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(71) Applicant and
(72) Inventor: **SCHUETT, Reiner** [US/US]; 3720 Starview Road, Mount Wolf, PA 17347 (US).

(74) Agents: **HABIB, Jeffrey, S.** et al.; Thomas Hooker, P.C., 100 Chestnut Street, Suite 304, Harrisburg, PA 17101 (US).

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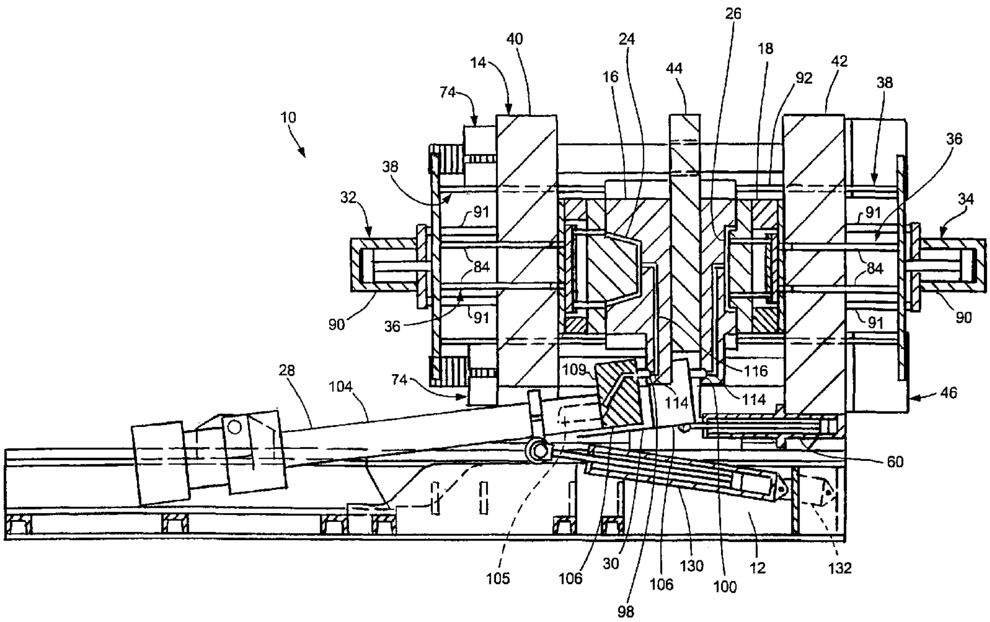
(54) Title: INJECTION MOLDING MACHINE



(57) Abstract: A compact injection molding machine (10) includes a clamping unit (14) mounted on a frame (12). The clamping unit has platens (40, 44; 42, 44) defining one or more mold stations (16; 18). An injection unit (28; 30) is associated with each mold station. Each injection unit extends into its associated mold station to engage a mold inlet (98; 100) in the mold station. The top and sides of the mold stations are accessible for removal of molded articles.

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INJECTION MOLDING MACHINE

TECHNICAL FIELD

The invention relates to injection molding machines.

BACKGROUND ART

Injection molding machines are widely used to produce molded articles. The articles are molded in molds having separable mold plates or mold halves. The mold halves have one or more facing recesses that define one or more mold cavities when the molds are closed. Molding material, commonly molten plastic, is injected into the closed molds and fills the mold cavities. After the molten plastic has cooled and solidified, the mold is opened and the molded article is removed. The mold is then closed to repeat the cycle.

A standard injection molding machine includes a clamping unit mounted on a frame. The clamping unit opens and closes a mold and includes a pair of platens that define a mold station. The mold halves are mounted on the platens in the mold station. One platen is stationary and the other platen moves horizontally towards and away the stationary platen to close and open the mold. The clamping unit holds the mold closed during injection of the molten plastic.

The mold half attached to the stationary platen includes a feed system, typically a hot runner system, that flows molten plastic through channels into the mold cavities. The hot runner system includes a mold inlet that faces an opening extending through the stationary platen. An injection unit extends through the opening in the stationary platen and is connected to the mold inlet. When the mold is closed, the injection unit injects molten plastic into the mold. The plastic flows through the channels and fills the mold cavities. After the mold is filled, the mold usually remains closed to allow the molten plastic to cool and solidify.

The molten plastic is injected into the mold under high pressure. The pressure of the plastic filling the mold attempts to open the mold and push apart the platens. The clamping unit clamps the platens and prevents the mold from opening during injection. After the mold cavities are filled, the injection pressure is relieved and the clamping pressure is relieved.

During molding, the injection unit remains engaged against the mold inlet to prevent leakage from the inlet.

Standard injection molding machines are molding increasingly larger and more complicated articles, including automobile bumpers and body panels. These require ever larger injection molding machines, with larger molds, clamping units and injection units. The machines have large "footprints" and take up large amounts of valuable factory floor space.

Injection molding machines modified to increase the productivity of standard injection molding machines are known. However, these injection molding machines are not suitable for molding large articles and do not provide much flexibility in the types of articles that can be molded in the machines. The machines also require molds that cannot be used in a standard injection molding machine for testing or production flexibility.

Injection molding machines having stack molds have been developed to mold articles in two or more molds simultaneously. A typical stack mold is in effect two molds connected together and includes a pair of end platens and a center platen between them. Mold stations are defined between the platens, with the facing sides of the platens defining mold cavities. The platens are mechanically interconnected so that moving the end platens simultaneously opens and closes both molds.

A stack mold enables molding of differently shaped articles in two molds at the same time. However, stack molds have a number of disadvantages. The mechanical interconnection of the mold plates is complicated and expensive, obstructs access to the mold stations for changing molds and interferes with removal of the molded articles. The injection unit extends through one end platen to engage the center platen to feed both molds. The mold surrounding the injection unit cannot have one large mold cavity so that large articles cannot be molded simultaneously in both molds. Stack molds therefore are generally limited to high production of small, identical parts.

Tandem injection molding machines are also known for molding in two molds with one machine. A tandem injection molding machine has two molds, each mold having its own feed system and separate mold inlets on the sides of the mold. The injection unit engages the mold inlet of the first mold and injects molten plastic into the first mold. Then, the injection unit moves to the mold inlet of the second mold and injects molten plastic into the second mold.

Tandem injection molding machines also have disadvantages. The injection unit cannot remain engaged against either mold inlet during opening and closing of the molds. Sealing the open mold inlets is difficult and so plastic will leak from the inlets. Both articles must be molded using the same molding material.

Thus, there is a need for an improved injection molding machine. The improved injection molding machine should enable molding of large articles in two or more molds simultaneously and yet be relatively compact for use in existing factories. The improved machine should be able to mold different articles with different material compositions. The improved injection molding machine should be usable with conventional hot runner systems, and should be able to use molds that can be used in a standard injection molding machine.

DISCLOSURE OF INVENTION

The present invention is directed to an improved injection molding machine. The improved injection molding machine can mold two or more large articles simultaneously and yet has a compact footprint. Articles molded with the improved injection molding machine may have different material compositions and may be molded using conventional hot runner systems. Molds usable in the improved injection molding machine can be adapted for use in a standard injection molding machine.

An injection molding machine having features of the present invention includes a clamping unit mounted on a frame. The clamping unit has a pair of platens defining a mold station. One platen moves horizontally with respect to the other to open and close a separable mold in the mold station. An injection unit adjacent one platen extends a nozzle into the mold station axially between the platens. The nozzle is engagable with a mold inlet to flow molding material through the nozzle and into the mold. The injection unit does not extend through the one platen.

Placing the nozzle between the platens to engage the mold inlet reduces the length of the machine and enables the machine to have a compact footprint. Preferably, the injection unit extends beneath the one platen so that the top and sides of the mold station are accessible for article removal and mold maintenance.

The injection unit can be moved to position the nozzle at a purge area away from the mold inlet for purging molding material from the injection unit or other maintenance. The nozzle is preferably located in the purge area such that purged molding material discharged from the nozzle does not flow against the mold or the mold inlet. Costly and time consuming clean up of purged plastic prior to restarting molding cycles are avoided. If desired, the molding cycle can restart immediately after purging and cleanup of the purged plastic can be postponed to a more convenient time.

In some embodiments of the present invention, the mold inlet is located on a mold half attached to the movable platen. The injection unit is movable with the mold half during the molding cycle and maintains a sealed flow connection between the nozzle and the mold inlet. The sealed connection prevents leakage from the mold inlet during the molding cycle. The injection unit can be driven during the molding cycle by a drive that also moves the injection unit to the purge area. In other possible embodiments the injection unit can be mechanically interconnected with the mold half during the molding cycle to maintain the sealed flow connection.

In yet other embodiments of the present invention an auxiliary drive is be mounted on the side of a platen facing away from the mold station to assist in opening the mold and positioning the mold halves. The auxiliary drive may form part of a multi-function device that incorporates a conventional ejector mechanism. The auxiliary drive and the ejector mechanism share common components to reduce cost.

In preferred embodiments of the present invention the clamping unit includes one or more additional movable platens and defines two or more horizontally aligned molding stations. One or more injection units are associated with each mold station. Each injection unit is beneath the clamping unit to engage a mold inlet of a mold in the molding station associated with that injection unit. Some or all of the molds may define a single large molding cavity for molding a large article. The machine can simultaneously mold a number of large articles, and yet has a compact footprint not substantially larger than that of a conventional single mold injection molding machine.

The injection units can inject different molding material into each of the different molds. For example, an injection unit associated with one mold station may inject red molten plastic in one mold and an injection unit associated with another mold station may inject green molten plastic in the other mold. The injection units can simultaneously inject the molding materials into the molds to minimize the mold cycle time. The operating parameters and mold processing in each mold are practically identical to those of a standard injection molding machine.

The movable platens are independently driven and are not mechanically interconnected. The platen drives do not block access to the sides or top of the molding stations. The opening and closing strokes of the individual platens can be individually controlled to adjust for different mold sizes and molding differently sized articles. The platens can also be individually moved to provide additional space in a molding station when changing molds or performing mold maintenance.

In possible embodiments the clamping unit can include two pairs of diagonally opposed tie bars that extend between the corners of a pair of movable platens. The platens are located adjacent to different mold stations. The tie bars apply a clamping force to the platens during injection of the molds. One pair of tie bars are mounted on one platen and move with the platen. The other pair of tie bars are mounted on the other platen and move with the other platen. When the molds are opened, the pairs of tie bars are spaced from the opposite platens and enable access to opposite sides of the mold stations.

Injection molding machines of the present invention may use molds adapted for use in standard injection molding machines. Such molds have a mold inlet for use with a standard injection molding machine and one or more mold inlets positioned for use in an injection molding machine of the present invention. Unused mold inlets are plugged. The molds may be used on either type of injection molding machine as needed and enables testing of molds on a standard machine without loss of production on the improved machine.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings illustrating the invention, of which there are thirteen sheets of five embodiments.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a partial sectional view of the side of a first embodiment injection molding machine in accordance with the present invention, showing the molds closed and the injection units positioned against the molds;

Figure 2 is a top view of the injection molding machine shown in Figure 1;

Figure 3 is a partial sectional view of the side of the injection molding machine shown in Figure 1 with the molds removed and the injection unit nozzles moved to purge areas;

Figure 4 is a view similar to Figure 1 but with the molds partially opened;

Figure 5 is a view similar to Figure 1 but with the molds opened;

Figure 6 is a sectional view taken along line 6-6 in Figure 5;

Figure 7 is a sectional view taken along line 7-7 in Figure 5;

Figure 8 is a partial sectional view of the side of a second embodiment injection molding machine in accordance with the present invention, showing the molds opened and molded articles in the molds;

Figure 9 is a partial sectional view of the side of a third embodiment injection molding machine in accordance with the present invention, showing the molds closed and the injection units positioned against the molds;

Figure 10 is a view similar to Figure 9 but with the molds opened;

Figure 11 is a partial sectional view of the side of a fourth embodiment injection molding machine in accordance with the present invention, showing the molds closed and the injection units positioned against the molds;

Figure 12 is a generally vertical sectional view of a mold half attached to a platen of a fifth embodiment injection molding machine in accordance with the present invention, the mold half having a mold inlet engaged by the nozzle of an injection unit; and

Figure 13 is a view similar to Figure 12 but illustrates the mold half attached to a platen of a standard injection molding machine.

MODES FOR CARRYING OUT INVENTION

Figures 1-7 illustrate a first embodiment injection molding machine 10 in accordance with the present invention. Molding machine 10 molds parts from a molten plastic resin. Other molding materials, including powdered metal, powdered ceramic and the like, may be used in all embodiments of the present invention.

The injection molding machine includes a frame 12 and a clamping unit 14 mounted on the frame 12 for opening and closing two separable molds 16, 18 along a horizontal axis. The clamping unit 14 extends along the axis and defines a pair of axially spaced mold stations 20, 22. The molds 16, 18 are mounted in the mold stations 20, 22 respectively and define mold cavities 24, 26 when the mold halves are closed. A pair of like, laterally spaced injection units 28, 30 are located beneath the clamping unit 14. The injection unit 28 is associated with the mold station 20 and injection unit 30 is associated with the mold station 22 for injecting molten plastic into the mold in the associated mold station. Multi-function ejector/opening devices 32, 34 mounted on the ends of the clamping unit 14 each include an ejector 36 for ejecting molded articles from the opened molds and an auxiliary drive 38 to assist the clamping unit 14 in opening and positioning the molds.

The clamping unit 14 includes a pair of axially spaced end platens 40, 42 located on opposite ends of the clamping unit 14 and a center platen 44 between the end platens 40 and 42. The platens define the mold stations 20 and 22 between adjacent platens. In each mold station 20, 22 the mold halves 16a, 16b and 18a, 18b are attached to the sides of the adjacent platens facing the mold station. The attachment of the mold halves to the platens is conventional. A conventional clamping device 46 clamps the platens while molten plastic is being injected into the molds.

The end platen 42 is stationary and is fixed to the frame 12. The other end platen 40 and center platen 44 are each movably supported on the frame 12 by a connection for axial movement towards and away from the stationary platen 42 to close and open the molds. The connection includes a pair of laterally spaced platen rails 48 fixed on the frame that carry the platens 40, 44.. Each platen 40, 44 has a pair of legs 50 carried on carriages 52 that ride on the platen rails 48. Bearing pads 53 on the carriages 52 engage the top and sides of the platen rails 48 and guide the platens along the rails.

The end platen 40 is driven by a conventional end platen drive 54. The drive 54 includes a pair of diagonally opposed, horizontal hydraulic cylinders 56 that extend from the stationary end platen 42 to the movable end platen 40 along opposite sides of the mold stations. The cylinders 56 are attached to the outside of the stationary platen 42 and have piston rods 58 with free ends mounted on the outside of the end platen 40. Extension and retraction of the piston rods 58 moves the end platen 40 along the rails away from and towards the stationary platen 42.

The center platen 44 is driven independently of the end platen 40 by a pair of hydraulic cylinders 60 that extend beneath the mold station 22. The cylinders 60 are attached to the bottom of the stationary platen 42. Piston rods 62 extend from the cylinders 60 to free ends attached to the lower edge of the center platen 44.

The clamping device 46 is conventional and includes four hydraulic clamping or pressure cylinders 64 mounted on the side of the stationary platen 42 opposite the mold stations. The pressure cylinders 64 generate the clamping force. Four horizontal tie bars 66 extend from the cylinders 64 and transmit the clamping force to the platens. The tie bars 66 are mounted on the corners of the stationary platen 42 and extend through tie bar passages 68 formed in the center platen 44 to threaded or grooved end portions 70. The center platen 44 can move along the tie bars 66. When the molds are closed, the tie bars 66 extend through tie bar passages 72 in the end platen 40. The threaded end portions 70 of the tie bars 66 extend through locking units 74 attached to the side of the end platen 40 opposite the mold stations. The locking units 74 have opposed, movable split nuts

76 that move from an unlocked position spaced from the tie bar threads 70, see Figure 4, to a locked position intermeshed with the tie bar threads 70 to lock the platen 40 to the tie bars as shown in Figure 1.

The like multi-function devices 32, 34 are mounted on the sides of the end platens 40, 42 respectively facing away from the mold stations. Each device 32, 34 is associated with the adjacent mold station 20, 22. The ejector 36 included with each device 32 or 34 actuates a conventional knock-out mechanism 78 housed in the mold half attached to the opposite side of the platen 40 or 42 mounting the ejector. The knock-out mechanism 78 includes a knock-out plate 80 facing the platen and a number of knock-out pins 82 journaled in the mold half. The knock-out plate 80 is movable towards the mold recess to extend the knock-out pins 82 and push a molded article from the opened mold.

The ejector 36 has a number of horizontal ejector push rods 84 carried by an ejector plate 86. The ejector push rods 84 extend from the ejector plate and face the knock-out plate. The ejector push rods 84 are individually journaled in throughbores 88 that extend through the platen 40 or 42. The size, number and spacing of the throughbores 88 is conventional and is compatible with the knock-out mechanisms 78 in the mold halves. Not all the bores 88 contain ejector pins. The ejector plate 86 is movable from a retracted position shown in Figure 1 towards the adjacent knock-out plate 80 by a hydraulic cylinder 90 attached to the platen 40 or 42 by guide rods 91 that guide movement of the ejector plate 86. When the ejector plate 86 is in its retracted position, the ends of the ejector push rods 84 are in the platen and spaced inwardly a predetermined distance from the adjacent open end of the ejector rod throughbores.

The auxiliary drive 38 included with each multi-function device 32, 34 shares the ejector plate and hydraulic cylinder of the ejector. A number of horizontal mold push rods 92 are carried on the ejector plate 86 and are journaled in otherwise unused ejector bores 88. The mold push rods 92 are located in bores 88 at the outer periphery of the platen 40 or 42 clear of the mold half. The mold push rods 92 are longer than the ejector push rods 84 and extend completely through their associated platen 40 or 42 to free ends facing outwardly extending stop blocks 96 attached to the outside of the opposite mold halves. When the ejector plate 86 is in its retracted position and the molds are closed, the free ends of the mold push rods 92 are immediately adjacent the facing stop blocks 96. See Figure 2.

In other possible embodiments of the auxiliary drive, the auxiliary drive can have a separate push rod plate and plate drive. In yet other possible embodiments, the mold push rods may each be a piston rod extending from an individual hydraulic cylinder.

The mold halves 16b and 18a attached to the center platen 44 have a mold inlet 98 and 100 respectively for receiving molten plastic. The mold inlets 98, 100 are located below the mold stations on the lower ends of downwardly extending extensions of the mold halves 16b, 18a. The mold inlets 98 and 100 are flow connected to conventional feed systems or flow passages, preferably a hot runner system 99 and a hot runner system 101 respectively, to flow the molten plastic from the mold inlets to the mold cavities. The mold inlets 98, 100 are laterally spaced apart and lie in a common horizontal plane.

Like injection units 28 and 30 are located on the same end of the clamp unit adjacent the end platen 40. Each injection unit 28, 30 extends along a longitudinal axis that lies in a vertical plane parallel with the horizontal axis and includes an elongate supply barrel 104 which houses a conventional screw extruder unit 105 (shown representationally in Figure 1). A screw drive motor 102 is located adjacent the intake end of the supply barrel 104 and a barrel head 106 is located on the discharge end of the supply barrel 104.

A conventional discharge nozzle 108 is attached to each respective barrel head 106. The nozzles 108 connect to the associated mold inlets 98, 100 during the molding cycle to form a flow connection from the injection unit 28, 30 to the hot runner system 99, 101 respectively. The injection units 28, 30 are laterally spaced from one another to laterally align the nozzles 108 and the mold inlets 98, 100.

Figure 1 illustrates both nozzles 108 in sealed engagement with the associated mold inlets 98, 100. The screw drive motors 102 and intake ends of the supply barrels 104 are adjacent the side of the end platen 40 facing away from the mold stations.

The supply barrels extend below the platen 40 but do not extend through the platen 40 to locate the nozzles 108 against the mold inlets. Each supply barrel 104 is inclined from the horizontal when the nozzle 108 engages its associated mold inlet, with the discharge end of the supply barrel above its intake end and the nozzle 108 spaced vertically above the intake end of its associated supply barrel 104.

Each barrel head 106 includes a flow channel 109 that extends upwardly and away from the supply barrel 104 to a discharge channel in the nozzle 108. The barrel heads 106 position the nozzle discharge channels horizontally when the nozzles are engaged against the mold inlets. The nozzles 108 each connect with a horizontal inlet channel 114 in the facing mold inlet 98 or 100 which flows into an upwardly extending mold flow channel 116 (see Figure 4). The nozzles 108 and mold inlets 98,100 have conforming convex and concave bearing surfaces respectively that press against each other and conventionally seal the flow connection between them.

The nozzles 108 remain against the mold inlets 98, 100 throughout the entire molding cycle. The center platen 44 moves along the platen rails 48 during the molding cycle. The injection units 28, 30 are movably mounted on the frame 12 for coordinated axial movement with the center platen 44 to maintain the flow connections between the nozzles and the mold inlets. The nozzles remain in horizontal and vertical alignment with the mold inlets to maintain sealed flow connections.

The injection units 28, 30 are supported on injection tracks formed from axial extensions 122 of the platen rails 48 away from the end platen 40 and a common inner rail 124. The injection rails 122, 124 support the injection units 28, 30 throughout their conjoint movement with the center platen 44. The injection units 28, 30 are mounted on like injection unit carriages 126 that move on the injection rails 122, 124 and have bearing pads 128 that engage the tops and sides of the injection rails 122, 124 and guide the carriages along the rails.

The injection units 28, 30 are independently driven by pairs of hydraulic cylinders 130, 132 respectively. The cylinders 130, 132 are located on opposite lateral sides of the supply barrels 104. Each pair of hydraulic cylinders 130 or 132 are attached to the frame 12 underneath its corresponding injection unit 28 or 30 and have piston rods 134, 136 respectively attached to its corresponding unit. The cylinders 130, 132 are inclined from the horizontal as shown. The pairs of cylinders 130, 132 can be axially offset from each other as shown to compensate for the axial spacing between the mold inlets and enable use of like cylinders 130, 132.

The injection rails 122, 124 extend a sufficient distance to enable the nozzles 108 of the injection units 28, 30 to be moved to a purge area 142 away from the center platen 44 for purging molding material from the injection units or other maintenance. The injection unit drive cylinders 130, 132 have a sufficient stroke to move the injection units 28, 30 to the purge area 142.

Figure 3 illustrates the injection units 28, 30 located in the purge area 142. As shown, the nozzles 108 are no longer vertically aligned with the mold inlets 98, 100 as during the normal molding cycle. Instead, the nozzles 108 are spaced vertically below the mold inlets 98, 100. The nozzles 108 are lowered when moved to the purge area 142 and are raised prior to re-engaging the mold inlets.

Each injection unit 28, 30 is movably mounted on its carriage 126 for raising and lowering a nozzle 108. The injection unit 28 or 30 is rotatably mounted on a respective axle 144 for raising or lowering the nozzle 108. Each supply barrel 104 is supported on a barrel carriage 146 spaced away from the associated axle 144. The end of the piston rods 134 or 136 are pivotally attached to respective barrel carriage 146 of the attached injection unit 28 or 30.

Each barrel carriage 146 moves along its own axially extending cam track beneath the clamping unit 14 formed from a pair of laterally spaced cam rails 148 or 150. The barrel carriages 146 have guide rollers 152 that engage the top and side surfaces of the cam rails 148 or 150 to guide the movement of the barrel carriages on their respective cam rails.

Each pair of cam rails 148, 150 include horizontal upper and lower sections 154 and 156 respectively connected by an inclined section 158. The barrel carriages 146 are located on the respective upper cam sections 154 when the nozzles 108 are engaged with mold inlets to maintain vertical alignment with the mold inlets. The barrel carriages are supported on the respective lower rail section 156 when the injection unit 28 or 30 is in the purge area 142.

Operation of the injection molding machine 10 will now be described by following one complete molding cycle, it being understood that the machine operates continuously. The injection molding machine 10 is operated by an automatic controller which is responsive to signals received from a number of switches, sensors, transducers and the like on the machine. The controller is conventional and is not illustrated.

The mold cavities defined by the molds 16, 18 may be of conventional design and may be identical to those in molds designed for standard injection molding machines. The molds 16, 18 close along coaxial, horizontal mold centerlines 16c, 18c. It is not necessary that the molds 16, 18 form identical molded parts. For illustration, the injection molding machine is shown molding a deep container in mold cavity 24 of mold 16 and a relatively flat lid for the container in mold cavity 26 of mold 18.

Different molding material may be used in each mold 16, 18. The container and lid may be molded from different plastic resin molding materials or may be molded in different colors. The plastic resin for the mold in a work station is supplied to the supply barrel 104of the injection unit 28 or 30 associated with that work station 20 or 22. The injection units 28, 30 melt the plastic resin and pressurize the molten plastic for injection into the molds 16, 18 in a conventional manner.

Figure 1 illustrates the injection molding machine 10 while molten plastic is being injected into the molds 16, 18 by the injection units 28, 30 respectively. For clarity, the molten plastic is not shown. Articles previously molded in the molds have been removed. Both ejector drive hydraulic cylinders 90 of the multi-function devices 32, 34 are retracted to retract both sets of ejector push rods 84 and the mold push rods 92. The clamping unit 14 is clamping the platens. The center platen 44 is pressing the closed mold 18 against the stationary end platen 42 and the movable end platen 40 is pressing the closed mold 16 against the center platen 44.

Each injection unit 28, 30 is positioned in an injection position on the injection rails 122, 124, with the barrel carriages 146 on the upper cam rail sections 154. The injection units 28, 30 are spaced laterally on opposite sides of the mold centerlines 16c, 18c. The curved bearing surfaces on the nozzles 108 and the mold inlets 98, 100 engage each other and form sealed flow connections as previously described. At each mold station pressurized molten plastic flows from the supply barrel 104, upwardly through the discharge channel 110 and horizontally through the nozzle 108 and the inlet channel 114. The molten plastic then flows upwardly from the mold inlets through the feed channels 109 of the hot runner systems 99 or 101 to fill the mold cavities 24 and 26.

The injection units 28, 30 operate in parallel and simultaneously inject molten plastic into each mold. If desired, the start of injection in one mold may be delayed so that the cycle times of the two molds differ. The top and sides of the mold stations 20, 22 are accessible and enable personnel or equipment to visually monitor molding operations and look for leaks and the like.

During injection the clamping device 46 applies a clamping force to hold the molds closed. The end platen 40 is locked to the tie bars 66. The pressure cylinders 64 are pressurized and pull the tie bars 66 and the end platen 40 towards the stationary platen 42 to apply a clamping force to the closed molds.

Both sides of the center platen 44 are compressed by the clamping force. The forces oppose each other and so forces tending to bend the center platen 44 are small. Because the platen 44 does not have to resist substantial bending forces, the platen 44 can be substantially thinner than either end platen 40 or 42 as shown.

After the mold cavities 24, 26 are filled, molten plastic stops flowing into the molds 16, 18 and the injection units 28, 30 relieve the injection pressure. The pressure applied to the pressure cylinders 64 is then released and the locking units 74 unlock to release the end platen 40 from the tie bars 66. The molds 16, 18 remain closed for a predetermined time to enable the cooling and solidifying of the plastic in the mold cavities.

When the plastic has sufficiently cooled, the molds 16, 18 are opened to remove the molded articles. Figure 4 illustrates the injection molding machine 10 during mold opening prior to the molds 16, 18 being fully opened. For clarity, the articles being molded are not shown.

The hydraulic cylinders 56 and 60 attached to the end and center platens 40 and 44 respectively act together and form a mold opening and closing drive. The cylinders 56, 60 extend simultaneously and move the platens 40, 44 along an opening stroke along the tie bars and away from the stationary platen 42. The end platen 40 is driven at a maximum speed and the center platen 44 is driven at a slower speed to open both molds 16, 18 simultaneously. The hydraulic cylinders 130, 132 attached to the injection units 28, 30 also simultaneously extend and move the injection units 28, 30 with the center platen 44. The barrel carriages 146 travel on the upper cam rail sections 154 during mold opening and closing to maintain alignment of the nozzles 108 with the mold inlets 98, 100. The injection units 28, 30 move at the same speed as the center platen 44 and maintain the sealed flow connection between the nozzles and the mold inlets.

Mold opening is resisted by adherence of the molded articles to the mold cavities 24 and 26. In particular, the opening motion of the end platen 44 is resisted by adherence in both mold cavities 24 and 26. The auxiliary drives 38 assist the mold opening and closing drive in overcoming such adherence. The auxiliary drives 38 are energized simultaneously with the mold opening and closing drive. The ejector hydraulic cylinders 90 move the ejector plates 86 and push the mold push rods 92 against the stop blocks 96. The mold push rods 92 apply an opening force to the molds in addition to the opening force generated by the mold opening and closing drive.

As the molds open, the hydraulic cylinders 90 of the multi-function devices continue to extend and push the mold push rods 92 against the stop blocks 96 for a predetermined initial opening distance. The ejector push rods 84 also move with the ejector plates 86. However, the extension of the hydraulic cylinders 90 stop before the ejector push rods 84 engage the mold knock-out plates 80. Figure 4 illustrates the clearance between the ends of the ejector push rods 84 and the knock-out plates 80 when the extension of the hydraulic cylinders 90 is stopped. The stop blocks 96 then separate from the mold push rods 92 as the molds 16, 18 continue to open during the opening stroke.

The ejectors 36 cooperate with a conventional take-out robot (not shown) to remove articles from the mold stations 20, 22. The robot has arms associated with each mold station 20, 22 to grasp ejected articles and transfer the articles away from the mold stations. The robot arms move in position between the opening mold halves 16a, 16b and 18a, 18b during the opening stroke. The injection units 28, 30 and the hydraulic cylinders 60, 130 and 132 are located beneath the molds and do not obstruct the robot arms.

Each ejector hydraulic cylinder 90 resumes extending its attached ejector plate 86 and set of ejector push rods 84 at the appropriate point in the opening stroke to enable a robot arm to grasp the ejected article. The ejector push rods 84 engage the facing knock-out mechanism 78 and push the knock-out plate 80 towards the other mold half. The knock-out pins 82 are forced against the article and eject the article from the mold half and into the grasp of the robot arm in a conventional manner.

Figure 5 illustrates the platens 40 and 44 moved to their opened positions at the end of the opening stroke and the molds 16, 18 fully opened. The end platen 40 is spaced away from the tie bars 66. The injection units 28, 30 have moved with the center platen 44 to open positions on the injection rails 122, 124. The barrel carriages 146 remain on the upper cam rail sections 154 to maintain the sealed flow connections between respective discharge nozzles 108 and mold inlets 98, 100.

The mold halves of each mold 16, 18 are separated by a distance representing a mold opening stroke of each mold station. The separation of the mold halves is sufficient to enable removal of the articles from the molds. The hydraulic cylinders 56, 130 and 132 are extended and the robot arms have removed the articles from between the separated mold halves. The ejector hydraulic cylinders 90 have retracted and the knock-out mechanisms have returned to their original positions.

As shown in Figure 5, the mold halves 16a, 16b forming the container must be separated a greater distance than the mold halves 18a, 18b forming the lid to permit removal of the container. The platens 40, 44 are driven independently of each other and so can be moved apart as necessary to achieve the required mold opening stroke for each mold station. The mold opening strokes do not have to be identical or have a fixed relationship and can be changed by the controller for each mold station 20 or 22 to accommodate changes in the size of the article being molded. This enables articles of substantially different size to be simultaneously molded in the machine 10.

The ejector hydraulic cylinders 90 of the multi-function devices retract when the molded articles are gripped by the robot arms. The clamping unit 14 then closes the molds 16, 18 after the articles are removed from the mold stations 20, 22. The end and center platens 40, 44 are returned to their closed positions. The closing speeds of the platens 40, 44 are coordinated to simultaneously close the mold halves without mutual interference. The injection units 28, 30 move with the center platen 44 to maintain the sealed flow connection between the discharge nozzles 108 and mold inlets 98, 100 and return to their injection positions shown in Figure 1.

After the molds are closed, the locking units 74 close and the split nuts 76 re-mesh with the tie bar threads. The pressure cylinders 64 are repressurized and apply a clamping force to the molds. Molten plastic is again injected into the molds 16, 18 and the molding cycle repeats.

It may be desired to stop the closing of one or both molds 16, 18 temporarily when the mold halves are closely spaced from each other. In compression injection molding, for example, plastic or other molding material is injected into the mold recesses of the stopped mold before the mold is closed. Closing the mold then compresses the molding material within the mold cavity.

The mold halves can be stopped a predetermined distance apart by stopping one or both of the platens 40, 44 as needed. The closing motion of the end platen 40 and the center platen 44 is coordinated by the controller to enable either mold station or both to be stopped when spaced apart for compression injection molding.

The auxiliary drive 38 associated with the appropriate mold station 20 or 22 assists the mold opening and closing drive in positioning the mold halves a predetermined distance apart. Operation of the auxiliary drive 38 for compression molding in the mold 16 is described, it being understood the operation of the other auxiliary drive associated with mold 18 is identical.

The ejector hydraulic cylinder 90 of the multi-function device 32 was extended as needed to eject the article from the mold 16. Before the molds 16, 18 begin to close, the ejector hydraulic cylinder 90 is partially retracted. The mold push rods 92 partially retract but extend outwardly an axial distance from their fully retracted positions. The partially extended mold push rods and the stop blocks 96 on the mold half 16b cooperate to hold the mold halves 16a, 16b a predetermined distance apart.

As the mold halves 16a, 16b approach each other to close the mold, the stop blocks 96 on the mold half 16b engages the extended mold push rods 92 and the mold halves 16a, 16b are held apart by the mold push rods 92. The spacing between the mold halves 16a, 16b can be changed by changing the retraction of the hydraulic cylinder 90.

The open locking units 74 face the threaded portions 70 of the tie bars 66 when the mold halves 16a, 16b are held apart. The locking units 74 close and lock the end platen 40 on the tie bars 66 prior to injection of molten plastic. Molten plastic is then injected into the partly open mold 16. While the molten plastic is being injected, the pressure in the hydraulic cylinder 90 is relieved and at the same time the pressure cylinders 64 are repressurized. The tie bars 66 pull the end platen 40 towards the stationary platen 42 and close and clamp the molds 16, 18. The remainder of the molten plastic is then injected into the closed mold 16 and the molding cycle is repeated.

The opened and closed positions of the movable platens 40 and 44 can be varied as needed to accommodate molds having differing axial mold heights. This enables a mold in either mold station 20, 22 to be replaced by a mold having a different mold height. The controller can also adjust the closing positions of the platens 40 and 44 to accommodate a change in mold height in either mold station. The controller can also adjust the open positions of the platens 40, 44 to accommodate a change in mold opening stroke as discussed above.

When purging, cleaning or maintaining the injection units 28, 30 or changing molds, the injection units are moved to the purge area 142. See Figure 3. As shown in the figure, the barrel carriages 146 have ridden down the inclined cam rail sections 158 and additional clearance around the mold stations 20, 22 for changing molds or other maintenance is provided. Also, the center platen 44 can be independently moved towards either end platen 40 or 42 to provide additional axial width in either mold station 20 or 22 for mold maintenance or other tasks. Cranes or other equipment can access the mold stations 20, 22 from the top and sides of the mold stations to support the molds during installation or removal.

The end platen 40 is moved to an open position away from the tie bars 66 as shown in Figure 4 prior to moving the injection units 28, 30 to the purge area 142. The hydraulic cylinders 130, 132 are then extended to move the injection units 28, 30 from their normal operating positions to the purge area. The barrel carriages 146 on the upper rail sections 154 ride down the inclined cam rail sections 158 and lower the nozzles 108 from the mold inlets. Each barrel carriage 146 acts as a cam follower whose motion on the cam rails 150 automatically lowers the nozzle 108 when the injection unit 28 or 30 is moved to the purge area 142. Returning the injection units 28, 30 to reengage the mold inlets 98, 100 causes the barrel carriages 146 to ride up on the inclined sections 158 and automatically return the nozzles 108 to vertical alignment with the mold inlets 98, 100.

The nozzles 108 point downwardly at a slight angle when the nozzles 108 are in the purge area 142. Molten plastic purged from the injection units and emerging from the nozzles 108 do not flow against the molds 16, 18 or their respective mold inlets.

When the injection units 28, 30 are moved from the purge area 142 to reengage the nozzles 108 and mold inlets 98, 100, the injection unit drive cylinders 130 and 132 each press the barrel carriage 146 attached to the cylinder downwardly against the upper rail sections 154. The barrel carriages 146 are held firmly against the upper rail sections 154 to assure the nozzles 108 are properly aligned with the mold inlets 98, 100 for engagement. The barrel carriages 146 are located near the discharge end of the supply barrels 104 so that deformation of the supply barrels by thermal expansion, gravity, and the like does not substantially affect the alignment of the nozzles 108 with the mold inlets.

Figure 8 illustrates a second embodiment injection molding machine 210 similar to injection molding machine 10. The injection molding machine 210 has a clamping unit 212 like clamping unit 14, with two mold stations 214, 216 and molds 218 and 220 in the mold stations. The mold 218 is like the mold 16, with the mold half 218b having a mold inlet 222 attached to the center platen 224. The other mold 220 has a mold inlet 226 on the mold half 220b attached to the stationary platen 228. Both mold inlets 222, 226 face away from the stationary platen 228 and towards their associated injection unit 230 or 232 respectively.

The injection unit 230 associated with the mold station 214 is driven by hydraulic cylinders 234 and moves with the center platen 224 like the injection unit 28 of the machine 10. Because the mold half 220b is stationary, the other injection unit 232 remains stationary for the entire molding cycle. The hydraulic cylinders 236 attached to the injection unit 232 moves the injection unit 232 to and from the purge area 238. If a mold like mold 18 replaces the mold 220, the injection unit 232 can operate like the injection unit 30.

Figures 9 and 10 illustrate a third embodiment injection molding machine 310. The injection molding machine 310 has a clamping unit 312 with two mold stations 314, 316 and molds 318 and 320 in the mold stations. Each mold station 314, 316 has an injection unit 322, 324 respectively associated with the mold station. The injection units 322 and 324 are located on opposite ends of the clamping unit 312 adjacent their associated mold stations 314, 316 respectively. The injection units 322, 324 directly oppose each other with the longitudinal axes of the injection units in a common plane. In other possible embodiments the longitudinal axes of the injection units may be laterally offset from each other.

The clamping unit 312 has a common stationary platen 326 between a pair of movable end platens 328, 330. The end platens 328, 330 are independently movable towards and away the stationary platen 326 to close and open the molds 318, 320. The mold halves 318b and 320a attached to the stationary platen 326 each include a mold inlet 332 and 334 respectively similar to a mold inlets 98 or 100 of the machine 10. The mold inlets 332, 334 face away from the stationary platen 326 and towards a nozzle of an injection unit 336 or 338 associated with the respective mold half.

The clamping unit 312 includes a clamping device having two pairs of diagonally opposed tie bars 338 and 340 that pass through throughbores located in the corners of the stationary platen 326. One pair of tie bars 338 are mounted on the end platen 328 and move with the end platen 328. The other pair of tie bars 340 are mounted on the other end platen 330 and move with the end platen 330. The tie bars 338 extend from pressure cylinders 342 to threaded free ends 344 between the end platens. The tie bars 340 extend from pressure cylinders 346 to threaded free ends 348 between the end platens. When the molds are closed, the threaded ends 344 and 348 extend through the opposite end platen 330 or 328 and extend through like locking units 350, each unit like locking unit 74, mounted on the end platens.

The end platen 328 is driven by a pair of diagonally opposed, horizontal hydraulic cylinders 352 that extend between the stationary platen 326 and the end platen 328. The hydraulic cylinders 352 are aligned with the tie bars 338 and are attached to the outer edges of the platens 326, 328 as shown. The other end platen 330 is driven by a similar pair of diagonally opposed hydraulic cylinders 354 that extend from the stationary platen 326 to the end platen 330. Opening a mold is resisted only by the adherence of the article in that mold and so auxiliary drives are not necessary. Such auxiliary drives could be included in embodiments similar to injection molding machine 310 if desired.

In operation, the nozzles press against the mold inlets 332, 334 to form sealed flow connections between the nozzles and the mold inlets. The mold inlets 332, 334 are stationary during the entire molding cycle and so both injection units 322, 324 remain stationary during the normal molding cycle. The hydraulic cylinders 356, 358 attached to the injection units 322, 324 drive the injection units to the purge areas 360, 362.

Each mold 318, 320 is independently opened or closed by moving the end platen 328 or 330 adjacent the mold. It is not necessary to coordinate simultaneous movement of two platens to open and close the molds.

When the molds 318, 320 are opened, each pair of tie bars 338, 340 extend only across the mold station adjacent the end platen 328 or 330 carrying the tie bars and do not extend to the other mold station. The free ends of the tie bars 338, 340 are in or near the stationary platen 326, see Figure 10. Opposite sides of the two mold stations 314, 316 are effectively clear of the tie bars for improved access to the opened mold stations 314, 316 by robot arms or cranes.

Figure 11 illustrates a fourth embodiment injection molding machine 410. Machine 410 has a clamping unit 412 similar to the clamping unit in machine 310 but includes two movable center platens 414 and 416 located between the stationary platen 418 and either end platen 420, 422. The platens define four axially aligned mold stations, with a pair of mold stations 424, 426 on one side of the stationary platen 418 and another pair of mold stations 428, 430 on the other side of the stationary platen 418. Molds are shown in the mold stations, with the mold halves attached to the center platens 414, 416 having mold inlets that face away from the stationary platen 418. Four injection units are each associated with a different mold station and are arranged in pairs 432, 434 and 436, 438 at opposite ends of the clamping unit. The molding machine 410 is in effect substantially equivalent to placing two injection molding machines 10 back to back, the back-to-back machines sharing a common stationary platen.

The center platens 414, 416 are driven axially towards and away the stationary platen 418 and along the tie bars by sets of laterally spaced hydraulic cylinders 440, 442 respectively that extend from the stationary platen 418 to the center platens 414, 416 respectively. Each set of hydraulic cylinders 440, 442 includes a first pair of laterally spaced cylinders above the mold station and a second pair of laterally spaced cylinders below the mold station. The pairs of molds 424, 426 and 428, 430 are independently opened and closed by coordinated movement of the end platens 420, 422 and center platens 414, 416, similar to the movement of the end platen 40 and center platen 44 as described for injection molding machine 10. Each of the four molds can have different opening strokes.

Both sides of the center platens 414, 416 and the stationary platen 418 mount mold halves and are not available for mounting a multi-function device. The molds in the interior mold stations 426, 428 must include conventional in-mold ejector systems (not shown) to eject molded articles.

The illustrated embodiments include one injection unit associated with each mold station. In other possible embodiments of the present invention, additional injection units may be associated with a mold station. For example, an injection molding machine similar to machine 310 has three injection units associated with its two mold stations. The three injection units are used for multi-component molding of articles, such as molding articles having three differently colored portions. Each mold half contains a separate hot runner system for each color. Each hot runner system has its own mold inlet associated with one injection unit.

It is also not necessary that all the injection units in a machine or all the injection units associated with a molding station be identical. Different sizes or types of injection units can be used depending on the type of molding material being injected, the amount of molding material injected per molding cycle, and other factors.

In yet other possible embodiments of the present invention, the injection rails and upper rail sections associated with of one or more injection units extend to another mold station to enable an injection unit associated with one mold station to be borrowed and temporarily used with a mold in the other mold station. For example, a mold half for use in the machine described immediately above may have four hot runner systems to mold a four-color article. The fourth hot runner system includes an inlet positioned to engage an injection unit associated with the other mold station. During the molding cycle an injection unit would be borrowed from the other mold station and remain engaged with the fourth inlet throughout the molding cycle and inject molding material of the fourth color.

Figure 12 illustrates a fifth embodiment injection molding machine of the present invention having a mold half 510. The mold half 510 forms part of a mold suitable for use in either improved injection molding machines of the present invention or in standard injection molding machines. The mold half 510 has a hot runner system 512 that feeds mold cavities partially defined by a pair of recesses 514. Separate standard and auxiliary mold inlets 516 and 518 respectively are arranged to flow molding material into the hot runner system 512. The standard inlet 516 is used with a standard injection molding machine and is positioned on one side of the mold half 510 in a conventional manner to engage the injection unit of the standard machine. The auxiliary inlet 518 is used with an injection molding machine of the present invention and is located on the mold half 510 to face a injection unit of such a machine. The inlets 516, 518 are each in communication with a common channel 520 of the hot runner system 512 to independently feed molding material to the mold recesses.

One mold inlet 516 or 518 is closed by a removable solid plug 522 and the other mold inlet 518 or 516 has an inlet formed in a removable inlet body 526. The plug 522 and inlet body 526 can be swapped between the mold inlets to open and close the inlets as needed. Each mold inlet 516, 518 extends inwardly to a reduced diameter, threaded neck 528, 530 for mounting a plug 522 or inlet body 526 in either mold inlet. The plug 522 has a threaded body that mounts the plug in the inlet neck and closes the mold inlet. The mold inlet formed on the inlet body 526 has a convex bearing surface 532 like the bearing surface 116 and a through flow channel 534 that communicates the mold inlet with the channel 520. The end of the inlet body 526 is threaded like the plug 522 for mounting the inlet body 526 in an inlet neck 528 or 530.

Figure 12 shows the mold half 510 attached to the platen 536 of an injection molding machine similar to the injection molding machine 10. The platen 536 includes a conventional locating ring 538 mounted in a center throughbore 540. The locating ring 538 surrounds the standard mold inlet 516 as shown. The plug 522 is mounted in the standard inlet neck 528 and closes the inlet 516. The inlet body 526 is mounted in the auxiliary inlet neck 530 for engagement of the mold inlet with a discharge port 542 of an injection unit as show in the figure.

Figure 13 shows the mold half 510 attached to the platen 544 of a standard injection molding machine. The plug 522 and inlet body 526 are swapped to open the standard mold inlet 516 and close the auxiliary mold inlet 518. The mold inlet on the inlet body 526 is shown engaged with a discharge port 546 a standard injection molding machine.

In this embodiment the standard inlet 516 and the auxiliary inlet 518 are located on opposite sides of the mold half 510. In other embodiments the auxiliary inlet 518 may be located on the same side of the mold half 510 as the standard inlet 516 or elsewhere. Additional auxiliary inlets could be provided to enable engagement with injection units facing either side of the mold half.

In other possible embodiments of the present invention a nozzle may engage an inlet formed on or in a platen itself. Such a platen may include a flow passage that communicates the inlet with a flow inlet on the mold half attached to the platen. In yet other possible embodiments of the present invention the movable platens, injection units and locking units may be driven all or in part by electric motors.

While I have illustrated and described preferred embodiments of my invention, it is understood that these are capable of modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

CLAIMS

1. An injection molding machine comprising a frame having a support surface; a clamping unit supported by the support surface and having a first mold station, the frame being configured to space the mold station above the support surface; the clamping unit including first and second platens defining and facing the mold station, a first connection mounting the platens on the frame for relative motion along a horizontal axis towards and away from each other for opening and closing the mold station, a mold opening and closing drive operatively connected to the platens to open and close the mold station, and a clamping device to apply a clamping force to the platens when the mold station is closed; a first mold in the mold station, the first mold including first and second mold halves defining a mold cavity when the mold station is closed, the first mold half mounted to the first platen and the second mold half mounted to the second platen; a first inlet located on one mold half or the platen mounting the one mold half, and one or more first flow passages for flowing molding material from the inlet into the mold cavity; a first injection unit having a discharge nozzle, the nozzle engageable with the first inlet for forming a flow connection between the first injection unit and the one or more first flow passages;

wherein the nozzle is spaced vertically below the first mold station when engaged with the first inlet.

2. The injection molding machine of claim 1 wherein the first injection unit is under at least one platen.

3. The injection molding machine of any of the preceding claims wherein the first platen is axially movable along the frame to open and close the first mold station;

the first inlet is on the first platen or the first mold half;

the first injection unit is movably mounted on the frame for movement parallel to the horizontal axis;

and the injection molding machine comprises a second connection between the nozzle and the first inlet to maintain the flow connection therebetween during the opening and closing of the first mold station.

4. The injection molding machine of claim 3 wherein the second connection comprises an injection unit drive that moves the first injection unit along a mold opening and closing stroke.

5. The injection molding machine of claim 4 wherein the injection unit drive has a sufficient stroke to move the nozzle to a purge area spaced away from the first inlet when the first mold station is opened.

6. The injection molding machine as in any of claims 3-5 wherein the first injection unit is movable to a purge area away from the first mold station and the nozzle is lowered when the first injection unit is moved to the purge area.

7. The injection molding machine as in claims 1 or 2 wherein the clamping unit comprises a third platen, the first and second platens on one side of the third platen, the second and third platens facing and defining a second mold station, the first connection mounting the third platen on the frame for relative motion along the horizontal axis towards and away the second platen to open and close the second mold station, one of the second and third platens being a stationary platen, the mold opening and closing drive operatively connected to the third platen to open and close the second mold station, and the clamping device applies clamping force to the platens when the mold stations are closed;

the injection molding machine further comprising a second mold in the second mold station, the second mold including first and second mold halves defining a second mold cavity when the second mold station is closed, the first mold half of the second mold attached to the third platen and the second mold half of the second mold attached to the second platen; the first inlet being on the second platen; one or more second flow passages for flowing molding material from the first inlet into the second mold cavity; and a second connection the nozzle and the first inlet to maintain the flow connection between the nozzle and the first inlet during opening and closing of the first and second mold stations.

8. The injection molding machine of claim 1 or 2 wherein the clamping unit includes a third platen, the first and second platens on one side of the third platen, the second and third platens facing and defining a second mold station, the first connection mounting the third platen on the frame for relative motion along the horizontal axis towards and away the second platen to open and close the second mold station, the mold opening and closing drive operatively connected to the third platen to open and close the second mold station, and the clamping device applies clamping force to the platens when the mold stations are closed; a second mold in the second mold station, the second mold including first and second mold halves defining a second mold cavity when the second mold station is closed, the first mold half of the second mold attached to the third platen and the second mold half of the second mold attached to the second platen; a second inlet located on one mold half of the second mold or the second or third platen mounting such mold half, and one or more second flow passages for flowing molding material from the second inlet into the second mold cavity; a second injection unit having a discharge nozzle, the nozzle engageable with the second inlet for forming a flow connection between the second injection unit and the one or more second flow passages; and

the nozzle of the second injection unit is spaced vertically below the second mold station when the nozzle is engaged with the second inlet.

9. The injection molding machine of claim 8 wherein the second platen is a stationary platen and the first and third platens are movable along the frame towards and away from the second platen.

10. The injection molding machine of claim 9 wherein the clamping device comprises first and second tie bars, the first tie bar having a first end portion fixed to the first platen and extending to an opposite free second end portion, the second tie bar having a first end portion fixed to the third platen and extending to an opposite free second end portion, the free end portion of each tie bar extending into an individual throughbore in the second platen when the mold stations are open whereby the

second platen supports the free end portions of the first and second tie bars.

11. The injection molding machine of claim 10 wherein the clamping device comprises third and fourth tie bars, the third tie bare having a first end portion fixed to the first platen and extending to an opposite free second end portion, the fourth tie bar having a first end portion fixed to the third platen and extending to an opposite free second end portion, the free end portion of each of the third and fourth tie bars each extending into an individual throughbore in the second platen when the mold stations are open whereby the second platen supports the free end portions of the third and fourth tie bars.

12. The injection molding machine of claim 9 wherein the first inlet is on one of: the second mold half of the first mold or the second platen, and the second inlet is on one of: the second mold half of the second mold or the second platen whereby the inlets are stationary during opening and closing of the mold stations.

13. The injection molding machine of claim 12 wherein each injection unit is movable for moving its respective nozzle to a purge area away from the mold station associated with the injection unit.

14. The injection molding machine of claim 8 wherein the third platen is a stationary platen and each of the first and second platens are movable along the frame towards and away the third platen.

15. The injection molding machine of claim 14 wherein the first inlet is on one of: the second mold half of the first mold or the second platen, and the second inlet is on one of the second mold half of the second mold or the second platen whereby the inlets are move with the second platen during opening and closing of the mold stations; and

each injection unit is movably mounted on the frame to maintain the flow connection between the nozzle of the injection unit and the inlet associated with the injection unit during opening and closing of the mold stations.

16. The injection molding machine of claim 14 wherein the first inlet is on one of: the second mold half of the first mold or the second platen, and the second inlet is on one of the first

mold half of the second mold or the third platen whereby the first inlet moves with the second platen and the second inlet is stationary during opening and closing of the mold stations; and

the first injection unit is movably mounted on the frame to maintain the flow connection between the nozzle of the first injection unit and the first inlet during opening and closing of the mold stations.

17. The injection molding machine as in either claim 15 or claim 16 wherein each injection unit is movable to a purge area away from the mold station associated with the injection unit.

18. The injection molding machine as of any of the claims 7-17 further comprising one or more additional platens and one or more additional injection units, the first, second and third platens on a side of each additional platen, each additional platen facing an adjacent platen to define an additional mold station between itself and the adjacent platen, an additional mold in each additional mold station and an additional inlet on each additional mold or additional platen to flow molding material into the additional mold, each additional injection unit engageable with a respective additional inlet to flow molding material into the inlet.

19. The injection molding machine as in any of the claims 1-18 further comprising an additional injection unit and an additional inlet for flowing molding material from the inlet into one of the molds, the additional injection unit engageable with the additional inlet for flowing molding material from the additional injection unit into the one mold.

20. The injection molding machine as in any of the claims 7-19 wherein each platen has a horizontal thickness and the thickness of the second platen is less than the thickness of at least one of the first and third platens.

21. The injection molding machine as in any of the preceding claims wherein each injection unit extends from one side of a platen to the other side of the platen without passing through the platen.

22. The injection molding machine as in any of the preceding claims wherein each mold includes a hot runner system.

23. The injection molding machine as in any of the preceding claims wherein molding material flows upwardly from each inlet to the mold cavity.

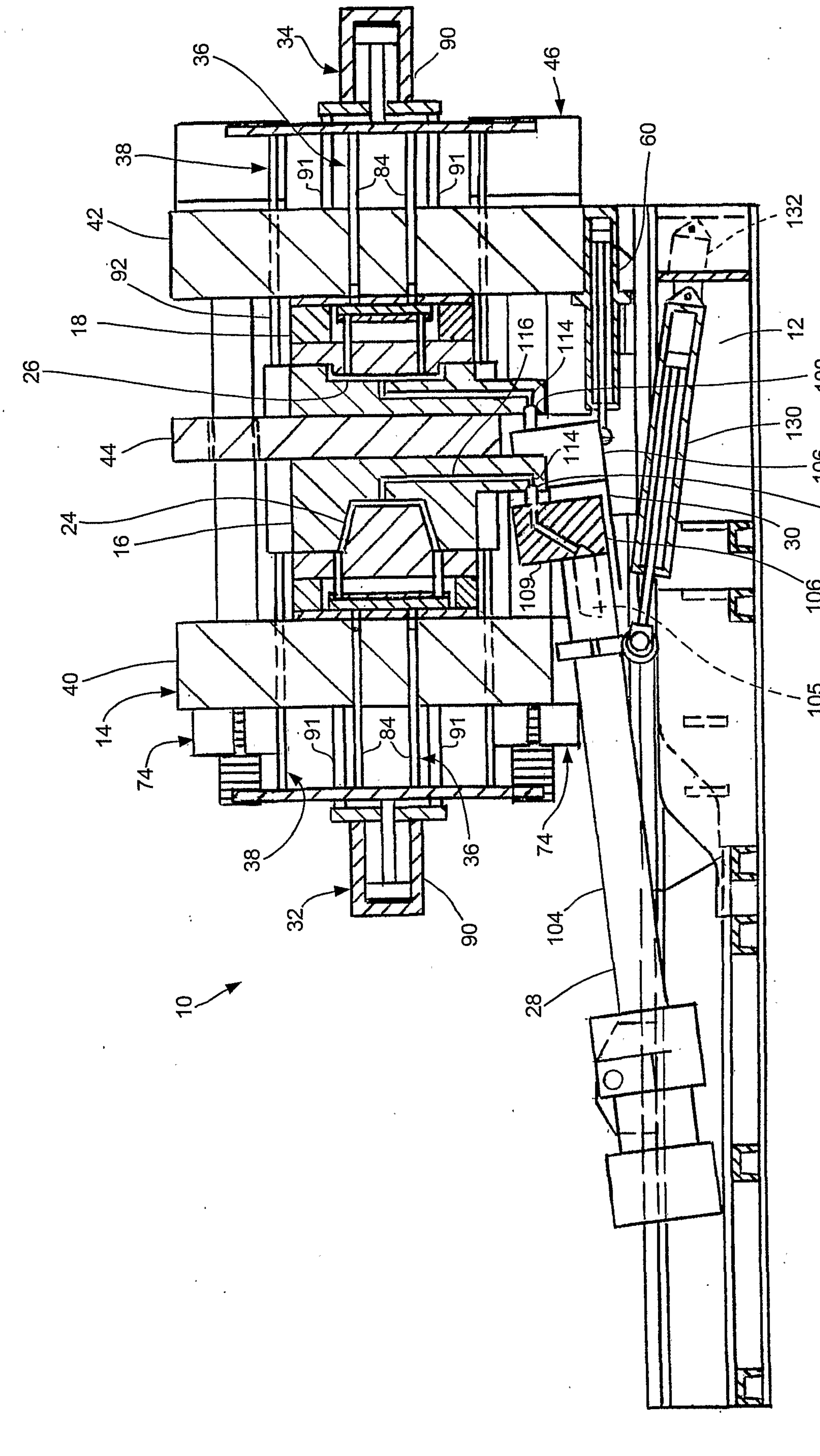
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FIG. 1

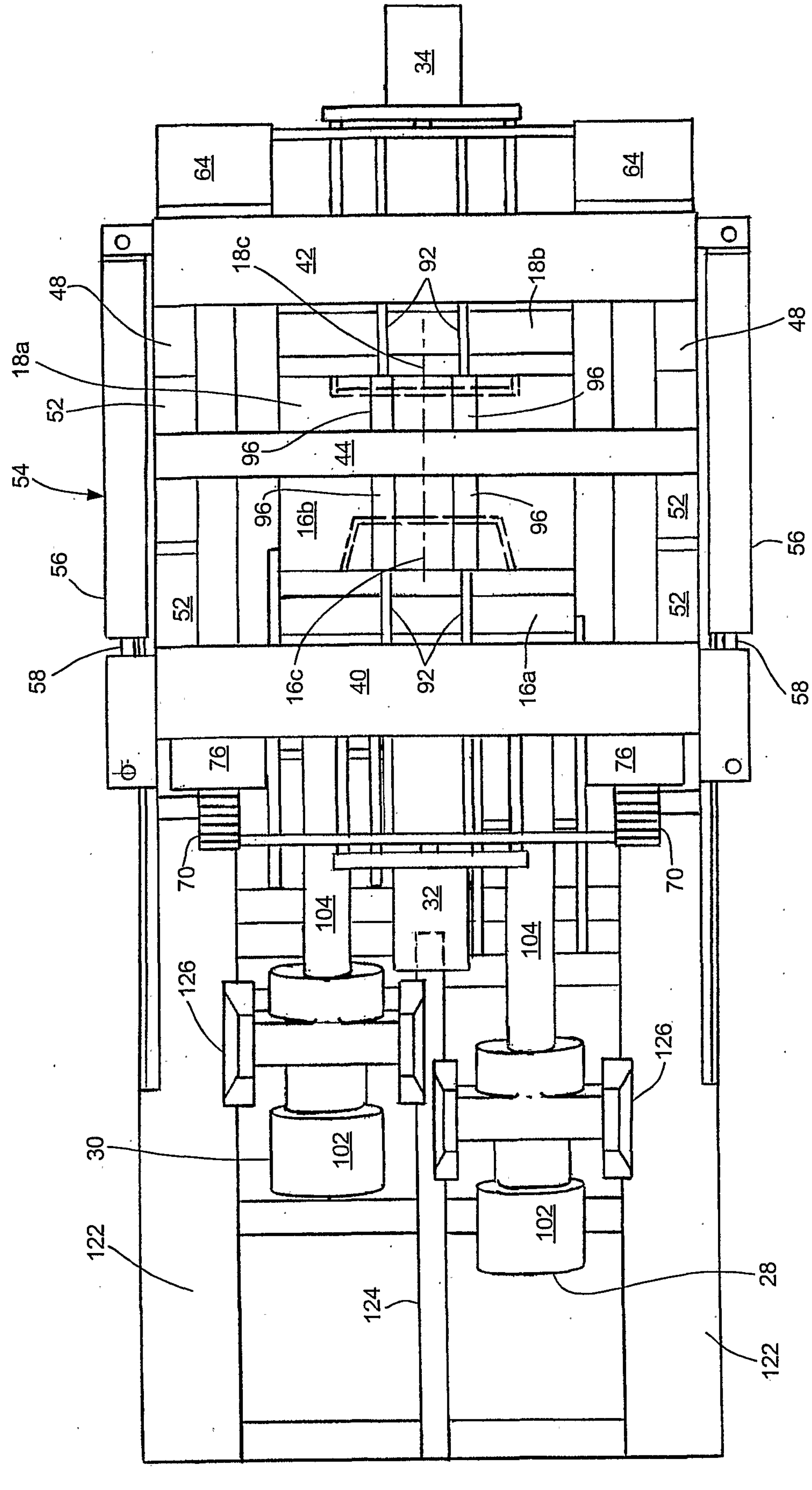
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FIG. 2

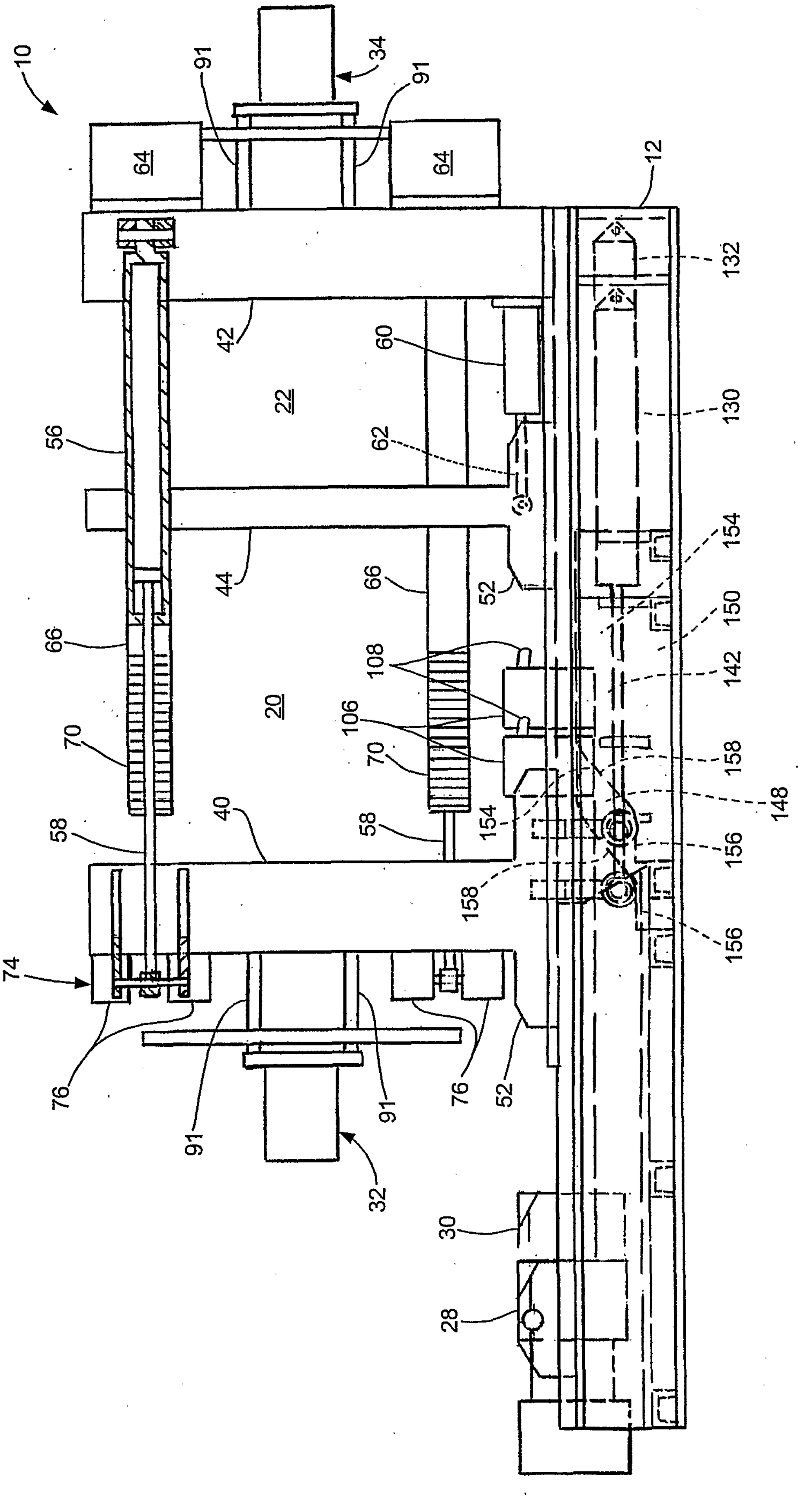
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FIG. 3

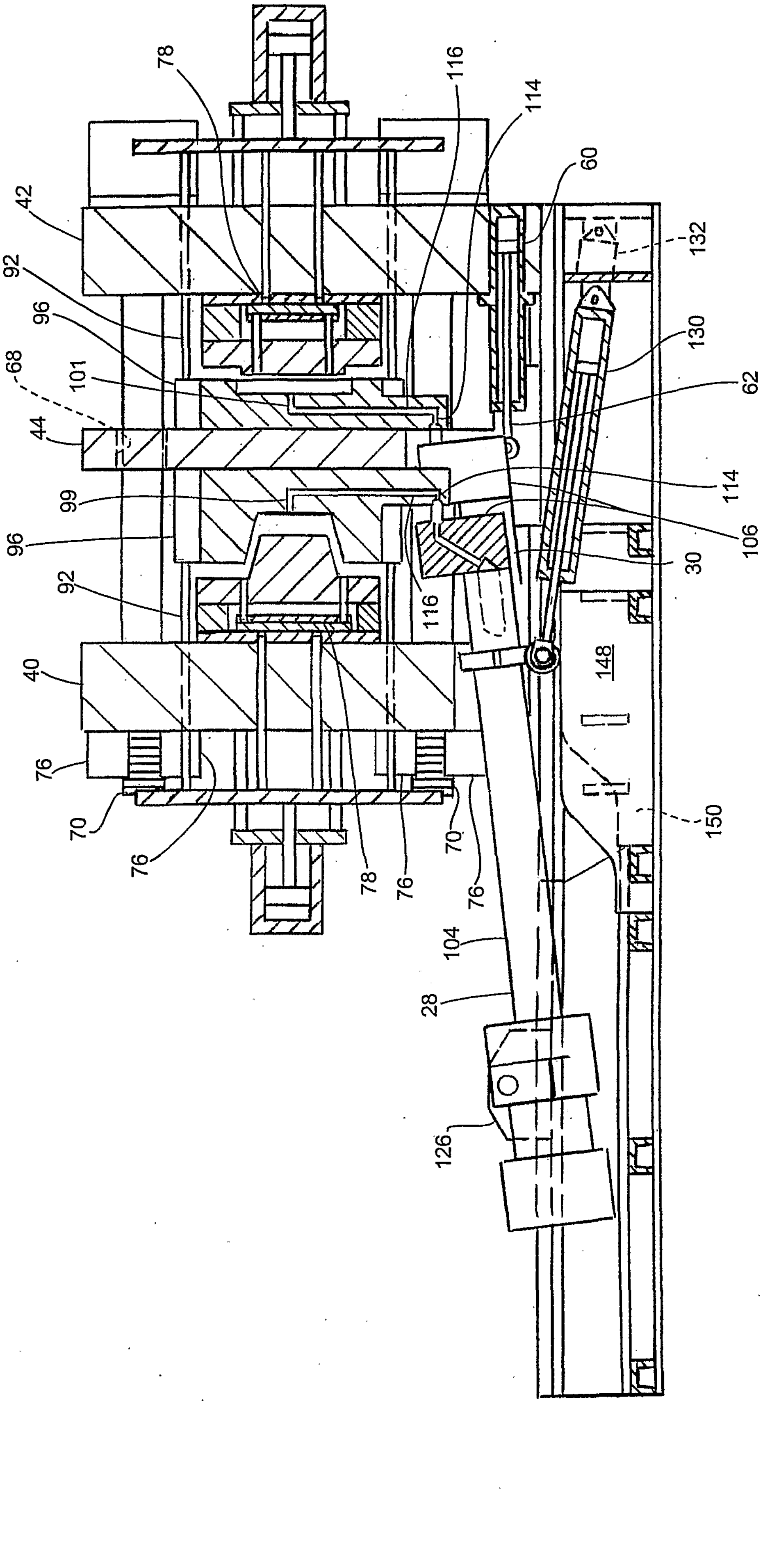
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FIG. 4

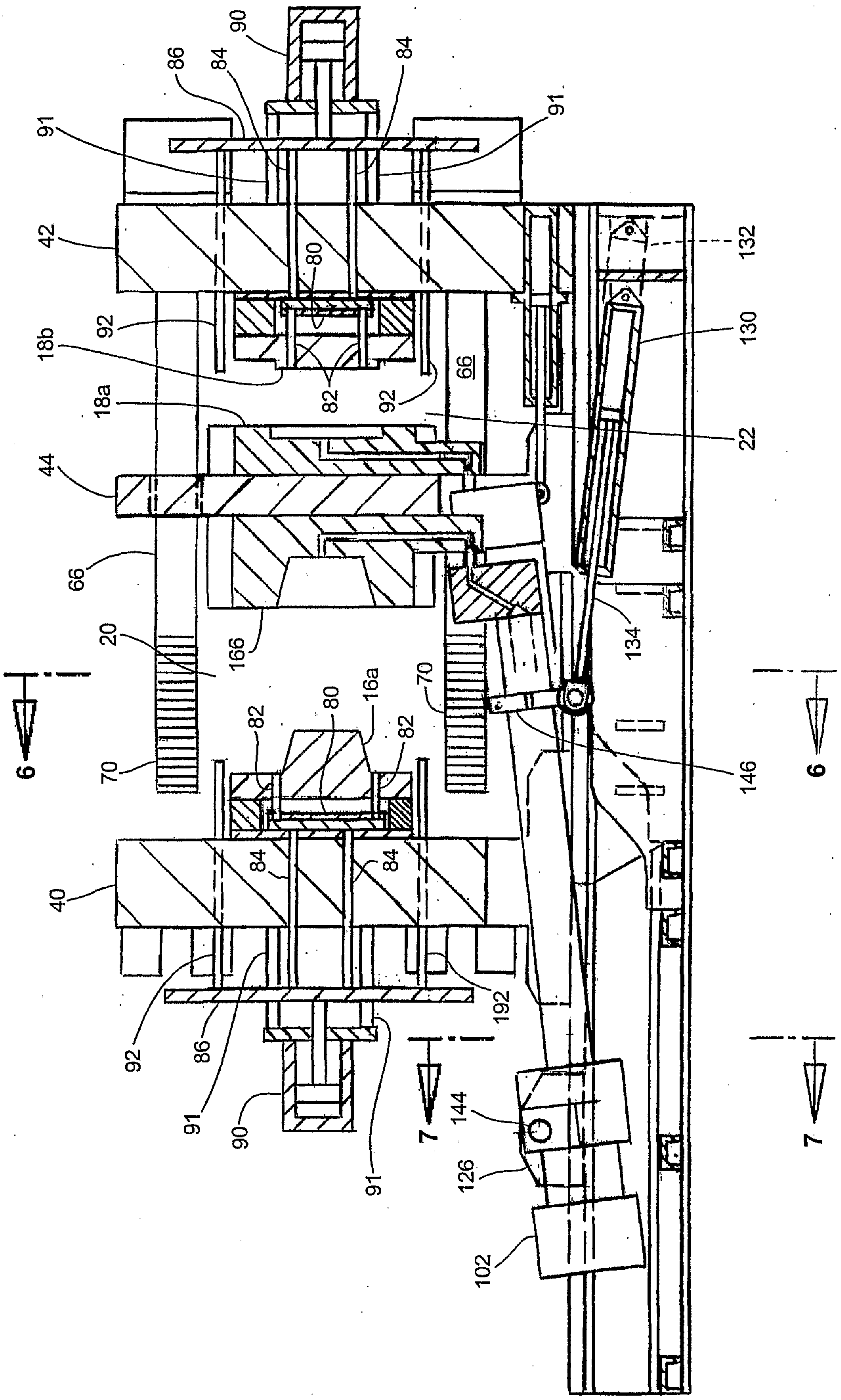
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FIG. 5

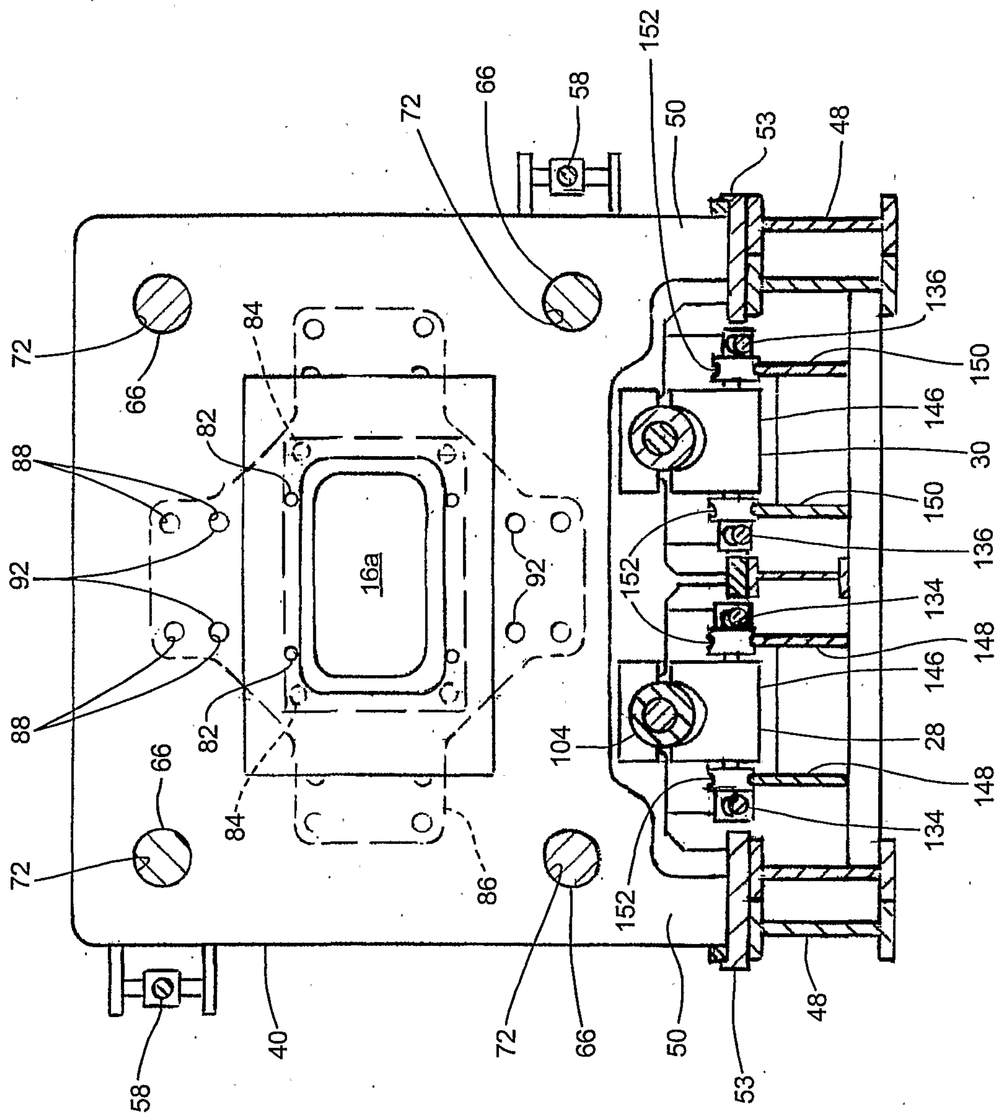
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FIG. 6

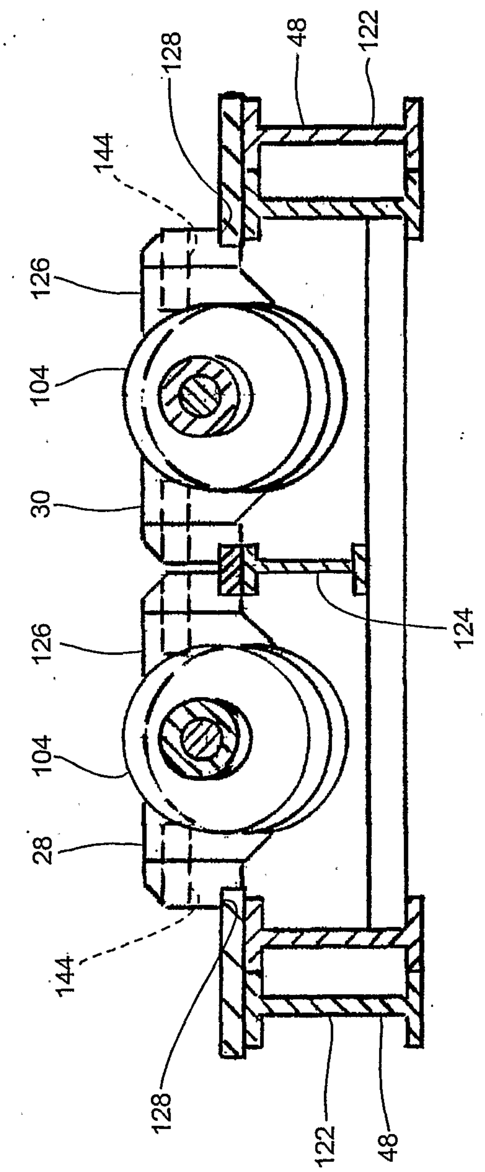

FIG. 7

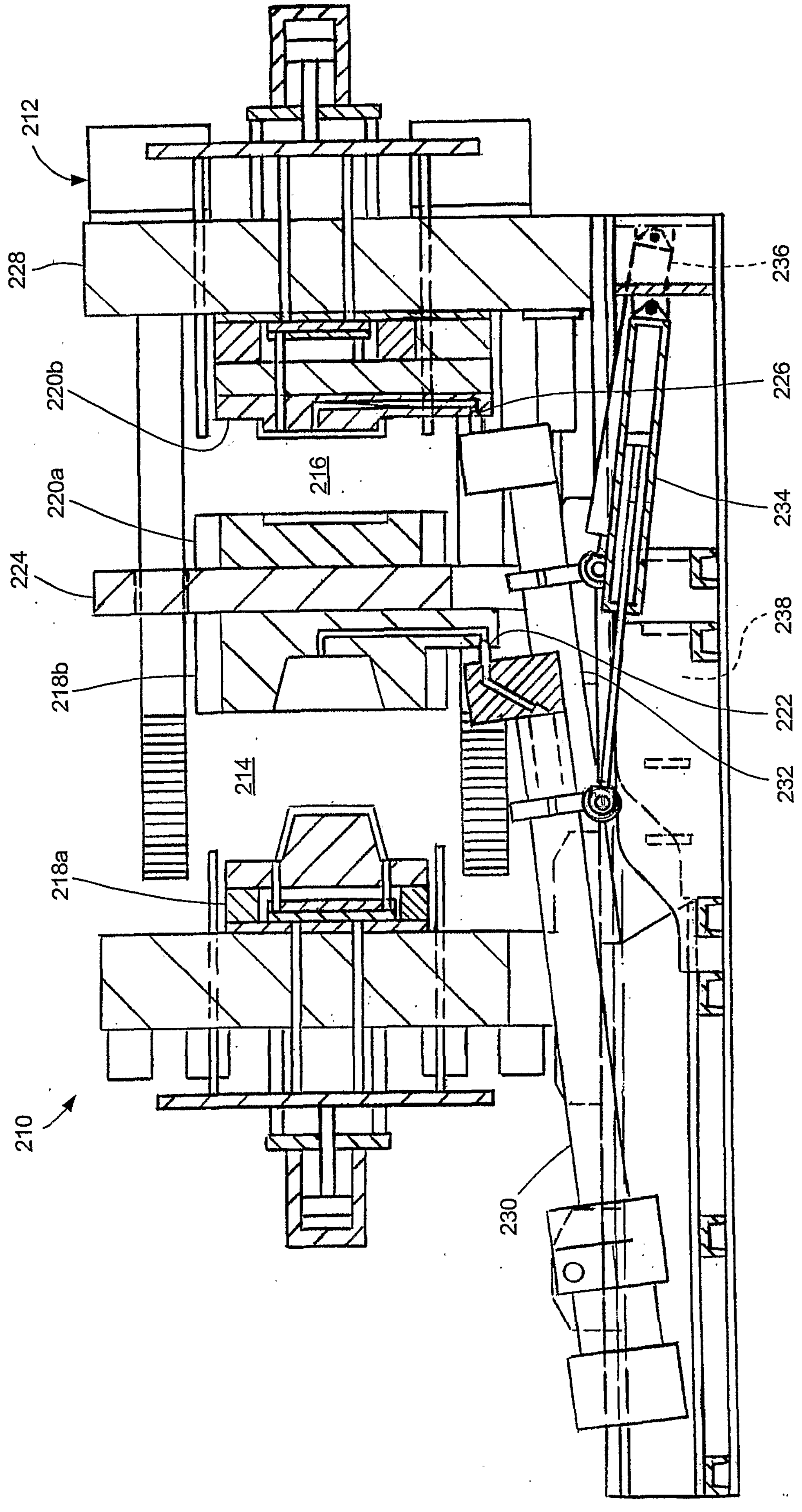
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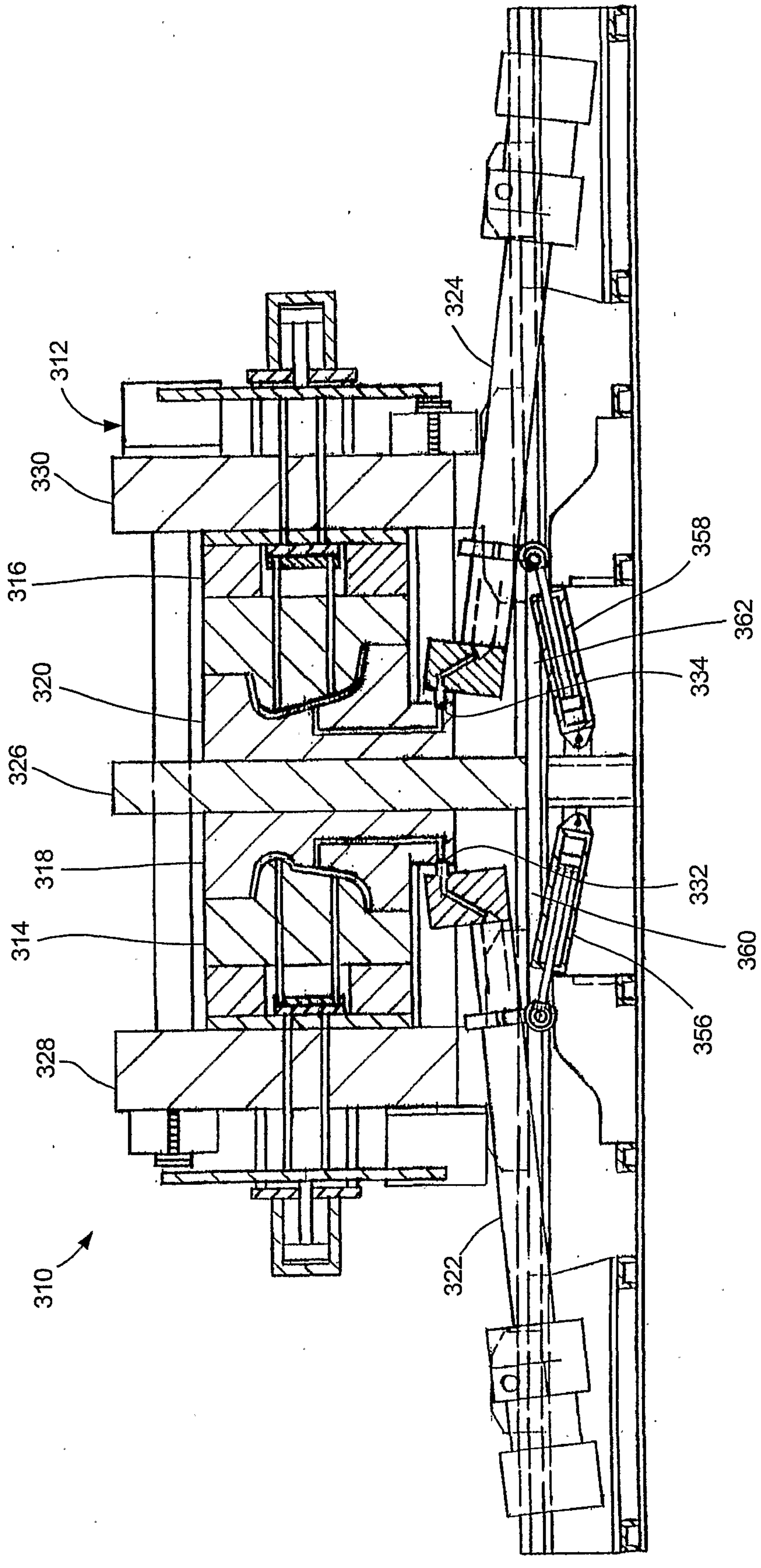
FIG. 8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334
332
360
356

FIG. 9

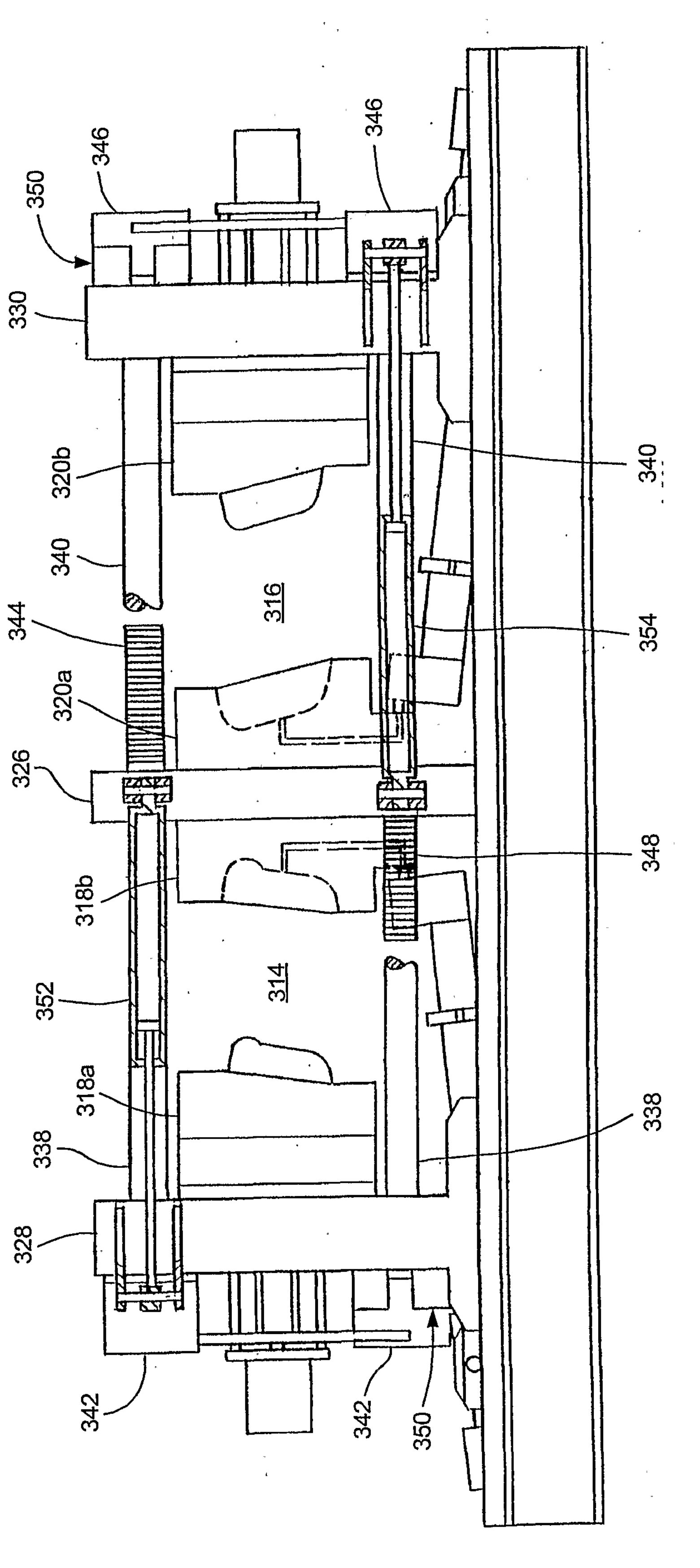
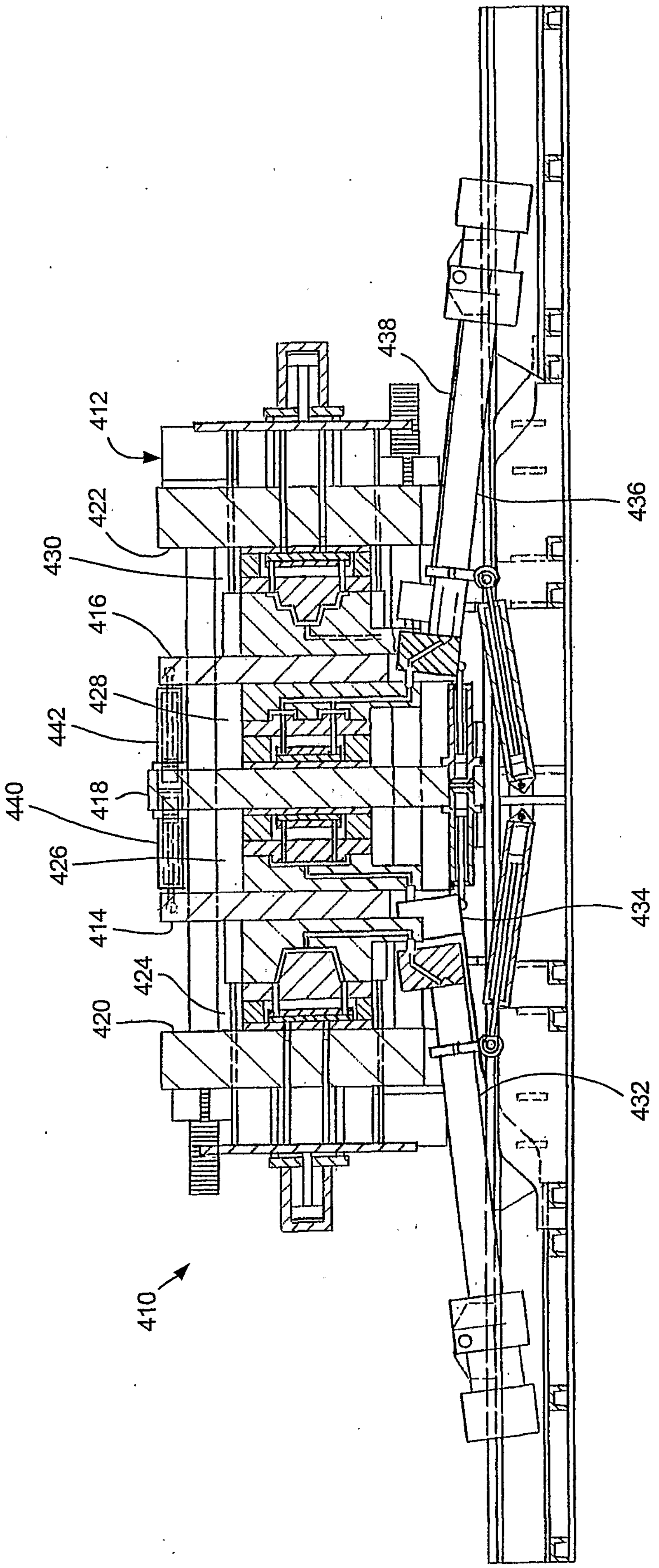

350
346
346
330
320b
340
340
316
344
354
320a
326
348
318b
352
314
318a
338
338
328
342
342
350

FIG. 10


412
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428
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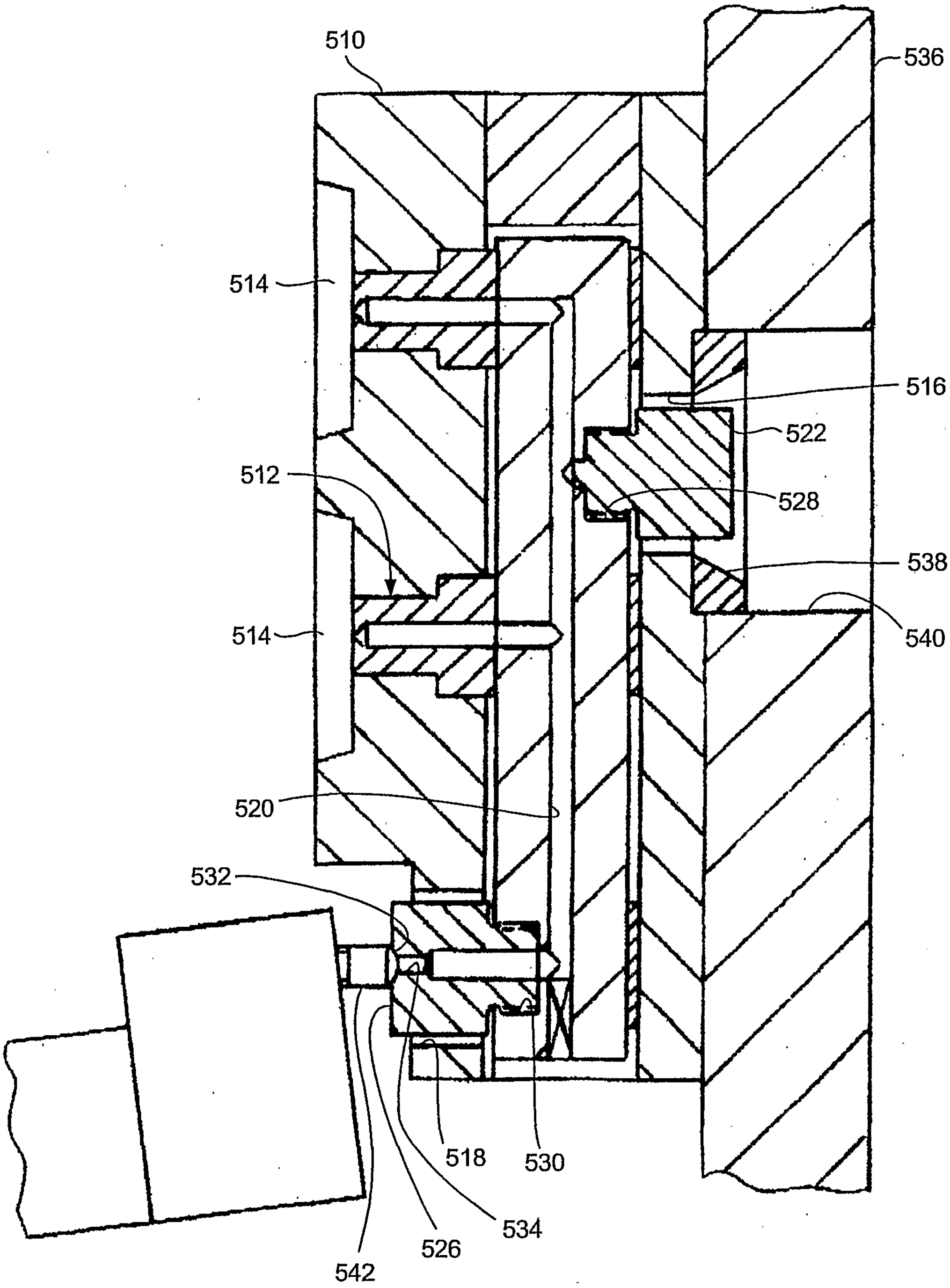
434
432

FIG. 11


510
536
514
516
522
512
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542

FIG. 12

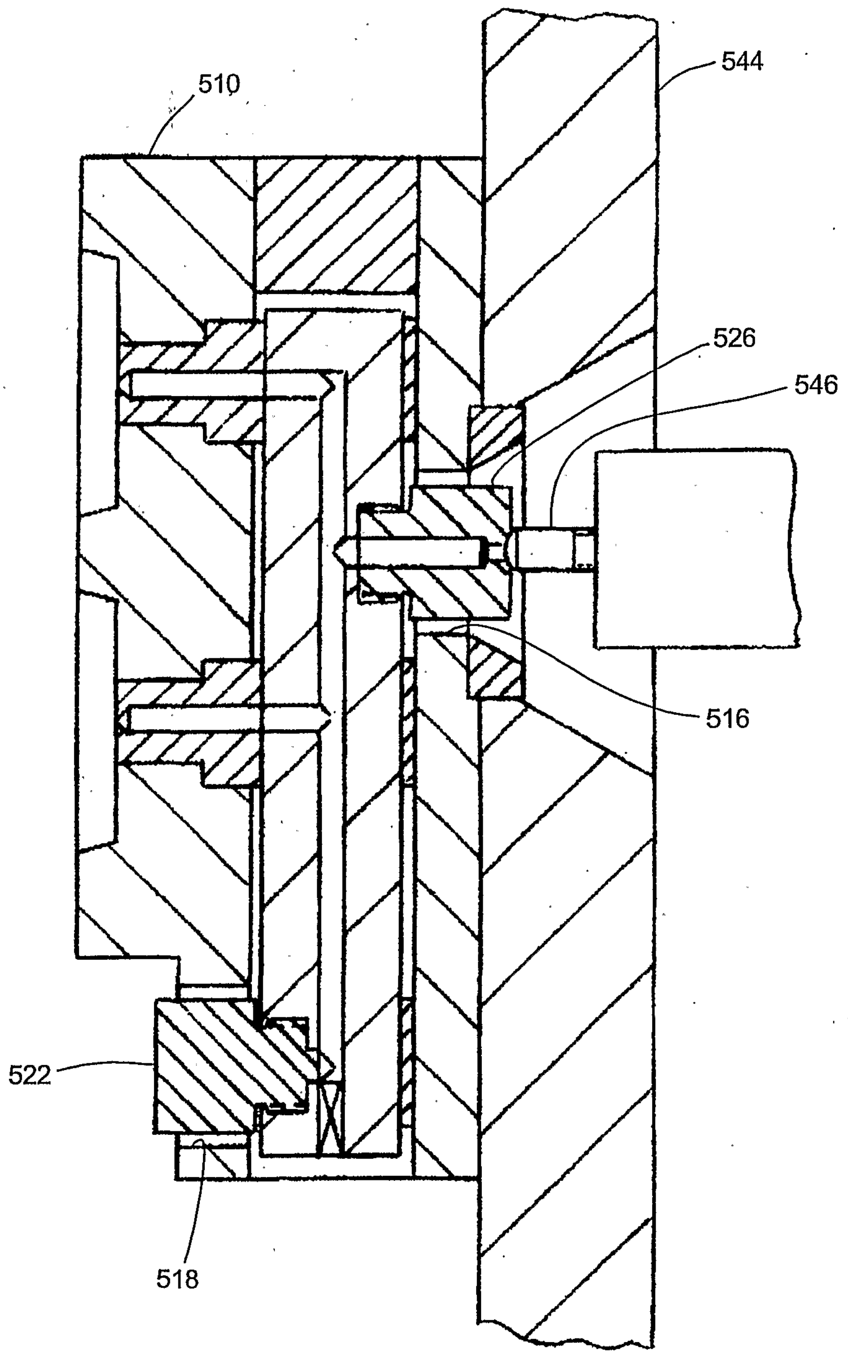

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/26504

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B29C 45/68
US CL :425/130,572,574,575,589
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 425/130,572,574,575,589

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US 5,620,723 A (GLAESENER et al) 15 April 1997, Fig. 1.	1,3,4,7 ---------- 1-5,7-17
Y	US 5,035,599 A (HARASHIMA et al.) 30 July 1991, Fig.4.	2-5, 7-17

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 NOVEMBER 2001	06 NOV 2001

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	TIM HEITBRINK
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0651

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/26504

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 6,18-23
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.