April 27, 1965 J. W. RYAN ETAL 3,179,980

TOY FORMING APPARATUS

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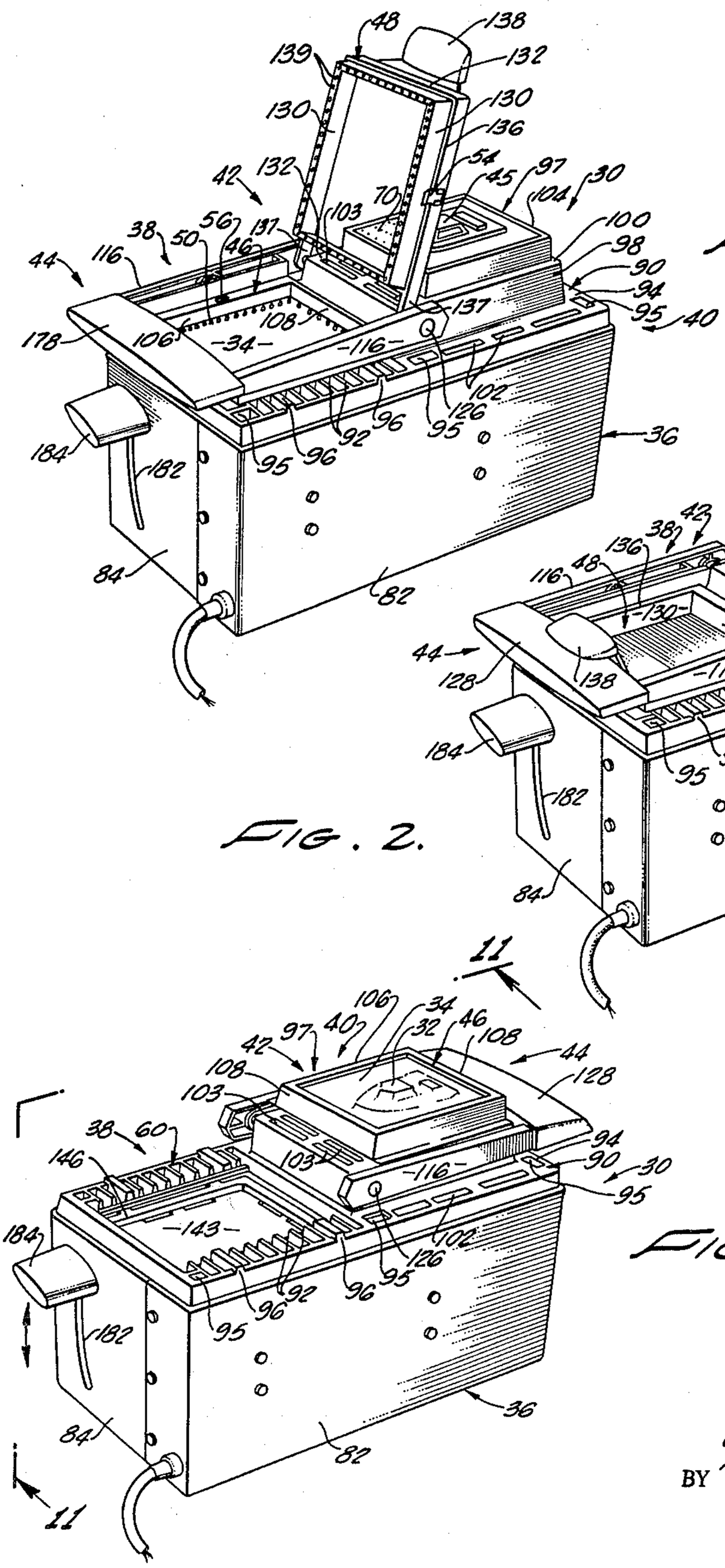

FIG. 1.

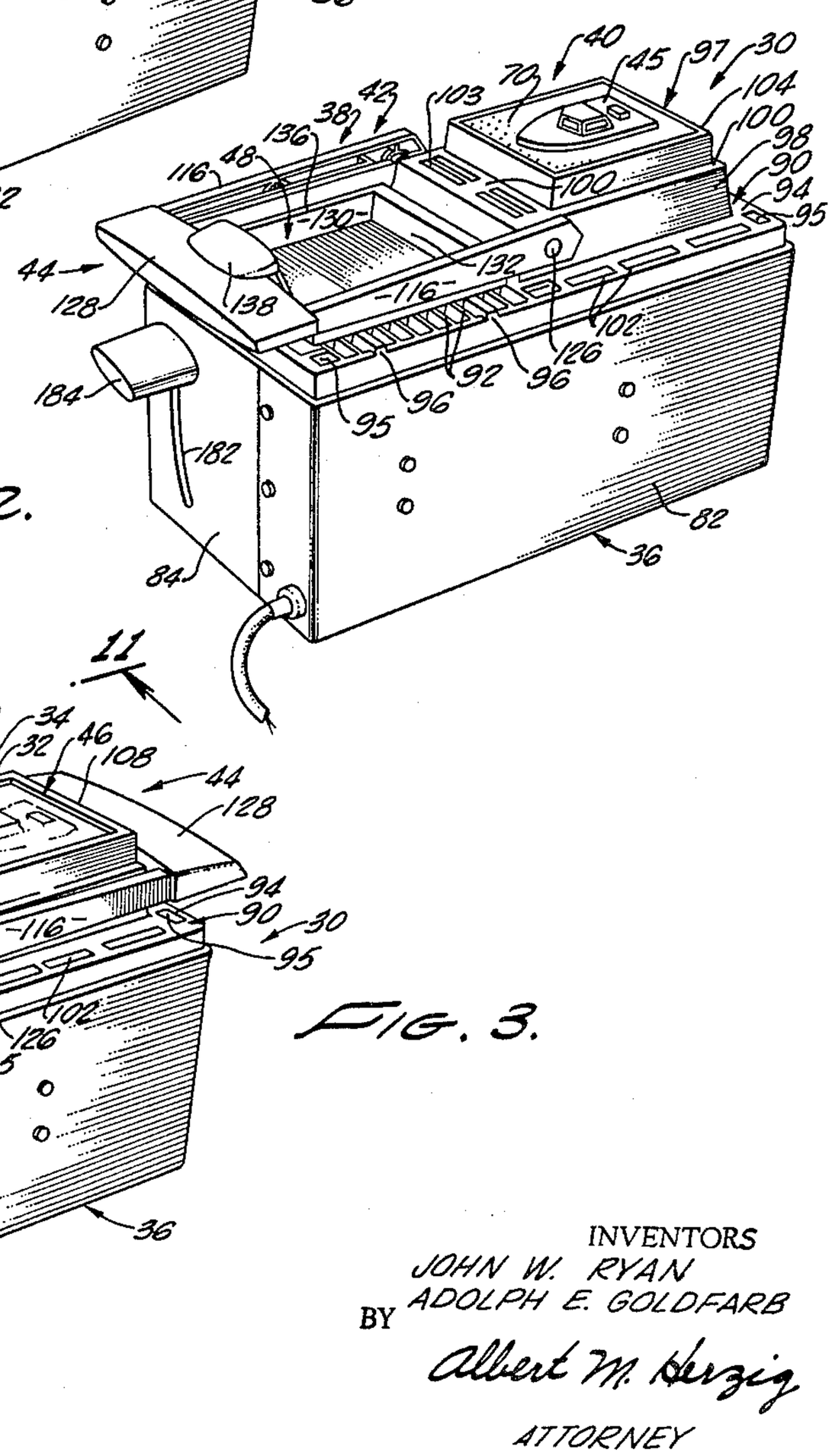

FIG. 2.

FIG. 3.

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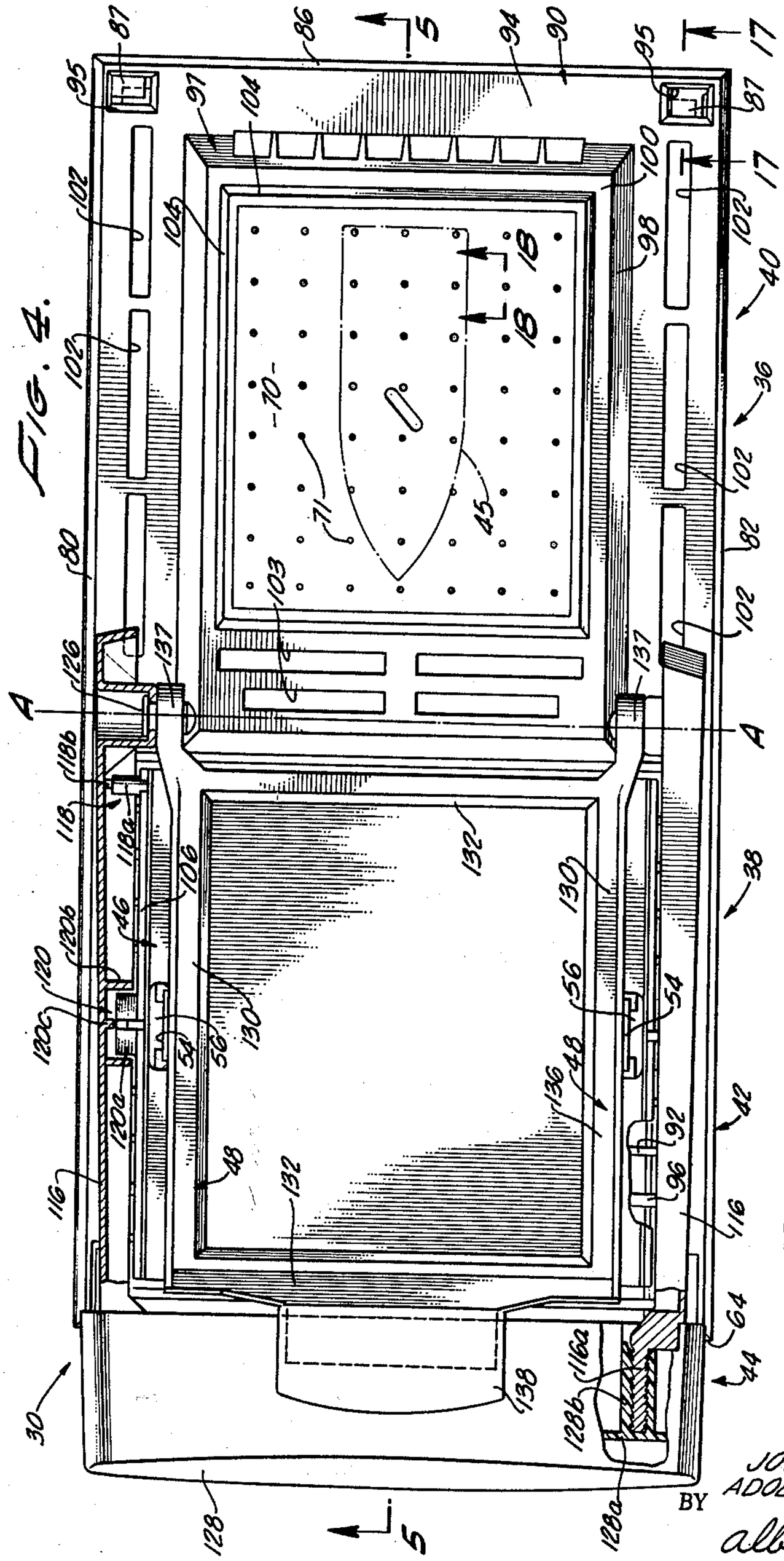

FIG. 4.

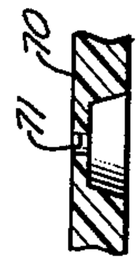

FIG. 18.

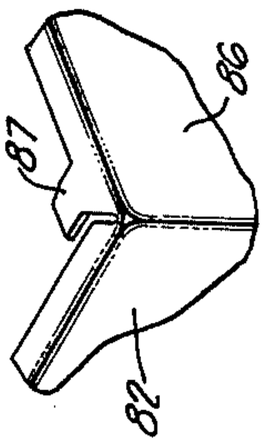

FIG. 19.

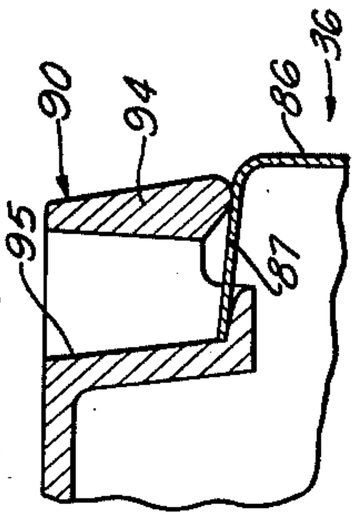

FIG. 17.

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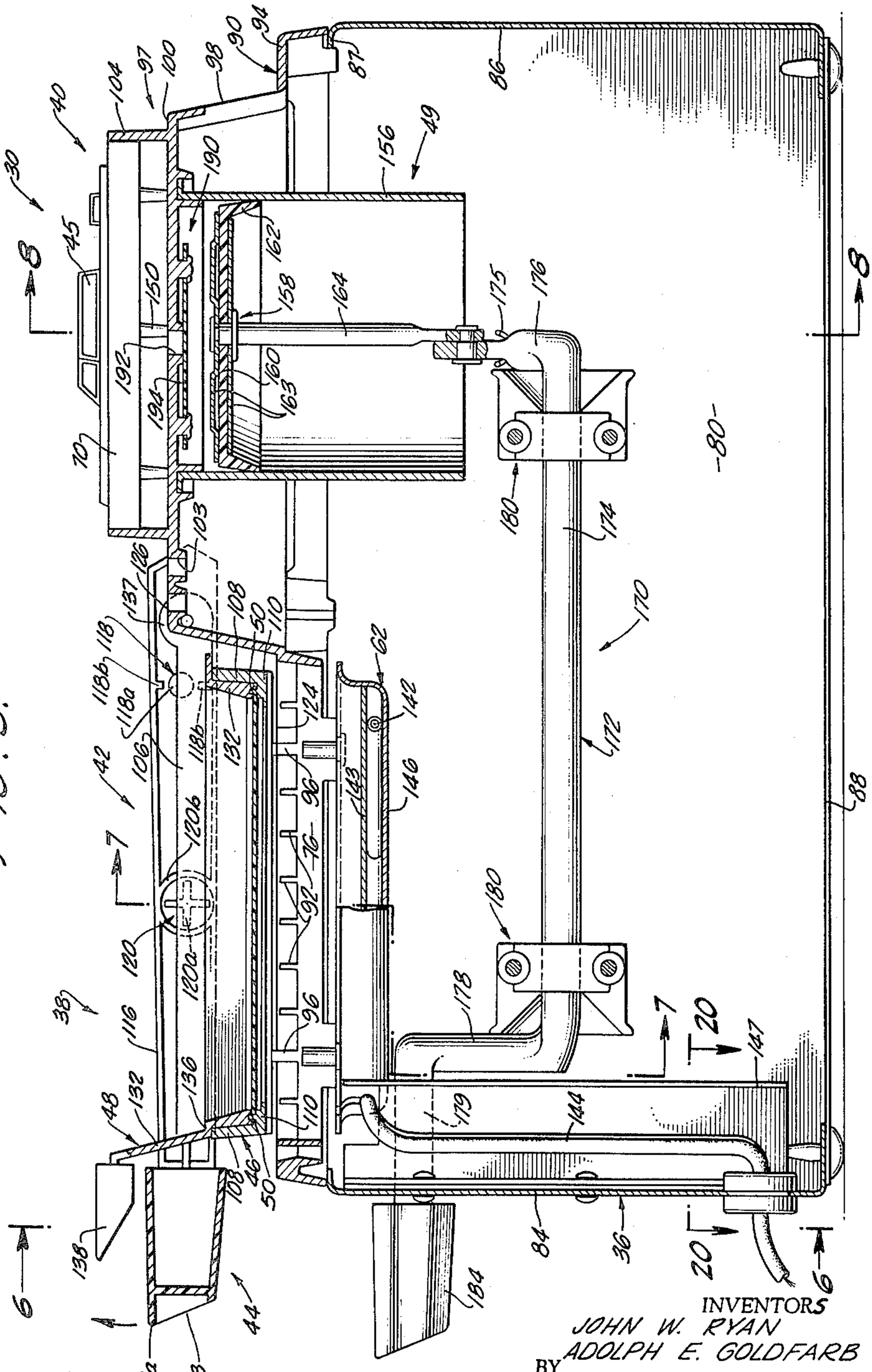

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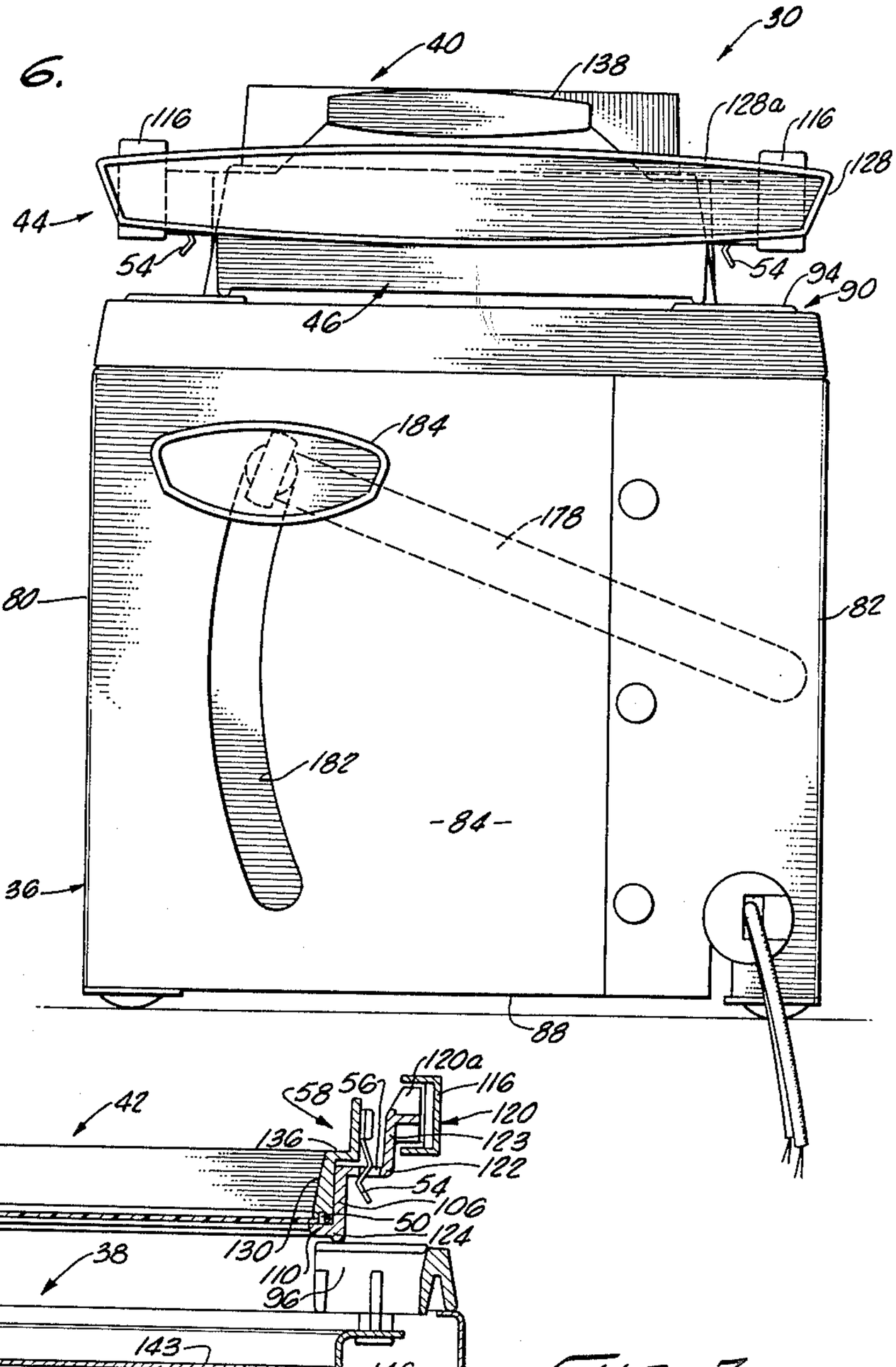
FIG. 6.



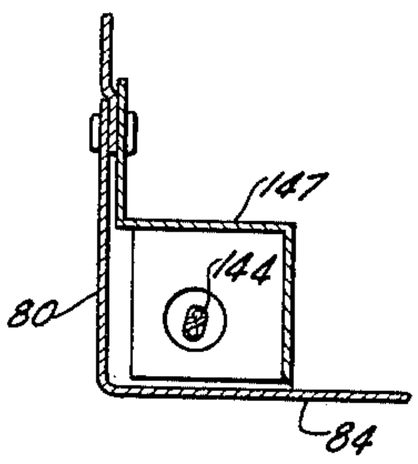


FIG. 20.

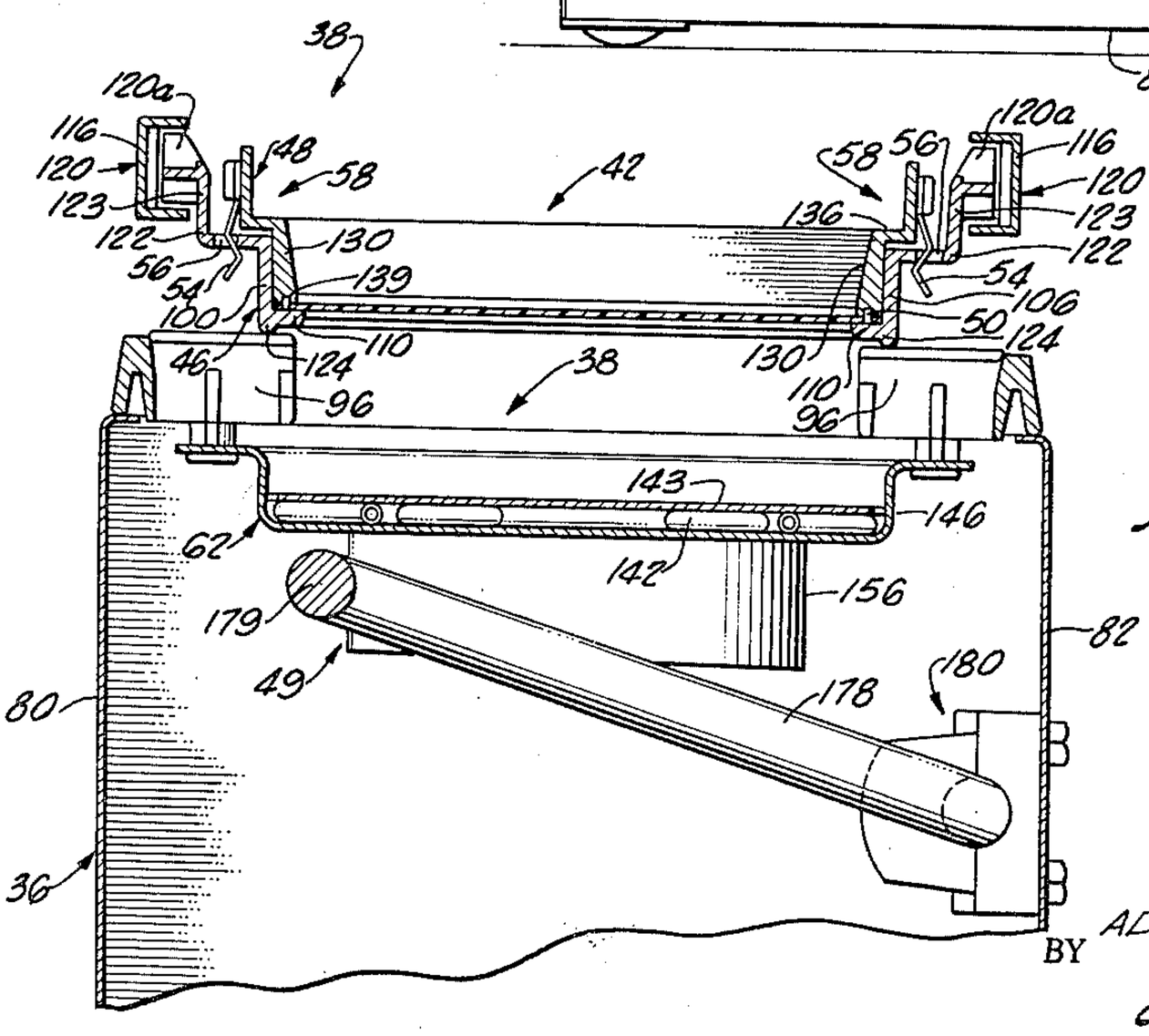


FIG. 7.

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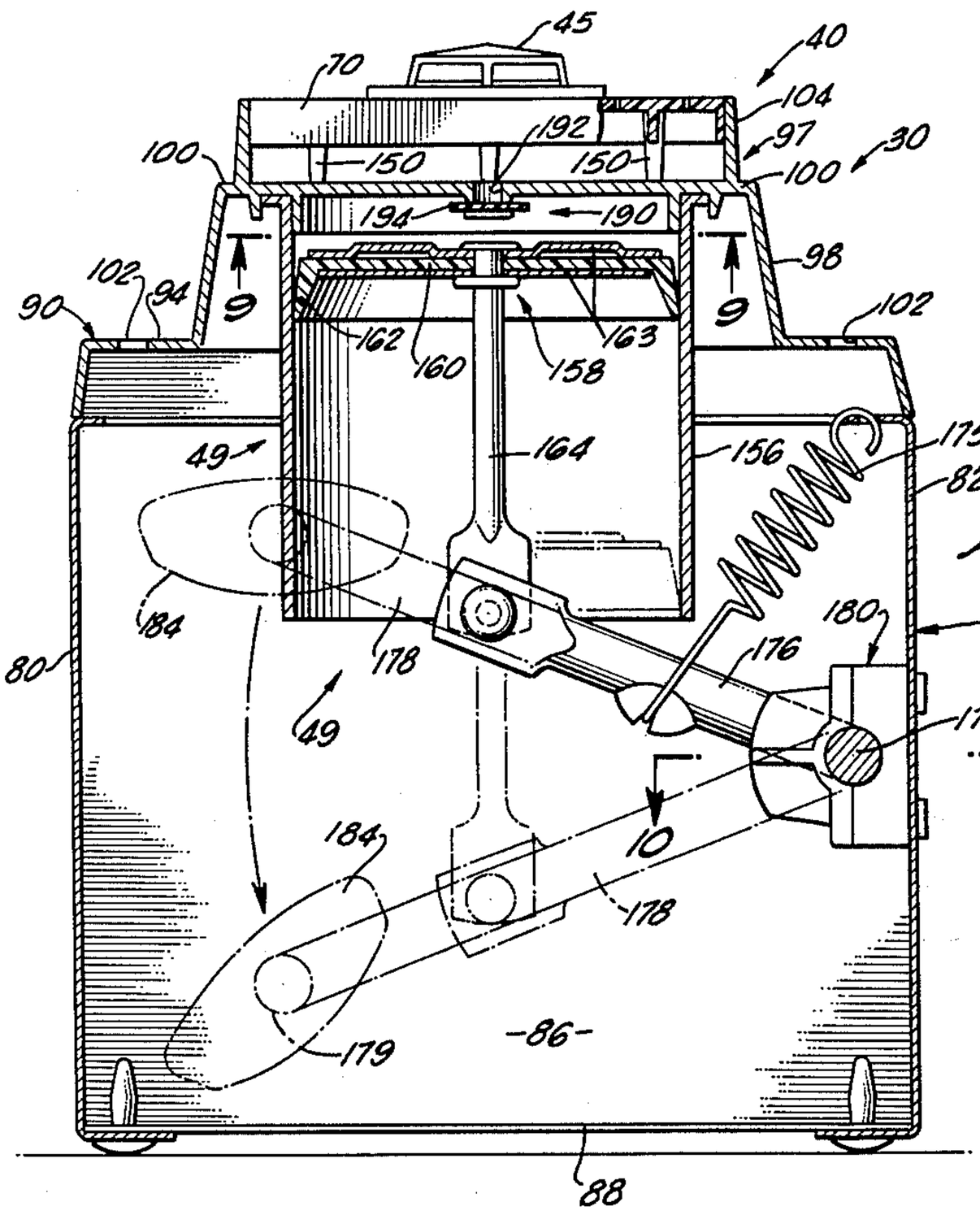
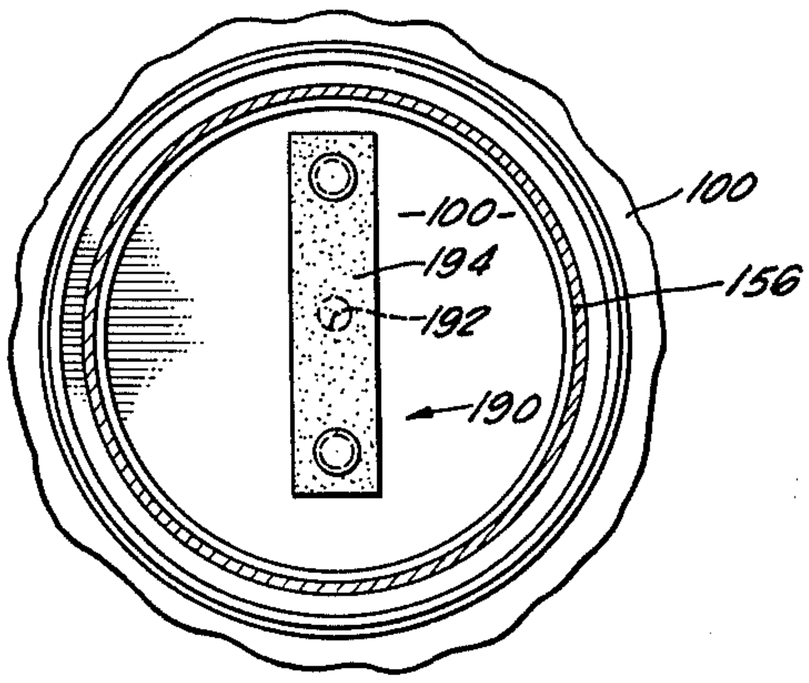


FIG. 8.

FIG. 9.



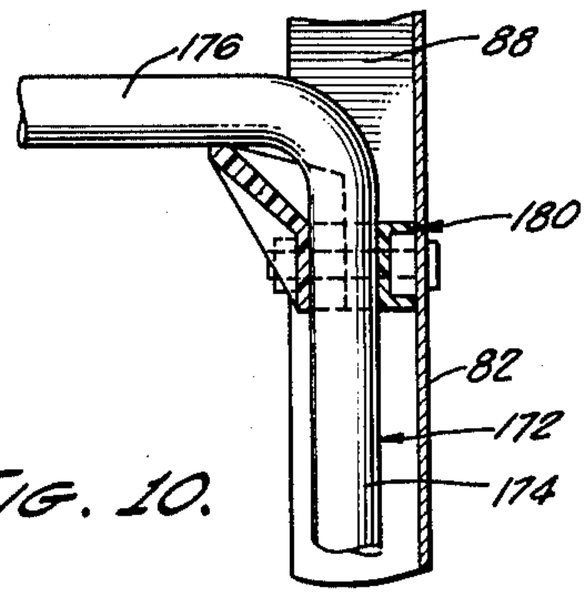


FIG. 10.

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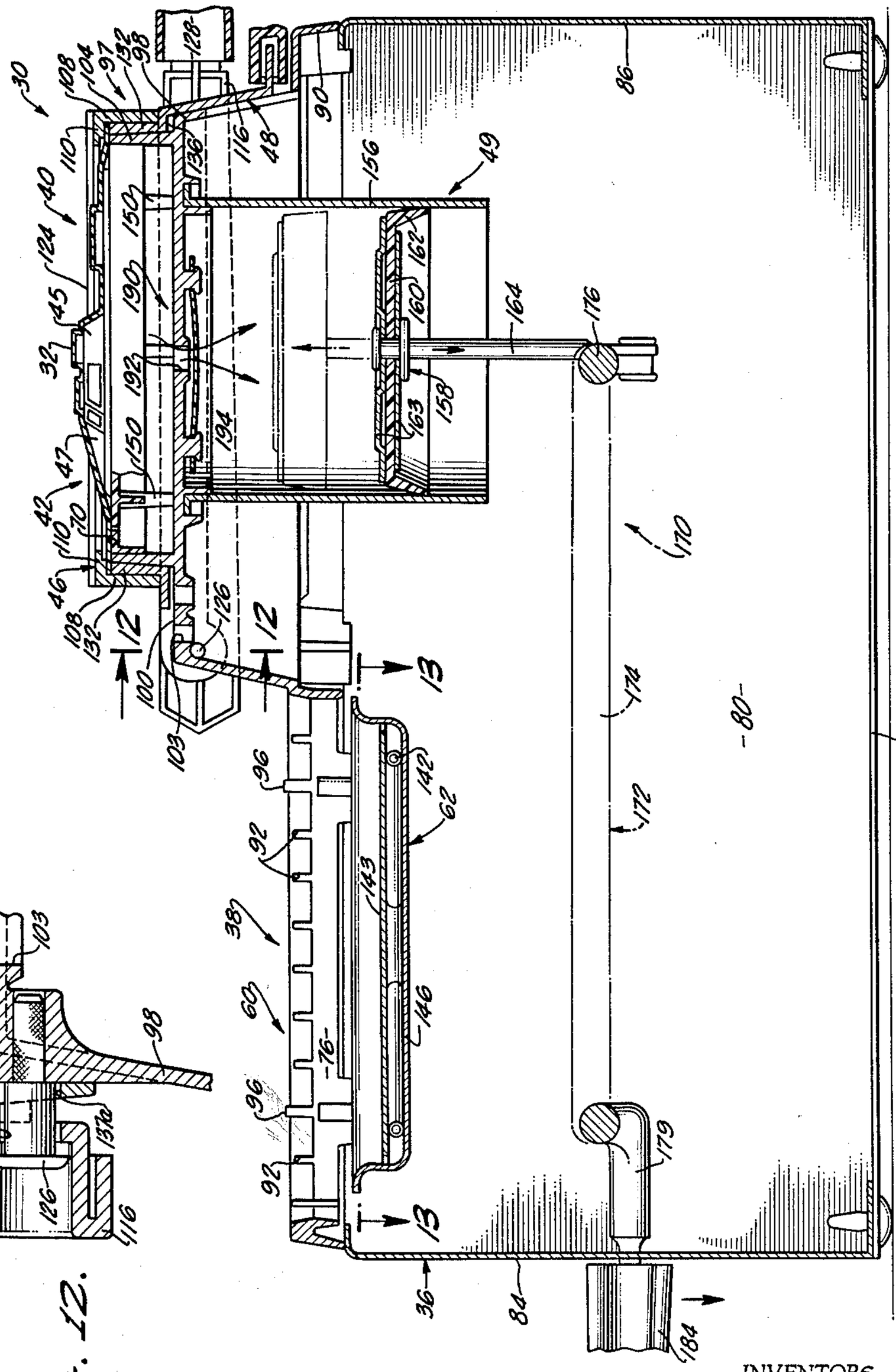

FIG. 11.

FIG. 12.

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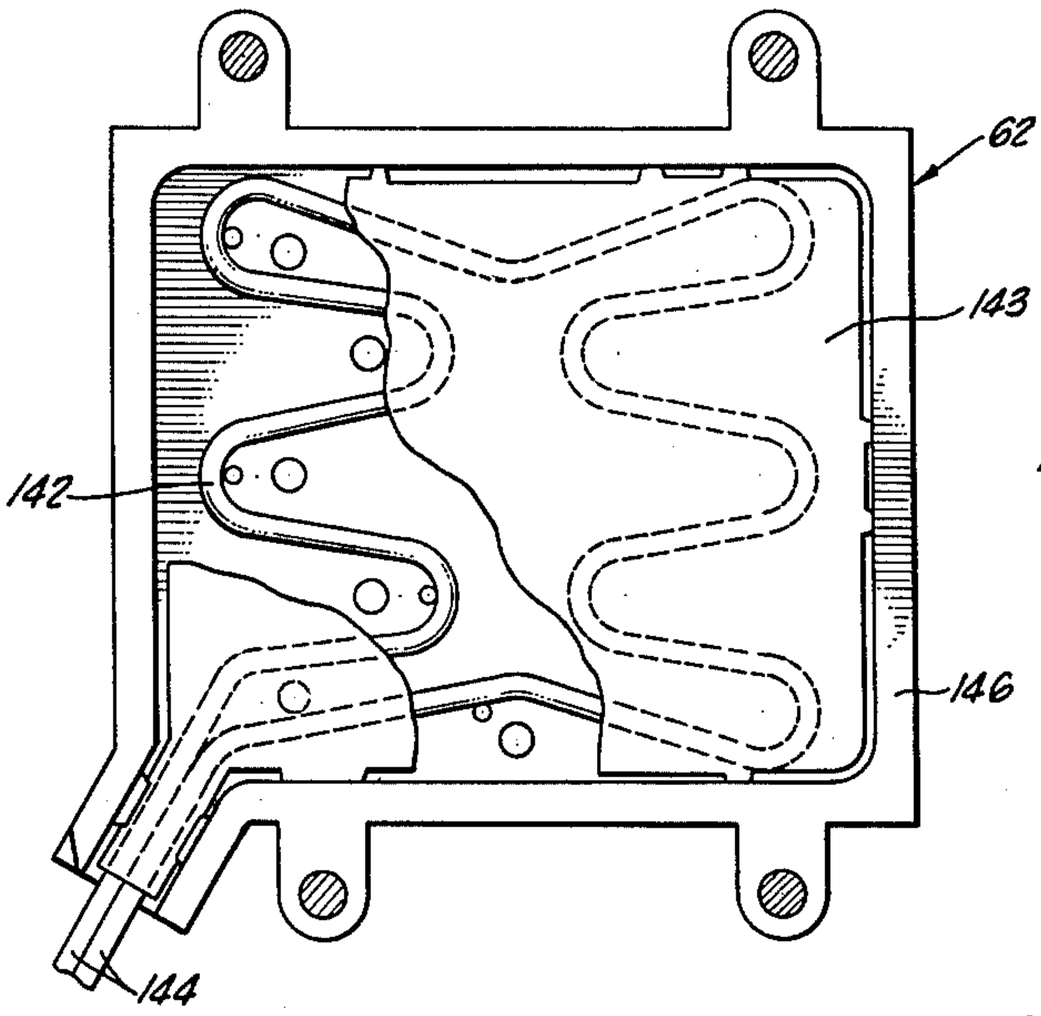


FIG. 13.

FIG. 15.

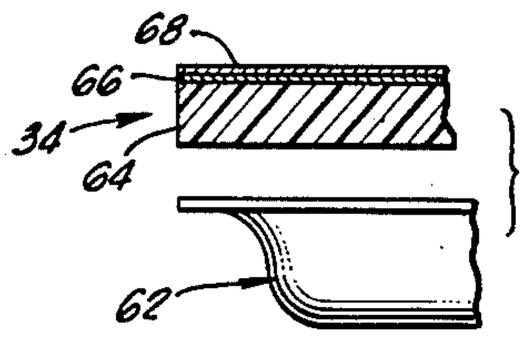
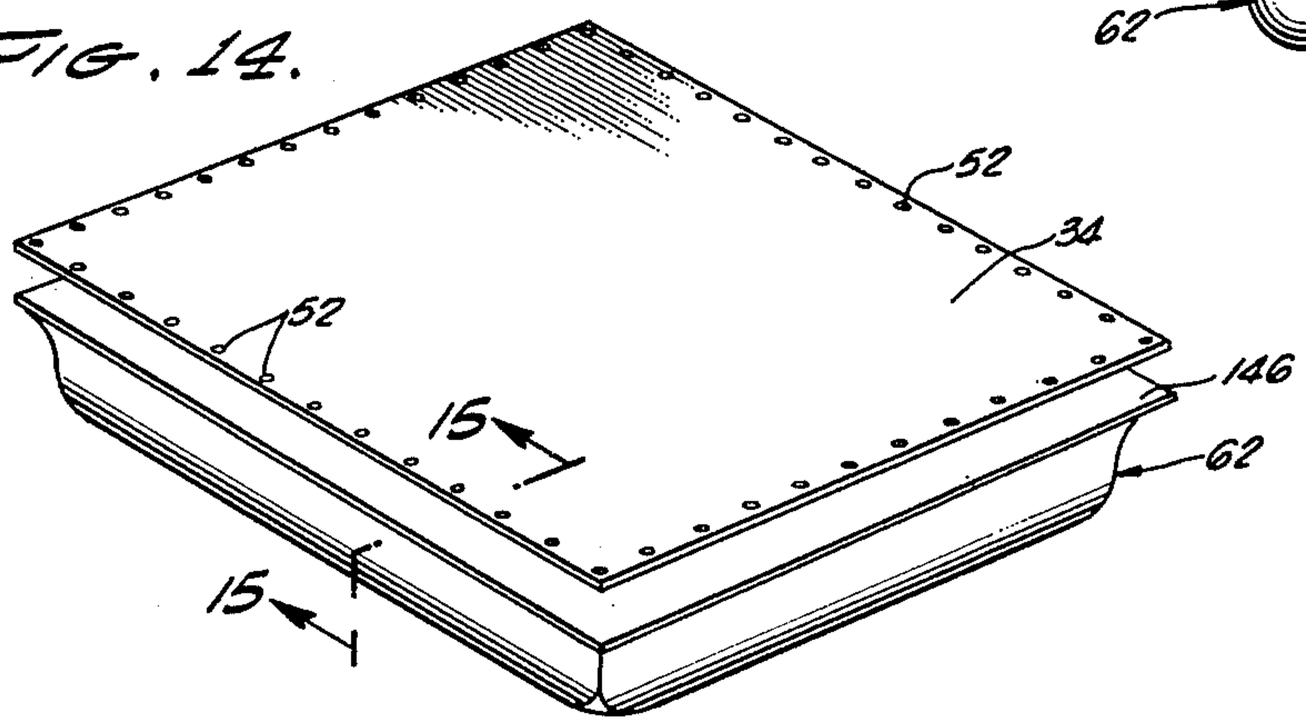


FIG. 14.



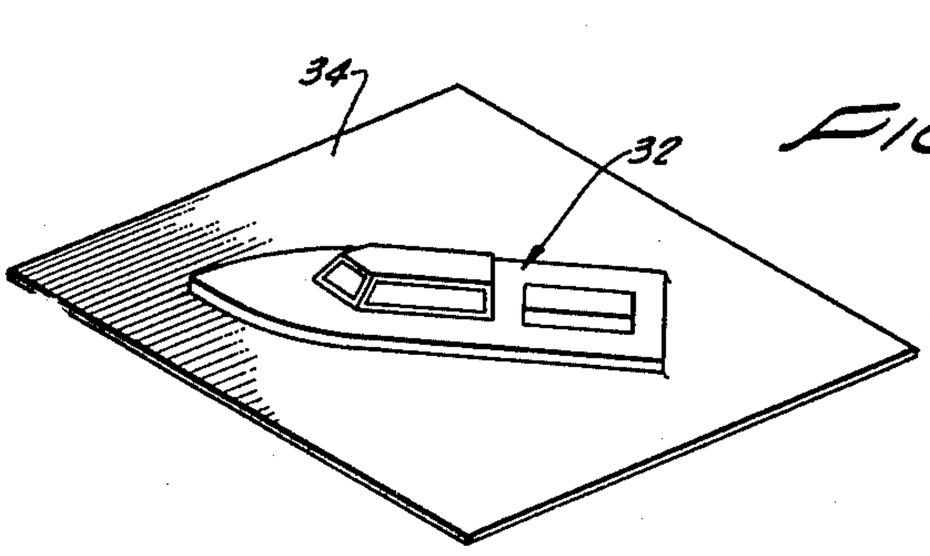


FIG. 16.

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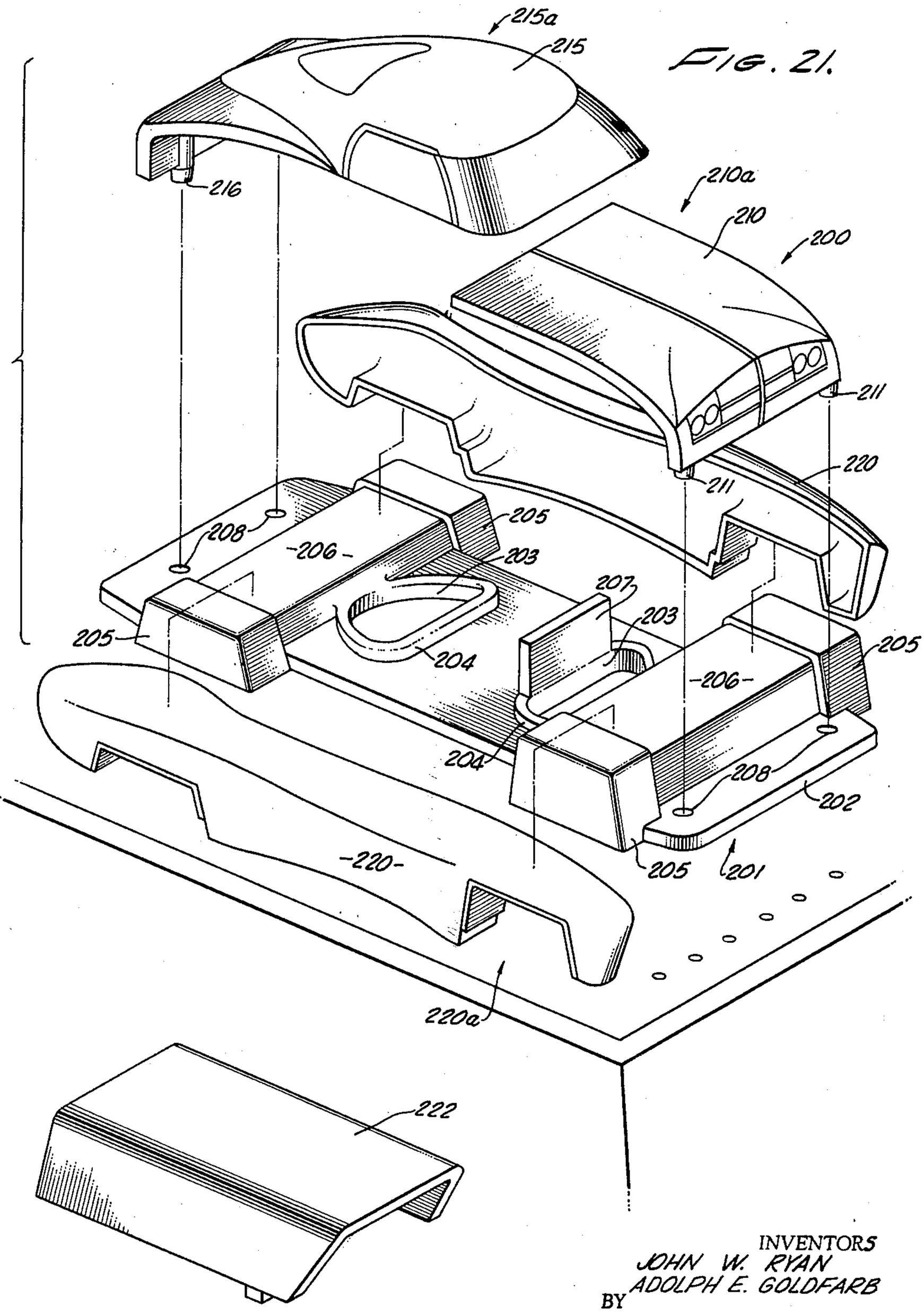

FIG. 21.

FIG. 22.

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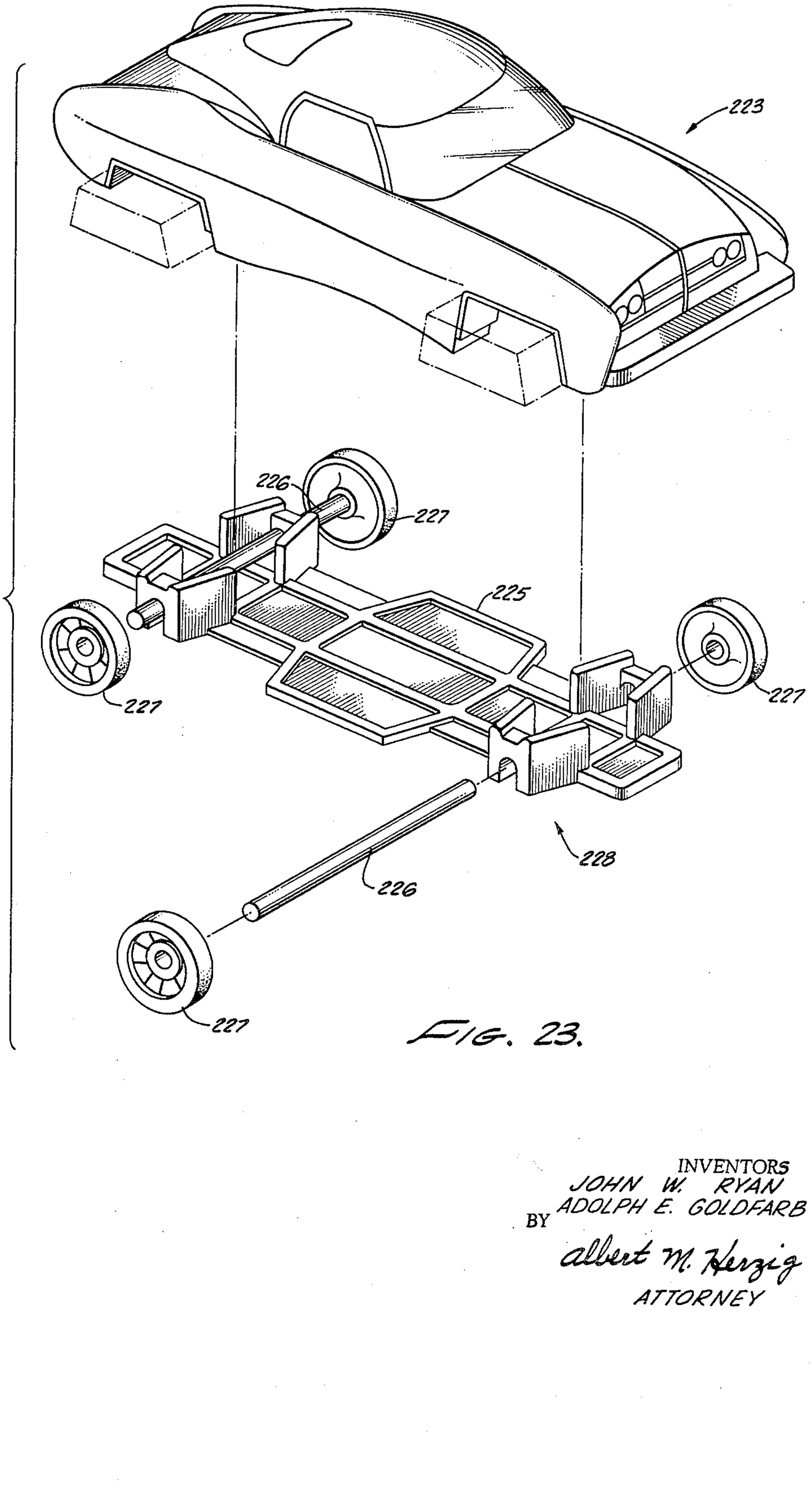

FIG. 23.

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FIG. 24.

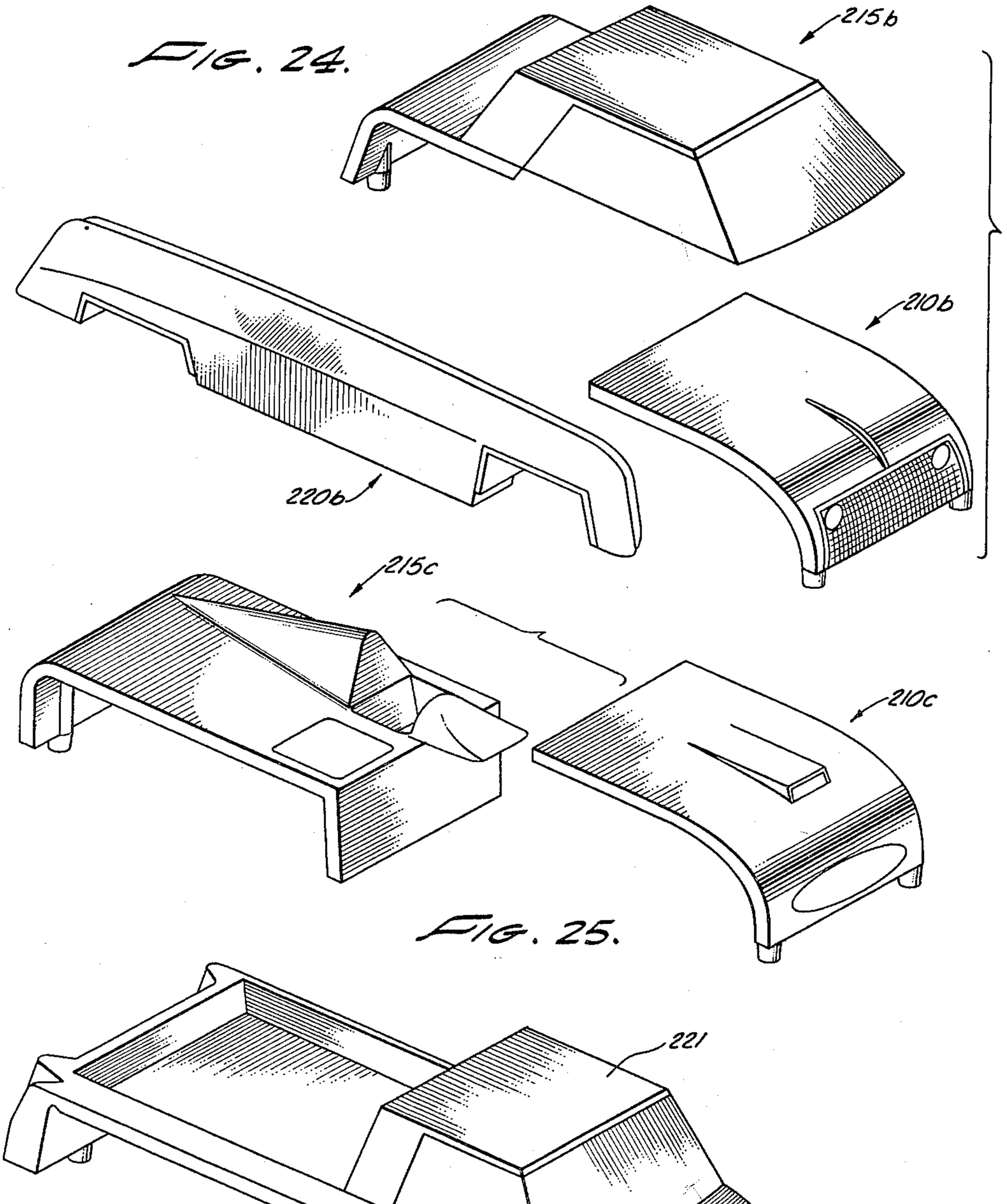

FIG. 25.

FIG. 26.

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United States Patent Office

3,179,980

Patented Apr. 27, 1965

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TOY FORMING APPARATUS

John W. Ryan, Bel Air, and Adolph E. Goldfarb, North Hollywood, Calif., assignors to Mattel, Inc., Hawthorne, Calif., a corporation of California

Filed Feb. 8, 1963, Ser. No. 257,129
5 Claims. (Cl. 18—19)

The present invention relates generally to a toy forming apparatus and more particularly to a novel and improved form of such an apparatus whereby a thermoplastic sheet is softened by heat and then formed into a desired shape by the application of a pressure differential.

There have been various commercial installations for the practice of the process generally known as "vacuum forming." This process entails generally subjecting a sheet of thermoplastic material to a heat source to soften and make the thermoplastic sheet pliable and workable. After the sheet is thus softened, a pressure differential between the two sides of the sheet is created as by inducing a "vacuum" on the side of the sheet adjacent a mold which causes the sheet to adhere to the form of the mold. Then when the sheet is allowed to cool it will retain its newly assumed shape to provide an object which is a reproduction of the mold. In commercial operation, however, it is necessary that this operation be conducted on a large scale and continuous basis with the sheet being heated rapidly, formed rapidly and then cooled rapidly to make way for the next sheet. Time is a prime consideration and therefore rather complicated and expensive equipment is utilized at the commercial level to provide rapid, reliable and often automatic operation. Further, to provide quick action, a high level heat source is often used in such apparatus.

The utilization of this general method in a toy apparatus for use by even small children obviously involves a number of difficulties. Initially, the toy must be relatively simple in construction and operation to enable small children to operate it. Further, it must be relatively simple and inexpensive to construct, so as to make it commercially feasible to produce and sell this item as a toy at a reasonable cost. Further, care must be taken to make the toy apparatus safe for use by small children.

Various more specific problems present themselves. There is a need for a simple, yet effective holder or clamping device to hold the plastic sheet during the various operations. This holding means must be sufficiently simple in operation so that it may be used by small children. At the same time it must be effective in securely holding the thermoplastic sheet securely and firmly while the sheet undergoes first the heating and softening operation and subsequently the forming operation. It is also desired that this holding means be readily and simply released when the sheet has been formed so that a new sheet may replace it. There are also problems incident to providing an effective seal for the area in which the pressure is to be reduced. There are also various other problems relating to heat dissipation and distribution.

Accordingly, it is a principal object of the present invention to provide a novel and improved toy forming apparatus.

It is another object to provide such a toy forming apparatus having a simple, yet effective holding means for securely, yet releasably holding a thermoplastic sheet during the operation of the apparatus.

Another object is the provision in a toy forming apparatus of releasable yet positive physical connection between the holding means and the thermoplastic sheet.

Still another object is the provision of holder means comprising a pair of interlocking holding frame members incorporating novel interconnection means therebetween.

Another object is the provision of an improved thermo-

plastic sheet construction for use with such a toy forming apparatus.

A further object of the present invention is the provision of an improved toy forming apparatus in which improved means are provided for controlling the flow and distribution of heat to the parts of the forming apparatus adjacent to the thermoplastic sheet during the heating operation.

Still another object of the present invention is the provision of an improved toy forming apparatus, having means for forming an effective seal for the reduced pressure compartment of the apparatus.

Still a further object of the present invention is to provide a toy forming apparatus having improved means for producing a pressure differential.

It is also an object of the present invention to provide a simple and inexpensive device which is also sturdy, durable and effective.

Various other objects and advantages of the present invention will become obvious from the following description and from the accompanying drawings, wherein:

FIGURE 1 is a perspective view of a toy former embodying the various features of the present invention with such toy former positioned ready to initiate its operation.

FIGURE 2 is a perspective view of the toy former of FIG. 1 with its parts positioned to perform the heating portion of its operation.

FIGURE 3 is a perspective view of the toy former of FIG. 1 showing its parts positioned to perform the forming portion of its operation.

FIGURE 4 is a top view of the toy former positioned as shown in FIG. 2 with portions of the apparatus broken away to show details of the construction.

FIGURE 5 is a cross-sectional view of FIG. 4 taken along the line 5—5 of FIG. 4.

FIGURE 6 is an end view of FIG. 5 taken along the line 6—6 of FIG. 5.

FIGURE 7 is a cross-sectional view of FIG. 5 taken along the lines 7—7 of FIG. 5.

FIGURE 8 is a cross-sectional view of FIG. 5 taken along the lines 8—8 of FIG. 5.

FIGURE 9 is a cross-sectional view of FIG. 8 taken along the lines 9—9 of FIG. 8.

FIGURE 10 is a cross-sectional view of FIG. 8 taken along the lines 10—10 of FIG. 8.

FIGURE 11 is a cross-sectional view of FIG. 3 taken along the lines 11—11 of FIG. 3.

FIGURE 12 is a cross-sectional view of FIG. 11 taken along the lines 12—12 of FIG. 11.

FIGURE 13 is a cross-sectional view of FIG. 11 taken along the lines 13—13 of FIG. 11.

FIGURE 14 is a perspective view of the thermoplastic sheet utilized in the present invention.

FIGURE 15 is a cross-sectional view of FIG. 14 taken along the lines 15—15 of FIG. 14 showing the orientation of the sheet with reference to the heating element of the toy former.

FIGURE 16 shows the thermoplastic sheet after it has been molded.

FIGURE 17 is a cross-sectional view of FIG. 4 taken along the lines 17—17 of FIG. 4.

FIGURE 18 is a cross-sectional view of FIG. 4 taken along the lines 18—18 of FIG. 4.

FIGURE 19 is an enlarged view of a detail of the corner of the housing.

FIGURE 20 is a cross-sectional view of FIG. 5 taken along the lines 20—20 of FIG. 5.

FIGURE 21 is an exploded perspective view of another embodiment of the mold of the present invention.

FIGURE 22 is a perspective view of another embodiment of the cap member element of the mold shown in FIG. 21.

FIGURE 23 is an exploded perspective view of the

vehicle body formed by the mold of FIG. 21 showing is relation to the other portions of the vehicle.

FIGURE 24 is a perspective view of another embodiment of the cap member, hood member and side panel elements of the mold shown in FIG. 21.

FIGURE 25 is a perspective view of still another embodiment of the cap member and hood member elements of the mold shown in FIG. 21.

FIGURE 26 is a perspective view of still another embodiment of the combined cap and hood member elements of the mold shown in FIG. 21.

Briefly, the illustrated toy forming apparatus **30** is adapted to form an object **32** from a sheet **34** of thermoplastic material by applying heat to the sheet of material and subjecting the sheet to a pressure differential. The illustrated apparatus **30** includes a housing **36** which partially encloses a heating station means **38** and a forming station means **40**. The illustrated toy **30** further includes an open-center holding frame means **42** for releasably holding the thermoplastic sheet **34** and a transfer or lever means **44** for moving the holding frame means **42** with sheet **34** between the heating station means **38** and the forming station means **40**.

The sheet **34** is heated first at the heating station means **38** to make it soft and workable and it is then moved by the transfer means **44** to the forming station means **46** where it is positioned down over a mold **25** having the shape of the object **32** on which the sheet is to be formed. The sheet **34**, the holding frame means **42** and the forming station means **40** combine to define a substantially sealed compartment or area **47** (FIGURE 11). The toy apparatus **30** also is provided with means **49** for reducing the pressure in the compartment **47**, thus causing the softened thermoplastic sheet to be formed or shaped to the outline of the mold **45**.

The illustrated holding frame means **42** includes a first or lower open-center holding frame member **46** and a second or upper open-center holding frame member **48** which interconnect to releasably, yet securely, hold the periphery of the thermoplastic sheet **34** during the various operations of the apparatus **30**. In the illustrated toy apparatus **30** the first holder frame member **46** is provided with locating and holding means in the form of a plurality of projections **50** which are adapted to engage a matching plurality of apertures **52**, extending along substantially the entire periphery of the thermoplastic sheet **34**. When the two holding frame members **46** and **48** are secured together with the projections **50** extending through the apertures **52** in the thermoplastic sheet, the sheet is securely held along its entire periphery against forces tending to distort or warp the sheet. The interaction of the two holder frame members serves to prevent the sheet from disengaging from the projections **50**.

In the illustrated toy forming apparatus **30**, the upper holding frame member **48** is constructed of metal connected to the upper holding frame member **48** and of the same material, is a pair of resilient flexible detent elements **54** which engage receptacle or reception means **56** on the lower holding frame member **46**. Thus, the detent elements **54** and the reception means **56** provide interconnection means **58** (FIGURE 7) whereby the two holding frame members are held in locked but releasable engagement. In the illustrated toy apparatus **30**, the reception means **56** is so positioned and constructed as to require flexing of the flexible detent element **54** incident to the engagement and disengagement of the element **54** with the reception means **56**.

In addition, the illustrated toy **30** is provided with heat distributing and dissipating means **60** which serves to maintain the parts of the toy apparatus **30** surrounding the thermoplastic sheet **34** relatively cool while the sheet is being heated by a suitable heating means **62** carried within the illustrated housing **36**.

The illustrated toy forming apparatus **30** is also usable to particular advantage with the thermoplastic sheet **34**

such as shown in the drawings which comprise a film **64** having a metallic layer **66** affixed to it to give the formed object **32** an aluminized appearance. The metallic layer **66** is secured to the surface of film **64** remote from the surface of the film **64** being heated as illustrated in FIGURE 15. The illustrated sheet **34** is further provided with a black layer **68** of lacquer or ink or other comparable material so that the thermoplastic sheet will readily and uniformly heat as desired and reach the necessary softened condition.

The preferred embodiment shown in the drawings includes a perforated plate **70** which supports the mold **45** and cooperates with the forming station means **40** to provide for passage of air to permit effective reduction of pressure in the volume **47** between the sheet **34** and the mold **45** incident to the forming of the sheet.

Thus a highly effective, yet simple and economical toy forming apparatus **30** is provided, having a variety of novel and improved features and particulars.

Now to consider the structure of the toy forming apparatus **30** in further detail, the apparatus includes a generally rectangular housing or frame **36** which is a generally rectangular box-like structure. The housing **36** includes a pair of elongated sidewalls **80** and **82**, a pair of foreshortened endwalls **84** and **86**, a bottom wall **88** and an upper wall **90**. In the illustrated housing **36**, an upper platform **94** provides the upper wall **90** of the housing **36**. The upper platform **94** is locked onto the housing **36** by means of flanges such as flange **87** on endwall **86** being slipped into apertures **95** in platform **94** as shown in FIGURE 17. The platform **94** also includes the heating station means **38**, adjacent endwall **84**, and the forming station means **40** which are located adjacent the endwall **86**.

The heating station means **38** includes a series of fins **92** and four enlarged fins **96** supporting the holding frame means **42** when it is positioned at the heating station as shown in FIGURE 5. The enlarged fins **96** permit the holding frame means **42** to be positioned adjoining the heating station means **38** while simultaneously permitting the fins **92** to efficiently radiate the excess heat away from the apparatus. The open or vented and finned network which comprises the heat dispensing and distributing means **60** serves to minimize heat transfer from the area of the heating station outwardly to those adjacent portions of the upper platform wall **94**.

The forming station means **40** are elevated on the structure relative to the heating station means **38**. The forming station means **40** include a generally rectangular turret structure **97** of lesser width than the upper platform **94** and of approximately one-half its length. The turret **97** is located somewhat inwardly from endwall **86** of the housing **36**. The turret **97** includes four generally vertical sidewalls **98** and a horizontal upper or top wall **100**. As seen best in FIGURES 1, 4 and 8, the upper platform wall **94** located outwardly of the turret **97** is provided with a plurality of air vents **102**, while the upper wall **100** of the turret **97** is provided with similar air vents **103** at its end closest to the heating station.

The forming station means **40** also include a vertical compartment wall or fence **104**, secured to the upper wall **100** and extending upwardly therefrom. The compartment wall **104** is generally rectangular in shape, having a slightly smaller width than upper wall **100** and having less length than wall **100**. The compartment wall **104** is located upon wall **100** toward its end furthest away from the heating station, thereby providing space for the air vents **103** in the wall **100** outwardly of the compartment wall **104**.

The holding frame means **42** of the illustrated apparatus includes a lower open-center holding frame member **46** and an upper open-center holding frame member **48**. These two members **46** and **48** are both pivoted about a common axis designated A—A and seen best in FIGURE 4 of the drawings. The holding frame means members

46 and 48 are shown generally disposed with their open centers over the heating station in FIGURES 2, 4 and 5–7. They are shown disposed over and embracing the forming station in FIGURES 3 and 11. FIGURE 1 shows the two holding frame members 46 and 48 separated from one another and pivoted somewhat relative to one another.

For convenience of description the holding frame members 46 and 48 will be described in their respective positions over the heating station except where specifically noted in another position. Of course, the frame members assume the entire spectrum of positions between that at the heating station and that at the forming station in the course of the operation of the apparatus wherein said frames are pivoted or tilted between the two stations.

The lower holding frame member 46 is a ring or loop structure of generally rectangular configuration having two vertical sidewalls 106 and a pair of vertical endwalls 108. The member 46 is provided with a narrow, inwardly extending annular lower lip or flange 110 at the lower edge of the vertical walls 106 and 108. A plurality of closely spaced apart vertically extending pins or projections 50 are secured along substantially the entire flange 110 and extending upwardly from the upwardly facing surface thereof. The illustrated projections 50 are arranged in aligned rows extending along each side of the frame member 46.

In the illustrated structure, the projections 50 are all alike, having a circular horizontal cross-section although other shapes of cross-section may be used such as triangular or rectangular. Furthemore, the projections 50 preferably taper outwardly towards their base e.g. for a circular cross-section, they may be frusto-conical in shape; however, they may have a uniform cross-section e.g. for a circular cross-section, they may be cylindrical in shape. The illustrated lower holding frame member 46 has longer sidewalls 106 than endwalls 108. However, if desired, each of the walls of the frame member 46 could be equal to permit ready reception of the thermoplastic sheet 34 by the frame member 46 regardless of the orientation of the sheet. On the other hand, it would also be possible to provide particular positioning means which would further restrict or limit the orientation of the thermoplastic sheet 14 in the frame member and this result could be accomplished by varying the position, size or construction of the projections 50 as will be readily understood as the description progresses. Also, if desired, the projections 50 may be located on upper frame member 48.

As shown in FIGURES 4, 5 and 7, particularly, frame member 46 is secured at each side to an elongated side bar 116 by a pair of horizontally extending connections 118 and 120. The illustrated side bars 116 extending outwardly of and generally parallel to vertical sidewalls 106 of the frame member 46 and extend beyond the frame member 46 at either end thereof. As shown in FIGURE 7, an annular upper lip or flange 122 extends horizontally outwardly from the upper edge of each sidewall 106 and then terminate in an upwardly extending annular lip or flange 123. The connections 118 and 120 at either side of the frame member 46 extend outwardly from the upper portion of the flange 103.

The connection 118 includes a knob 118*a* extending from the sidewall 106 of the lower frame member 46 and a pair of ribs 118*b* separated by the knob 118*a* and attached to the side bar 116. The edges of the ribs 118*b* adjoining the knob 118*a* are spaced slightly away therefrom to achieve a loose fit and thus to permit the frame member 46 to move or tilt slightly in relation to the side bar 116 while retaining a secure connection therebetween. Such spacing may be in the range of about $\frac{1}{32}$ inch to $\frac{1}{8}$ inch but it is preferably about $\frac{1}{16}$ inch.

The connection 120 includes an X-shaped boss 120*a* extending from the sidewall 106 of the lower frame member 46 and a socket 120*b* attached to the side bar 116 and

into which the boss 120*a* is inserted. The socket 120*b* has a rib 120*c* across its base which adjoins the end of the boss 120*a*. Such arrangement minimizes the frictional resistance to movement between the lower frame member 46 and the side bar 116. In addition, the peripheral edges of the boss 120*a* are spaced slightly away from the internal surfaces of the socket 120*b*. Thus, similar to the connection 118, the connection 120 achieves a loose fit and permits the frame member 46 to move or tilt slightly in relation to the side bar 116 while retaining a secure connection therewith. Such spacing is preferably about $\frac{1}{32}$ to $\frac{1}{16}$ inch.

From the foregoing description it will be apparent that the workpiece holding frame is mounted for limited universal movement on its carrying structure.

Along the lower edge of each sidewall 106 runs a small lower guide extension 124 which serves to support the frame member 46 when the frame member 46 is lowered down into the first position over the heating station. As seen best in FIGURE 7, the extensions 124 rest outwardly of the lower flange 110 of the lower holding frame member 26 upon the enlarged fins 96.

The transfer or lever means 44 include the elongated side bars 116 which extend beyond the sidewalls 106 of the frame member 46, as noted above. At their outer ends, the side bars 116 are secured to the large handle 128 which extends substantially across the width of the apparatus. The handle 128 is hollow with an open side formed by a thin wall 128*a*. The handle 128 is connected to the side bars 116 by the engagement of grooved sockets 128*b* with correspondingly grooved fingers 116*a* extending from the side bars 116 (see FIG. 4). Such construction minimizes heat conduction to the handle 128 from the apparatus while promoting heat loss by means such as free air circulation adjoining all of its surfaces.

The other ends of the side bars 116 are pivoted about line A—A to the vertical sidewall 98 of turret 97 by means of cylindrical pivot pins 126. The aperture 116*b* in each of the sidebars 116 through which the pivot pin 126 extends is slightly larger in diameter than the pivot pin 126 to achieve a loose fit therebetween. Thus the transfer means 44 is permitted to universally move or tilt slightly with respect to the turret 97 while retaining a secure connection therebetween. Such spacing may be in the range of about $\frac{1}{32}$ inch to $\frac{1}{8}$ inch.

The upper holding frame member 48 is a rectangular loop or ring constructed somewhat like lower frame member 46 and is adapted to be positioned or nest into frame member 46 in the relative position shown, for example, in FIGURE 2. Upper frame holding frame member 48 includes a pair of generally vertical sidewalls 130 and a pair of generally vertical end walls 132. While vertical walls 130 and 132 shall be referred to as vertical, they are in fact somewhat sloped in the preferred embodiment of the apparatus both from the standpoint of ease of fabrication and also to provide effective fit with the walls of the lower holding frame member 46 and the forming station means 40 as will be understood from the following description.

Vertical walls 130 and 132 have their upper portion offset outwardly somewhat to provide an annular external shoulder 136 for the frame member 48. This shoulder 136 may serve to engage the upper edge of the walls 106 and 108 of lower frame member 26 when the two holding frame members are nested together as for example shown in FIGURES 5 and 7.

Upper holding frame member 48 is provided with a pair of outwardly extending legs 137 which are pivotally mounted on the same pivot pins 126 that pivotally support the elongated side bars 116 supporting the lower holding frame member 46. This common pivot enables the two frame members 46 and 48 to pivot together as a unit when interconnected, it will be described below, or to pivot relative to one another, as shown in FIGURE 1. The apertures 137*a* in the legs 137 through with the pivot

pins **126** extend is slightly larger in diameter than the pivot pins **126** to achieve a loose fit therewith. Thus both the transfer means **44** and the upper frame member **48** is permitted to move or tilt slightly with respect to the turret **97** while retaining a secure connection therebetween. The spacing between the apertures **137***a* and the pivot pins **126** may be in the range of about 1/32 inch to 1/8 inch.

The endwall **132** of the illustrated upper holding frame members **48** furthest from the pivot point of the frame or pivot axis of the frame member **48** is provided with an outwardly extending handle plate **138** designed to be grasped by the user for manipulating or moving the frame member **48** relative to the other frame member **48**. Also, the member **48** has a plurality of recesses **139** into which the ends of the projections **50** of the lower member **46** are received.

When the two frame members **46** and **48** are separated, the rectangular thermoplastic sheets **34** are supported on the lower holding frame member **46**. More specifically, the periphery or edge of the sheet **34** lays upon the annular ledge **112** with the projections **50** of the frame member **46** protruding through the apertures **54** of the illustrated sheet. This construction of the lower holding frame member **46** facilitates the rapid and accurate placement of the sheet within the holding frame member while positive physical or mechanical engagement and support is provided to the sheet along substantially its entire periphery. Again, it should be noted that the projections **50** may be mounted on the upper frame member **48** and the corresponding recesses **139** made in the lower frame member **46**.

Upper holding frame member **48** may then be pivoted into position, as shown in FIGURE 2, with the underside of the vertical sidewalls **130** and the vertical endwalls **132** overlying annular flange **110** of the lower frame member **26** and also overlying the periphery of the sheet **34** and the projection **50** to prevent the sheet from being displaced from its position upon those projections. Because of this positive physical interconnection between the sheet **34** and the projection **50**, the pulling, stretching and the like which takes place during the operation of the apparatus will not dislodge the projections from the apertures in the sheet so long as the two frame members are maintained in locked or interconnected relationship. Further, when the two frame members **46** and **48** are in interconnected relationship, a substantially air tight seal is created between the interior of the frame and the exterior by virtue of the three layer seal between the flange **110**, the sidewalls **130** and **132** and the thermoplastic sheet **34** inwardly of the rows of apertures **52**. This area of seal is generally rectangular following the configuration of the thermoplastic sheet and being essentially a narrow strip extending around the peripheral area of the sheet but spaced inwardly of that sheet as determined by the rows of apertures.

Frame members **46** and **48** are held together by the interconnecting means **58** which comprise in the illustrated structure a pair of flexible, resilient, detent elements **54** (see FIGURE 7) and a matching pair of reception or receptacle means **56** on the lower frame member **46**.

More specifically, each of the illustrated detent elements **54** is a generally rectangular flap which extends downwardly from approximately the center of the upper edge of the sidewall **132** of the upper frame member **48** and externally thereof. The detent elements **54** extend downwardly and somewhat outwardly as seen best in FIGURE 7, and these elements **54** may be formed integrally with the upper frame member **48** of the same resilient, flexible material such as nylon or various other plastics. One of these detent elements is positioned at either side of the frame member **48**.

At either side of the lower frame member **26** and extending through about the center of the annular flange or lip **122**, just inwardly of the vertical annular lip, flange or wall **123**, is an aperture providing the reception or receptacle means **56** which is adapted to receive the detent element **54**.

In the preferred embodiment of the apparatus, the parts are so arranged in proportion that the elements **54** are flexed inwardly by engaging the vertical annular wall **123** and are then urged into the respective apertures **56** incident to the two holding frame members **46** and **48** being brought together. The detent elements **54** are thus flexed and maintained in a tension position which tends to create a resilient, flexible coupling or interconnection or interlocking between the two frame members **46** and **48**, allowing them to move together when desired but permitting readily separating these frames from one another.

The heating means **62** includes a heating element **142** which is secured within the housing **36** a short distance below the cradle structure **76** of the heating station. The illustrated heating element **142** produces a low level heat output and in addition, to prevent the child user from burning his hand on the heating element, a panel **143** is wedged in over the heating element to shield it from direct contact from the outside of the apparatus.

The heating means **62** of the illustrated apparatus also includes a pair of electrical leads **144**, as seen in FIGURE 13. The leads **144** are secured at their upper end to the heating element **142** at its side closest to end wall **84** and the leads then extend vertically downwardly adjacent to that end wall **84** and extend outwardly through an aperture provided adjacent the bottom of wall **84** to connect to a suitable source of electric power (not shown). As an obvious alternative, the structure could be provided with an internal source of power for the heating element, such as a storage battery. The electrical leads **144** and the connection between them and the heating element **142** are closed into a separate area relative to the remainder of the interior of the housing **136** by a suitable shield **146** and **147**, secured to the housing wall. This is an added safety feature should the child gain access to the interior of the housing as by removing the bottom wall of the housing.

The forming station means **20** of the illustrated apparatus include a generally rectangular plate or platform **70** of slightly smaller dimensions than the rectangular compartment wall **104** and which is received within the compartment wall **104** adjacent the upper edges of that wall. Thus, while plate **70** fits within the rectangular space defined by the wall, there is sufficient play or space between the edges of the plate and the wall to permit ready passage of air therebetween. In addition, plate **70** has perforations **71** to permit ready passage of air therethrough. The plate **70** is supported in the illustrated embodiment of the apparatus by vertically extending support pins **150** which are connected at their upper end to the plate **70** and at their lower end rest upon the horizontal upper wall **100** of the turret **97**. If desired, the pins **150**, instead of being connected to both plate **70** and wall **100**, may be free relative to either plate **70** or wall **100** so that the plate **70** may be removed from the apparatus if desired.

The mold **45** rests atop the plate **70** and is shaped to provide the shape of the object **32** to which the thermoplastic sheet **34** will be formed by the operation of the illustrated apparatus **30**. While the mold **45** of the illustrated apparatus is not secured to the plate **70**, it would be possible that they be secured together or even integrally formed, in which case either the plate **70** itself or the plate **70** and the support pins **150** would be unsecured to and free to move relative to the turret **97**. In this way, a plurality of different molds, each of which included its own plate **70** could be provided with the toy apparatus, although there is an obvious material saving by providing a single plate **70** as in the preferred embodiment and merely placing a variety of different molds **45**

upon that plate. The advantage of having the mold 45 integrally formed or connected to the plate 70 on the other hand is the elimination of any possibility of the mold shifting or moving relative to the plate during the operation of the apparatus to provide a defective molded object. This problem could be dealt with in the case of a separate mold by the use of one or more interlocking pins and apertures between the mold 45 and the plate 70.

As illustrated in FIGURES 1–20, the mold 45 consists of an integral structure in the form of a ship. However, in another embodiment of the present invention shown in FIGURES 21–26, the mold 200 is constructed of a set of interchangeable elements. As illustrated, the mold 200 is adapted to form a plurality of different vehicles by changing the elements thereof. The elements of the mold 200 include a base member 201 adapted to position and engage a plurality of vehicle body members. The base member 201 has a plate 202 with several apertures 203 therethrough, with ridges 204 surrounding each aperture 203. The apertures 203 are adapted to permit free escape of the gases within the mold 200 during the forming process.

Approximately at each corner of the plate 202 in "wheel position" are wheel lugs 205 extending upwardly from the plate 202. Connecting each adjoining pair of wheel lugs 205 across the plate 202 are rails 206. Between the rails 206 and extending upwardly from adjacent the front aperture 203 is a support lug 207. Each of the wheel lugs 205, the rails 206 and the support lug 207 is adapted to support other mold elements. At the front and rear ends of the plate 202 are pin holes 208 adapted to receive the pins extending the other mold elements.

Covering the front portion of base member 201 is a hood member 210 which rests on the front rail 206 and the support lug 207 and is positioned between the front wheel lugs 205. The hood member 210 has pins 211 extending downwardly from its front portion which pins 211 are received in the front pin holes 208 of the plate 202. Covering the rear portion of the base member 201 is a cap member 215 which rests on the rear rail 206, and the hood member 210 and is positioned between the rear wheel lugs 205. The cap member 215 has pins 216 extending downwardly from its rear portion which are received in the rear pin holes 211 of the plate 202. Covering each side of the base member 201 is a side panel 220 which is slidably engaged between the hood member 210 and the cap member 215 and the wheel lugs 205.

The mold 200 is placed on a plate 70 and the sheet 34 is molded thereover as set forth elsewhere in this application. As illustrated, the hood member 210 used in the mold 200 may be of a variety of shapes, such as hood members 210*a*, 210*b* and 210*c*. Similarly, the cap member 215 and side panel member 220 may each be of a variety of shapes, such as 215*a*, 215*b* 215*c*, 220*a* and 220*b*. Also, the mold 220 may be simply a truck mold 221 or a panel back member 222. Each form of each of the elements is interchangeable with all other forms so that a wide variety of vehicle styles may be produced. For example, in any vehicle any one of the hood members, 210*a*, 210*b* or 210*c* may be used. The mold 200 is preferably made of an organic plastic material, such as styrene, having a softening temperature at least equal to the softening temperature of the sheet 34. Thus, the mold 200 may even have a somewhat lower softening temperature than the sheet 34, but because of its large mass compared to the sheet 34 it quickly cools the heated sheet 34 when it comes in contact therewith. Consequently, the mold 200 will not be heated up to its softening temperature.

After the sheet 34 has been formed by mold 200 into a vehicle body 223, the vehicle body 223 is cut from the sheet. A separate chassis 225 with axles 226 inserted therein and wheels 227 pressed onto the ends of the axles 226 is then used to complete the vehicle assembly. The chassis assembly 228 is attached to the vehicle body 223 by means of an adhesive, such as glue.

The reduced pressure compartment 47 is formed by the vertical rectangular compartment wall 104, the sheet of thermoplastic material 34 itself, the upper wall 100 of the turret 97, and the vertical walls 130 and 132 of the upper holding frame member 48 which engages with the compartment wall 104 as shown in cross section in FIGURE 11. The compartment wall 104 if of generally the same size externally as the internal dimension of the vertical walls 130 and 132 of the upper frame member 48, and the parts are so constructed and arranged and the pivot axis is so located that when the frame members 46 and 48 are pivoted to the forming station they will be positioned directly over the wall 104. In the illustrated structure, compartment wall 104 and frame member wall 130 are slightly tapered which will tend to give a wedging fit there between and provide an effective air seal between the two walls. Also, at this point, it should be noted that as set forth above, not only is there a loose fit between the turret 97 and both the transfer means 44 and the upper frame member 48 but also there is a loose fit between the transfer means 44 and the lower frame member 46. Such construction causes the upper frame member 48 to be self-alignment when it is seated on the turret 97. Thus the necessity of precise alignment of the various portions of the apparatus is eliminated and there is compensation for the wear and tear to which the apparatus is normally subjected by children. Similarly, such construction causes the upper frame member 48 and the lower frame member 46 to become self-aligning with respect to each other when the upper frame member 48 is seated in the lower frame member 46. Such self-aligning feature permits the apparatus to tightly clamp the plastic sheet between the frame members and to obtain an air-tight seal when molding the plastic sheet.

The plate 70 supports the mold 45 upon it, but permits passage of air between its edges and the adjacent compartment wall 104 and through its perforations 71 as noted above. Alternatively, the upper surface of plate 70, at least adjacent its outer periphery, may be provided with an irregular or uneven surface by scoring corrugating or other means, to prevent a seal being formed between that upper surface and the sheet 34. Such irregular upper surface construction of the plate 70 combined with the space between the edges of the plate 70 and the adjacent compartment wall 84, would permit free flow of air between the areas on either side of the horizontal plate 70.

The means 49 of the illustrated apparatus for reducing pressure include a vertically oriented cylinder 156 which is secured at its upper edge to the underside of the top wall 100 of the turret 97 and extends downwardly into the interior of the housing 36. The cylinder 156 is generally centered below the compartment 47 and it is open at its lower end. Piston means 158 is disposed within the cylinder 156 for vertical reciprocation. The piston means 158 includes a circular piston 160 of flexible, resilient material, such as for example neoprene, which is disposed to extend generally horizontally across the cylinder 156. The piston 160 includes a downwardly and outwardly extending flange or flap 162 adapted to resiliently and yieldingly engage the interior surface of the cylinder 156. The piston means 158 further includes a pair of circular piston plates 163 of rigid materials, such as metal, one plate 163 being disposed above the piston 160 while the other is disposed below it to give the piston means 158 the necessary rigidity. The plates 163 are of smalled diameter than the cylinder 156 so that they do not engage the cylinder wall, and the annular flap 162 extends beyond the plates 163 to engage the cylinder wall as noted above. A vertically oriented piston rod 164 is secured at its upper end to the piston 160 and the piston plate 163 and serves to hold them together in an assembled condition.

The piston means 158 is vertically reciprocated by actuating or linkage means 170 which includes an elongated formed rod 172, pivotally mounted within the housing 36. The rod 172 has an elongated center sec-

tion 174 and a pair of branch sections 176 and 178 which extend outwardly from either end of the center section 174 at generally right angles. The center section 174 extends longitudinally of the apparatus in a generally horizontal position and is supported on the inside of sidewall 82 by a pair of bearings 180 for rotation about the horizontal axis of the center section 174. As illustrated, the bearings 180 are made of low friction plastic material such as nylon. Preferably, the pivot means 158 is biased into an upward position by a spring 175 connected between the branch section 176 of the linkable means 170 and the housing 36, as illustrated in FIG. 8.

The branch section 176 extends inwardly of the housing 36 and is pivotally connected at its end to the lower end of the piston rod 164. The other branch 178 of the rod 172 extends inwardly of the housing 36 and there is provided at its outer end a further longitudinally extending section 179 which emerges from the housing 36 through an arcuate aperture or slot 182 in end wall 84. A handle 184 is provided on the ends of section 179. By moving the handle 184 generally up and down in its arcuate path, as limited by the length of the vertical arcuate slot 182, the piston means 158 is caused to reciprocate vertically within the cylinder 156. The lower end of the piston rod 164 moves in a slight arc comparable to that defined by slot 182, and this action is permitted by the flexible material from which the piston 160 is constructed and by the fit of the piston through the annular flap 162 with the surrounding cylinder wall 156. Connected between branch section 176 and the upper portion of the housing 36 is a coiled spring 175 which is adapted to bias the piston means 158 upwardly so that it will automatically return to its raised position when released. Such arrangement permits the pressure reducing means 49 to be operated solely by applying force to cause its downstroke.

The pressure reducing means 49 further includes valve means 190. The valve means of the illustrated apparatus comprises a valve aperture 192 extending through the upper wall 100 of the turret 97 in a location slightly off center of the center of the cylinder 156. As seen best in FIGURES 5 and 8, an elongated rectangular valve strip 194 of a flexible resilient material is secured at either end in a position generally flush against the underside of wall 100 and is positioned such that the intermediate part of the strip 194 extends across the valve aperture 192.

Thus, when the handle 184 is pumped, causing the piston means 158 to reciprocate within the cylinder 156, the result is to draw air through the aperture 192 from the area above the horizontal wall 100. Specifically, on the down stroke of the piston means 158, air is drawn through aperture 192 and the action of the piston means tends to draw the strip 194 away from its position over the aperture 192 to permit this air flow. On the upstroke of the piston means 158, the strip 194 is forced up against the aperture 192 to block it and trap air in the cylinder 156 above the piston means 158. As the piston means 158 is forced upwardly, this trapped air passes between the flexible flange 162 of the piston 160 and the cylinder wall 156. This process is repeated with each stroke of the piston.

This removal of air from the volume above the horizontal wall 100, which volume includes compartment 47, above plate 70 by virtue of the above described construction of plate 50. Thus a low pressure area is created immediately beneath the thermoplastic sheet 34 causing it to form about the mold 45.

The thermoplastic sheet 34 of the illustrated apparatus is generally rectangular in shape and is provided with a plurality of equally spaced small circular apertures 52 which extend in a continuous row located a specific distance from the periphery of the sheet. These apertures 52, as described above, cooperate with the projections 50 of the frame holding means and various modifications and changes of the specific structure without varying from the spirit and scope of the invention may be made so long as the projections 50 and the apertures 52 are maintained in the corresponding or mating relationship. For example, the horizontal cross-section of the apertures and projections could be rectangular, oval or triangular rather than circular, the spacing or positioning could be varied, the size could obviously be varied and it would not be necessary that each of the mating pairs of projections and apertures be like the other pairs of projections and apertures. For example, by the size, spacing, shape or other variation of mating pairs of projections and apertures means could be provided for guiding or locating the thermoplastic sheet upon the frame in some particular desired orientation.

The illustrated sheet 34 shown in FIGURE 15 includes a thin rectangular film 64 of thermoplastic material which will readily reduce to a softened and workable state with the application of relatively low level heat source. The film 64 should also have whatever characteristics are desired to be obtained in the formed object 32. In the illustrated sheet 34, the metallic layer 66 is secured to the surface of the film 64 remote from the surface heated by heating means 62 and will thus produce a metalicized appearance to the inner surface of the object 32 formed from the sheet. Secured to the upper surface of the metallic layer 66 is a black layer 68 which may be formed by black lacquer or ink or other suitable material.

Now considering the operation of the toy forming apparatus 30 in further detail, the upper and lower holding frame members 48 and 46 respectively should be separated from one another as shown in FIGURE 1 of the drawing. The thermoplastic sheet 34 is then placed in the lower holding frame member 46, its correct location being assisted by the engagement of the projections 50 of the frame member 46 with the apertures 52 and the periphery of the sheet. The lower holding frame member 46 may conveniently be positioned at the heating station as in FIGURE 1 during the insertion of the sheet although this position is not necessary. Once the sheet 34 is properly located in the lower holding frame member 46, the upper holding frame member 48 is releasably locked into position as shown in FIGURE 2 by the manipulation of its handle 138, the detents 54 of the upper member 48 being in a resilient pressure fit and extending through the aperture 56 of the lower frame member 48. The sheet 34 is thus securely held in positive physical engagement along substantially its entire periphery in the frame holding means 42. In addition, as noted above, a substantial air seal is provided between the two sides of the sheet 34 adjacent its edges.

The thermoplastic sheet is allowed to remain within the frame holding means 42 at the heating station a sufficient time to allow the sheet to soften and become pliable and workable. It has been found that effective results may be achieved if a temperature of 350 degrees Fahrenheit is applied to a thermoplastic sheet for about 6 minutes.

After the sheet is sufficiently softened, the entire assembly of the two frame members 46 and 48 and the softened sheet 34 are moved by the large handle 128 to the forming station. As best seen in FIGURE 3, this is a pivoting operation wherein the frame members are turned completely over, in the position shown in FIGURE 3. The pump handle 184 is then manipulated up and down to create the reduced pressure immediately below the softened sheet 34 as explained in detail above. This will cause the sheet to assume the shape of the mold 45.

The formed sheet is then allowed to cool in this position. It has been found that approximately 15 seconds are sufficient for allowing the thermoplastic sheet to fix or set in its new configuration.

The sheet 34 is then removed from the frame holding means 42 by separating the upper and lower holding frame members 48 and 46. This separation is achieved by pulling apart the two handles 138 and 128 respectively,

either before or after the frame holding means 42 is removed from the forming station.

FIGURE 16 illustrates one possible form of object 32 which may be produced from a thermoplastic sheet by the illustrated forming apparatus, this object 32 having the form of a ship. The excess material around the edges of the formed object may be trimmed or cut away. It is, of course, possible to form a great variety of different kind, sizes and types of objects on the illustrated apparatus all within the scope of the invention.

After the formed sheet has been removed from the frame holding means, a fresh sheet 34 may be put into its place and the process repeated.

Thus, a novel and approved toy forming apparatus is provided by the preferred embodiment shown in the drawings. This embodiment includes a pair of frame members which hold the thermoplastic sheet in positive physical contact along substantially its entire periphery to prevent any undesirable deformation or distortion of the sheet incident to the operation of the apparatus. Further, in the illustrated toy apparatus, improved interlocking means between the two frame members are provided and a novel and improved thermoplastic sheet construction particularly adapted for use with such a toy forming apparatus is presented. The illustrated embodiment includes improved heat distributing and dissipating means, and improved means in the combination for providing substantially air-sealed compartment when the pressure may be reduced to cause the formation of the sheet. A number of other advantages and features of the illustrated structure are also noted above in the course of the description. Thus, a simple and durable yet highly effective toy forming apparatus is provided which will give children long hours of safe and enjoyable activity.

Obviously various modifications and changes in addition to the few noted above in the course of the description may be made without departing from the spirit and scope of the present invention. Various features of the invention are set forth in the following claims.

What is claimed is:

1. In a toy apparatus for molding an article from a sheet of thermoplastic material, the improvement comprising: means defining a heater having a generally horizontal heating surface; means defining a mold laterally spaced from said heater; support means defining a horizontal axis disposed between said heater and said mold; work holding means comprising a first open center frame mounted on said support means for pivotal movement about said axis between positions where the open center thereof overlies said heating surface and said mold, said mold including a generally horizontal peripheral edge portion; said work holding means comprising a second open center frame pivotally mounted on said axis; said first open center frame being mounted in the open center of said second frame for limited universal tilting movement therein whereby to assure proper alignment of said first frame with said peripheral edge portion of said mold.

2. A toy apparatus as defined in claim 1 wherein said mold includes a generally horizontal peripheral edge portion; said open-center frame having an inner shoulder portion overlying and closely adjacent said peripheral edge portion when said open center overlies said mold.

3. A toy apparatus as defined in claim 2 wherein said mold comprises means defining an open-topped box-like chamber having upstanding side walls, the upper edges of said side walls defining said peripheral edge portion; an air pervious mold device positioned in said chamber and extending upwardly therein at least to said open top; and manually operable pump means for drawing a vacuum in said chamber.

4. A toy apparatus as defined in claim 3 wherein said mold device comprises a perforated plate-like member having an upper surface substantially flush with said peripheral edge portion and a forming mold removably resting on said upper surface.

5. In a toy apparatus for molding an article from a sheet of thermoplastic material, the improvement comprising: a support having means thereon defining a horizontal axis; heating means on said support, on one side of said axis, and having a generally horizontal upwardly facing, heating surface below the level of said axis; upstanding mold means on said support, on the other side of said axis, and above the level of said axis; a work holding frame loosely pivoted on said axis; boundary walls on said frame defining an open center thereof and extending laterally of a plane containing said axis; said frame being swingable over said axis from a first position wherein said open center overlies said heating surface with said boundary wall extending downwardly from said plane to a second position wherein said boundary walls embrace said upstanding mold and extend upwardly from said plane; and clamping means on said frame for holding a workpiece across said open center and in a plane substantially at the lower edges of said boundary walls when said frame is in said first position.

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