June 8, 1971 G. W. BROWN ET AL Re. 27,137

DIFFERENTIAL PRESSURE FORMING MACHINE

Original Filed July 10, 1963

5 Sheets-Sheet 1

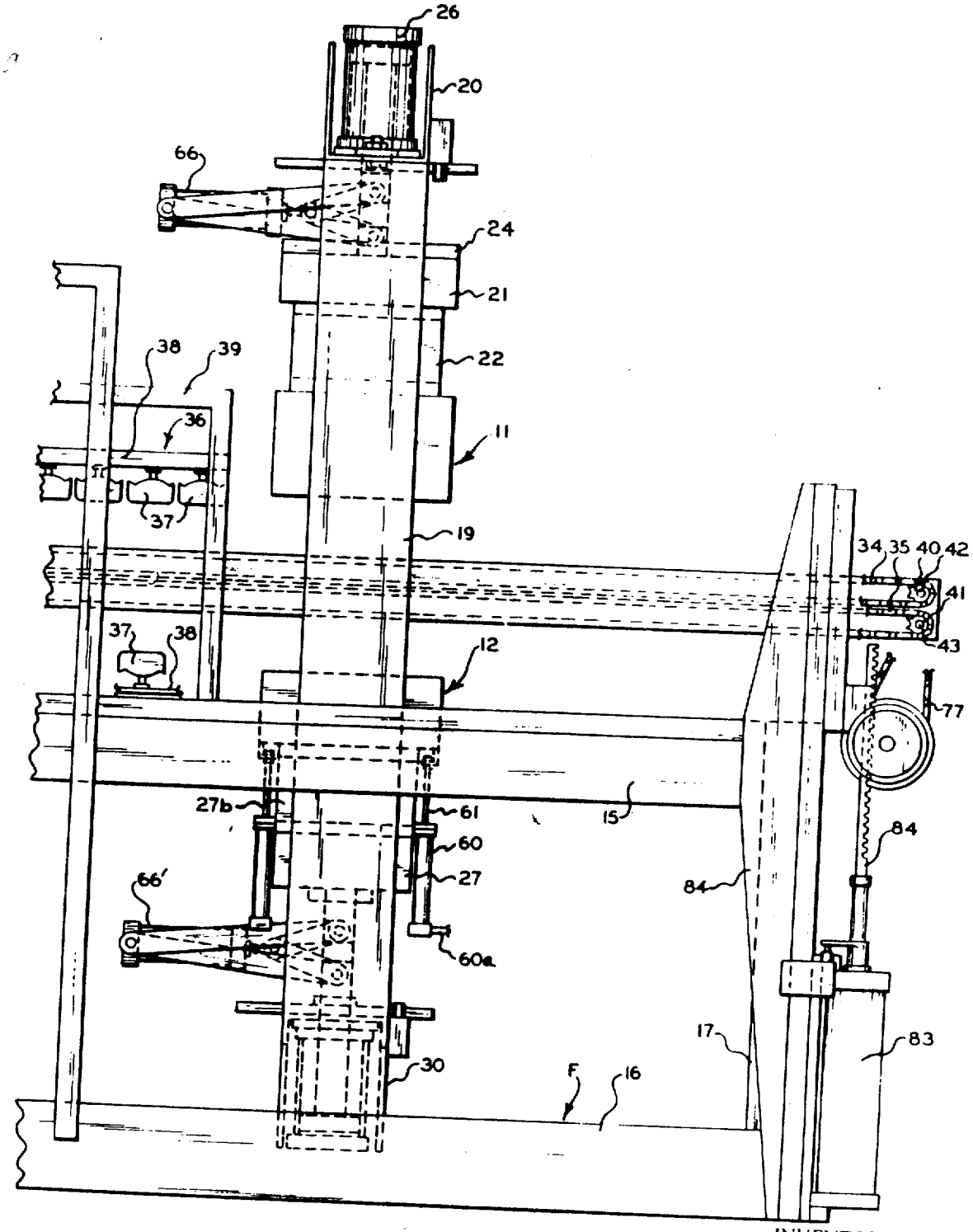


FIG. 1

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DIFFERENTIAL PRESSURE FORMING MACHINE

Original Filed July 10, 1963 5 Sheets-Sheet 2

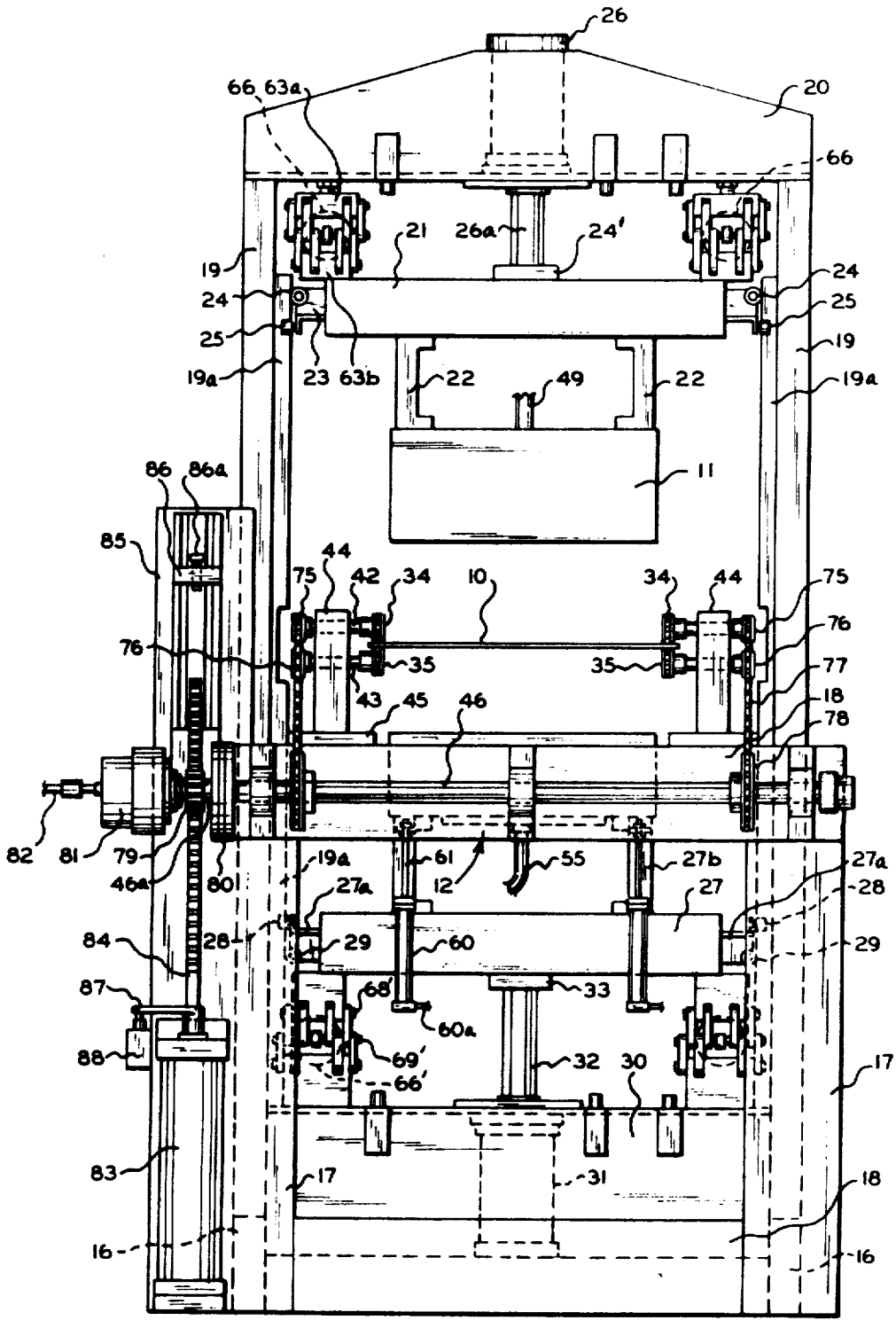


FIG. 2

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DIFFERENTIAL PRESSURE FORMING MACHINE

Original Filed July 10, 1963 5 Sheets-Sheet 3

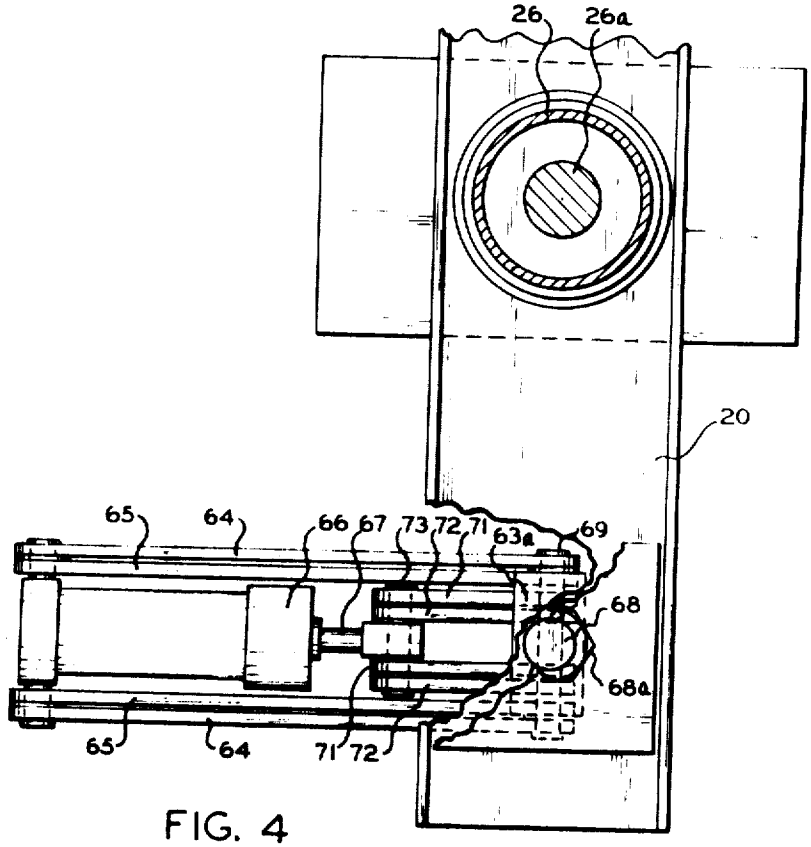


FIG. 4

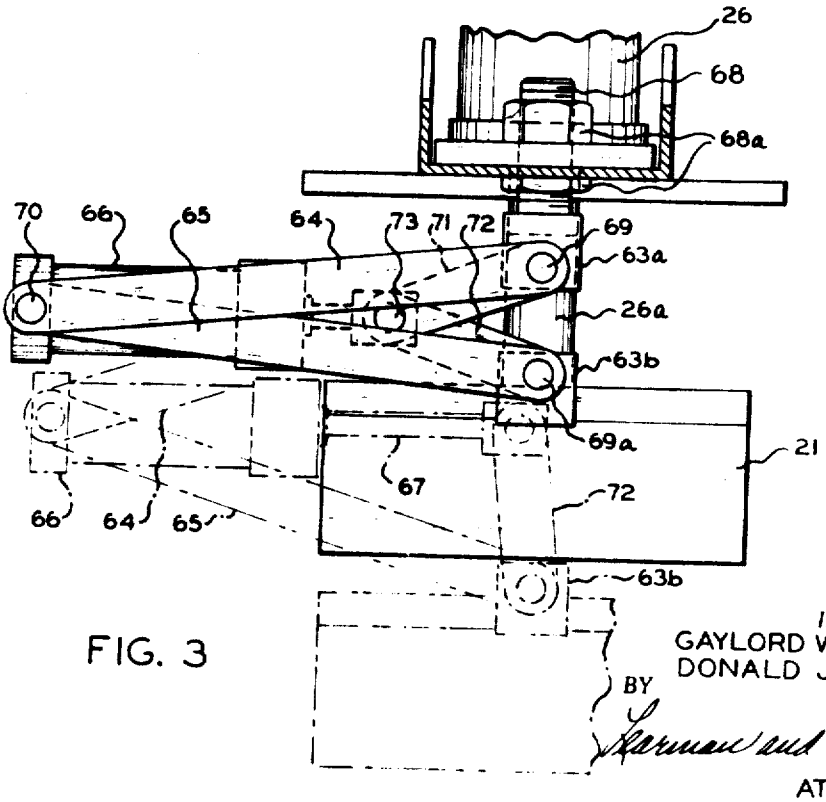


FIG. 3

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DIFFERENTIAL PRESSURE FORMING MACHINE

Original Filed July 10, 1963 5 Sheets-Sheet 4

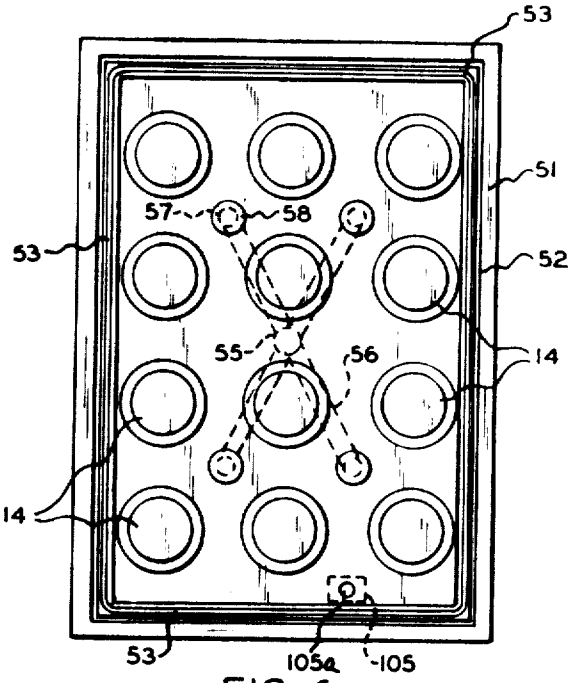


FIG. 6

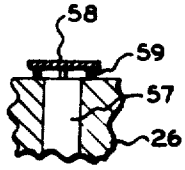


FIG. 7

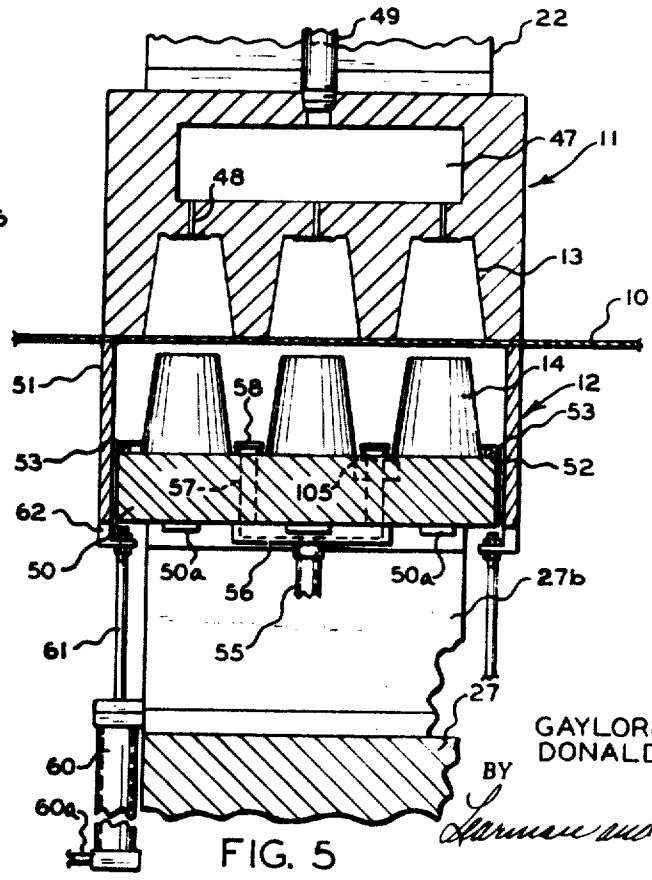


FIG. 5

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DIFFERENTIAL PRESSURE FORMING MACHINE

Original Filed July 10, 1963 5 Sheets-Sheet 5

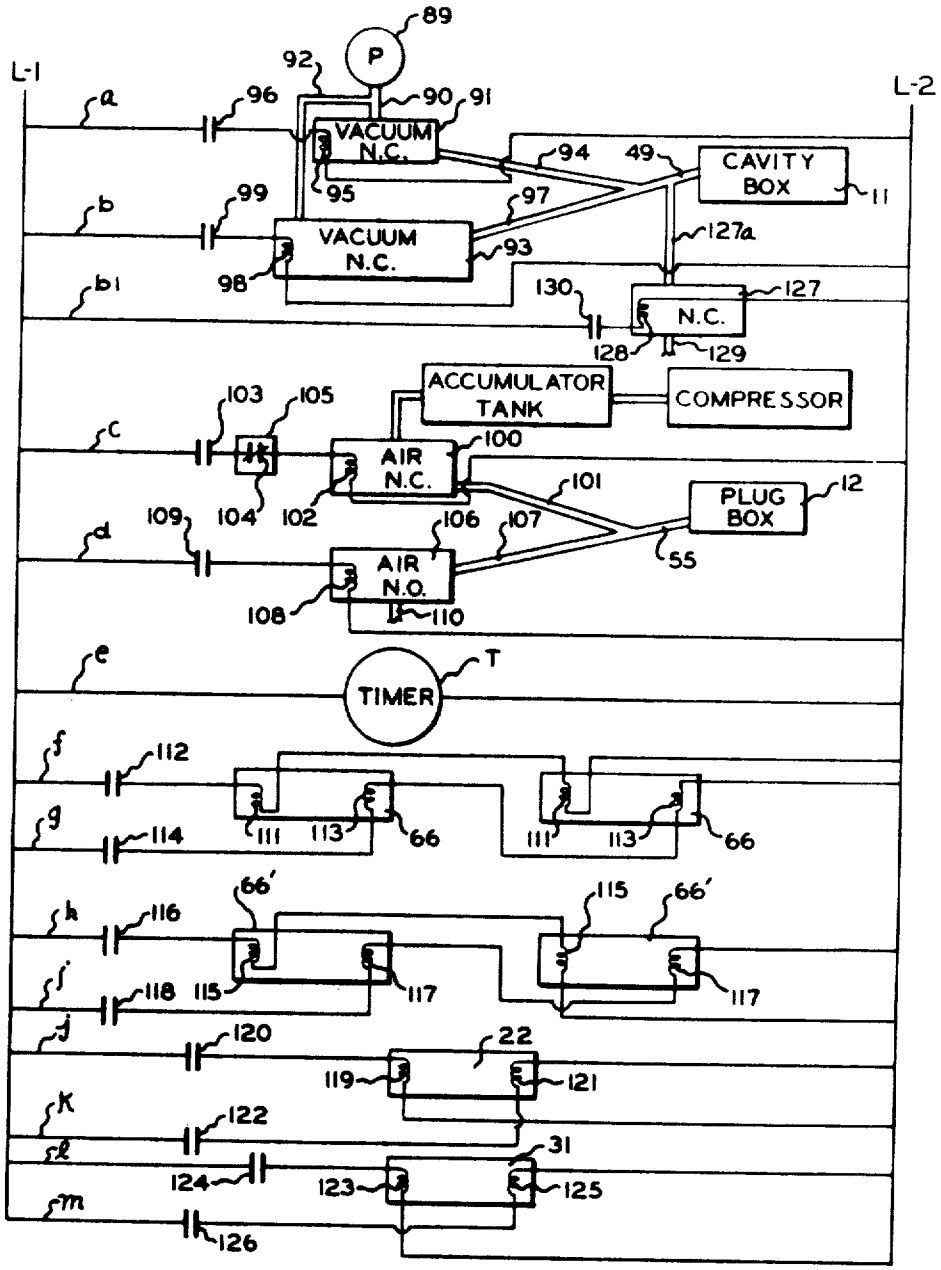


FIG. 8

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United States Patent Office

Re. 27,137
Reissued June 8, 1971

27,137

DIFFERENTIAL PRESSURE FORMING MACHINE

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Original No. 3,346,923, dated Oct. 17, 1967, Ser. No. 293,959, July 10, 1963. Application for reissue Oct. 17, 1969, Ser. No. 877,912

Int. Cl. B29c *3/04, 3/06;* B30b *1/16*

U.S. Cl. 18—19F 16 Claims

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

This disclosure relates to differential pressure forming machines for molding articles in thermoplastic material, and more particularly to certain novel and useful improvements in machines of this nature which permit such machines to cycle more rapidly and therefore to produce an increased quantity of products in an given operating time. The invention is concerned with a machine of the type which can be placed in position for in-line operation with an extruder issuing a continuous sheet of thermoplastic material, or which may be adapted to mold sheets of thermoplastic material which are drawn from a roll. Accordingly, such machines usually include banks of heaters, mounted above and below the level of the sheet which is brought into the machine, to bring the plastic to the forming temperature. Further, forming machines of this character usually employ a pair of platens, one above and one below the sheet or web of material, for mounting male and female die members which cooperate to form products in the preheated sheet of material in accordance with the configuration of the molds. Such machines may be deep draw machines such as are suitable for forming cups and the like or shallow draw machines for forming articles such as cup lids and like articles. Generally speaking, in deep draw machines of this type the male dies are plug assists which aid in moving portions of the plastic sheet into the female cavities, and a vacuum pump is connected to the female cavities to draw the material into engagement with the walls thereof at an appropriate time. Nesting chains are conventionally employed to clamp the sides of the sheet material and at intervals to draw successive lengths of it from the heating zone to a position between the forming dies.

One of the prime objects of the present invention is to provide a machine to form products in a plastic web which can be brought between the forming dies and formed at a lower temperature than heretofore possible, without losing the detail of the dies in the formation process.

A corollary object of the invention is to also provide a machine in which the molds can be used at lower temperatures than the molds of conventional machines, so that the less hot web virtually sets instantaneously when it is brought into intimate contact with the molds and it is not necessary to wait a certain time for the material to cool and set prior to stripping the molds and commencing the next cycle. The deep draw machine which will presently be described can process a sheet which is nearer to setting temperature and can employ a mold which is substantially at room temperature, because air under pressure is employed in conjunction with the suction forces to insure 100% contact of the sheet with the female mold cavities and accordingly 100% heat transfer between the mold surfaces and sheet. However, it has been determined that when air under pressure is introduced in the forming operation the molds tend to separate so that air is lost and this affects the uniformity of the parts molded. The present invention provides means which load the vacuum and air box die frames in a direction to take up the slack in the machine frame, so to speak, and effect a positive seal which permits uniformity to be achieved.

It is another object of the present invention to employ toggle means on the forming machine for effecting this loading and toggle means actuators which are not mounted on the machine frame and restrained thereby, the actuators being so mounted that the preloading forces in the present instance are exerted only in the vertical direction.

A further object of the invention is to provide a machine which applies the air pressure to the sheet in a manner which does not create cold spots on the sheet which would not be formed with the full detail of the molds.

Other objects and advantages of the invention will be pointed out specifically or will become apparent from the following description when it is considered in conjunction with the appended claims and the accompanying drawings, in which:

FIGURE 1 is a side elevational view of the portion of the machine with which the invention is concerned;

FIGURE 2 is a front end elevational view thereof;

FIGURE 3 is an enlarged, fragmentary, side elevational view illustrating particularly the toggle mechanism for loading the upper platen of the machine, the chain lines illustrating the open or force applying position of the toggle mechanism;

FIGURE 4 is a fragmentary, top plan view thereof with parts of the frame broken away to more clearly illustrate elements of the mechanism which otherwise would be obscured;

FIGURE 5 is an enlarged, transverse, sectional view with the die boxes shown in confronting relationship with the plastic web;

FIGURE 6 is a top plan view of the lower die box and the plug assist members which it carries;

FIGURE 7 is a still more enlarged, fragmentary view illustrating one of the baffles used to deflect one of the air streams which are released to pressurize the lower die box at a designated time in the forming operation and prevent the air stream for forming a cold spot on the plastic sheet which would prevent proper molding of the plastic with the necessary detail;

FIGURE 8 is a view illustrating a typical electropneumatic circuit which may be used to control the operation of the various elements of the machine; and

[FIGURE 9 is a schematic view of the pressure responsive valve which is employed to limit the pressure of the air in the lower die box.]

Referring now more particularly to the accompanying drawings, wherein only a preferred embodiment of a deep draw machine is illustrated, a web **10** of a suitable thermoplastic material, such as polystyrene, is shown in FIGURES 2 and 5 disposed between a female die box assembly designated **11** and a male die box assembly generally designated **12**. For the sake of convenience, the female die box assembly **11** is shown as having spaced apart cavities **13** of a size to form a truncated, cone-shaped, thin walled cups in the plastic web suitable for use as drinking cups when separated from the web, and it will be noted that the male die box assembly **12** includes spaced apart, plug assist members **14** in vertical axial alignment with the cavities [**14**] *13*. The cups, which are formed in the plastic web **10**, are formed in inverted position and the formed web is then fed through a separate trim press which severs the cups from the web.

The frame of the forming machine, which is generally designated F, is shown, for the sake of convenience, as comprising upper and lower longitudinal sill members **15** and **16**, respectively, which are connected at both ends by vertical members **17** and upper and lower end cross members **18**. Only the front end of the machine is shown in FIGS. 1 and 2. However, it is to be understood that the frame F is oblong in shape and that the left end also includes suitable end connecting members. Mounted intermediate the ends of the frame are vertical columns **19** which are joined to the lower sill members **16** at their lower ends and are connected by a header channel member **20** at their upper ends. It is the function of the columns **19** to support the female die box assembly **11** and the male die box assembly **12** for vertical travel.

Vertical rails **19a** are secured on the inner walls of the columns **19** to furnish guide surfaces for a vertically traveling upper platen **21** which carries the female die box assembly **11**, angle members **22** supporting the assembly **11** on the platen **21**, as shown. It will be seen that transversely extending angle brackets **23** on the platen **21** support follower roller members **24** and **25** which guide on the inner and side faces of the guide rails **19a**, as shown, during vertical travel of the platen **21**. Mounted on the header member **20** is a pressure fluid cylinder **26** including a piston rod **26a** which is coupled to the platen **21** by a member **[24]** *24'* and clearly, when a suitable fluid under pressure, such as air, is introduced to the upper end of the double-acting cylinder **26**, the platen **21** will be lowered toward the plastic web **10**.

A lower platen **27** is also mounted for vertical travel on the guide **19a**, there being angle brackets **27a** provided on the sides of the platen **27** which mount follower rollers **28** and **29** and angle members **27b** which connect the platen **27** and die box assembly **12**. A sill channel member **30** connects the lower ends of the columns **19** and houses a double-acting, lower platen, pressure fluid cylinder **31** which has a piston rod **32** coupled, by a member **33**, to the lower platen **27**.

The plastic web **10** is fed intermittently between the upper and lower die assemblies **11** and **12** in the usual manner by pairs of superposed, nesting, upper and lower endless chains **34** and **35**, respectively, which are intermittently powered to advance the plastic web **10** from a heating station generally designated **36** (see FIG. 1). The heating station **36** comprises banks of electrically powered heaters **37** mounted on crossbars **38** supported on a frame **39**. While only a few of the heaters **37** are shown, it is to be understood that to the left of the portion of the machine shown in FIG. 1 are banks of heaters above and below the level of the plastic sheet **10** which bring the plastic to the forming temperature. The material advancing chains **34** and **35** are trained around sprockets **40** and **41** at each end which are supported by shafts **42** and **43** journaled by bearing block members **44** (FIG. 2) on support plates **45** which extend from the end sill member **18**. The manner in which the chains **34** and **35** are driven by a shaft **46** will be later explained. For the present, it is simply to be understood that a heated portion of the plastic web **10** is advanced to a position between the die units **11** and **12** by the chains **34** and **35** and that the units **11** and **12** are then moved vertically to the plastic web **10** so that the forming operation can take place.

The upper die unit **11** includes a vacuum manifold chamber **47** which connects to the cavities **13** by means of passages **48**, and a line member **49** is employed to connect the vacuum manifold chamber **47** with a conventional rotary pump and surge tank. The vacuum pump which has been found suitable for the purpose is that manufactured by Gast Manufacturing Co. of Benton Harbor, Mich., which is a 1½ horsepower, 21.6 cubic feet per minute pump.

The plug assist box assembly **12** includes a member **50** mounting the plug assist member **14** in spaced apart relation and a surrounding clamp frame **51**. It is to be understood that there is a clearance of about ⅛ inch

between the clamp frame **51** and the member **50**, and that the member **50** includes a rim **52** mounting a resilient seal **53** which maintains a sealed airtight relationship between the web **10** and plug assist mounting member **50**. The member **50** may be electrically heated by thermostat incorporating resistance heating elements **50a** of the chromalox type. Air under a pressure of about 80 p.s.i. and traveling at about 20 cubic feet per minute is supplied to the assembly **12** via a line **55** which connects with pipes **56** leading from the air supply hose **55** to bored openings **57** in the member **50** and, as shown in FIG. 7, baffle plates **58** are supported over each of the openings **57** on spaced apart pins **59** so that the air stream passing through openings **57** is deflected laterally and does not impinge directly on the plastic web **10**. This prevents cold spots from being formed on the plastic sheet **10** which would not be moldable to take the detail of the die cavities **13**. Mounted by the angle members **27b** in position to urge the clamping frame **51** upwardly into engagement with the plastic strip **10** are pressure fluid cylinders **60** including piston rods **61** connected to brackets **62** which secure to the clamping frame **51**. A pressure of about 80 p.s.i. is maintained in the cylinders **60**, which are connected through lines **60a** at their lower ends to a suitable source of air under pressure.

In order that the platens **21** and **27** will remain in tightly sealed relationship with the plastic web **10** during the time the forming operation is taking place, toggle mechanism is provided for forcing the platens **21** and **27** toward one another and locking them in position. Toggle mechanism is provided in association with both the upper platen **21** and the lower platen **27**, and is particularly illustrated in FIGS. 3 and 4. Mounted at each side of the platen **21** and connected to the channel member **20** and platen **21** are a pair of spaced apart blocks **63a** and **63b** and it will be seen that pairs of links **64** and **65** at each side of the platen **21** connect the upper and lower blocks **63a** and **63b**, respectively, with the outer end of horizontally disposed pressure fluid cylinder **66** which has a piston rod **67**. The blocks **63a** are connected to the channel **20** by threaded members **68** which are secured by nuts **68a**. The relatively expandable and contractable links **64** and **65** are pivotally connected to the upper and lower blocks **63a** and **63b**, at each end of the platen **21**, as with pins **69** and **69a**, and are pivotally connected to the end of each cylinder **65** by a pin **70**. The front end of each piston rod **67** is pivotally connected to the upper and lower blocks **63a** and **63b** by pairs of links **71** and **72**. The links **71** and **72** are connected to the blocks **63a** and **63b** by the pins **69** and **69a** and to the piston rod **67** in each case by a pin **73**. Plainly, when fluid is supplied to the cylinder **26** to move the platen **21** downwardly, the links **64–65** and **71–72** are expanded. Then when the piston rods **67** are moved outwardly the links **64–65** and **71–72** are further expanded to preload the system.

It will be noted that the cylinders **66** and associated linkage are utilized at the sides of the lower platen member **27** as well, except that the toggle mechanisms are inverted so that the blocks **63b** are uppermost. Accordingly, it will not be necessary to describe the toggle mechanisms for the lower platen **27** in detail. The identical parts are given the same numbers except that primed numerals have been employed. The piston rods **67'** of the cylinders **66'** are actuated at the same time as the piston rod **32** and function both to aid in raising the platen **27** and to preload the platen **27** in a direction toward the plastic web and lock it in position. Inasmuch as the cylinders **66** and **66'** are not in any way mounted on the frame of the machine, the preloading movement is not in any way restricted. The down position of the linkage is indicated in the chain lines in FIG. 3 and it will be seen that the links **71** and **72** have not quite reached the dead center position [assumed after the preloading force is exerted.] When the pistons **66** and **66'** are actuated the links move *substantially* to dead center (vertical) position but never beyond it.

The sheet advancing chains **34** and **35** are operated after the forming operation has taken place and the platens **21** and **27** have been retracted vertically, as shown in FIG. 2. Mounted on the opposite ends of shafts **42** and **43** are sprockets **75** and **76** around which are trained chains **77** which are also trained around sprockets **78** provided on the shaft **46**. The mechanism for driving shaft **46** is illustrated in applicants' Pat. No. 3,217,852 and will only be briefly described. A pinion **79** mounted on a shaft **46a** revolves the shaft **46** when the air operated clutch **80** is engaged, there being a diaphragm housing **81** which engages the clutch **80** when air under pressure is supplied to the diaphragm housing **81** through a line **82** in the manner described in the said application. Cylinder **83** includes a rack **84** connected with its piston rod which is in mesh with the pinion **79** and, as the aforementioned application discloses, when the rack member **84** is moved downwardly air is supplied through the line **82** to the air operated diaphragm housing **81** to engage the clutch **80** and transmit the rotation of pinion **79** to the advancing chains **34** and **35**. The cylinder **83** is mounted on a frame column member **85** and mounted on the upper end thereof is a stop bar **86** provided with an adjustable stop bolt **86a**, as shown. When the rack **84** is withdrawn to lowered position in its plastic web advancing stroke, an arm **87** thereon actuates a limit switch **88** mounted on the frame **84** and makes a circuit to immediately energize cylinder **83** to force rack **84** upwardly. At this time, however, the clutch **80** is disengaged since the air under pressure has been bled from line **82** and the pinion **79** is not revolved. The rack **84** continues upwardly until stopped by the stop bolt **86a** and remains in "up" position until the forming operation has been completed and the platens **21** and **27** withdrawn.

The control system

In FIG. 8 is shown a typical circuit diagram including line wires L–**1** and L–**2** and conventional electric and pneumatic components which may be used in the operation of the machine. It is to be understood that other systems may also be used and the instant control arrangement is intended only as exemplary of one system which may be used. The vacuum pump **89** is shown connected by a line **90** to a main vacuum valve **91** and by a branch line **92** to a vacuum bleed valve **93**. The valves **91** and **93** may be normally closed Johnson valves of the type manufactured by Johnson Corporation of Three Rivers, Mich., the valve **91** having an attached valve actuator Model AV114CM such as manufactured by Automatic Valve Co. of Farmington, Mich., and the valve **93** having a similar valve actuator. Valve **91** connects with the flexible vacuum line **49** via a line **94** and includes a solenoid **95** connected in a circuit line a with switch contacts **96**. The valve **93** is connected with vacuum line **49** via a line **97** and includes a solenoid **98** connected in circuit line b in series with switch contacts **99**.

Also provided to supply the plug box assembly **12** with air at the proper time is a normally closed valve **100** connected by means of line **101** with the flexible air supply line **55** leading to the plug box assembly **12**. The valve **100** is preferably a normally closed Mac air valve Model No. 4084, such as manufactured by Mechanical Air Controls Inc. of Detroit, Mich., and includes a solenoid **102** connected in series in circuit line c with switch contacts **103**. Also connected in circuit line c are the normally closed contacts **104** of a conventional pressure actuated switch **105**, the contacts being opened when a predetermined pressure, such as, for example, 40 p.s.i. is reached in the plug box **12**. The pressure switch **105** may be the Model 836–T manufactured by Allen Bradley Company of Milwaukee, Wis. and can be mounted in the member **50** in communication with an opening **105a** as shown in FIG. 6. [A schematic representation of a suitable switch is shown in FIG. 8 and comprises a cylinder **105b** within which is a diaphragm **105c** having a contact **104** on its stem **105d** which is forced normally into engagement with a fixed contact **104** by a spring **105e** of predetermined strength. The contacts **104** are suitably insulated from the cylinder and an opening **105f** is provided in the cylinder to admit the pressure fluid thereto.] A normally open air valve **106** also communicates with the air line **55** via a line **107** and has a solenoid **108** connected in a circuit line d in series with normally open contacts **109**. The valve **106** may also be a Mac valve No. 4086 which exhausts to atmosphere out a port **110**.

Also, as will be seen, the lines L–**1** and L–**2** power a timer motor T which is disposed in circuit line e. The timer can be an Eagle Multiflex timer of the type manufactured by Eagle Signal Co. of Moline, Ill. The double-acting air cylinders **66** for locking the toggle links **64**, **65**, **71**, and **72**, which preload the upper platen **21**, are shown as having advance solenoids **111** connected in a series line f with normally open switch contacts **112** and retract solenoids **113** connected in a circuit line g with normally open switch contacts **114**. Similarly, the double-acting air cylinders **66'** which preload the lower platen **27** are shown as having advance solenoids **115** connected in a circuit line h with normally open switch contacts **116** and retract solenoids **117** connected in a circuit line i with normally open switch contacts **118**. The double-acting air cylinder [**22**] *26* for powering the upper platen **21** includes an advance solenoid **119** connected in a circuit line j with normally open switch contacts **120** and a retract solenoid **121** connected in the circuit line k with normally open switch contacts **122**. Similarly, the double-acting air cylinder **31** for powering the lower platen **27** includes an advancing solenoid **123** connected in a circuit line l with normally open switch contacts **124** and a retract solenoid **125** connected in a circuit line m with normally open switch contacts **126**, as shown. Each of the air cylinders **66**, **66'**, [**22**] *26* and **31** may be of the type manufactured by The Bellows Co. of Akron, Ohio.

To refill the die box **11** with air once the vacuum forces are released, a valve **127**, which is operated by a solenoid **128** and opens to atmosphere as at **129**, is connected with line **49** as shown via line **127a**. The valve may be a Skinner solenoid valve Model L2DB4–150 of the type manufactured by Skinner Chuck Co. of New Britain, Conn. and is operated by switch contacts **130** in circuit line b_1.

It may be assumed for the sake of simplicity and convenience that the normally open contacts **96**, **99**, **103**, **109**, **112**, **114**, **116**, **118**, **120**, **122**, **124**, **126**, and **130** are switch contacts closed by the timer motor T for the length of time required in each instance, and at the proper time, but obviously they could be limit switches located in the path of the various moving elements to operate the components in proper sequence. For instance, the switch contacts **120** and **112** could be additional contacts of the limit switch **88**, the contacts **124** and **116** could be limit switch contacts located in the path of platen **21**, the contacts **99** could be limit switch contacts located in the path of platen **27**, the contacts **103** and **96** could be limit switch contacts located in the path of the pistons of cylinders **66**, and the contacts **122** could be limit switch contacts located in the path of the clamp frame **50**.

The operation

Once the sheet advancing chains **34** and **35** have moved to draw an unformed portion of the plastic web **10** between the die boxes **11** and **12**, the timer T operating the cylinder **83** in the manner defined in the application mentioned, the contacts **120** in line j are closed to energize the advance solenoid **119** of air cylinder [**22**] *26* and lower the upper die box **11** into engagement with the plastic web **10**. At the same time the contacts **112** in circuit line f are closed and when the cylinders **66** are able to do so, at the time the platen **11** has reached the position in which it is shown in FIG. 3, they spread the links **64**, **65** and **71**, **72** a final increment which may be

1/32 of an inch to lock the platen in position. Then the contacts **124** in circuit line l are closed and energize the advance solenoid **123** of the air cylinder **31** so that the lower platen **27** commences to move upwardly toward the plastic sheet **10**. First of all, the clamp frame **51** will engage the plastic web **10** to clamp the sheet firmly between itself and the upper die box **11** and thereafter further upward movement of the piston rod **32** and platen **27** will cause the plug assist members **14** to deform the heated plastic as the plug assists **14** commence to enter the cavities **13**. Just as the plastic web **10** commences to enter the cavities **13**, the contacts **99** in circuit line b are closed and the solenoid **98** is energized to open the normally closed vacuum bleed valve **93** and bleed the air out of the cavities **13** at a controlled rate corresponding to the displacement of air within the cavities **13** which is caused by the plug assists and plastic entering the cavities **13**. At the same time the contacts **116** in circuit line h are closed to energize the advance solenoids **115** of the cylinders **66'** and, when the piston rod **32** reaches the limit of its upward travel, the links **64'**, **65'** and **71'**, **72'** are spread a final increment, which may be about 1/32 of an inch, to lock the die members **11** and **50** in sealed relation. Then the contacts **103** in circuit line c are closed and normally closed valve **100** is opened to admit air under pressure from the compressor accumulator tank to the air line **55** and to the interior of the plug box assembly **12**. Just before the contacts **103** are closed and air valve **100** is opened, the contacts **96** in circuit line a are closed and the main vacuum valve **91** is opened to remove the remainder of the air from the female die **11**. At the same time the contacts **109** are closed and valve **106** closes. Thus, both the air pressure developed in the plug assist box assembly **12** and vacuum forces are utilized to move the plastic into intimate contact with the die cavity walls to insure that the deformed plastic conforms exactly to the cavities **13** in detail.

Because the dies **13** are maintained at substantially room temperature, the plastic sets immediately upon contact with metal of the die **11** and the set is uniform over all of the area of the plastic displaced within the cavities **13** because the plastic comes into intimate contact with all of the area of the die surface. For this reason it is only necessary for the die boxes **11** and **12** to remain closed for an instant. When the pressure within the plug assist box assembly **12** reaches a predetermined value, such as 40 p.s.i., the pressure switch **105** is actuated to open normally closed contacts **104** in circuit line c and, of course, deenergize solenoid **102** so that normally closed valve **100** closes immediately. In this way, then, the pressure is prevented from building to a point where it would separate the mold boxes and, of course, with the pressure streams being deflected by baffles **58**, cold spots are not created by the air stream which would cause local hardening of the plastic during the forming operation. The male members **14** are maintained at a suitable temperature so that they also do not cause local hardening of the plastic when they engage it.

Once the plastic web **10** has been fully formed in the manner described, normally open contacts **109** in circuit line d can be opened to deenergize the solenoid **108** of the exhaust valve **106** and open the valve **106** to bleed air from the plug assist box assembly **12** to atmosphere. At the same time, the contacts **96** in circuit line a, and **99** in circuit line b are opened, and normally closed valves **91** and **93** are closed and release the vacuum forces in line **49** and vacuum box assembly **11**. Also at this time, the normally open contacts **130** in line b, are closed and the solenoid **128** of valve **127** is energized so that the normally closed valve **127** is opened to furnish the vacuum box **11** with air. At substantially the same time, the contacts **118** in circuit line i and **126** in circuit line m are closed to energize solenoids **117** and **125**, respectively, and first retract the piston rods of cylinders **66'** so that the preloading forces are removed from the platen **27** and thence

retract the platen **27**. The clamp frame **51** will remain in engagement with the plastic web **10** as the plug assists **14** are retracted during the initial part of the retracting stroke because of the pressure developed in the cylinders **60**. However, during the remainder of the stroke the pressure in cylinders **60** will be relieved with downward movement of the platen **27** and the clamp frame **51** will also be retracted from engagement with the plastic web **10**. As soon as the frame **51** clears the sheet **10** the contacts **114** in circuit line g and **122** in circuit line k are closed to energize solenoids **113** and **121** and unlock and retract the upper platen **11**. The timer T then will again energize cylinder **83** to power the advancing chains **34** and **35** and advance the plastic web **10** an increment sufficient to dispose unformed plastic between the die assemblies **11** and **12** once again, the rack **84** having been returned upwardly when the limit switch **88** was energized on the retract stroke of the rack **84** but failing to drive the shaft **46** because of the disengagement of the clutch **80**. Accordingly, the cycle can be repeated.

It should be appreciated that the cycle requires only about two seconds to complete, and thus it should be clear that the machine operates much faster than conventional machines and is a considerable improvement in the art. Whereas the cavity die box of conventional machines has been maintained at a temperature of about 130° F., it now can operate at room temperature. The cylinders **66** and **66'** which lock the die boxes **11** and **12** in assembled relation positively prevent any separation of the boxes **11** and **12** at the crucial moment when the air pressure within the plug assist box assembly **12** has reached a maximum and there is no need for a cooling period once the cups have been formed in the web **10** because the plastic virtually sets immediately over the whole surface of the plastic formed.

It is to be understood that the drawings and descriptive matter are in all cases to be interpreted as merely illustrative of the principles of the invention, rather than as limiting the same in any way, since it is contemplated that various changes may be made in the various elements to achieve like results without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. In a differential pressure forming machine for molding articles in a sheet of thermoplastic material: a pair of oppositely disposed die support box frames mounted for relative movement toward and away from one another; aligned male and female die means for said frames; fluid pressure actuated means connected with one of said frames for moving it toward the other frame; means for supporting a web of plastic between said frames; means for sealing both frames at a time when they are brought into engagement with said web; means for applying a vacuum to one of said box frames; means for substantially simultaneously introducing air under pressure through a line into the other box frame at a line pressure; and pressure responsive means downstream from said line and in said other box frame continuously sensitive to the actual pressure of the air in said other box frame for disabling said means for introducing air under pressure and limiting the pressure of the air in said other box frame to a maximum designated pressure less than said line pressure.

2. In a differential pressure forming machine for molding articles in a sheet of thermoplastic material; stationary frame means; a pair of oppositely disposed die support frames thereon mounted for relative movement; means for supporting a plastic web therebetween; cooperating male and female die members arranged in aligned, spaced relation on said frames; fluid pressure operated motor means for moving at least one of said frames toward the other to engage said web; expandable toggle link means carried by one of said frame means and connected to react between said frame means and at least one of said die support frames and lock said one of said die support frames in position on said web; means actuatable to expand said

link means and exert a loading force on said one frame in a direction toward the other frame; and means operable *for* only thereafter [for introducing] *providing* a fluid under *a* pressure *which would otherwise spread said die frames* in [to] one of said die frames to form the web to the configuration of the female die means.

3. The combination defined in claim 2 in which said means actuatable to expand said link means comprises a fluid pressure cylinder and a piston rod therein; and said link means comprises: a block connected to said stationary frame means, a block connected to said one of said die support frames, links connected to the rear of said cylinder and to each of said blocks, and links connected to said piston rod and to each of said blocks.

4. In a differential pressure forming machine for forming articles in thermoplastic material; frame means; a pair of oppositely disposed die support platens mounted in spaced relation thereon for movement toward and away from one another; a female die box on one of said platens and a plug assist die box on the other with the plug assists in alignment with the cavities of the female die means; means for supporting a web of formable plastic between said die boxes against which said boxes seal when they are brought together; means for moving said female die box into engagement with the web; means for thereafter moving said plug assist die box into engagement with said web and deforming said web into said cavities with said plug assists; means for introducing air through a line under pressure into said plug assist die box after said plug assist die box has traveled to its extended position; means for substantially simultaneously evacuating the air from said female die box; and means sensitive to the pressure in said plug assist die box in said plug assist die box and for terminating the introducion of air under pressure to said plug assist die box when a predetermined pressure less than said line pressure has been reached therein.

5. In a differential pressure forming machine for forming articles in a sheet of thermoplastic material; frame means; a pair of oppositely disposed, vertically spaced, die support platens mounted in spaced relation thereon for movement toward and away from one another; a female die means with cavity means on one of said platens and a plug assist die means with *at least one air admitting opening and* plug assist means on the other, the plug assist means being in alignment with the cavity means of the female die means; means for supporting a web of formable plastic between said die means against which said die means seal when they are brought together; an electrical control circuit; first fluid pressure operated motor means connected in said circuit for moving said female die means into engagement with the web; second fluid pressure operated motor means connected in said circuit for moving said plug assist die means into engagement with said web and deforming said web into said cavity means with said plug assist means; expandable toggle linkage means carried by said platens and reactable between said frame means and said platens for preloading said platens and locking them against said web; means connected in said circuit and operable to expand said linkage means; means connected in said circuit *and communicating with said air admitting opening* for [introducing] *providing* air under a *forming* pressure *which otherwise would spread said platens in* [into] said plug assist die means only after said linkage means has been expanded; means for substantially simultaneously evacuating the air from said female die box; means connected in said circuit for thereafter retracting said first and second fluid pressure operated motor means and moving said platens away from said web; and means connected in said circuit releasing said linkage means to contract at the time said platens move away from said web.

6. In a differential pressure forming machine for forming articles in thermoplastic material; frame means; a pair of oppositely disposed die support platens mounted in spaced relation thereon for movement toward and away from one another; a female die box on one of said platens and a plug assist die box on the other with the plug assists in alignment with the cavities of the female die means; said plug assist die box including a clamp frame and a plug assist plate mounted therein for relative movement therewith; yieldable means connecting said clamp frame and plug assist plate; means for supporting a web of formable plastic between said die boxes against which said boxes seal when they are brought together; means for moving said female die box into engagement with the web; means for moving said plug assist die box toward said web with said clamp frame first engaging said web and said plug assist plate continuing to move to deform said web into said cavities with said plug assists; means for introducing air under pressure into said plug assist die box after said plug assist die box has traveled to its extended position; means for simultaneously evacuating the air from said female die box; and means in said plug assist die box and sensitive to the pressure in said plug assist die box for terminating the introduction of air under pressure to said plug assist die box when a predetermined pressure has been reached therein.

7. The combination defined in claim 6 in which said yieldable means comprises fluid cylinders mounted to one of said clamp frame and plug assist plate with the piston rods thereof mounted to the other.

8. In a differential pressure forming machine for molding articles in thermoplastic material: frame means; a pair of oppositely disposed mold frames mounted thereon; one of said frames including cavity means and the other comprising an air box frame; means connected with at least one of said frames for moving it toward the other frame; means for supporting a web of plastic between said frames; means for applying a vacuum to said cavity means; line means for introducing fluid under pressure into the air box frame at a line pressure greater than that desired in said air box frame; and pressure responsive means, downstream from said line means and sensitive to the pressure in said air box frame, disabling the fluid pressure introducing means when a designated pressure less than said line pressure is reached in said air box frame.

9. In a differential pressure forming machine for forming articles in a sheet of thermoplastic material; frame means; a pair of oppositely disposed, vertically spaced, die support platens mounted in spaced relation thereon; one of said platens having a female die with cavity means and the other having an air box *having at least one air admitting opening therein*; means for supporting a web of formable plastic between said platens; an electrical control circuit; motor means connected in said circuit for moving one of said platens to the other and into engagement with the web; expandable toggle linkage means reactable between said frame means and said movable platen for locking said platen against said web; means connected in said circuit *communicating with said opening* and operable to expand said linkage means; means connected in said circuit for [introducing] *providing* air under *a forming* pressure *which otherwise would spread said platens in* [into] said air box only after said linkage means has been expanded; means for substantially simultaneously evacuating air from said cavity means; means connected in said circuit for thereafter retracting said motor means and moving said movable platen away from said web; and means connected in said circuit releasing said linkage means to contract to permit said platen to move away from said web.

10. In a differential pressure forming machine for forming articles in thermoplastic material: frame means; a pair of oppositely disposed die support platens mounted in spaced relation thereon for movement toward and away from one another; a female die box on one of said platens and a plug assist die box on the other with the plug assists in alignment with the cavities of the female die means; means for supporting a web of formable plastic between said die boxes against which said boxes seal when they are brought together; means for moving said female

die box into engagement with the web; means for thereafter moving said plug assist die box into engagement with said web and deforming said web into said cavities with said plug assists; means for introducing air under pressure into said plug assist die box after said plug assist die box has traveled to its extended position; means for substantially simultaneously evacuating air from said female die box; and means for terminating the introduction of air under pressure to said plug assist die box when a predetermined pressure has been reached therein; said means actuatable to expand said link means comprising an air cylinder with a piston rod therein; and said link means comprising: a member connected to said stationary frame means, a member connected to said one of said die support frames, links connected to the rear of said cylinder and to each of said members, and links connected to said piston rod and to each of said members.

11. In a differential pressure forming machine for molding articles in thermoplastic material: frame means; a pair of oppositely disposed mold frames mounted thereon; one of said frames including mold cavity means and the other comprising an air box frame *communicating therewith*; means connected with at least one of said frames for moving it toward the other frame; means for supporting a web of plastic between said frames; means for applying a vacuum to said cavity means; toggle linkage means reactable between said frame means and movable frame *movable substantially* to a dead center position to positively lock said movable frame against the plastic web; motor means independent of said frame moving means for moving said toggle linkage means to and from *substantially* dead center position; and means operable *substantially* only after said toggle linkage has been moved to *substantially* dead center position for introducing air under pressure to said air box frame to aid the differential pressure molding operation.

12. The combination defined in claim **8** wherein expandable toggle linkage means is reactable between said movable frame and frame means to *substantially* a dead center position *to* lock said frame against said web prior to the time said means for introducing fluid under pressure is operated.

13. In a machine for deforming a sheet of thermoplastic synthetic plastic material: a frame; a pair of opposed die parts mounted thereon; means for supporting a web of plastic between said die parts; drive means, connected with at least one of said die parts, for moving it toward the other die part, through a path of travel to substantially engage one side of said web of plastic and for returning it to a remote position; toggle linkage means, reactable between said frame and said movable die part, and movable, after said die part has moved to substantially engage said web, to a substantially dead center position to lock the movable die part against the plastic web; motor means supported by said toggle linkage means independently of said die part moving means for moving said toggle linkage means to and from substantially dead center position; and control means for cyclically operating said drive means and motor means.

14. A machine as set forth in claim 13, wherein said toggle linkage means includes first and second toggle link sets connected between said one die part and said frame, said motor means being reactable between said first toggle link set and said second toggle link set to move one of said toggle link sets to substantially dead center position.

15. A machine as set forth in claim 14 wherein said first toggle link set comprises a firstt pair of pivotally connected links pivotally connected by a first connecting pin, one of the links of said first pair of pivotally connected links being pivotally connected with said frame and the other of the links of said first pair of pivotally connected links being pivotally connected with said die part; said second toggle link set comprises a second pair of pivotally connected links pivotally connected by a second connecting pin, one of the links of said second pair of links being pivotally connected to said frame and the other of the links, of said second pair of links being pivotally connected to said die part; and said motor means comprises a pressure fluid operated device, including a cylinder pivotally connected with said first connecting pin, and a piston rod pivotally connected with said second connecting pin.

16. In a differential pressure forming machine for molding articles in a sheet of thermoplastic material: stationary frame means; a pair of oppositely disposed die support frames thereon mounted for relative movement; said die support frames including cooperating male and female die members arranged in aligned, spaced relation on said die support frames; means for supporting a plastic web between said die members; fluid pressure operated motor means for moving at least one of said die support frames toward the other to engage said web; expandable toggle link means carried by one of said die support frames and connected to react between said frame means and at least one of said die support frames and lock said one of said die support frames in position on said web; means actuatable to expand said link means and exert a loading force on said one die support frame in a direction toward the other die support frame; and means operable only thereafter for introducing a fluid under pressure to one of said die members to form the web to the configuration of the female die member.

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U.S. Cl. X.R.

18—16T, 16.5, 19R

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. Re. 27,137 Dated June 8, 1971

Inventor(s) G. W. Brown et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In column 10, line 54, delete "communicating with said opening".

In column 10, line 56, after "circuit" insert -- communicating with said opening --.

Signed and sealed this 21st day of December 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents

ORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334