a front elevation partly in section of the operating mechanism in an intermediate position.

Figure 7 is a view similar to Figure 6 with the machine in the extreme position after the folding operation has been completed.

Figure 8 is a vertical cross section of the machine in the lowermost position, taken on the line 8—8 of Figure 7.

Figure 9 is a horizontal sectional view taken on the line 9—9 of Figure 7.

Figure 10 is a vertical section of one detail of the machine taken on the line 10—10 of Figure 7.

Figure 11 is a horizontal section illustrating the operating shafts and cams in plan and taken on the line 11—11 of Figure 1.

Figure 12 is a vertical detailed section of a portion of the folding mechanism taken on the line 12—12 of Figure 7.

Figure 13 is a horizontal detailed section of the same portion of the mechanism taken on the line 13—13 of Figure 7.

Figure 14 is an end elevation of the end die.

Figure 15 is a vertical section illustrating one of the operationg rods and two cams which control the movement of this rod, taken on the line 15—15 of Figure 11.

Figure 16 is a vertical section through the operating shaft illustrating the other operating cam and taken on the line 16—16 of Figure 11.

Figure 17 is a vertical section illustrating the operation of the foot treadle and single revolution clutch and taken on the line 17—17 of Figure 11.

Figure 18 is a plan view of a blank adapted to be folded in the machine.

Figure 19 is a perspective of this blank in a partially folded position.

Figure 20 is a perspective of the plate to be incorporated in the folded hollow blank.

Figure 21 is a perspective of the completely folded hollow blank.

The apparatus illustrated in the drawings is supported in a side frame 25 having a plate 26 attached to its top by suitable means, such as bolts 27. The legs of frame 25 are preferably firmly secured in any suitable manner and serve to support the operating shafts; the operating mechanism for performing the folding operations is mounted on plate 26. This folding and forming mechanism comprises a die member 28, one end of which is shaped like a frustrum of a pyramid. Die member 28, as may be seen in Figure 4, is fixed to a vertically movable rod 29 by suitable means, such as the set screw 30. The rear end of die 28 is arranged to slide between the two vertical guide posts 31 and 32, which are fixed to plate 26. Rod 29 carries at its upper end a die section 33, spaced from the die 28 by means of the spring 34 and having a lower surface adapted to cooperate with the upper surface of the die 28. Countersunk portions 34a in die member 28 and 34b in die section 33 may be provided to allow the die member and die section to be brought into contact with each other upon compression of the spring 34.

A plate 35 is firmly attached to the tops of the rods 37 and 38, and to the top of die section 33, and is limited in its upward movement by the collar 36 on rod 29. Rod 29 is free to slide through the sleeve 29a in plate 35 and die section 33 upon compression of spring 34, and is guided by the sleeve 29b fixed to plate 26 and depending therefrom.

A pair of cam blocks 39 and 40 are fixed to rods

37 and 38, respectively, and these rods are adapted to reciprocate vertically in the bearing sleeves 41 and 42 with their lower ends connected by means of the tie plate 43.

Immediately below the die member 28, a lower die section 44 is mounted having an upper surface complemental to the lower surface of die 28. This lower die section 44 is resiliently supported on the plunger 45 operating in the sleeve 46 which is fixed to plate 26. Plunger 45 is normally held in uppermost position by means of the spring 47 and upward movement is limited by suitable means such as the bolt 45a and nuts 45b. Die 28 is arranged to descend between the stationary side die sections 48 and 49 with a clearance on each side corresponding approximately to the thickness of the material to be treated. A pair of movable slides 50 and 51 are arranged in the guide ways 52, 52 and 53, 53 for inward movement under the action of the cam blocks 39 and 40 toward the die 28. These slides move in a plane about level with the top of the side die sections 48 and 49 and are provided with openings 54 and 55, respectively, to permit free passage of the die blocks 39 and 40 and to provide for rotatably mounting the roller followers 56 and 57 which cooperate with the cam blocks. These slides have a pair of plates 58 and 59 fixed to their forward ends at an angle corresponding to the angle of the upper surface of die member 28. The slides 50 and 51 may be provided with rods 60 and 61 which slide through openings in the plates 60a and 61a. The slides are thus retracted upon upward movement of the cam blocks 39 and 40 by means of the springs 60b and 61b on rods 60 and 61.

A pair of stationary plates 62 and 63 may be mounted on the frame members 64 and 65 fixed to plate 26, at an angle parallel to the lower surface of die member 28 and below the plane of this lower surface when the die member 28 is in its raised position. Suitable guide members 67 and 68 may be attached to these plates for aligning the blank 66 with the die sections before starting the folding operation. The plates 62 and 63 are preferably cut away, as at 62a and 63a, to provide for free movement of cam blocks 39 and 40. The portion of the apparatus described thus far is operated by the vertical reciprocation of the operating rod 69 pivotally attached to the member 70, as by means of pin 71. The upper end of the member 70 projects through the tie plates 43 and carries a spring 72.

The lower end of operating rod 69 is pivotally connected to one arm of a bell crank 73, as by pin 74, and this bell crank 73 is pivotally mounted on the fixed shaft 75. The arm of bell crank 73, to which rod 69 is attached, carries a roller follower 76 intermediate its ends which is adapted to be operated by the cam 77 fixed to shaft 78. The other arm of bell crank 73 carries a roller follower 79 arranged to cooperate with cam 80 which is also fixed to shaft 78 but which is spaced from cam 77. Shaft 78 may be rotated one revolution at a time by suitable means such as the reduction gearing 81 operating through a single revolution clutch 82 of any well known construction. For example, clutch 82 may be engaged to rotate shaft 78 by depressing foot treadle 83 which trips a dog 84 engaging a portion of the clutch. Dog 84 is held against the clutch mechanism by the action of spring 85 which, through rods 86 and 87, serves to return the foot treadle 83 to an elevated position, and thus disengages the clutch 82 after one revolution of shaft 78. Brake 78a serves to aid in stopping rotation of shaft 78 at the end of each revolution. Any other suitable means may be substituted for reciprocating the rod 69.

It may be desirable to incorporate a plate 88 of metal or other material in one end of the final article and for this purpose the end of die member 28 is provided with a protuberance 89 adapted to fit the hole 90 in plate 88. Means may be provided for folding the ends or tabs 91, 92, 93 and the tab 94 of double thickness over against the plate 88 when the latter is placed on the end of die member 28. These means may comprise the fixed plate 95 having an upwardly extending finger 96, the fingers 97 and 98 integral with side plates 58 and 59, respectively, and the plate 99 having a downwardly extending finger 100 and attached to the front end of the upper die section 33.

An end die 101 may be provided for pressing these folded tabs 91, 92, 93, and 94 against plate 88, the end of the die member being recessed as shown in Fig. 14 to allow for the several fingers above-mentioned, and the protuberance 89 on die member 28. A pair of guideways 102 and 103 are fixed to plate 26 and connected at their top portions by plate 104 provided with a slot 105. End die 101 is arranged to reciprocate horizontally between these guides 102 and 103, and is provided with a pin 106 fitting in slot 105 to limit movement of this die member.

A rocker 107 is pivotally mounted on a shaft 108 in frame 25, and one arm of this rocker is pivotally connected to the outer end of die 101 by means of the pin 109. The other end of rocker 107 is preferably pivotally connected to operating rod 110 by a pin 111. With reference more particularly to Fig. 3, it may be seen that the rod 110 is divided into two sections, the lower section 110a extending into the housing 112 which is attached to rod section 110. By the arrangement of spring 113 between one end of housing 112 and the piston shaped end 114 of rod 110a, an operating rod is provided which has a small degree of extensibility under tension to allow for different thicknesses of material being treated. The lower end of rod section 110a is pivotally connected to an arm 115 by a pin 116, and the other end of this arm is pivotally mounted on shaft 75. Intermediate its ends, the arm 115 carries a roller follower 117 which is held against cam 118 fixed to shaft 78 by the action of spring 119 connected to plate 26 and rocker 107.

The blank 66 to be folded by this apparatus may be flat and of a shape adapted to be folded into the form of a truncated pyramid (Fig. 18). The end edges of the blank are long enough to overlap each other and adhesive may be applied to one or both of the overlapping edges before folding, as illustrated in Figs. 18 and 19. A suitable adhesive may also be applied to the end tabs 91, 92, 93, and 94 and/or one side of the plate 88.

To operate the apparatus according to the preferred embodiment of the invention, a plate 88 is fitted to the die member 28 with the plate opening 90 over the protuberance 89, and with the adhesive side of the plate, if adhesive is used, facing outwardly. A flat blank 66 is then laid on the stationary plates 62 and 63 with suitable notches in the blank registered with the fixed guides 67, 67. The foot treadle 83 is then depressed and released to engage the clutch and start rotation of shaft 78 and the three cams 77, 80, and 118.

Cam 77 operates first to depress the longer arm

of bell crank 73 which moves the operating rod 69 downwardly. As rod 69 is moved downwardly, tie plate 43 and rods 37 and 38 are pulled down. Plate 35, which is attached to the top of these posts, likewise moves downwardly, pressing die section 33 down, which in turn moves die 28 down by the action of spring 34. The lower portion of die 28 pushes a section of the blank 66 down between the fixed plates 62 and 63 and the fixed die sections 48 and 49, and the remaining portions of blank 66 are thus folded up to a vertical position adjacent the sides of die 28; this position of the partially folded blank is illustrated in Fig. 19. A short downward movement of die 28 brings the central section of the blank firmly against the lower die section 44, which is also carried downwardly, holding this portion of the blank in place. Upon continued downward movement of the die 28, it is brought to a position in which its upper surface is immediately below the level of the side plates 58 and 59 fixed to slides 50 and 51. The lower tab 92 by this time has been folded upwardly about the end of die 28 by the fixed finger 96 of plate 95. Cam blocks 39 and 40 have moved downwardly a similar distance and now begin to actuate the slides 50 and 51 through contact with rollers 56 and 57. Cam block 39 is preferably arranged slightly in advance of block 49 in order to move plate 58 inwardly ahead of plate 59. As these plates move in toward the die 28, they fold over the upstanding edges of the blank 66, and by reason of the staggered relationship of the cam blocks 39 and 40, these edges are folded over in overlapping relationship. Fingers 97 and 98, integral with folding plates 58 and 59, fold the end tabs 91 and 93 of the blank inwardly, simultaneously with the folding action of plates 58 and 59. The lower die section 44 and die 28 have now reached their lowermost positions and further downward movement of rod 69 moves the upper die section 33 down against the action of spring 34 to press the overlapped edges of the blank firmly together. Die section 33 is provided with a lower surface of just sufficient width to fit between the plates 58 and 59 in the position illustrated in Fig. 9. Finger 100 fixed to the upper die section 33 folds the end tab 94 down as the die section 33 moves downwardly. In this position the die section 33 exerts considerable pressure on the blank, depending on the strength of spring 72, and firmly secures the overlapping edges together. Spring 72 allows some flexibility in this movement of the die members necessary to obtain this pressure in order to allow for varying thicknesses of material.

In this position of the folding mechanism, cam 118 becomes effective to depress arm 115 and rod sections 110 and 110*a*. This movement of rod section 110 rocks the rocker 107 and moves the end die 101 inwardly until it presses firmly against the tabs 91, 92, 93, and 94 securing them adhesively to the plate 88.

Continued rotation of shaft 78 releases rod 110 which is returned to its original position by the action of spring 119, thus retracting the end die 101. The final portion of this single revolution of shaft 78 renders the cam 80 effective to move the shorter arm of bell crank 73 to the left (Fig. 15) thus positively lifting operating rod 69. The raising of rod 69 allows the die sections 33 and 44, and folding plates 62 and 63 to be restored to their original positions by the action of their respective springs 34, 47, 60*b* and 61*b*. Die member 28 is positively restored to its original position by the action of plate 35 on collar 36 attached to rod 29.

The completely folded article may be now removed by simply pulling it off the die member 28. Apparatus of the character described may be readily employed for folding and/or forming flat blanks into various other hollow shapes than that specifically described and illustrated. The apparatus of our invention is particularly adapted to the use of some material, such as a thermo-plastic resin, as an adhesive. When employing such an adhesive, die section 33 and end die 101 are preferably provided with internal heating means such as electrical resistances 120 and 122 illustrated diagrammatically in dotted lines (Figs. 4 and 8). If desired, the die member 28 may also be heated by the unit 121.

Cams 77, 80, and 118 may be suitably designed to press the adhesively coated portions of the blank for the requisite time to secure a good bond, depending on the temperature of the dies and the character of the adhesive employed. With a given thermo-plastic adhesive, a longer time is generally necessary with lower temperatures within temperature limits such as would normally be employed, e. g., in the neighborhood of 200° F.

If a non-thermo-plastic adhesive is employed, heating of the dies will, of course, not be necessary nor will it be necessary to employ the timing arrangement of cam operating means; the apparatus may simply be operated by a foot treadle in any suitable manner. Various modifications of the embodiment described may be made within the scope of our invention as will be apparent to those skilled in the art. If it is not desired to fold the end tabs of the blank inwardly, the several fingers for performing these operations may be readily omitted. The die 28 may be of any suitable shape, even cylindrical or conical, and the blank may be provided with end tabs of other shapes arranged to be folded and secured together in overlapping position to form a hollow article open only at one end. Although the die members 48 and 49 have been described as stationary or fixed, they may be resiliently mounted to provide for folding sheet material of varying thickness without binding. The terms "fixed members" and "fixed die members" used in the claims are intended to include members which are capable of such movement, although relatively fixed with respect to the movement of the main die.

The terms and expressions which we have employed are used as terms of description and not of limitation, and we have no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but recognize that various modifications are possible within the scope of the invention claimed.

We claim:

1. Apparatus for folding a blank of sheet material into a hollow shape comprising means for clamping an intermediate section of said blank and simultaneously folding the side sections thereof with respect to said intermediate section, means for folding portions of said side sections and restraining movement of the remaining portions of said side sections, and means for synchronously operating said means.

2. Apparatus for folding a blank of sheet material into a hollow shape comprising means for clamping an intermediate section of said blank and folding the side sections thereof with respect to said intermediate section, means for folding

portions of said side sections into an overlapping position while restraining movement of the remaining portions of said side sections, and reciprocating means for synchronously operating said means by a single stroke.

3. Apparatus for folding a blank of sheet material into a hollow shape comprising means for clamping an intermediate section of said blank and folding the side sections thereof with respect to said intermediate section, means for folding portions of said side sections and restraining movement of the remaining portions of said side sections, means for pressing said overlapped portions together, and means for synchronously operating said means, said first named means being actuated by movement of said pressing means.

4. Apparatus for folding a blank of sheet material into a hollow shape comprising means for clamping an intermediate section of said blank and folding the side sections thereof with respect to said intermediate section, means for folding portions of said side sections and restraining movement of the remaining portions of said side sections, and a single reciprocating rod for actuating said means in synchronism.

5. Apparatus for folding a sheet of material comprising means for simultaneously clamping, moving an intermediate section of said sheet and folding side sections of the sheet with respect to said intermediate section, and means for subsequently folding the end portions of said side sections inwardly toward each other.

6. Apparatus for forming a sheet of material comprising a die, a pair of fixed members, means for moving said die to press an intermediate section of said sheet into the opening between said fixed members thus folding side sections of said sheet about said die, and means for folding free portions of said side sections about said die while the remaining portions of said side sections are held by said fixed members to form said sheet into a hollow blank.

7. Apparatus for forming a sheet of material comprising a die, a pair of fixed members, means for moving said die to press an intermediate section of said sheet into the opening between said fixed members thus folding side sections of said sheet about said die, means for folding free portions of said side sections about said die and into overlapping relationship while the remaining portions of said side sections are held by said fixed members, and means for securing said overlapped portions together.

8. Apparatus for forming a sheet of material comprising a die, a pair of fixed die members spaced from each other, reciprocating means for moving said die into the space between said members to fold said sheet, and a pair of plate-like members for subsequently folding the free ends of said sheet about said die, said reciprocating means also actuating said plate-like members.

9. Apparatus for forming a sheet of material comprising a die, a pair of fixed die members spaced from each other, reciprocating means for moving said die into the space between said members to fold said sheet, a pair of plate-like members for subsequently folding the free ends of said sheet about said die, and means for securing said folded ends together, said reciprocating means also actuating said plate-like members and said securing means.

10. Apparatus for forming a sheet of material comprising a die, a pair of fixed die members spaced from each other, reciprocating means for moving said die into the space between said members to fold said sheet, and a pair of plate-like members for subsequently folding the free ends of said sheet about said die, said plate-like members being arranged to fold one of the free ends before folding the other of said ends and being actuated by said reciprocating means.

11. Apparatus for forming a sheet of material comprising a die, a pair of fixed die members spaced from each other, means for moving said die into the space between said members to fold said sheet, a pair of plate-like members for subsequently folding the free ends of said sheet about said die, said plate-like members being arranged to fold one of the free ends before folding the other of said ends, a movable die section for securing said folded ends together, and spring means between said die and movable die section for normally maintaining said die and die section spaced from each other.

12. Apparatus as defined in claim 7 in which the overlapped portions are pressed together by heated die means.

13. Apparatus for folding a blank of sheet material into a hollow shape comprising means for clamping an intermediate section of said blank and simultaneously folding the side sections thereof with respect to said intermediate section, means for folding portions of said side sections and restraining movement of the remaining portions of said side sections, and means cooperating with said aforementioned means for folding the ends of said intermediate and side sections inwardly toward each other.

14. Apparatus for forming a sheet of material comprising a die, a pair of fixed members, means for moving said die to press an intermediate section of said sheet into the opening between said fixed members thus folding side sections of said sheet about said die, means for simultaneously folding an end portion of said intermediate section against one end of said die, means for folding free portions of said side sections about said die and simultaneously folding end portions of the remainder of said side sections about the end of said die, and means for securing said free portions together.

15. Apparatus for forming a sheet of material comprising a die, a pair of fixed members, means for moving said die to press an intermediate section of said sheet into the opening between said fixed members thus folding side sections of said sheet about said die, means for simultaneously folding an end portion of said intermediate section against one end of said die, means for folding free portions of said side sections about said die and simultaneously folding end portions of the remainder of said side sections about the end of said die, means for securing said free portions together, and means securing the several end portions together.

16. Apparatus as defined in claim 15 in which said free portions and end portions are secured together by heated die means.

17. Apparatus as defined in claim 15 in which said free portions and end portions are secured together by die means provided with adjustable heating means and including means for pressing said die means against said blank for a predetermined period of time adjusted according to the temperature of said heating means.

18. The method of folding a blank of sheet material about a die comprising simultaneously clamping an intermediate section and folding side sections of said sheet with respect to said inter-

mediate section, folding the free portions of said side sections toward each other about the die and in overlapping position while restraining the remainder of said side sections from movement, and securing said overlapped portions together.

19. The method of folding a flat blank of sheet material into a hollow shape comprising applying thermo-plastic resin to an edge of said blank, folding side sections of said blank with respect to an intermediate section thereof, restraining portions of said side sections against movement while folding the free portions thereof inwardly into overlapping position with the resin therebetween, and heating and pressing said overlapped portions to secure a bonding action with said resin.

20. The method of folding a blank of sheet material about a die comprising folding side sections of said sheet with respect to an intermediate section thereof, folding an end of said intermediate section about one end of the die, folding free portions of said side sections inwardly into overlapping relation and simultaneously folding ends of the remainder of said side sections inwardly about the end of said die, securing said overlapped portions together, folding an end of said overlapped portions about the end of the die, and securing said ends together.

21. Apparatus for folding a sheet of material comprising a movable die, means for folding a blank of sheet material about said die as the die is moved, and means for securing the free edges of the folded blank together, said die being moved by a resilient connection to said securing means.

22. Apparatus for folding a sheet of material comprising a die about which said sheet is to be folded, side members for folding side sections of the sheet with respect to an intermediate section thereof, means for simultaneously folding an end of said intermediate section about the die, means for folding free portions of said side sections and for simultaneously folding end portions of the remainder of said side sections about the die, and means for securing said free portions together.

23. The method of folding a blank about a die comprising folding side sections with respect to an intermediate section thereof, folding free portions of said side sections together, and folding and securing the ends of said side and intermediate sections to a stiffening member associated with said die.

24. Apparatus as defined in claim 15 in which said free portions and end portions are secured together by heated die means and including means for pressing said heated die means against said portions for a predetermined period of time and under a predetermined pressure adjusted in accordance with the temperature of said die means.

25. A method as defined in claim 18 in which the overlapped portions are secured together with a thermo-plastic adhesive by heating and pressing the portions together under a predetermined pressure and for a predetermined period of time adjusted in accordance with the temperature to which said portions are heated.

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