Oct. 29, 1963 J. K. MUREK 3,108,503

HIGH ENERGY RATE FORMING MACHINE

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FIG. 1.

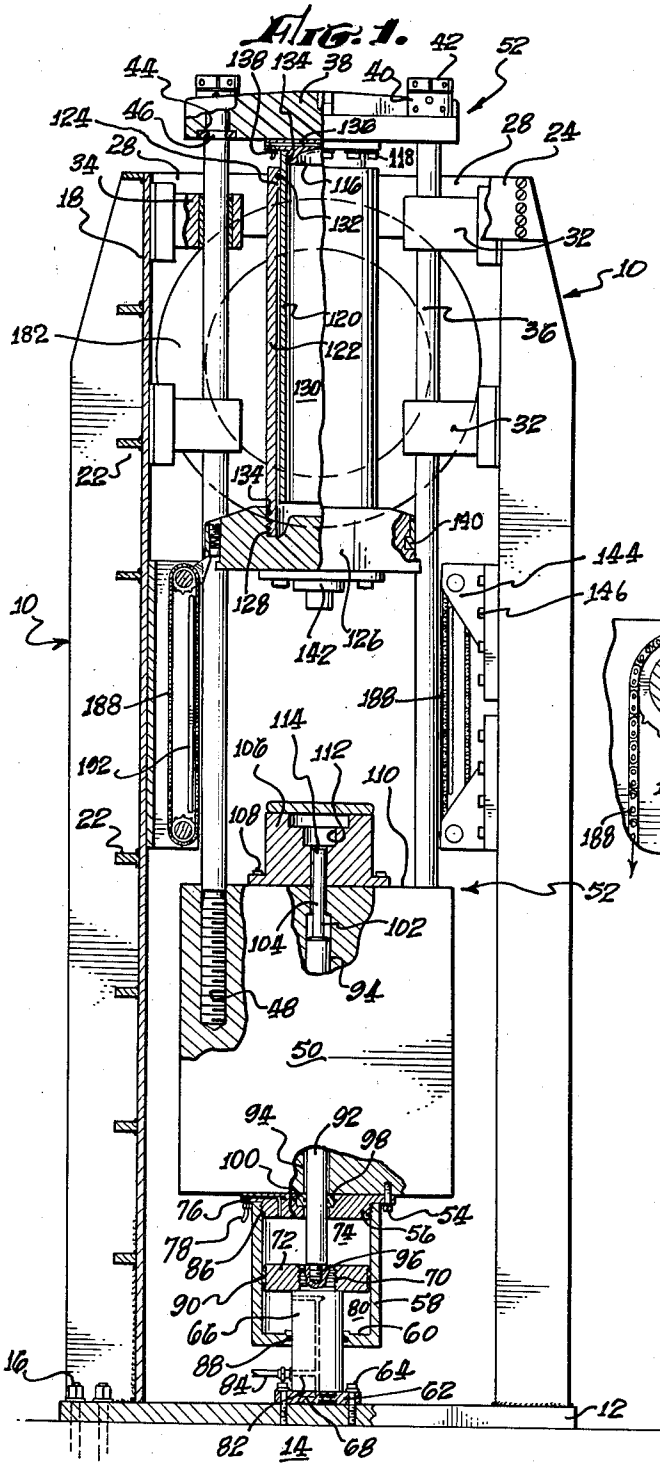
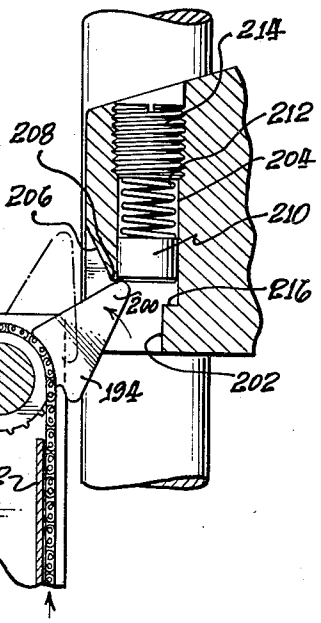


FIG. 3



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FIG. 2.

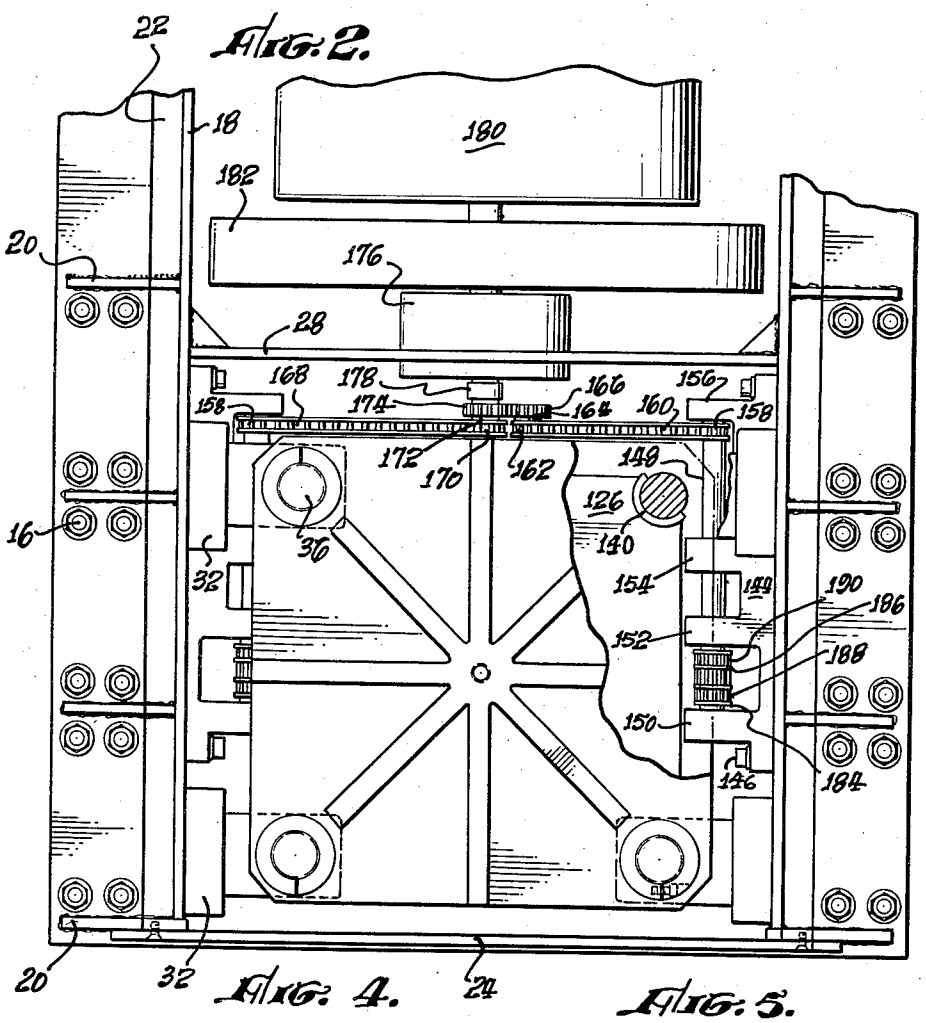


FIG. 4.

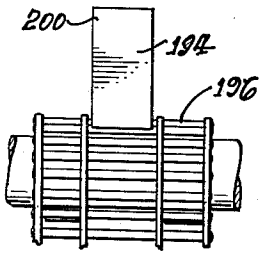
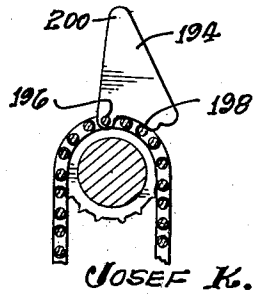


FIG. 5.



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HIGH ENERGY RATE FORMING MACHINE

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FIG. 6.

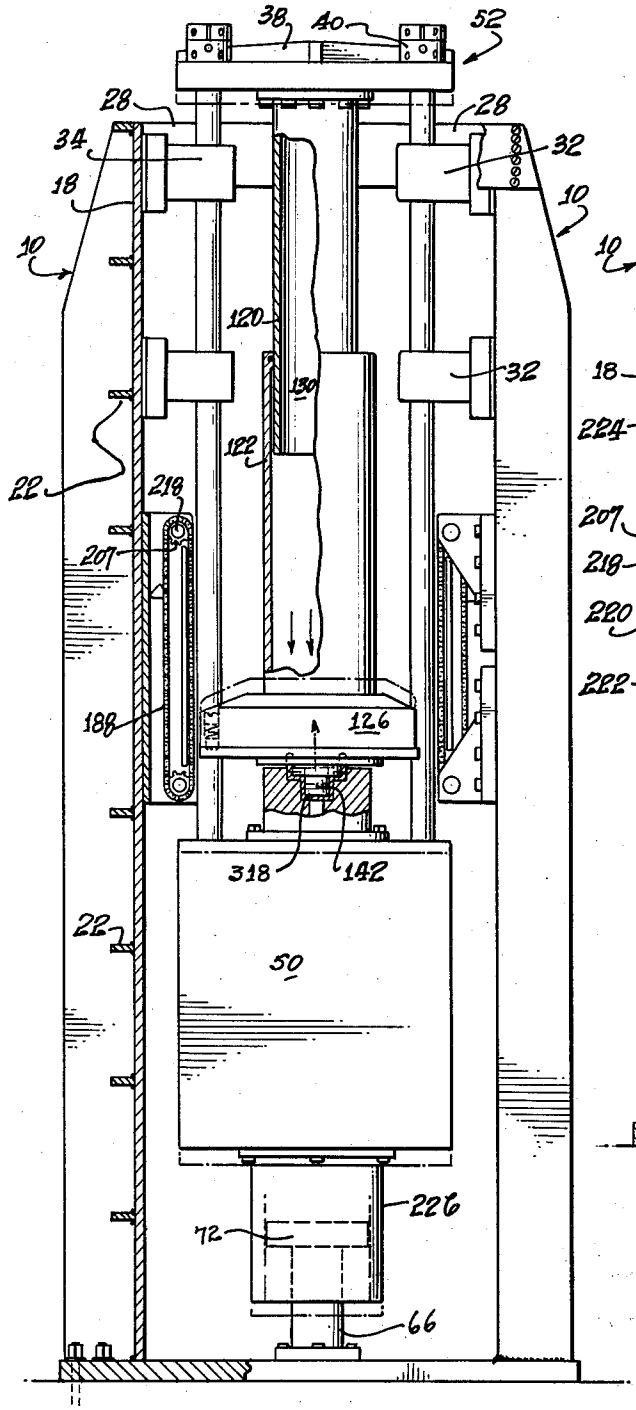
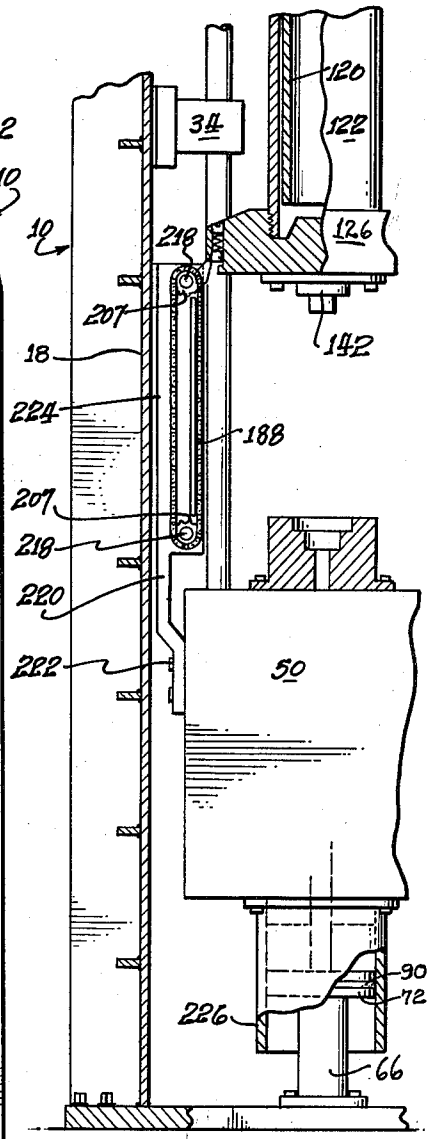


FIG. 7.



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FIG. 8.

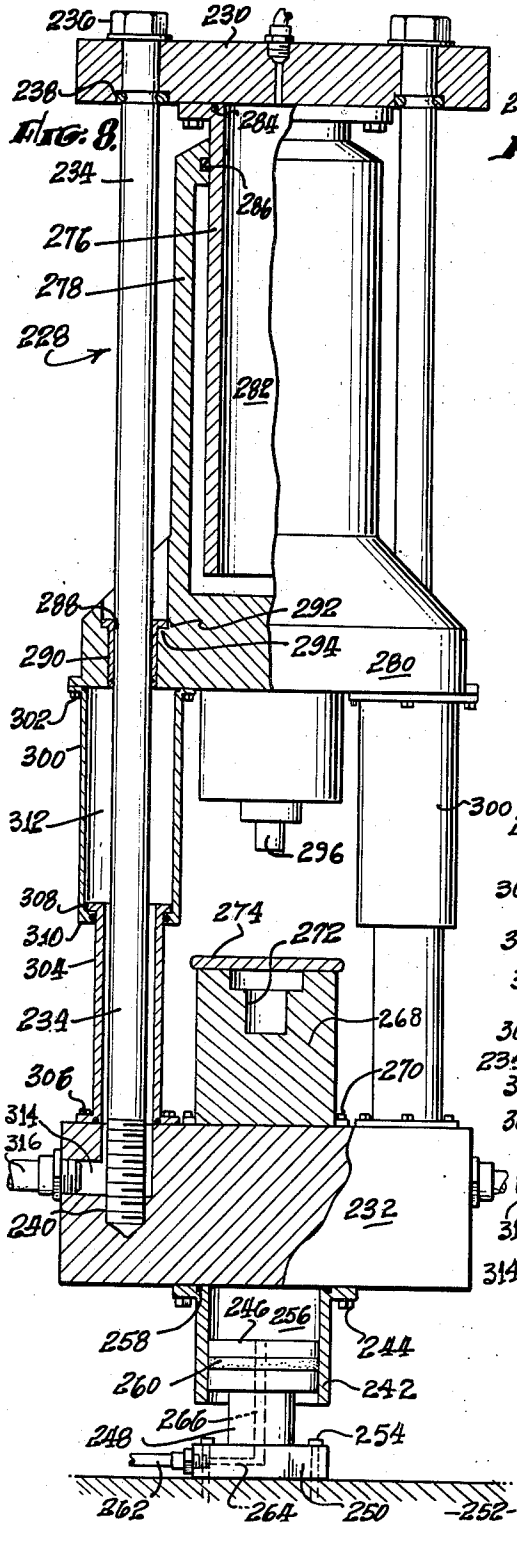
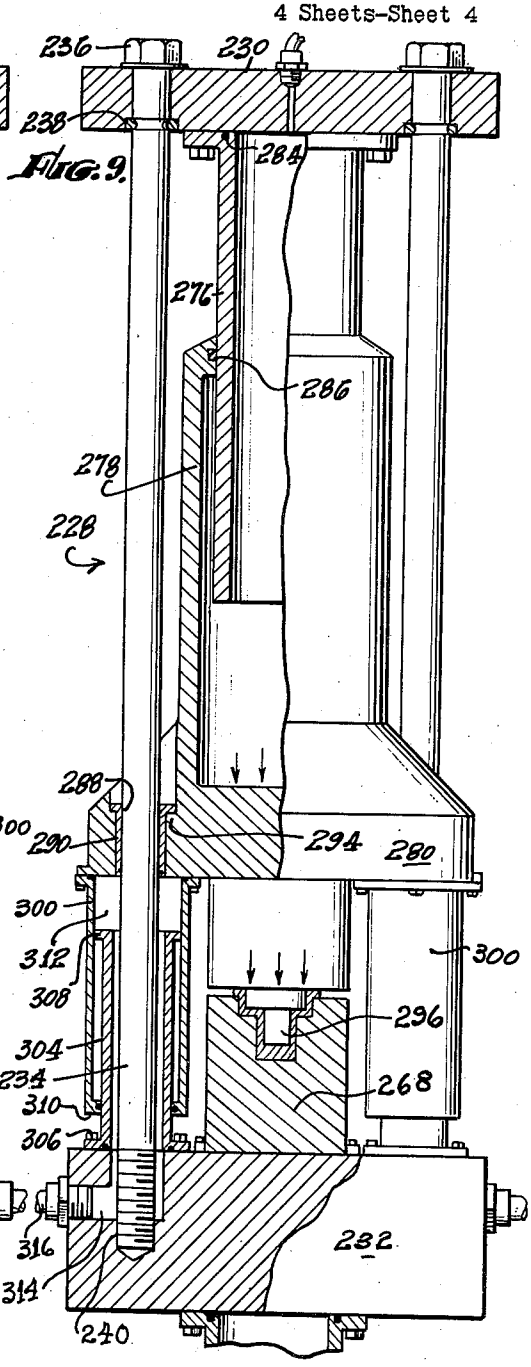


FIG. 9.



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United States Patent Office 3,108,503 Patented Oct. 29, 1963

3,108,503

HIGH ENERGY RATE FORMING MACHINE

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Filed Oct. 31, 1960, Ser. No. 66,142
20 Claims. (Cl. 78—42)

The present invention relates generally to forming machines; more particularly, the invention relates to high energy rate forming or impacting machines wherein a ram is driven to contract an expansible chamber to compress gas to provide an actuating pressure and is released for an output stroke energized by the actuating pressure.

High energy rate impacting and forming machines of the prior art have been characterized by certain shortcomings and disadvantages. The machines have generally lacked versatility of application. They have generally been relatively complex and have involved specialized fabrication. Functional or accessory devices and components have been required, such as pneumatic actuators, hydraulic valves, regulators and solenoid valves. Accumulators or other special devices have been required for the rapid removal of formed workpieces from dies to minimize heat transfer and to rapidly eject formed parts.

A major disadvantages of many such machines is the reduction in efficiency and in output energy caused by internal energy losses, such as the orifice losses of high energy rate actuators which are utilized with some machines. These losses result from high rate flow of gas or fluid and increase with increases in actuating pressure.

The present invention provides high energy rate forming machines which alleviate or eliminate the foregoing and other disadvantages and shortcomings. A ram cooperates with other machine components to define an expansible actuating pressure chamber. The ram is driven to compress gas in the expansible chamber to produce an actuating pressure. The ram is then rapidly triggered or released, whereupon the actuating pressure energizes a high velocity output stroke of the ram for high rate application of energy to a workpiece or other object. Mechanical, hydraulic or pneumatic means may be provided for the driving or resetting of the ram. In one embodiment, telescoping resetting cylinders are positioned to apply force to the ram. Pressure is introduced into these telescoping cylinders to drive and reset the ram. This pressure is rapidly relieved to release the ram for its output stroke. In a preferred embodiment, resetting and triggering are effected by power-driven endless belt means carrying hooks which engage and drive the ram. The hooks coact with the ram to effect rapid triggering of the ram after compression of gas in the actuating pressure chamber. The belt means are continuously driven by a motor through appropriate gearing and other components.

Machines of the present invention are highly efficient, because the only internal energy losses involved are minor frictional losses involved in the relative movements of the telescoping cylinders and other components. Efficiency improves with increases in actuating pressure, whereas in prior art machines the internal losses increase with higher actuating pressures.

Telescoping cylinders are preferably utilized to define the expansible actuating pressure chamber. The ram is connected to one cylinder and a movable bolster is connected with the other. Upon the release of the ram for its output stroke, the reaction causes the bolster to move toward the ram. The bolster and ram therefore move toward each other to impact a workpiece or object between them. Transmission of impact loading to a foundation is thereby minimized, and such loading is also reduced by the supporting of the bolster and its connected

frame structure by pressure in a chamber under the bolster.

Machines according to the invention provide a high degree of versatility. They are capable of functioning as simple drop hammers and as versatile high energy rate forming machines. Accurate and convenient selection of the time or period of a cycle of machine operation may be made merely by adjusting the speed of the above-mentioned endless belt means. The length of the ram output stroke is conveniently controlled by a simple adjustment of the position of the endless belt means relative to the ram and the bolster. The movements of the machine components are inherently adapted to rapidly eject formed workpieces from die parts without requiring special mechanisms for this purpose.

It is therefore an object of the present invention to provide a novel and improved impacting or forming machine.

An object of the invention is the provision of a high energy rate forming machine wherein a ram is driven to store energy by compressing a gas and is then released to utilize the stored energy for a high velocity output stroke.

It is an object of the invention to provide a high energy rate forming machine which provides improved efficiency and increased output energy by minimizing internal energy losses.

An object of this invention is to provide a versatile high energy rate forming machine.

It is an object of the present invention to provide a forming machine capable of functioning either as a drop hammer or as a versatile high energy rate forming machine.

An object of this invention is the provision of a high energy rate forming machine the operating cycle time of which is conveniently governable.

It is an object of the invention to provide a high energy rate forming machine wherein the length of a ram output stroke is conveniently adjustable.

An object of this invention is the provision of an impacting or forming machine capable of energy transmission to a workpiece at a high controlled rate.

It is an object of the invention to provide a high energy rate forming machine which minimizes the transmission of impact loading to a foundation.

An object of the present invention is to provide a high energy rate forming machine of simplified and economical construction.

It is an object of the invention to provide a high energy rate forming machine which is inherently adapted for the rapid ejection of formed workpieces.

Other objects, features and advantages of the present invention will become apparent to those versed in the art from a consideration of the following description, the appended claims and the accompanying drawings, wherein:

FIGURE 1 is an elevational view, partially in section, showing a preferred embodiment of the forming machine of the present invention;

FIGURE 2 is a partial plan view, partially in section, of the forming machine of FIGURE 1;

FIGURE 3 is an enlarged fragmentary elevational view showing a hook and associated elements utilized with the forming machine of FIGURE 1;

FIGURE 4 is an enlarged fragmentary plan view showing the hook and certain other elements shown in FIGURE 3;

FIGURE 5 is an enlarged fragmentary elevational view of the hook and elements of FIGURE 4;

FIGURE 6 is an elevational view similar to the view of FIGURE 1, showing the machine of FIGURE 1 with its components in different positions during a cycle of operation of the machine;

FIGURE 7 is a partial elevational view, partially in

section of a modified embodiment of the forming machine of the present invention;

FIGURE 8 is an elevational view, partially in section of another preferred embodiment of the forming machine of the present invention; and

FIGURE 9 is an elevational view similar to the view of FIGURE 8, showing the forming machine of FIGURE 8 with its components in different positions during a cycle operation of the machine.

Referring to the drawings, and particularly to FIGURES 1, 2 and 3, there is shown a preferred embodiment of the high energy rate forming machine of the present invention. Two identical vertical supports **10** are welded to a base plate **12** which is secured to a foundation **14** by bolts **16**. Each of the supports **10** includes a vertical mounting plate **18** to which are welded a plurality of vertical gussets **20** which extend perpendicularly from the mounting plate **18**, as shown in FIGURE 2, and which are welded to the base plate **12**. A plurality of horizontal ribs **22** are welded to and extend from the mounting plate **18** to provide structural reinforcement.

A connecting plate **24** is secured by screws to the upper portions of the outer gussets **20** and extends between the gussets. Another connecting plate **28** is welded between the upper portions of the mounting plates **18** at the rear of the machine. Secured to mounting plate **18** by bolts (not shown) are eight bearing blocks **32**. A sleeve bearing **34** is secured in each of the bearing blocks to provide four pairs of vertically aligned bearings.

Four guide rods **36** are slidable in the bearings **34**. To form a unitary frame structure, the guide rods are secured to an end plate **38** by nuts **40**, clamping nuts **42** and split lock rings **44**, the latter being disposed in recesses in the end plate and fitting in grooves **46** in the rods, as shown in FIGURE 1. The guide rods have threaded lower end portions **48** secured in appropriate openings in a bolster **50**, thereby forming a rigidly interconnected bolster and frame assembly **52**.

Secured by screws **54** to the lower surface of the bolster is a cap element **56** to which a cylindrical housing or shell **58** is threadedly secured. An annular wall portion **60** of the shell extends inwardly, as shown.

A mounting ring **62** is secured by bolts **64** to the base plate **12**. A stationary locating column **66** is secured in a threaded axial opening **68** of the mounting ring. An upper threaded end portion of the locating column is secured in an axial opening **70** of a stationary locating piston **72** positioned within the cylindrical shell **58**.

A locating pressure chamber **74** is defined above the stationary piston **72** and is connected with a source of locating pressure (not shown) by a passage **76** in the cap element and a fluid coupling **78**. A positioning pressure chamber **80** is defined below the piston **72** and is connected with a source of positioning pressure (not shown) by a passage **82** in the locating column and a fluid coupling **84**. Pressure sealing for the chambers is provided by a resilient sealing ring **86** between the cylindrical housing or shell **58** and the cap element **56**, by a sealing ring **88** in a groove in the annular wall portion **60** about the locating column, and by a sealing ring **90** in a peripheral groove of the loacting piston.

An ejector shaft **92** extends through an axial bore **94** in the bolster and has its end portion **96** threadedly secured in an opening in the threaded end portion of the locating column **66**. The ejector shaft is slidably received by an annular bearing **98** secured in an enlarged bore of an axial opening **100** of the cap element. An adapter rod **102** rests on the upper end of the ejector shaft and extends through a reduced portion **104** of the bolster bore **94**.

A die part **106** is secured by bolts **108** to the upper surface **110** of the bolter. A die cavity **112** and an axial bore **114** in die part **106** are aligned with the bolster bore portion **104**.

A cup element **116** is secured by screws **118** in a central position on the end plate **38**. Secured to a reduced

threaded portion of the cup element is an inner actuator cylinder **120**. An outer actuator cylinder or ram cylinder **122** is in telescoping relation with the inner cylinder **120** and has an inwardly extending portion **124** slidable on the inner cylinder. A ram **126** is secured to the outer cylinder by engagement of its threaded opening **128** with a lower end portion of the cylinder.

From the foregoing description it will be understood that the frame structure including the end plate **38** and the guide rods **36** combines with the bolster to form an integral bolster and frame assembly **52**, which is slidably mounted relative to the supports **10** and the foundation.

The ram and the outer actuator cylinder **122** constitute ram means which cooperate with the inner cylinder and the cup element **116** to define an actuating pressure chamber **130**. Pressure sealing for this chamber is provided by a resilient sealing ring **132** disposed in an appropriate groove in the outer cylinder and by similar sealing elements **134** in a groove in the cup element adjacent to the inner cylinder, and in a groove in the outer cylinder **122** adjacent to the ram **126**. The chamber is connected with a source of actuating pressure (not shown) by a passage **136** in the cup member and by a fluid coupling **138**.

Secured in an arcuate recess in each corner of the rectangular ram **126** is an arcuate bearing element **140**, as shown in FIGURES 1 and 2. A flange portion of each bearing element engages a groove in one of the recesses. Each bearing slidably engages a guide rod **36**. A male die part or punch **142** is secured by bolts to the lower surface of the ram.

Four mounting blocks **144** are secured by bolts **146** to the supports **10**, two mounting blocks being secured to each support in the positions shown in FIGURES 1 and 2. An axle **148** is journaled in bearing portions **150**, **152**, **154** and **156** of each mounting block. A sprocket wheel **158** is mounted on the axle **148** of each of the upper mounting blocks and is adjacent to the bearing portion **156**. An endless sprocket chain belt **160** is entrained on each sprocket wheel **158** of the upper axle **148** and on a sprocket wheel **162** mounted on a shaft **164** with a gear **166**. An endless sprocket chain belt **168** is entrained on the sprocket wheel **158** on the left axle **148** and on a sprocket wheel **170** mounted on a drive shaft portion **172**. The drive shaft carries a gear **174** which meshes with the gear **166**, as shown.

Power to drive the endless chain belts **160**, **168** is applied through transmission means including a gear box **176**, a clutch **178**. The power is furnished by an electric motor **180** and a flywheel **182**.

A pair of sprocket wheels **184**, **186** are mounted on each of the upper axles **148** between bearing portions **150** and **152**. A pair of endless chain belts **188**, **190** are entrained on cooperating sets of upper and lower sprocket wheels **184**, **186** with the inner runs of the chain belts adjacent to the ram **126**. To provide lateral support for the chain belts, a support plate **192** is welded in a vertical position between bearing portions **150** and **152** of the two mounting blocks on each support frame **10**.

A hook **194** is secured between the adjacent chain belts **188**, **190** on each side of the ram. As shown in FIGURES 3, 4 and 5, the hook is pivotally mounted on a rod **196** and is supported on a similar rod **198**, these rods extending laterally between the chain belts **188** and **190**. Each hook **194** has a rounded triangular end portion **200**.

From the foregoing description and from the drawings, it will be understood that the endless chain belts **188**, **190** and the hooks **194** thereon are power-driven in opposite rotational directions at the same speed by the motor **180** through the above-described transmission system. The hooks move upward on the inner runs of the endless belts in positions wherein they are engageable with the ram **126** in the manner indicated in FIGURE 3.

Referring to FIGURES 1 and 3, there are defined in

each side of the ram adjacent to the endless chain belts a recess 202 and a bore 204. The recess has an inclined surface 206 which cooperates with the bore wall to define a rounded triangular edge portion 208, which is positioned and adapted to coact with the end portion 200 of the hook 194 in a manner which is hereinafter described. A plunger 210 is slidable in each of the bores 204 and is positioned to receive the first contact of a moving hook as it moves upward to engage the ram. A helical spring 212 is retained in the bore by an adjustment screw 214 and exerts a biasing force on the plunger normally urging the plunger against a shoulder 216.

To prepare the forming machine of FIGURES 1 through 5 for operation, quantities of gas under appropriate pressures are introduced into the actuating pressure chamber 130, the locating pressure chamber 74 and the positioning pressure chamber 80. After these quantities of gas are established in the chambers, they are maintained therein without change during repeated cycles of operation of the machine. A gas under appropriate pressure is introduced into the actuating pressure chamber 130 through the coupling 138 and the passage 136. This is preferably done with the ram in the position shown in FIGURE 6. When the ram 126 is in the upward position shown in FIGURE 1, the gas in the chamber is compressed to provide an actuating pressure. A locating pressure is introduced into the chamber 74 through the passage 76 and the coupling 78. The pressure supports the bolster and frame assembly 52. A positioning pressure is established in the chamber 80 through the passage 82 in the locating column 66 and through the coupling 84. This pressure acts on the annular wall area 60 to urge the bolster and frame assembly downwardly and to restrain its upward movement toward the ram. The locating pressure in chamber 74 and the positioning pressure in chamber 80 cooperate to urge the bolster and frame assembly into and maintain it in a proper normal position relative to the ram 126, as shown in FIGURE 1. The two pressures and the respective areas upon which they act are so established that the locating pressure supports the weight of the bolster and frame assembly 52 and in addition balances the opposite force of the positioning pressure on the annular wall portion 60.

The operating cycle of the machine is described hereinafter and includes the driving of the ram to contract the actuating pressure chamber to provide an actuating pressure, and the rapid release of the ram for an output stroke against an object on the bolster, the output stroke being energized by the actuating pressure.

In the operation of the machine, the motor 180 continuously transmits power through the flywheel 182 and the gears 166, 174 to the endless chain belts 160, 168. The hooks continuously move with the endless belts and first engage the ram when it is in the position shown in FIGURE 6. The initial impact of the hooks on the ram is absorbed by the plungers 210 and the springs 212, shown in detail in FIGURE 3, which reduce shock and prevent damage to the hooks and to the ram edge portions 208. Force for driving the ram is applied by the hooks to the edge portions 208 of the ram. The continuous movement of the hooks with the endless belts drives the ram upward to contract the actuating pressure chamber 130, thereby compressing the gas therein to provide an actuating pressure. The ram is thus reset or recocked.

After the driving or resetting of the ram to establish the actuating pressure, the hooks 194 coact with the ram to rapidly release the ram for a downward output stroke energized by the actuating pressure. FIGURE 3 shows a hook 194 immediately prior to its disengagement from the ram. The continuous movement of the endless chain belts 188, 190 and the rotary movement of the hooks 194 about the sprocket wheels 184 move the hook from the position shown in solid lines to the position shown in phantom outline in FIGURE 3. The rotary hook movement, the spring pressure on plungers 210 and the actuating pressure in chamber 130 effect a very rapid disengagement of the rounded triangular end portions 200 of the hooks from the rounded triangular edge portions 208 of the ram. The hook end portions then slide freely along the inclined surfaces 206 to the position indicated in phantom outline in FIGURE 3.

The disengagement of the hooks permits the energy stored by the compression of the gas in the actuating pressure chamber to be imparted to the ram to energize its downward output stroke. The male die part 142 on the ram impacts a workpiece positioned on the die part 106 on the bolster 50. Immediately following its output stroke, the ram is positioned as shown in solid lines in FIGURE 6.

In reaction to the high velocity downward output stroke of the ram, the bolster and frame assembly 52 moves upwardly toward the ram a relatively short distance to the position shown in solid lines in FIGURE 6. Then, the bolster and frame assembly 52 moves downwardly away from the ram to the position shown in phantom outline in FIGURE 6. This downward movement is caused partly by the impact of the ram on the bolster and to a greater extent by the action of the gas in the positioning pressure chamber 80, which was compressed to a pressure greater than its normal positioning pressure by the above-described upward bolster movement toward the ram. Thus, the bolster is urged downwardly toward its normal position, shown in FIGURE 1, by the expansion of the gas which was compressed in the positioning pressure chamber by the upward bolster movement.

Impact loading of the foundation is reduced by the pressure in the locating pressure chamber 80, which serves as a shock absorber.

The stationary ejector shaft 92 and adaptor rod 114, which extend through the bolster, eject a formed workpiece or part 318 from the die part 106 upon the downward movement of the bolster to the position shown in phantom outline in FIGURE 6. The formed part is ejected into the open space which is provided by the upward ram movement and the downward bolster movement. The part may therefore be readily grasped manually or automatically.

Any oscillation of the bolster and frame assembly 52 which might occur after the impact of the ram would have no adverse effect on the formed part 318, because there can be no second impact on the formed part, this being precluded by the above-described downward bolster movement.

During the foregoing movements of the bolster and frame assembly 52, the continuously moving hooks engage the ram and move it upward to the position shown in phantom outline in FIGURE 6. The ram is then driven by the hooks to contract the actuating pressure chamber and compress the gas therein to re-establish the actuating pressure. A cycle of operation of the machine is thereby completed and the machine is prepared for a repeat cycle.

During the driving of the ram to establish the actuating pressure on each cycle of operation, the pressure in the positioning pressure chamber 80 exerts a continuous downward force on the annular wall portion 60 which prevents the bolster and frame assembly 52 from being lifted by the force of the increasing pressure in the actuating pressure chamber 130. Proper compression in the chamber 130 is thereby effected. The positioning pressure force on annular wall portion 60 is greater than the actuating pressure force on the area of cup member 116 in the actuating pressure chamber. Therefore the increased pressure in the actuating pressure chamber 130 produced by the resetting of the ram cannot exert sufficient force to lift the bolster and frame assembly.

It will be readily appreciated that the time period for a cycle of operation of the machine may readily be adjusted by regulating the speed of the endless chain belts, by governing the speed of the motor 180, by changing gear ratios, or by other apropriate means.

The length of the output stroke of the ram is readily adjustable by lowering or raising the endless belts by repositioning the mounting blocks 144. A relatively short ram stroke obviously results in the workpiece being impacted with greater energy, because there is less expansion of the gas in the actuating pressure chamber.

In addition to operating in the foregoing manner, the forming machine of FIGURE 1 is capable of operation as a simple drop hammer. For such operation, the endless chain belts and the hooks thereon operate in the above-described manner to lift or drive the ram to the position shown in FIGURE 1. The hooks 194 then coact with the ram in the manner hereinbefore described to rapidly release the ram for a downward stroke or drop against the workpiece to be formed.

The time period of a cycle of operation may be governed by controlling the rotational speed of the endless belts.

FIGURE 7 illustrates a modified form of the machine of FIGURES 1 through 5. It differs therefrom primarily in that the sprocket wheels and the endless chain belts are mounted on shafts 218 journaled on mounting brackets 220 secured to each side of the bolster by bolts 222. A rail portion 224 of each bracket is slidably positioned against the adjacent mounting plate 18 of a support 10. The machine of FIGURE 7 also differs from that of FIGURE 1 in that no positioning pressure chamber is utilized. A modified cylindrical shell 226 has no lower wall and is open to the atmosphere, as shown.

The operation of the embodiment shown in FIGURE 7 differs from that hereinbefore described in that the driving force exerted by the hooks 194 on the ram is exerated oppositely on the bolster through the brackets 220. The force of the hooks on the ram is therefore reacted on the bolster. The ram is therefore moved effectively relative to the bolster with no lifting of the bolster by the increasing pressure in the actuating pressure chamber 130 during the driving of the ram. No positioning pressure chamber is required to prevent such lifting of the bolster and frame assembly. Adjustment of the length of the ram output stroke is readily accomplished by changing the position of the brackets 220 on the bolster 50.

FIGURES 8 and 9 illustrate another preferred embodiment of the present invention, which differs from those hereinbefore described primarily in that pressure actuated telescoping cylinders are utilized for driving or resetting the ram and compressing the gas in the actuating pressure chamber.

A frame and bolster assembly 228 includes an end plate 230 and a bolster 232 which are rigidly interconnected by four guide rods 234. The guide rods extend through appropriate openings in the end plate and are secured thereto by bolt heads 236 and by split lock rings 238 which are disposed in recesses in the end plate and fit in annular grooves in the rods, as shown. Threaded lower end portions of the guide rods are secured in appropriate openings 240 in the bolster. A cylindrical housing shell 242 is secured to the lower surface of the bolster by bolts 244. A stationary locating piston 246 is disposed within the cylindrical shell and is secured to a stationary locating column 248 mounted on a base member 250. The base member is secured to a fundation 252 by bolts 254.

A locating pressure chamber 256 is defined by the piston, the bolster and the cylindrical shell. Pressure sealing is provided by a resilient sealing ring 258 in a groove in the cylindrical shell adjacent to the bolster and by a resilient sealing ring 260 in a peripheral groove of the piston. The pressure chamber is connected with a source of locating pressure (not shown) by a fluid coupling 262, a passage 264 in the base member 250, and a passage 266 in the locating column and piston.

A die part 268 is secured to the upper surface of the bolster by bolts 270 which extend through its flange portion. A die cavity or recess 272 is defined in the die and

a workpiece 274 is positioned atop the die preparatory to being formed.

An inner actuator cylinder 276 is secured to the lower surface of end plate 230 by bolts which extend through a flange portion of the cylinder. An outer telescoping actuator cylinder 278 is slidably positioned about the inner cylinder and is integral with a ram 280.

An actuating pressure chamber 282 is defined by the inner cylinder, the end plate, the outer cylinder and the ram. Pressure sealing for the chamber is provided by a resilient sealing ring 284 in an appropriate groove in the inner cylinder adjacent to the end plate, and by a resilient sealing ring 286 in a groove in the outer cylinder adjacent to the inner cylinder.

To slidably accommodate the guide rods 234, bores 288 are defined near the corners of the ram. Sleeve bearings 290 are secured therein by their retaining flange portions 292 which engage shoulders 294 within the bores. A male die part 296 is secured to the lower surface of the ram.

Outer resetting cylinders 300 are secured to the lower surface of the ram by bolts 302 and are axially disposed about the respective guide rods 234, as shown. Inner resetting cylinders 304 of smaller diameter are secured by bolts 306 to the upper surface of the bolster. Each inner resetting cylinder is axially disposed about a guide rod and has an outwardly extending flange portion 308 which is positioned within an outer resetting cylinder and which is engageable with an inwardly extending flange portion 310 of the outer cylinder. Resetting pressure chambers 312 are defined within the respective resetting cylinders, and pressure sealing for the chambers is provided by appropriately positioned seal rings, as shown. Each of the resetting pressure chambers is connected with a source of resetting pressure (not shown) by a large passage 314 in the bolster and by fluid coupling 316.

The operation of the machine shown in FIGURES 8 and 9 differs from that of the embodiments hereinbefore described in that the telescoping resetting cylinders 300, 304 are utilized to reset or drive the ram to compress the gas in the actuating pressure chamber 282. An appropriate resetting pressure is introduced through passages 314 in the bolster and through fluid couplings 316 into the resetting pressure chambers 312 within the respective sets of telescoping cylinders. The resetting pressure exerts a driving force on the ram to contract the actuating pressure and compress the gas in the actuating pressure chamber.

After the resetting of the ram and the establishing of the actuating pressure, release or triggering of the ram is effected by rapidly releasing the pressure in the resetting pressure chambers 312 through the passages 314 and the couplings 316 by means of appropriate valves (not shown).

The resetting pressure acts on the ram areas within the resetting chambers to drive the ram, and resetting pressure acts oppositely on the bolster areas within the chambers. The ram is therefore moved relative to the bolter so that the increasing pressure in the actuating pressure chamber does not lift the bolster.

In other respects, the operation of the machine of FIGURES 8 and 9 is generally similar to that hereinbefore described in relation to the forming machine shown in FIGURE 7.

From the foregoing description, these versed in the art will appreciate that the present invention achieves the objects and realizes the advantages hereinbefore mentioned.

Although specific embodiments of the present invention have been illustrated and described herein, it will be understood that the same are merely exemplary of presently preferred embodiments capable of attaining the objects and advantages hereinbefore mentioned, and that the invention is not limited thereto; variations will be readily apparent to those versed in the art, and the invention is to be given its broadest interpretation within the terms of the appended claims.

The inventor claims:

1. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the bolster being mounted for movement relative to each other, means supporting said bolster on a foundation for vertical movement relative thereto, means for moving the telescoping cylinders relative to each other to compress a gas in the actuating pressure chamber to provide an actuating pressure, and triggering means for rapidly releasing the cylinders for relative movement under the action of the actuating pressure, whereby the ram and the bolster move toward each other to impact an object therebetween.

2. A forming machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster confronting the ram, a frame structure interconnecting the bolster and the end of the second cylinder opposite from the ram, means supporting said bolster and frame structure on a foundation for vertical movement relative thereto, means for moving the ram means in a direction to compress a gas in said actuating pressure chamber, and means for holding the ram and for rapidly releasing the ram for an output stroke toward the bolster energized by the actuating pressure, the bolster moving toward the ram in reaction to said ram output stroke, whereby an object is impacted between the ram and the bolster.

3. A forming machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster, a frame structure including guide rods interconnecting the bolter and the end of the second cylinder opposite from the ram to provide an integral bolster and frame assembly, said ram being slidable on the guide rods, means supporting said bolster and frame assembly for vertical movement relative to a foundation, and means for driving the ram to compress a gas in the actuating pressure chamber and for rapidly releasing the ram after the compression, whereby the ram is triggered for an output stroke energized by the actuating pressure, the bolster moving toward the ram in reaction to the ram output stroke, whereby an object is impacted between the ram and the bolster.

4. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber containing a gas, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the bolster being mounted for movement relative to each other, means supporting said bolster on a foundation for vertical movement relative thereto, means defining an expansible resetting pressure chamber connected with the ram means, means for introducing a resetting pressure into said resetting chamber to drive the ram in a direction to contract the actuating pressure chamber and to compress the gas therein to provide an actuating pressure, and means for rapidly relieving the resetting pressure from the resetting chamber to trigger the ram for an output stroke against an object to be formed, whereby the compression provides an actuating pressure and the ram is triggered for an output stroke energized by the actuating pressure.

5. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the bolster being mounted for movement relative to each other, means for moving said telescoping cylinders relative to each other to compress a gas in the actuating pressure chamber to provide an actuating pressure, triggering means for suddenly releasing the cylinders for relative movement under the action of the actuating pressure, whereby the ram and the bolster move toward each other to impact an object therebetween, and means defining a positioning pressure chamber containing a gas under pressure normally restraining movement of the bolster toward the ram, whereby the gas in the positioning pressure chamber is compressed upon said movement of the bolster toward the ram and expands thereafter to urge the bolster toward its normal position.

6. A forming machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster confronting the ram, a frame structure interconnecting the bolster and the end of the second cylinder opposite from the ram, means for moving the ram means in a direction to compress a gas in the actuating pressure chamber, means for holding and for rapidly releasing the ram for an output stroke toward the bolster energized by the actuating pressure, the bolster moving toward the ram in reaction to said ram output stroke, whereby an object is impacted between the ram and the bolster, and means including a stationary piston defining a positioning pressure chamber containing a gas under pressure normally restraining movement of the bolster toward the ram, wherby said gas in the positioning pressure chamber is compressed upon said movement of the bolster toward the ram and expands thereafter to urge the bolster means toward its normal position.

7. A forming machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster, a frame structure including guide rods interconnecting the bolster and the end of the second cylinder opposite from the ram to provide an integral bolster and frame assembly, the ram being slidable on said guide rods, means supporting said bolster and frame assembly for vertical movement relative to a foundation, means for driving the ram to compress a gas in the actuating pressure chamber and for rapidly releasing the ram after the compression, whereby the ram is triggered for a downward output stroke energized by the actuating pressure, said bolster moving upward toward the ram means in reaction to said ram output stroke, whereby an object is impacted between the ram and the bolster, means including a stationary piston defining a locating pressure chamber below the bolster containing a locating pressure to support said bolster and frame assembly and to reduce the transmission of impact loading to a foundation, and means including said stationary piston defining a positioning pressure chamber containing a gas under a positioning pressure normally urging the bolster downwardly, whereby the gas in the positioning pressure chamber is compressed upon said movement of the bolster toward the ram and expands thereafter to urge the bolster means toward its normal position.

8. An impacting machine comprising ram cylinder means, means including a telescoping cylinder cooperating with the ram cylinder means to define an expansible actuating pressure chamber, and means for moving the ram cylinder means to compress a gas in the actuating pressure chamber and for releasing the ram cylinder means after the compression, whereby the compression provides an actuating pressure and the ram cylinder means is triggered for an output stroke energized by the actuating pressure, bolster means confronting the ram cylinder means and mounted for movement relative thereto, whereby a workpiece disposed on the bolster receives a forming impact from the ram cylinder means, the bolster means moving in a direction away from the ram cylinder means after said impact, and stationary ejection means to eject the formed workpiece upon said bolster means movement away from the ram cylinder means.

9. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster connected with the second cylinder and carrying a workpiece to be formed, the ram and the bolster being mounted for movement relative to each other, means for moving said telescoping cylinders relative to each other to compress a gas in the actuating pressure chamber to provide an actuating pressure, and triggering means for suddenly releasing the cylinders for relative movement under the action of the actuating pressure, whereby the ram and the bolster move toward each other to impact said workpiece therebetween, means defining a positioning pressure chamber containing a gas under pressure normally restraining movement of the bolster toward the ram, whereby the gas in the positioning pressure chamber is compressed upon said movement of the bolster means toward the ram, the bolster being moved in a direction away from the ram by said impact and by expansion of said compressed gas in the positioning pressure chamber, and stationary ejection means extending through the bolster to eject the formed workpiece upon said bolster movement away from the ram.

10. A forming machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster carrying die means, a frame structure including guide rods interconnecting the bolster and the end of the second cylinder opposite from the ram to provide an integral bolster and frame assembly, the ram being slidable on said guide rods, means supporting said bolster and frame assembly for vertical movement relative to a foundation, means for driving the ram to compress a gas in the actuating pressure chamber and for rapidly releasing the ram after the compression, whereby the ram is triggered for a downward output stroke energized by the actuating pressure, said bolster moving upward toward the ram means in reaction to said ram output stroke, whereby a workpiece is impacted between the ram and the bolster, means including a stationary piston defining a positioning pressure chamber containing a gas under a positioning pressure normally urging the bolster downwardly, the gas in the positioning pressure chamber being compressed upon said movement of the bolster toward the ram, the bolster being moved downwardly by the impact of the ram and by expansion of said compressed gas in the positioning pressure chamber, stationary ejection means connected with said stationary piston and extending through the bolster to engage and to eject the formed workpiece upon said downward movement of the bolster, and means including said stationary piston defining a locating pressure chamber below the bolster containing a locating pressure to support said bolster and frame assembly and to reduce the transmission of impact loading to a foundation.

11. An automatic drop hammer comprising first and second telescoping cylinders, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the bolster being mounted for vertical movement relative to each other, power driven endless belt means, and hook means carried by the endless belt means to engage the ram and move the ram in an upward direction, said hook means being adapted to coact with the ram to release the ram rapidly and automatically after said upward movement for a downward output stroke against an object to be former, the length of the ram output stroke being governed by the positioning of the endless means relative to a foundation, whereby the endless means raises the ram means and the engaging means then automatically trigger the ram means, and whereby the time period of a cycle of operation is controlled by governing the speed of the power driven endless means.

12. An automatic drop hammer comprising first and second telescoping cylinders, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the bolster being mounted for vertical movement relative to each other, power driven endless belt means, hook means carried by the endless belt means, said hook means having a rounded triangular end portion engageable with a rounded triangular edge portion of the ram for exerting force on the ram to move the ram upward, said hook end portion being disengaged from said ram edge portion by continuous movement of the endless belt means, whereby the ram is rapidly and automatically released for a downward output stroke, whereby endless means raises the ram means and the engaging means then automatically trigger the ram means, and whereby the time period of a cycle of operation is controlled by governing the speed of the power driven endless means.

13. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the bolster being mounted for movement relative to each other, power driven endless belt means, and hook means carried by the endless belt means to engage the ram and drive the ram in a direction to compress gas within said actuating pressure chamber to provide an actuating pressure, said hook means coacting with the ram to release the ram rapidly and automatically after said compression for an outptut stroke against an object to be formed, the length of the ram output stroke being governed by the positioning of the endless belt means relative to a foundation, whereby said compression provides an actuating pressure which energizes the output stroke of the ram, and whereby the time period of a cycle of compression and output stroke is controlled by governing the speed of the power driven endless means.

14. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the bolster being mounted for movement relative to each other, means supporting said bolster on a foundation for vertical movement relative thereto, power driven endless belt means carried by the bolster, and hook means carried by the endless belt means to engage the ram and exert force thereon in a direction to compress gas within said actuating pressure chamber to provide an actuating pressure, said force of the hook means on the ram being reacted on the bolster, whereby the ram is moved relative to the bolster for said compression, said hook means coacting with the ram to release the ram rapidly and automatically after said compression for an output stroke against an object to be formed, the length of the ram output stroke being governed by the positioning of the endless belt means on the bolster, whereby said compression provides an actuating pressure which energizes the output stroke of the ram, and whereby the time period of a cycle of compression and output stroke is controlled by governing the speed of the power driven endless means.

15. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster confronting the ram and connected with the second cylinder, the ram and the bolster being mounted for movement relative to each other, power driven endless belt means entrained on wheel means, and hook means carried by the endless belt means, said hook means having a rounded triangular end portion engageable with a rounded triangular edge portion of the ram for exerting force on the ram to drive the ram in a direction to compress gas in the actuating pressure chamber, said hook end portion being disengaged from said ram edge

portion by continuous movement of the endless belt means, whereby the ram is rapidly released for an output stroke, the length of the ram output stroke being governed by the positioning of the endless means relative to a foundation, whereby the compression provides an actuating pressure which energizes the output stroke of the ram, and whereby the time period of a compression and output stroke cycle is controlled by governing the speed of the power driven endless means.

16. A forming machine comprising first and second telescoping cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster connected with the second cylinder, the ram and the boster being mounted for movement relative to each other, means supporting said bolster on a foundation for vertical movement relative thereto, power driven endless belt means carried by the bolster, and hook means carried by the endless belt means, said hook means having a rounded triangular end portion engageable with a rounded triangular edge portion of the ram for exerting force on the ram to drive the ram in a direction to compress gas in the actuating pressure chamber, the force of the hook means on the ram being reacted on the bolster, whereby the ram is moved relative to the bolster for said compression, said hook end portion being disengaged from said ram edge portion by continuous movement of the endless belt means, whereby the ram is rapidly released for an output stroke, whereby the compression provides an actuating pressure which energizes the output stroke of the ram, and whereby the time period of a compression and output stroke cycle is controlled by governing the speed of the power driven endless means.

17. A forming machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster confronting the ram, a frame structure interconnecting the bolster and the end of the second cylinder opposite from the ram, power driven endless means, and engaging means carried by the endless means to engage the ram means and drive the ram means in a direction to compress gas within the actuating pressure chamber and provide an actuating pressure, said engaging means coacting with the ram means to release the ram means rapidly and automatically after said compression for an output stroke against an object to be formed, the bolster moving toward the ram in reaction to said ram output stroke, whereby an object is impacted between the ram and the bolster, and means including a stationary piston defining a positioning pressure chamber containing a gas under pressure normally restraining movement of the bolster toward the ram, whereby said gas in the positioning pressure chamber is compressed upon said movement of the bolster toward the ram and expands thereafter to urge the bolster means toward its normal position.

18. An impacting machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster, a frame structure including guide rods interconnecting the bolster and the end of the second cylinder opposite from the ram to provide an integral bolster and frame assembly, the ram being slidable on said guide rods, means supporting said bolster and frame assembly for vertical movement relative to a foundation, power driven endless belt means entrained on wheel means, hook means carried by the endless belt means to engage the ram and drive the ram in a direction to compress gas within said actuating pressure chamber to provide an actuating pressure, said hook means coacting with the ram to release the ram rapidly and automatically after said compression for a downward output stroke against an object to be formed, the length of the ram output stroke being governed by the positioning of the endless means relative to a foundation, said bolster moving upward toward the ram means in reaction to said ram output stroke, whereby an object is impacted between the ram and the bolster, means including a stationary piston defining a locating pressure chamber below the bolster containing a locating pressure to support said bolster and frame assembly and to reduce the transmission of impact loading to a foundation, and means including said stationary piston defining a positioning pressure chamber containing a gas under a positioning pressure normally urging the bolster downwardly, whereby the gas in the positioning pressure chamber is compressed upon said movement of the bolster toward the ram and expands thereafter to urge the bolster means toward its normal position.

19. An impacting machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster, a frame structure including guide rods interconnecting the bolster and the end of the second cylinder opposite from the ram to provide an integral bolster and frame assembly, the ram being slidable on said guide rods, means supporting said bolster and frame assembly for vertical movement relative to a foundation, power driven endless belt means carried by the bolster, hook means carried by the endless belt means to engage the ram and exert force thereon in a direction to compress gas within said actuating pressure chamber to provide an actuating pressure, the force of the hook means on the ram being reacted on the bolster, whereby the ram is moved relative to the bolster for said compression, said hook means coacting with the ram to release the ram rapidly and automatically after said compression for an output stroke against an object to be formed, the length of the ram output stroke being governed by the positioning of the endless belt means on the bolster, the bolster moving toward the ram means in reaction to said ram output stroke, whereby an object is impacted between the ram and the bolster, means including a stationary piston defining a locating pressure chamber below the bolster containing a locating pressure to support said bolster and frame assembly and to reduce the transmission of impact loading to a foundation, and means including said stationary piston defining a positioning pressure chamber containing a gas under a positioning pressure normally urging the bolster downwardly, whereby the gas in the positioning pressure chamber is compressed upon said movement of the bolster toward the ram and expands thereafter to urge the bolster means toward its normal position.

20. An impacting machine comprising telescoping first and second cylinders, means cooperating with the telescoping cylinders to define an expansible actuating pressure chamber, a ram connected to the first cylinder, a bolster, a frame structure including guide rods interconnecting the bolster and the end of the second cylinder opposite from the ram to provide an integral bolster and frame assembly, the ram being slidable on the guide rods, means supporting said bolster and frame assembly for vertical movement relative to a foundation, power driven endless belt means carried by the bolster, hook means carried by the endless belt means to engage the ram and exert force thereon in a direction to compress gas within said actuating pressure chamber to provide an actuating pressure, the force of the hook means on the ram being reacted on the bolster, whereby the ram is moved relative to the bolster for said compression, said hook means coacting with the ram to release the ram rapidly and automatically after said compression for an output stroke against an object to be formed, the length of the ram output stroke being governed by the positioning of the endless belt means on the bolster, the bolster moving toward the ram means in reaction to said ram output stroke, whereby

an object is impacted between the ram and the bolster, means including a stationary piston defining a locating pressure chamber below the bolster containing a locating pressure to support said bolster and frame assembly and to reduce the transmission of impact loading to a foundation, and means including said stationary piston defining a positioning pressure chamber containing a gas under a positioning pressure normally urging the bolster downwardly, whereby the gas in the positioning pressure chamber is compressed upon said movement of the bolster means toward the ram, the bolster being moved in a direction away from the ram by said impact and by expansion of said compressed gas in the positioning pressure chamber, and stationary ejection means extending through the bolster to eject the formed workpiece upon said bolster movement away from the ram.

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