Feb. 18, 1969 A. MICHELSON 3,427,851

HIGH ENERGY RATE METAL FORMING MACHINE

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FIG. 1

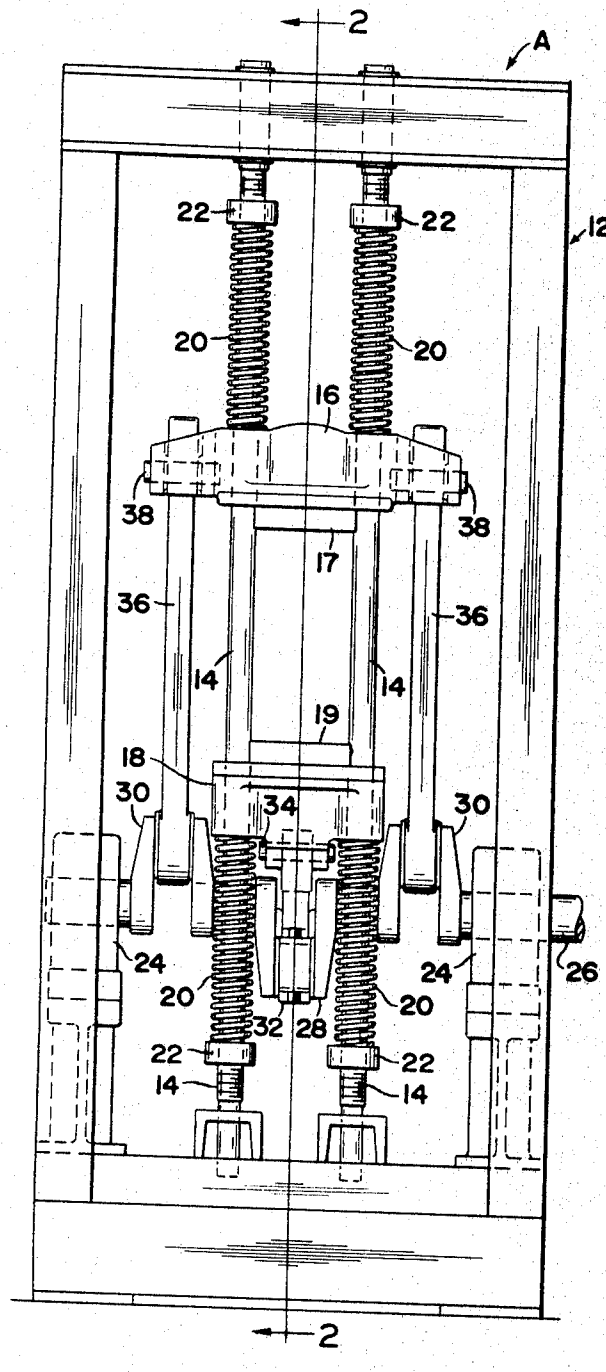
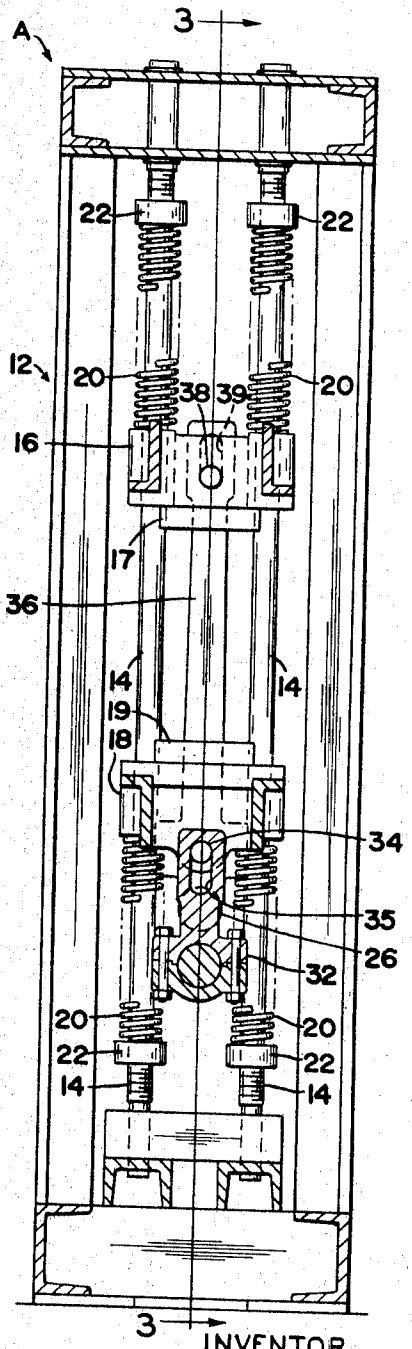



FIG. 2




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FIG. 3

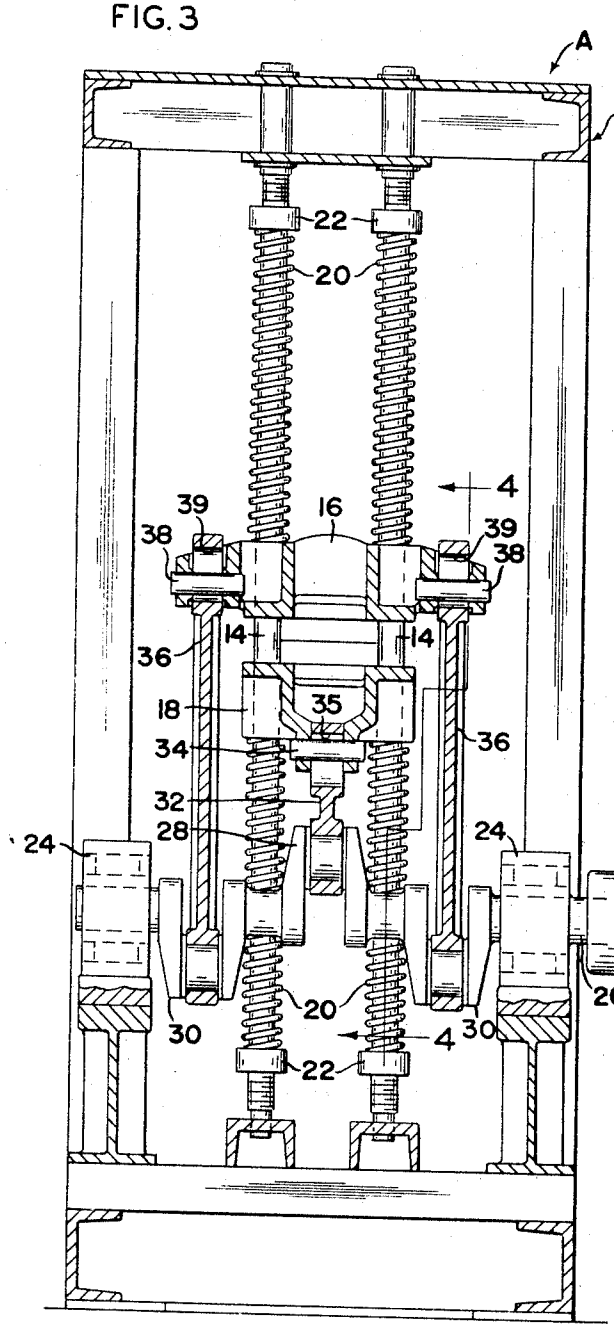
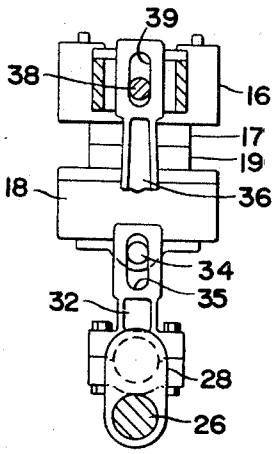
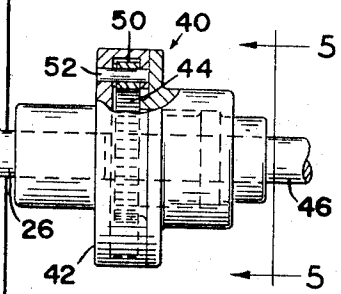



FIG. 4



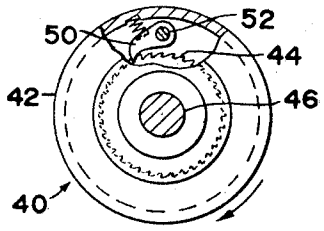




FIG. 5

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FIG. 6

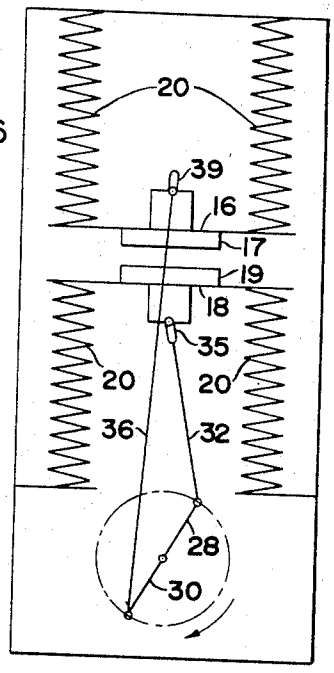



FIG. 7

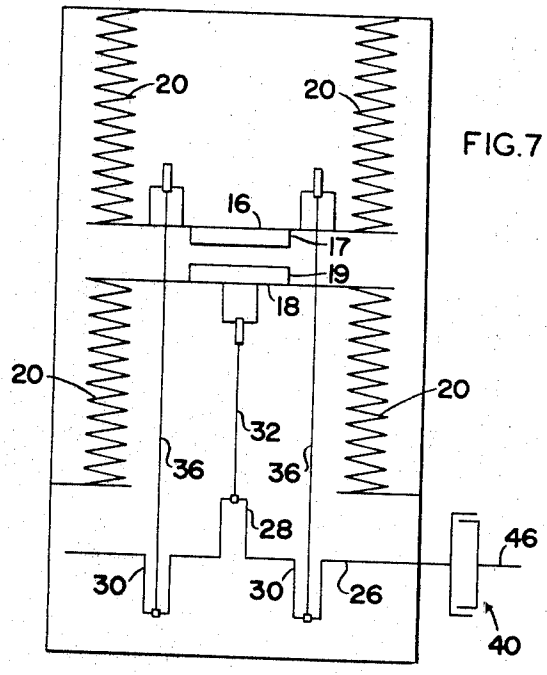



FIG. 8

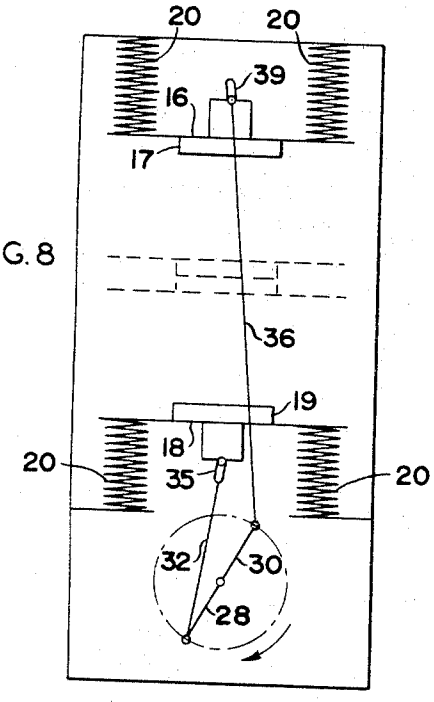
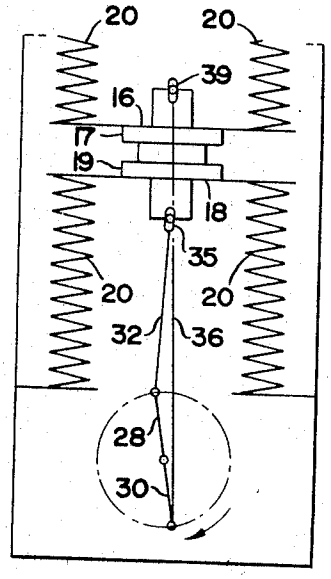



FIG. 9




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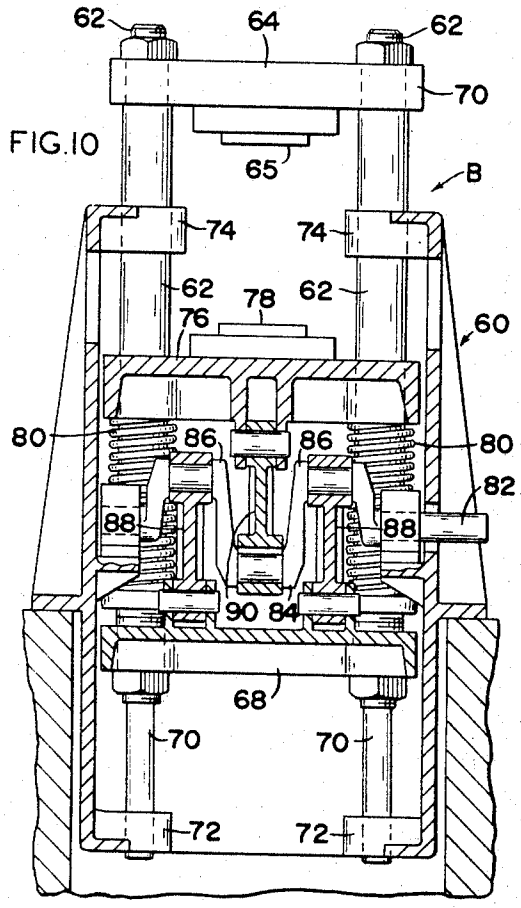
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FIG.10



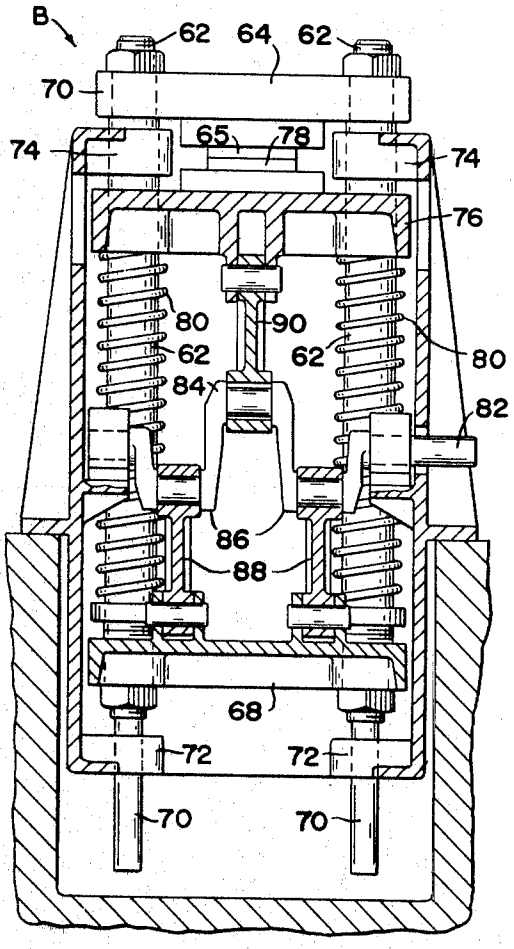




FIG.11

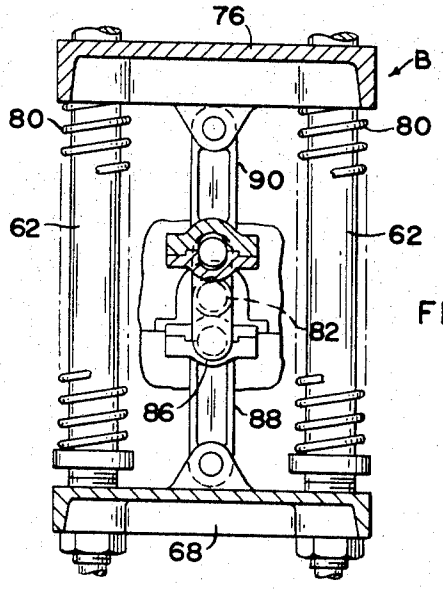



FIG.12

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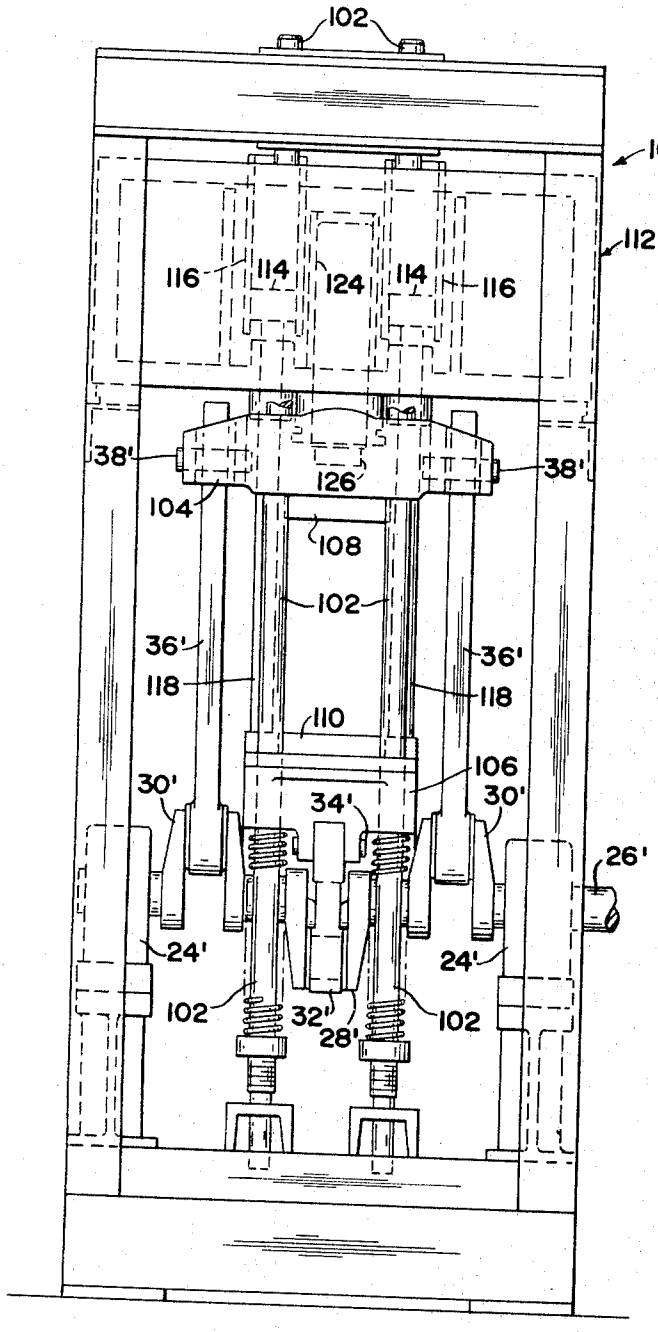



FIG. 13

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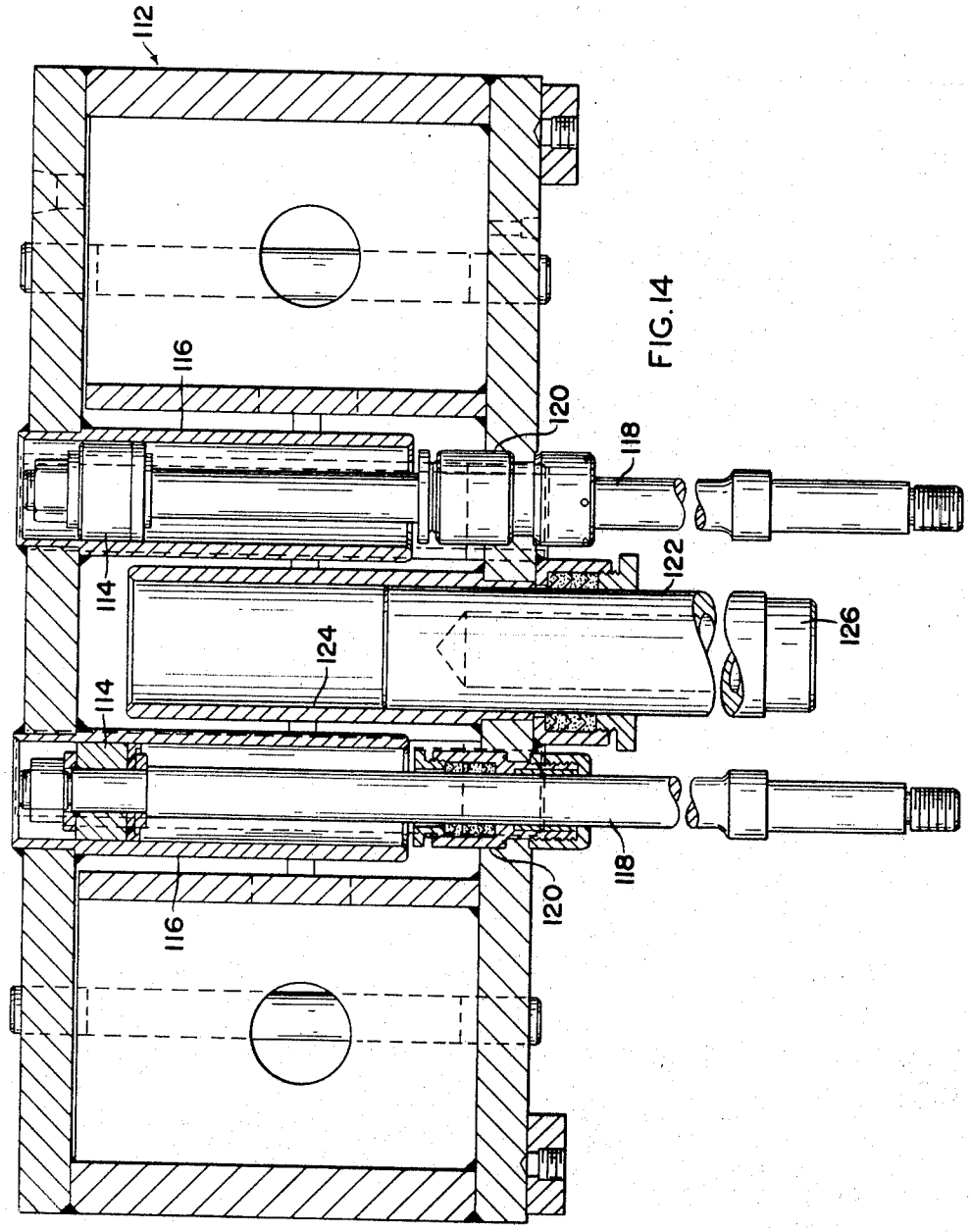



FIG. 14

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United States Patent Office 3,427,851 Patented Feb. 18, 1969



3,427,851

# HIGH ENERGY RATE METAL FORMING MACHINE

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U.S. Cl. 72—408 10 Claims
Int. Cl. B21j 7/12; B30b 1/00; B21d 37/00

## ABSTRACT OF THE DISCLOSURE

A high energy rate metal forming press including a pair of opposed rams mounted on guide rods for reciprocating movement between an open and a closed or work contacting position. The rams are moved to their open position by a crankshaft driven through an overrunning clutch and having crank arms spaced 180° apart. One of the crank arms is connected to one of the rams while others, spaced 180° from the first, are connected to the other ram. Energy storing means in the form of springs or a vessel containing pre-compressed gas are provided to resist the movement of the rams to their open position and to store energy which is released to drive the rams rapidly together as the crank passes a neutral center position and the clutch overruns.

The present invention relates to high energy or impact-type metal forming equipment. More particularly the invention relates to a mechanical high energy rate forming or cold forging machine of the type wherein opposed rams or die carriers are driven rapidly towards each other with substantially equal momentum into impact with metal stock to be formed, the energy of the impact being absorbed entirely by the stock so that no impact forces are transmitted to the frame of the machine or to its support.

Various types of mechanical and pneumatic-mechanical high energy rate forming equipment are used to forge metal into desired shapes using either dies carried by reciprocating die carriers or closed dies which are impacted by rams so that substantially all of the developed energy is transmitted to the metal.

The pneumatic and mechanical type machines generally include a compressible energy accumulator such as a gas vessel or mechanical springs which store energy as the platens or die carriers are moved apart by either a hydraulic or mechanical drive. When the energy is released, the rams or die carriers are driven together at high velocities such as from 16 to 80 feet per second.

Machines presently in use, however, have very complex mechanical operating systems for raising, cocking, and uncocking the rams or die carriers. Thus the time required for each forming operation is generally greater than one second and time-consuming maintenance on the different systems is often required. Also these machines are expensive both as to initial cost and cost of operation.

The machine of the present invention eliminates the above objections and affords other advantages heretofore not obtainable.

According to the present invention there is provided a high energy rate metal forming machine including two opposed rams mounted on a frame for reciprocating movement between an open and a closed position, and adapted either to carry dies which impact the workpiece located therebetween or to impact closed dies which support a workpiece, energy storing means biasing the rams toward their closed position and means for withdrawing and releasing the rams including a crankshaft operatively associated with the rams and driven by a suitable power unit through an overrunning clutch. Accordingly, energy



is stored in the energy storing means as the rams are withdrawn until the crank arms reach a neutral center condition after which the energy storing means rotates the crankshaft and the clutch overruns and permits the rams to move rapidly together.

It is among the objects of the present invention to provide a new and improved high energy rate metal forming machine capable of high operating speeds and which requires only a small amount of space for installation and a minimum of maintenance.

Another object of the invention is to provide a high energy rate metal forming machine utilizing only purely mechanical components and which may be driven by a continuously operating conventional motor.

A further object of the invention is to provide a high energy rate metal forming machine which does not require separate systems for cocking and uncocking the rams preparatory to the impact stroke.

A still further object of the invention is to provide a high energy rate metal forming machine capable of operating speeds of as high as 10 cycles per second.

Other objects, uses, and advantages of the invention will become apparent from the following detailed description and drawings which relate to specific embodiments of the invention intended for the purpose of illustration rather than limitation, wherein like parts are identified by like numerals and wherein:

FIGURE 1 is a front elevational view of a mechanical high energy rate metal forming machine embodying the invention shown with the die carriers in their open position;

FIGURE 2 is a sectional view taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view taken on the line 3—3 of FIGURE 2 but showing the die carriers in their closed position;

FIGURE 4 is a sectional view with parts broken away taken on the line 4—4 of FIGURE 3 and showing the crankshaft, a connecting rod and opposed die carriers;

FIGURE 5 is a sectional view showing the overrunning clutch assembly and taken on the line 5—5 of FIGURE 3 with parts broken away to show the internal features of the clutch;

FIGURE 6 is a diagrammatic end view showing the machine of FIGURE 1 in the spring compressing portion of its crankshaft cycle;

FIGURE 7 is a diagrammatic front view showing the machine of FIGURE 1 in the same condition shown in FIGURE 6;

FIGURE 8 is a diagrammatic end view of the machine of FIGURE 1 showing the springs in their energy releasing condition prior to impact and showing the crankshaft in its clutch overrunning condition;

FIGURE 9 is a diagrammatic end view showing the machine of FIGURE 1 at the moment of impact;

FIGURE 10 is a longitudinal sectional view of a modified form of high energy rate metal forming machine embodying the invention and showing the die carriers of the machine in their open position with the springs compressed;

FIGURE 11 is a longitudinal sectional view of the machine of FIGURE 10 showing the platens in their closed condition upon release of the stored energy in the springs;

FIGURE 12 is a fragmentary transverse sectional view of the machine of FIGURE 10 with parts broken away and shown in section;

FIGURE 13 is a front elevational view of a modified form of high energy rate machine embodying the invention in which a compressible medium contained in a pressure vessel is used as the energy storing means; and,

FIGURE 14 is a sectional view through the energy storing pressure vessel of the embodiment of FIGURE 13.

Referring now to the drawings wherein the showings are for the purpose of illustrating preferred embodiments of the invention only, and not for purposes of limiting same, FIGURES 1–9 show a high energy rate metal forming machine A of a type embodying the invention. The machine A includes a frame **12** having four vertical guide rods **14** mounted therein. Mounted for reciprocating movement on the guide rods **14** are an upper ram **16** and a lower ram **18**. The rams **16** and **18** carry die plates **17** and **19** and are adapted for reciprocating movement toward and away from one another between a closed position shown in FIGURE 3 and an open position shown in FIGURES 1 and 2. The rams **16** and **18** are normally biased toward their closed position shown in FIGURES 3 and 4 by energy storing means which in the embodiment shown in FIGURES 1–9 are helical coil springs **20** mounted on the guide rods **14**. The springs **20** are interposed between one of the rams and an adjusting nut **22** threadedly received on the ends of the guide rods and which serve to adjust the tension in the springs **20**. Other energy storing means may be employed such as a compressible medium contained in a hermetically sealed chamber as shown in the embodiment shown in FIGURE 13.

Means are provided for moving the rams away from each other and compressing the springs **20**. Such means in the preferred embodiment comprise a crankshaft **26** journaled in bearings **24** mounted on the frame **12** and having a central crank arm **28** and two end crank arms **30** spaced on either side of the central crank arm **28** and extending from the crankshaft **26** in 180° relation with the central crank arm. Connected to the central crank arm **28** is a connecting rod **32** which serves to drive the lower ram **18**. The upper end of the connecting rod **32** is connected to the lower ram **18** by means of a pivot pin **34** so that the ram **18** is reciprocated between its open and closed positions during each cycle of the crankshaft **26**.

Connected to the end crank arms **30** are connecting rods **36** which serve to drive the upper ram **16**. The opposite ends of the connecting rods **36** are connected to the ends of the upper ram **16** by means of pivot pins **38** so that the ram **16** is also reciprocated between its open and closed positions during each cycle of the crankshaft **26**.

In accordance with the invention, the crankshaft **26** is connected to a suitable drive means such as an electric motor and reducer (not shown), through a standard overrunning clutch assembly **40**. The clutch may take a number of different forms but in the embodiment shown is a ratchet and pawl type clutch which is mounted in a suitable housing **42**. A ratchet **44** is fixed to the end of a drive shaft **46** as best shown in FIGURES 3 and 5. A pawl carrier flange **42** is fixed to the end of the crankshaft **26** and carries a pawl **50** pivotally secured thereto by a pin **52**. More than one pawl **50** may be used if desired to provide a more balanced coupling.

The connection between the connecting rods **36** and the pins **38** is adapted to permit limited play between the ram **16** and the rods **36** during impact, i.e. at the closed position of rams **16** and **18**. For this purpose the pivot pins **38** are received in longitudinal slots **39** formed in the ends of the connecting rods **36** as best shown in FIGURE 4. The connecting rod **32** is also connected in a manner to provide some play between the lower ram **18** and the connecting rod **32**, the pivot pin **34** being received in a slot **35** formed in the end of the connecting rod **32**. This arrangement prevents slow down of the rams as the crankshaft **26** approaches the bottom neutral center portion of its cycle as shown in FIGURE 9. Also, the slots prevent overloading of the drive mechanism in the event of variations in stock thickness in the closed position of the rams.

*Operation*

The operation of the machine A of FIGURES 1–9 is best illustrated diagrammatically in FIGURES 6, 7, 8, and 9. As the crankshaft **26** rotates through a portion of its cycle, as indicated in FIGURES 6 and 7, it moves the rams **16** and **18** apart toward their open positions thus compressing the coil springs **20**. The compression of the springs **20** continues until the crankshaft **26** reaches the first neutral center position of its cycle. During this portion of the crankshaft cycle, the pawl **50** is in engagement with the ratchet **44** so that the drive shaft **46** drives the crankshaft **26**.

As the crankshaft **26** passes its neutral center position, the springs **20** exert a force tending to continue rather than resist the rotation of the crankshaft **26**. Accordingly, the energy stored in the springs is released and the clutch **40** overruns permitting the rams **16** and **18** to be driven rapidly toward one another with substantially equal force. After achieving a high velocity, the dies **17** and **19** carried by the rams **16** and **18** impact on the metal stock. The momentum provides kinetic energy necessary for forming the metal stock located between the dies. Since both the upper and lower rams are mechanically connected, the equality of their velocity is assured and the coordinates of their meeting constant. This results in a high degree of energy utilization. Immediately after impact, the pawl **50** engages in the ratchet **44** and the compression portion of the crankshaft cycle begins. The machine can operate at practically any rate of cycles per second depending on the capacity of the driving motor, with the cycles being performed at a faster rate than the driveshaft rotation due to the overrunning of the clutch.

*FIGURES 10–12*

FIGURES 10–12 show an alternate form of high energy rate metal forming machine embodying the invention and generally indicated by the letter B. This embodiment includes a frame **60** which slidably supports four vertical rods **62** which carry an upper ram **64** and a die **65**. The rods **62** are connected together at the bottom thereof by a connecting plate **68**. The lower ends **70** of the rods **62** are slidably received in guide members **72** mounted on the frame **60**. The upper ends of the rods **62** are slidably received in guide members **74** mounted at the top of the frame **60**.

Mounted for sliding movement on the rods **62** is a lower ram **76** which carries a die **78**. The upper ram **64** and lower ram **76** are adapted for movement toward one another from an open position shown in FIGURE 10 to a closed position shown in FIGURE 11 by means of helical coil springs **80** circumlocated on the rods **62** and which oppositely bear against the connecting plate **68** and the ram **76**.

Journaled in the frame **60** is a crankshaft **82** having a central crank **84** and two oppositely extending end cranks **86**. The end cranks **86** are connected to the connecting plate **68** by means of connecting rods **88** and the central crank **84** is connected to the lower ram **76** by means of a connecting rod **90**.

The crankshaft **82** is connected to a suitable drive means such as a motor-reducer unit (not shown) through an overrunning clutch such as shown in the embodiment of FIGURES 1–9.

*Operation*

The operation of the machine B of FIGURES 10–12 is similar to that of the machine A shown in FIGURES 1–9, the principal difference being that both the upper ram **64** and lower ram **76** are driven together by the same spring **80**. During a portion of the crankshaft cycle, the rams **64** and **76** are moved away from one another to their open position, as shown in FIGURE 10, thus compressing the springs **80** between the connecting plate **68** and the lower ram **76** until the crankshaft **82** reaches a neutral center position.

After passing the neutral center position, the force of the springs **80** acts in a direction tending to assist rather than resist rotation of the crankshaft **82**. Accordingly, the clutch overruns permitting the release of the energy

stored in the springs **80** so that the rams **64** and **76** are driven rapidly toward one another to impact a workpiece positioned between dies **65** and **78**. Since the energy source is the same for both rams **70** and **76**, they achieve an equal kinetic energy before impact, thus transmitting all the energy to the metal stock to be formed rather than transmitting it to the frame and support.

*FIGURES 13 and 14*

FIGURES 13 and 14 show another embodiment of the present invention. This embodiment differs from the preceding embodiments primarily in the form of energy storing device used.

As shown in FIGURE 13 this embodiment includes a frame **100** having four vertical guide rods **102** mounted therein and arranged approximately in the manner of guide rods **14** of the embodiment of FIGURES 1–9. Mounted for reciprocating movement on the guide rods **102** are an upper ram **104** and a lower ram **106**. The rams **104** and **106** carry dies **108** and **110**.

The means provided for moving the rams away from each other are identical in arrangement to those shown in the embodiment of FIGURES 1–9 and are identified with the same reference numerals with the addition of a prime (') suffix. The important difference between this embodiment and the embodiment of FIGURES 1–9 is the energy storing means utilized. In this embodiment, the energy storing function of the springs **20** of the embodiment of FIGURES 1–9 is performed by a precompressed gas contained in a hermetically sealed pressure vessel **112**.

As best shown in FIGURE 14, vessel **112** is of welded construction and has a pair of pistons **114** carried in cylinders **116** welded or otherwise connected to the top wall of the vessel. Piston rods **118** are connected to pistons **114** and extend downwardly through stuffing boxes **120** into connection with lower ram **106**. Vessel **112** is also provided with a third piston or plunger **122** which is carried in a cylinder **124** welded to the bottom wall of the vessel. Piston **122** is provided with an extension **124** which is connected to upper ram **104**. The upper ram **104** is provided with openings which permit piston rods **118** to pass freely therethrough.

*Operation*

The operation of the machine of FIGURES 13 and 14 is as follows. As crankshaft **26'** is rotated through its overrunning clutch and drive (not shown), lower ram **106** and upper ram **104** are moved apart to the position shown in FIGURE 13. This causes pistons **114** which are connected with ram **104** to move downwardly into vessel **112** to further compress the precompressed gas therein. Simultaneously, piston or plunger **122** connected to upper ram **106** is moved upwardly into the vessel to further compress the gas. Thus, during this portion of the cycle the gas functions to store the energy supplied by the driving motor. As the crankshaft moves through its vertical center point, the force of the compressed gas in vessel **112** is acting in the direction of free rotation of the overrunning clutch so that the energy accumulated in the vessel is suddenly released to drive rams **104** and **106** together with equal velocity to form a workpiece between dies **108** and **110**.

The invention has been described in great detail sufficient to enable one skilled in the art to practice the invention. Obviously modifications and alterations of the preferred embodiment will occur to others upon a reading and understanding of this specification and it is my intention to include all such alterations and modifications as part of my invention insofar as they come within the scope of the appended claims.

Having thus described my invention, I claim:

**1.** A high energy rate metal forming machine comprising a frame, two opposed rams mounted for reciprocating movement on said frame toward and away from one another, energy storing means biasing said rams toward one another, a crankshaft journaled in said frame, and operatively associated with said rams to move said rams apart during a portion of a crankshaft cycle and to permit said rams to move together after passing a neutral center, drive means for said crankshaft, an overrunning clutch coupling said drive means to said crankshaft whereby said crankshaft is driven by said drive means to move said rams apart and store energy in said means until said crankshaft passes neutral center after which said clutch overruns said drive means and the energy stored by said energy storing means is released to drive said rams rapidly toward one another.

**2.** A machine as defined in claim **1** wherein said energy storing means comprises coil springs.

**3.** A machine as defined in claim **1** wherein said energy storing means comprises at least one vessel containing a compressible medium.

**4.** A machine as defined in claim **1** wherein said overrunning clutch comprises a driving portion and a driven portion, and means are provided to permit free rotation of the driven portion in one direction and rigid engagement with the driving portion in the other direction.

**5.** A machine as defined in claim **1** wherein said crankshaft is operatively associated with said rams by mechanical means which maintain said rams connected together during the entire crankshaft cycle except at their moment of impact.

**6.** A machine as defined in claim **5** wherein said mechanical means comprise connecting rods connected between said crank and said rams and including means forming longitudinal slots in said connecting rods at their point of connection to the rams to thereby permit the rams to be freely movable relative one another at the moment of impact.

**7.** A machine as defined in claim **1** wherein said energy storing means includes a first means biasing one of said rams and a second means biasing the other of said rams.

**8.** A machine as defined in claim **5** wherein said rams are guided for reciprocating movement on fixed guide rods and wherein said first and second means both comprise coil springs circumlocated on said guide rods and including means connected to said frame for adjusting the tension of each of said springs independently.

**9.** A machine as defined in claim **1** wherein said energy storing means is independent of said frame and releases energy in opposite directions simultaneously.

**10.** A machine as defined in claim **7** wherein one of said rams is mounted at one end of reciprocable rods slidably mounted in said frame and connected at their opposite ends to a connecting member, said other ram being slidably mounted on said rods and being located between said one ram and said connecting member and wherein said energy storing means comprises coil springs circumlocated on said rods between said other ram and said connecting member.

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U.S. Cl. X.R.

100—266, 270; 173—102, 119; 72—432, 434, 437