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Rusch

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(54) **MULTI-MODE HAMMERING MACHINE**

(76) Inventor: **Christopher J. Rusch**, 3718 Riverview Dr., Two Rivers, WI (US) 54241

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B21J 13/00 (2006.01)

(52) **U.S. Cl.** **72/450**; 72/375; 72/441; 72/446; 72/448; 72/472; 72/481.1

(58) **Field of Classification Search** 72/435, 72/440, 441, 446, 448, 450, 451, 453.07, 72/472, 481.1
See application file for complete search history.

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Primary Examiner—David B Jones
(74) *Attorney, Agent, or Firm*—Jeffrey S. Sokol

(57) **ABSTRACT**

The invention is a multi-mode hammering machine that operates in a rigid mode, a flexible power hammer mode and a machine press mode to contour, shape and form sheet metal products. In all three modes, a ram is linearly stroked toward and away from a fixed die by a common ram drive assembly that includes a lever drive assembly and a reciprocating lever. The lever drive assembly moves in a rigid non-flexing manner. The reciprocating lever includes a rigid mode and a flexible mode. A conversion pin is used to engage one and simultaneously disengage the other. The lever drive assembly includes a control link that interfaces with a stroke adjustment mechanism. The gap adjustment mechanism is located at the fulcrum of the reciprocating lever. Both stroke length and gap are adjusted independently during the operation while the ram is cycling.

22 Claims, 12 Drawing Sheets

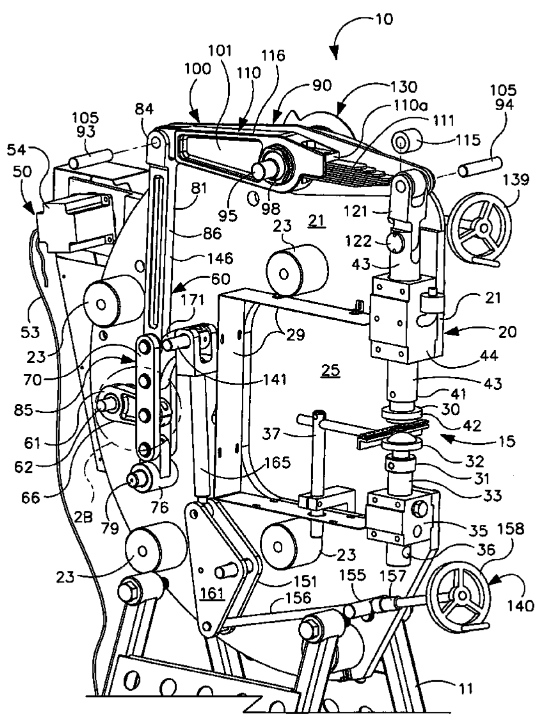
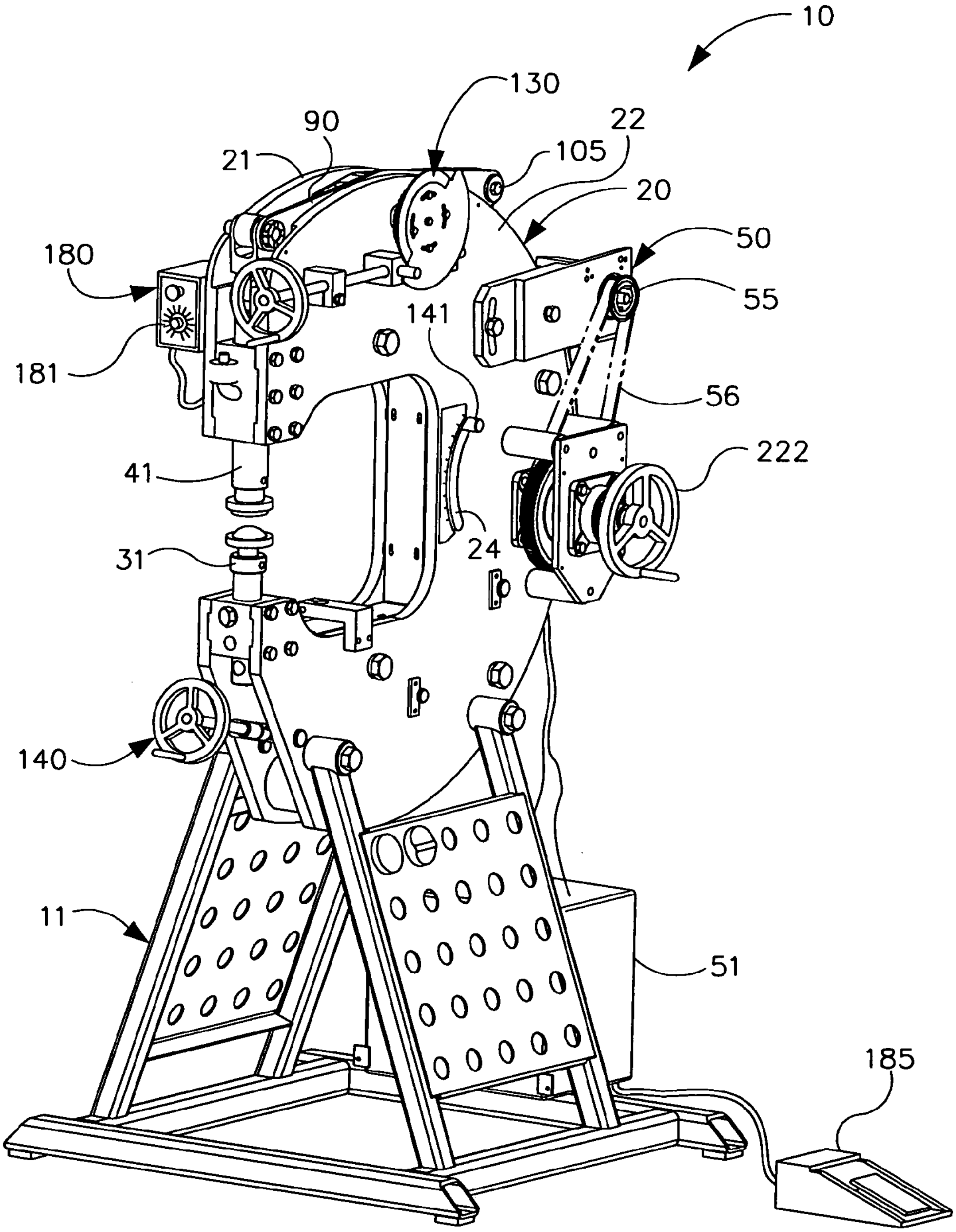


FIG. 1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130
90
22
21
105
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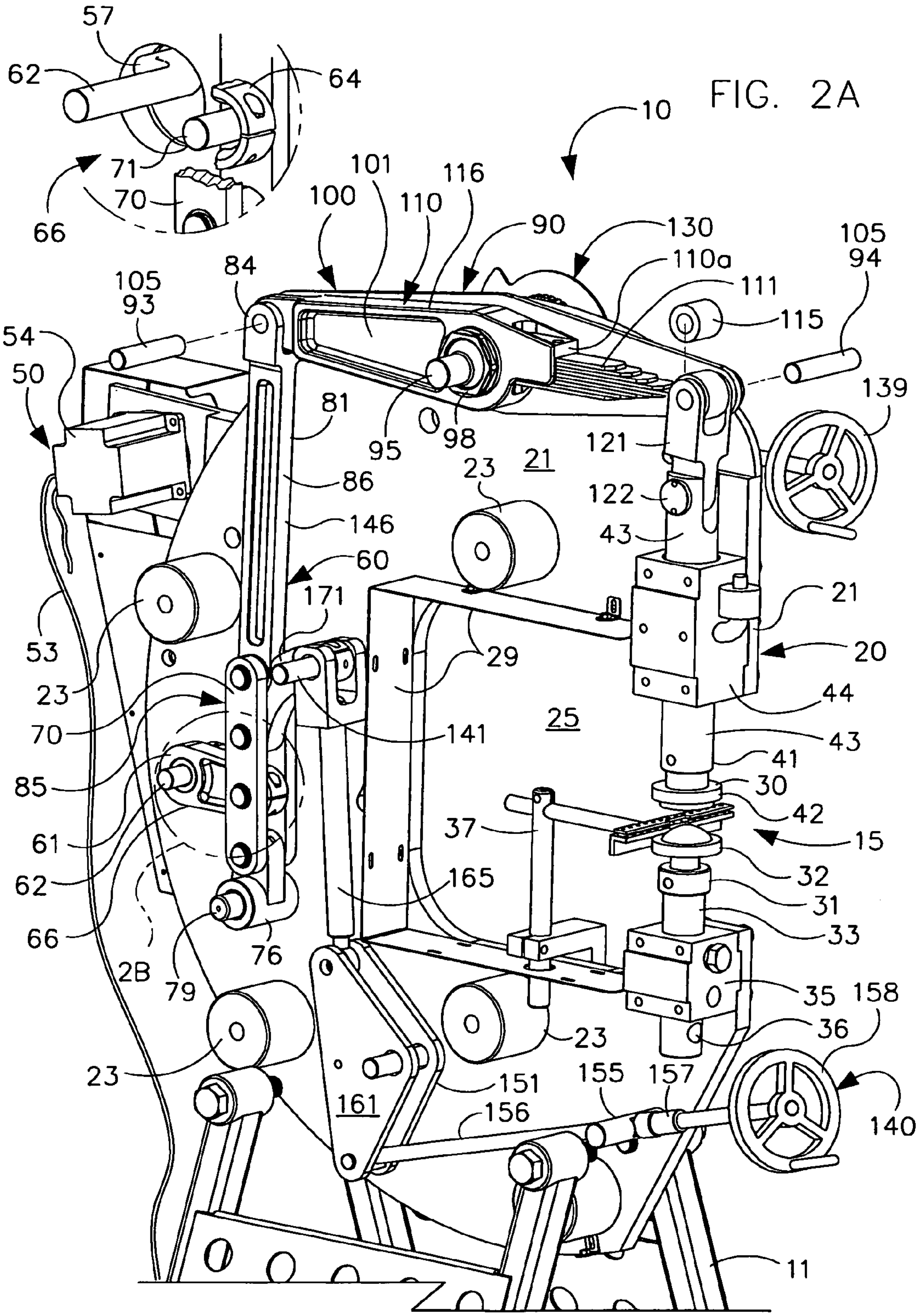
11
51
185

FIG. 2B

FIG. 2A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62
64
71
66
70
10
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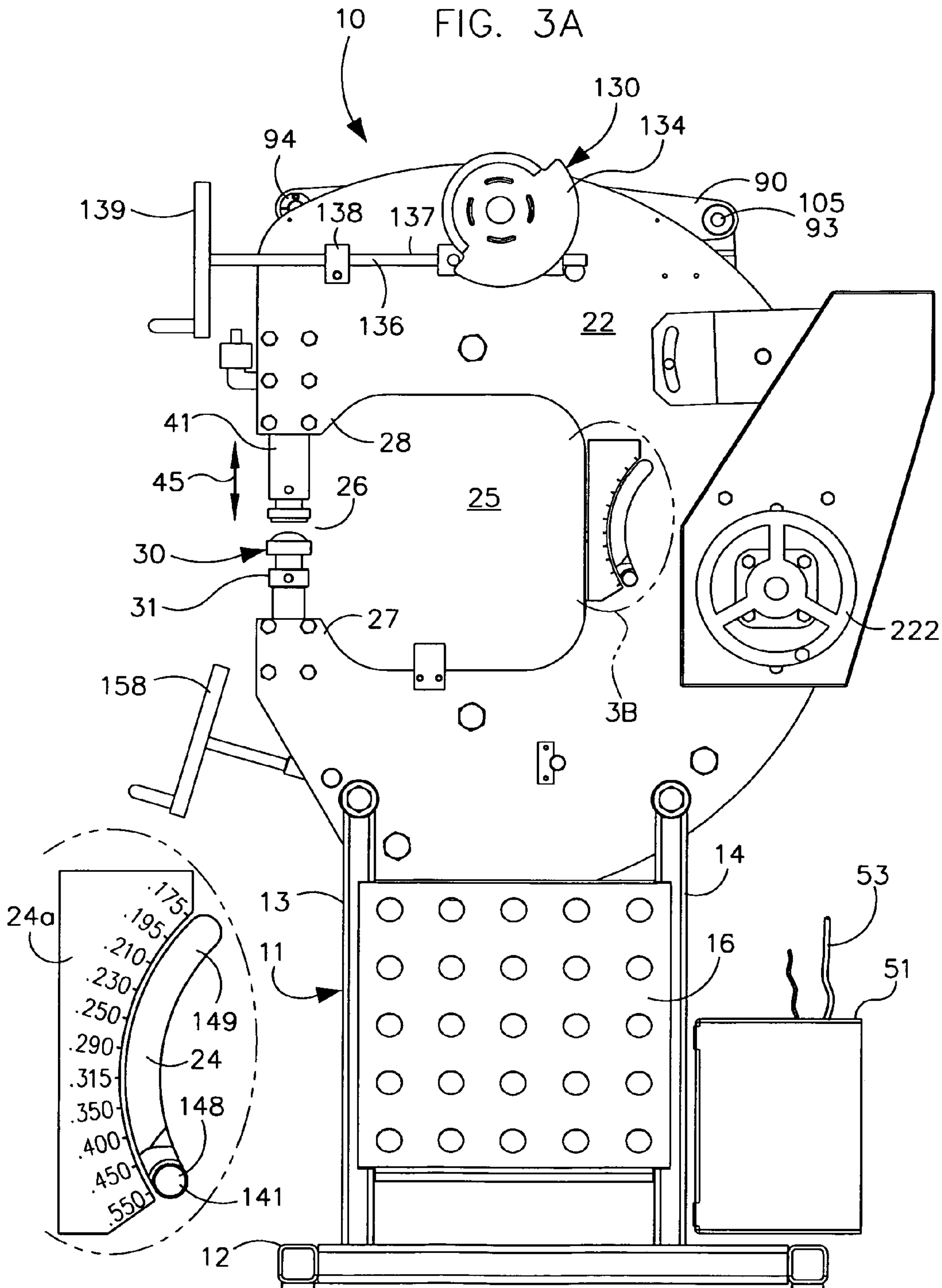
54
50
81
95
98
139
121
21
86
23
122
146
43
60
171
21
53
20
29
23
44
70
141
25
43
41
85
30
42
37
15
61
32
62
165
31
66
33
79
76
2B
35
158
36
23
23
155
157
151
161
156
140
11

FIG. 3A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130
134
94
90
105
93
139
138
137
136
22
41
28
45
26
25
30
31
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222
158
3B
14
53
13
16
11
51
12
24a
.175
.195
.210
.230
.250
.290
.315
.350
.400
.450
.550
149
24
148
141

FIG. 3B

FIG. 4

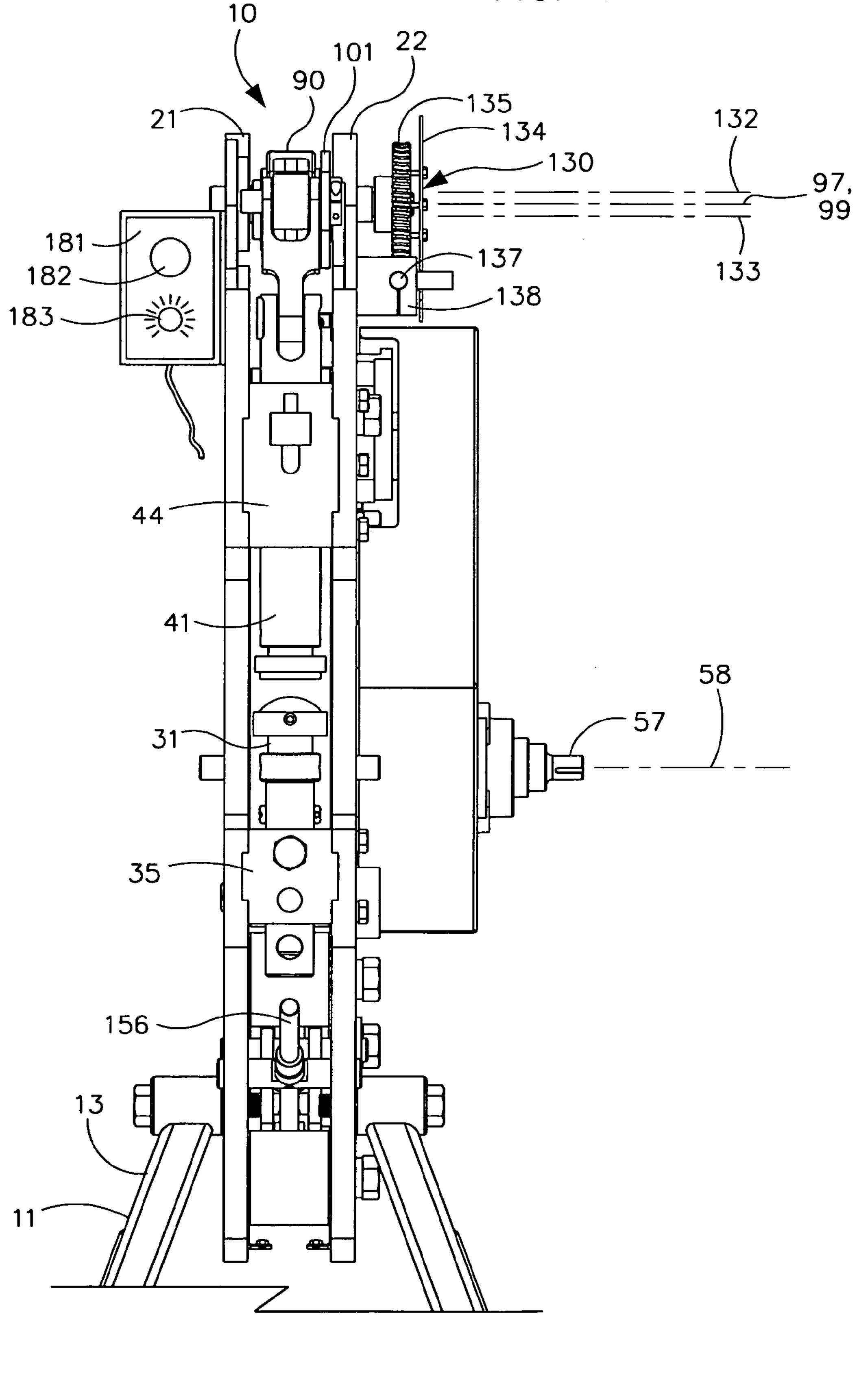
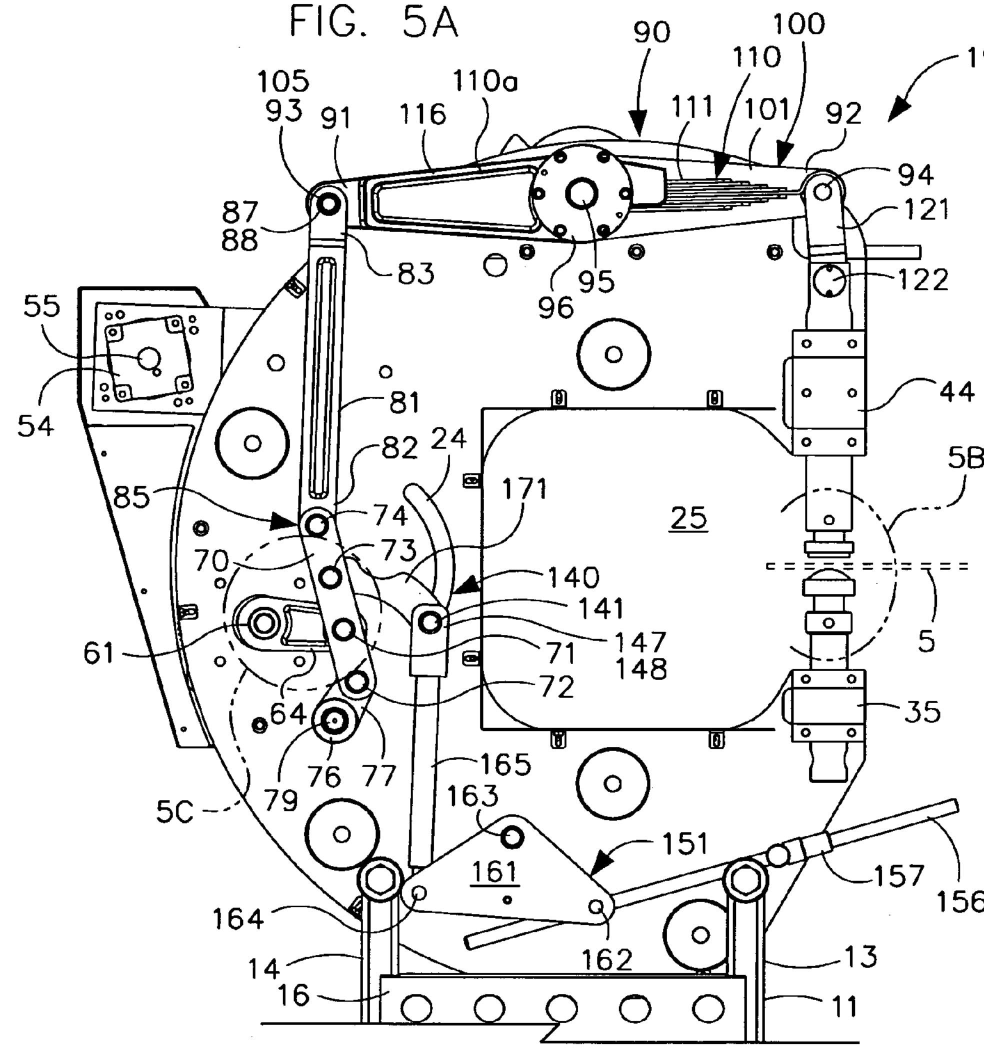

10
90
101
22
21
135
134
130
132
97,
99
133
181
182
183
137
138
44
41
31
58
57
35
156
13
11

FIG. 5A



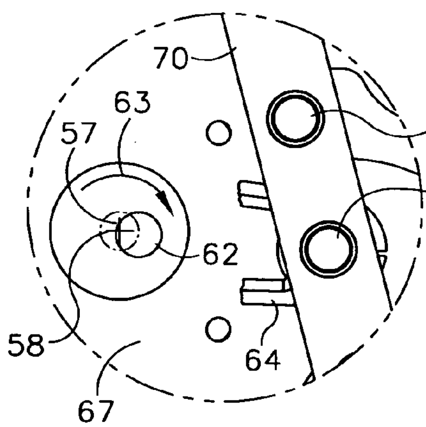


FIG. 5C

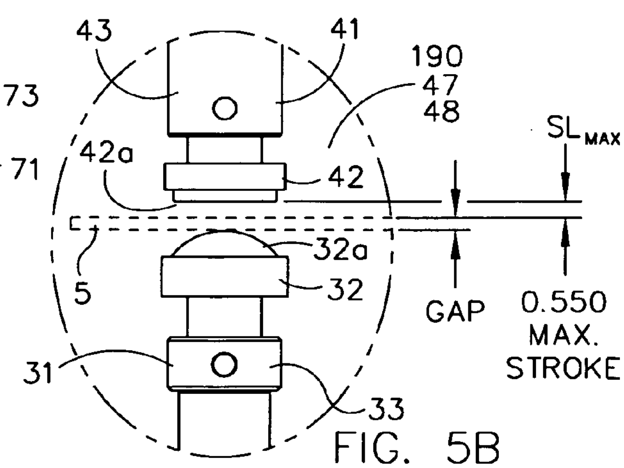


FIG. 5B

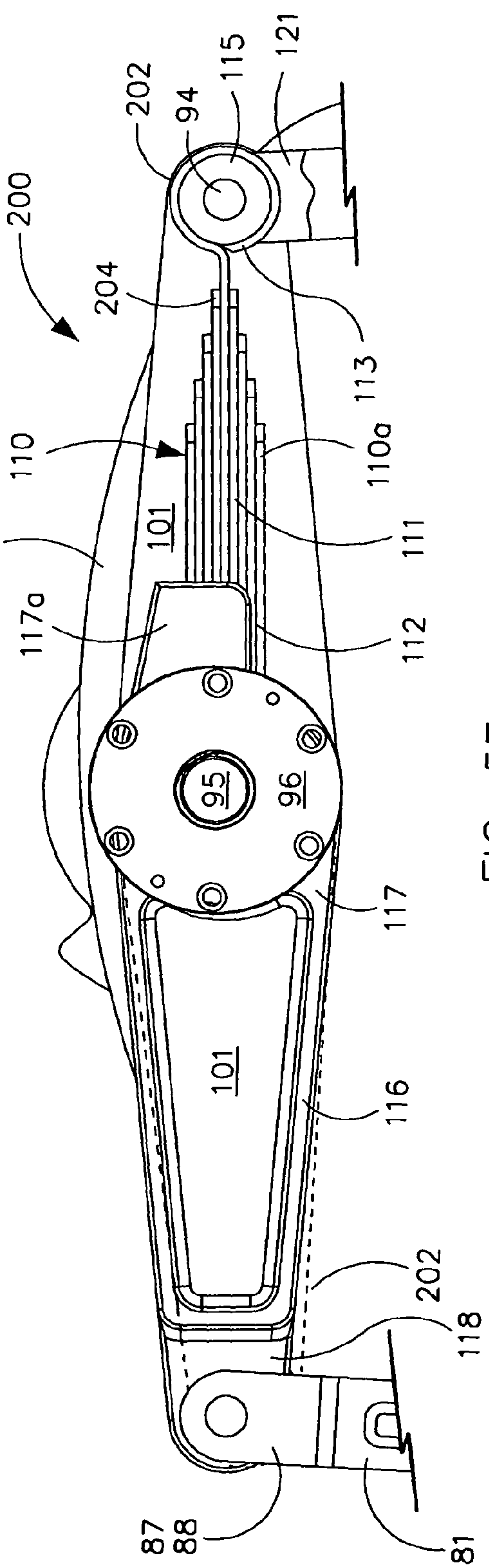
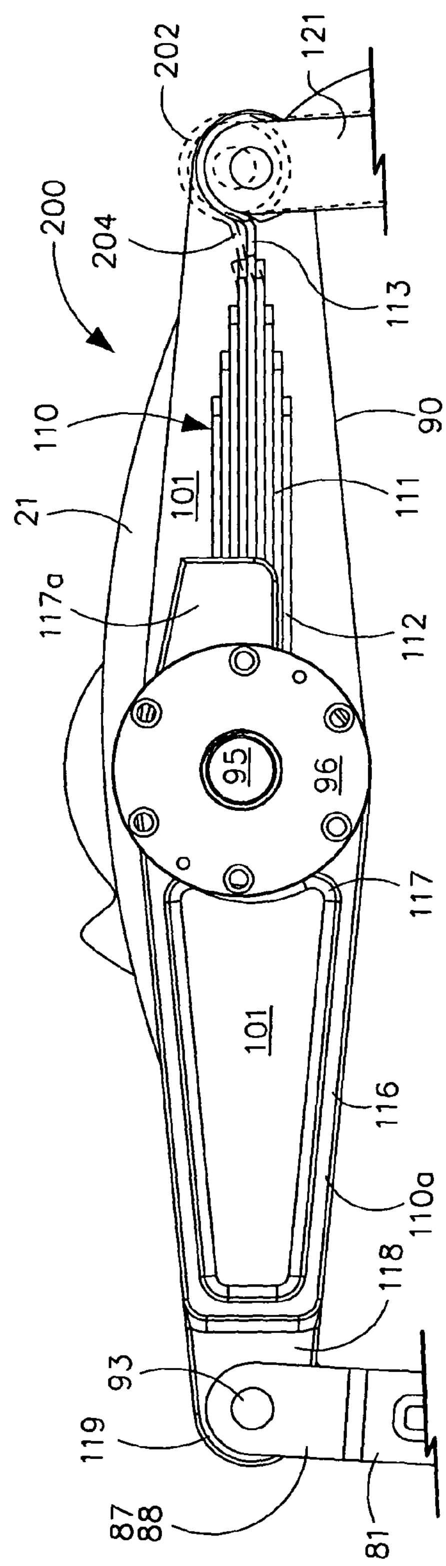

200
202
94
115
121
204
113
110
110a
101
111
21
117a
112
95
96
117
116
202
118
87
88
81

FIG. 5D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121
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204
113
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90
101
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21
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116
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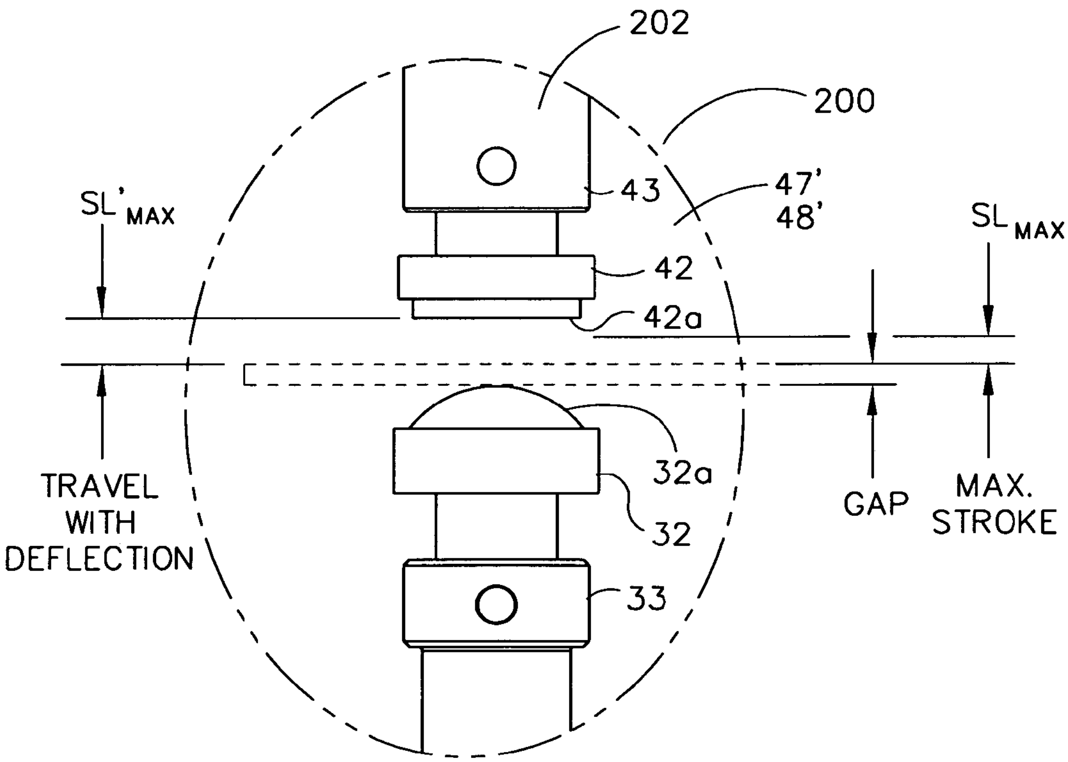
118
93
119
87
88
81

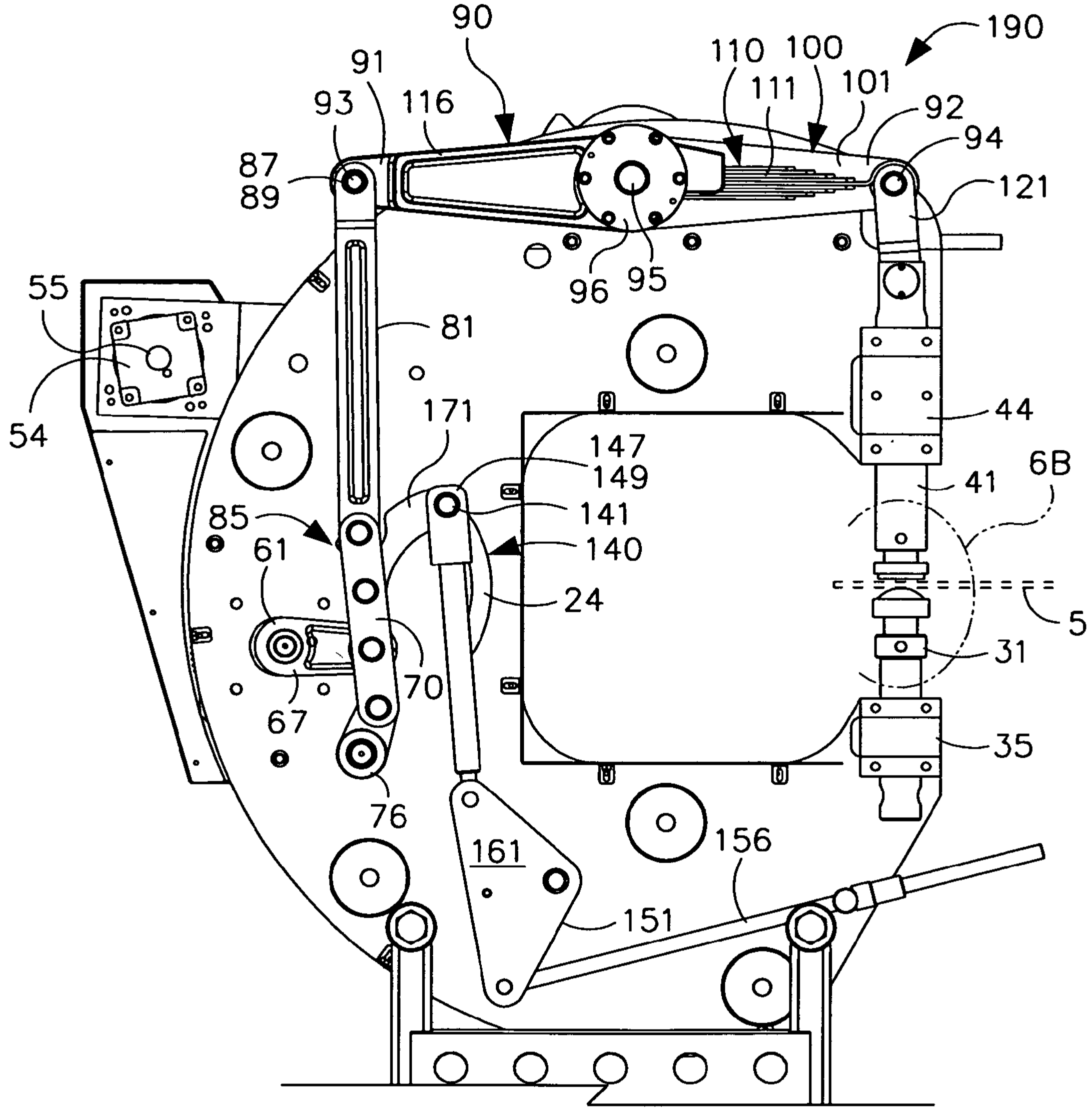
FIG. 5E

FIG. 5F



202
200
43
47'
48'
SL'MAX
SLMAX
42
42a
32a
32
33
TRAVEL
WITH
DEFLECTION
GAP
MAX.
STROKE

FIG. 6A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90
91
93
116
110
100
111
101
92
94
87
89
121
55
81
96
95
54
44
171
147
149
41
6B
85
141
140
61
24
5
31
70
67
35
76
156
161
151

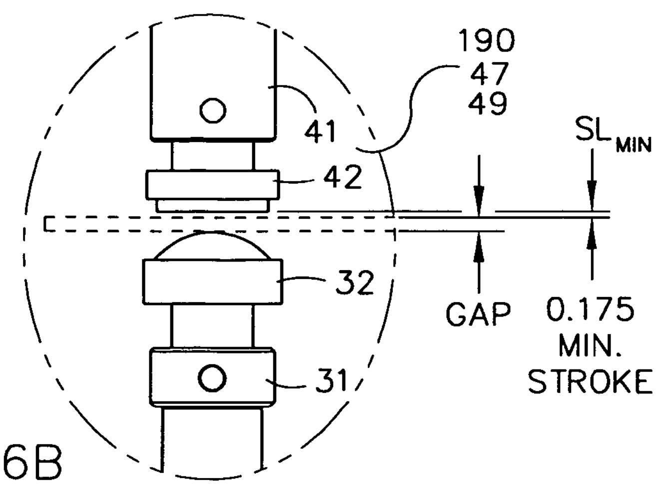
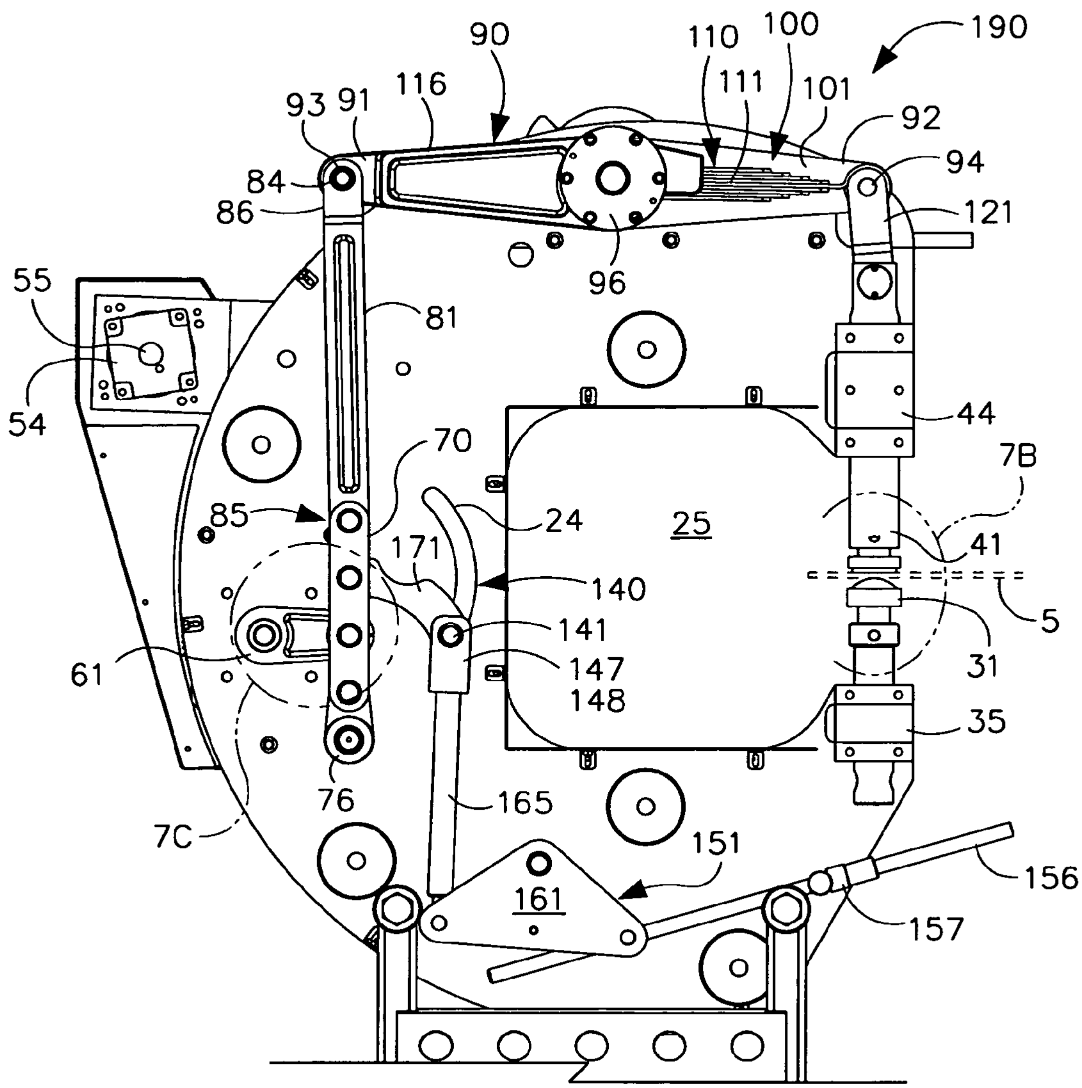

190
47
49
41
SL_MIN
42
32
GAP
0.175
MIN.
STROKE
31

FIG. 6B

FIG. 7A



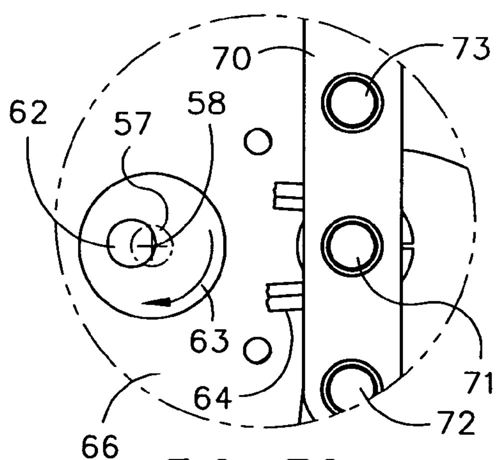


FIG. 7C

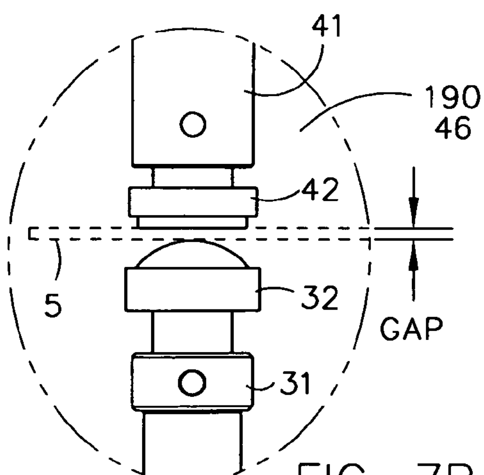
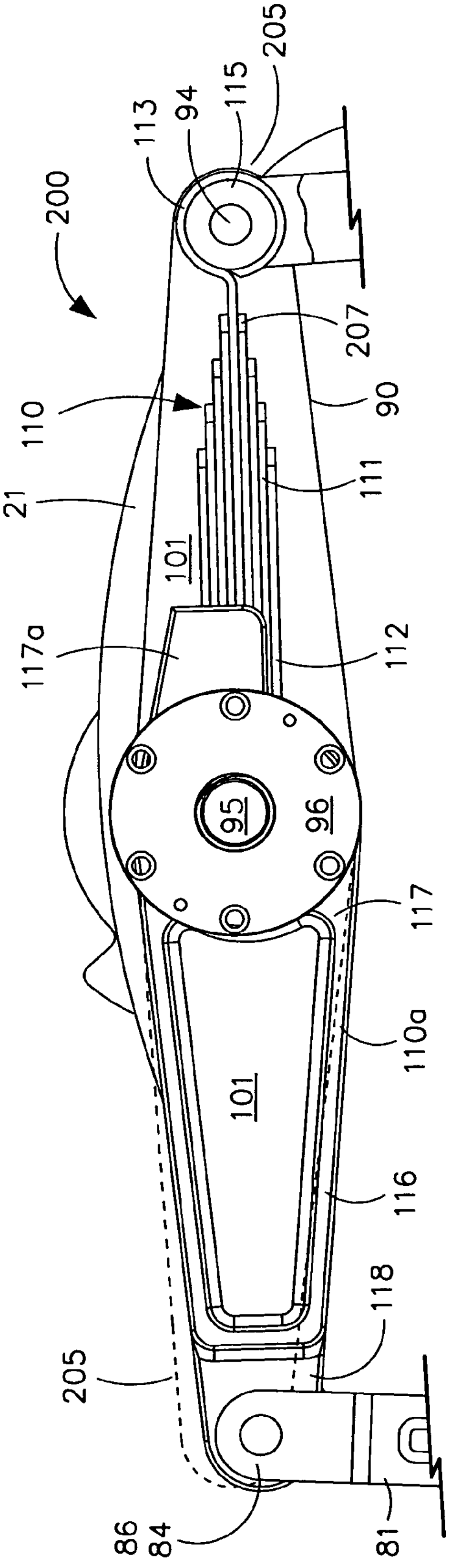


FIG. 7B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207
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118
205
86
84
81

FIG. 7D

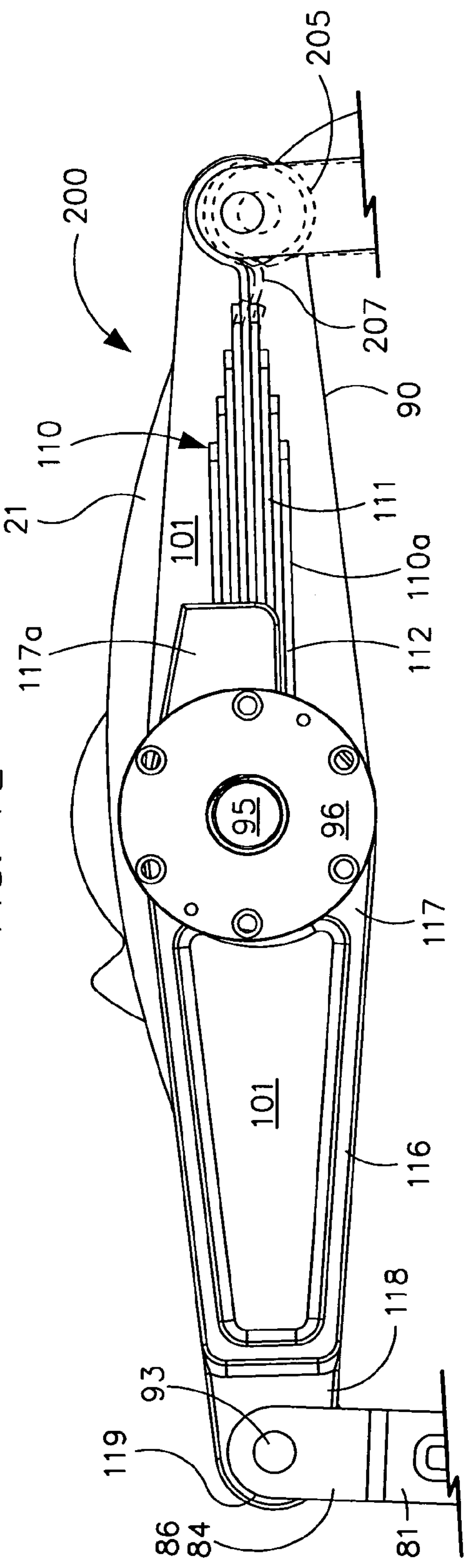
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FIG. 7E

FIG. 7F

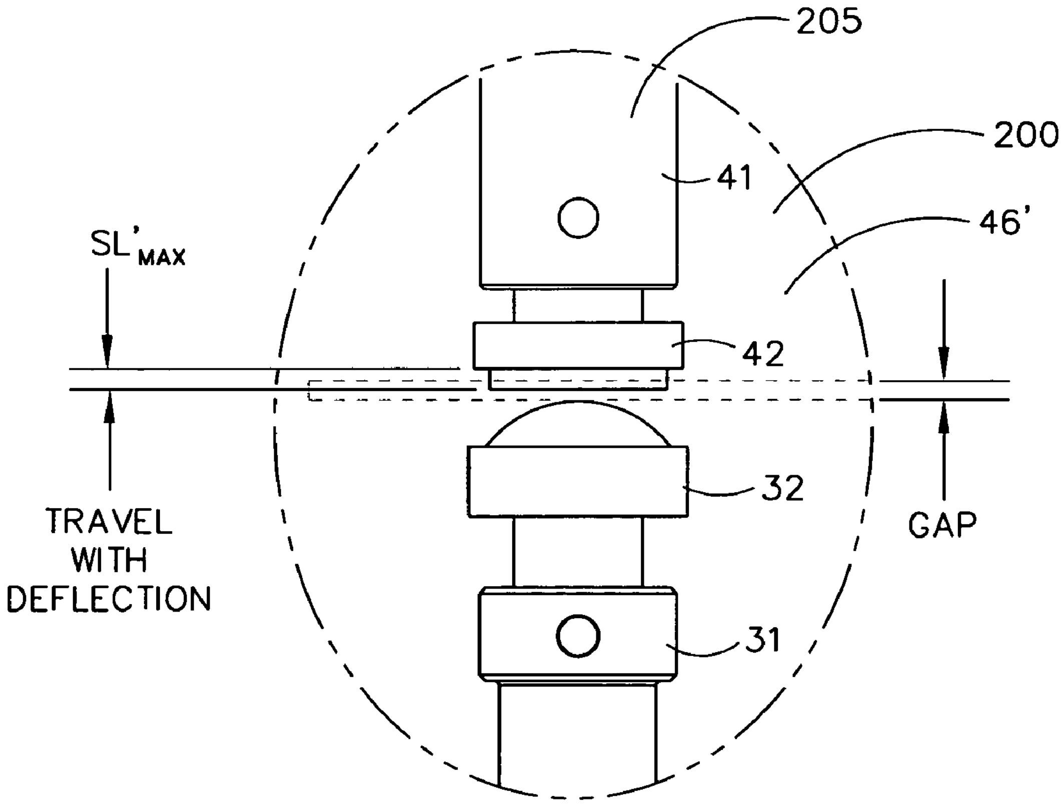
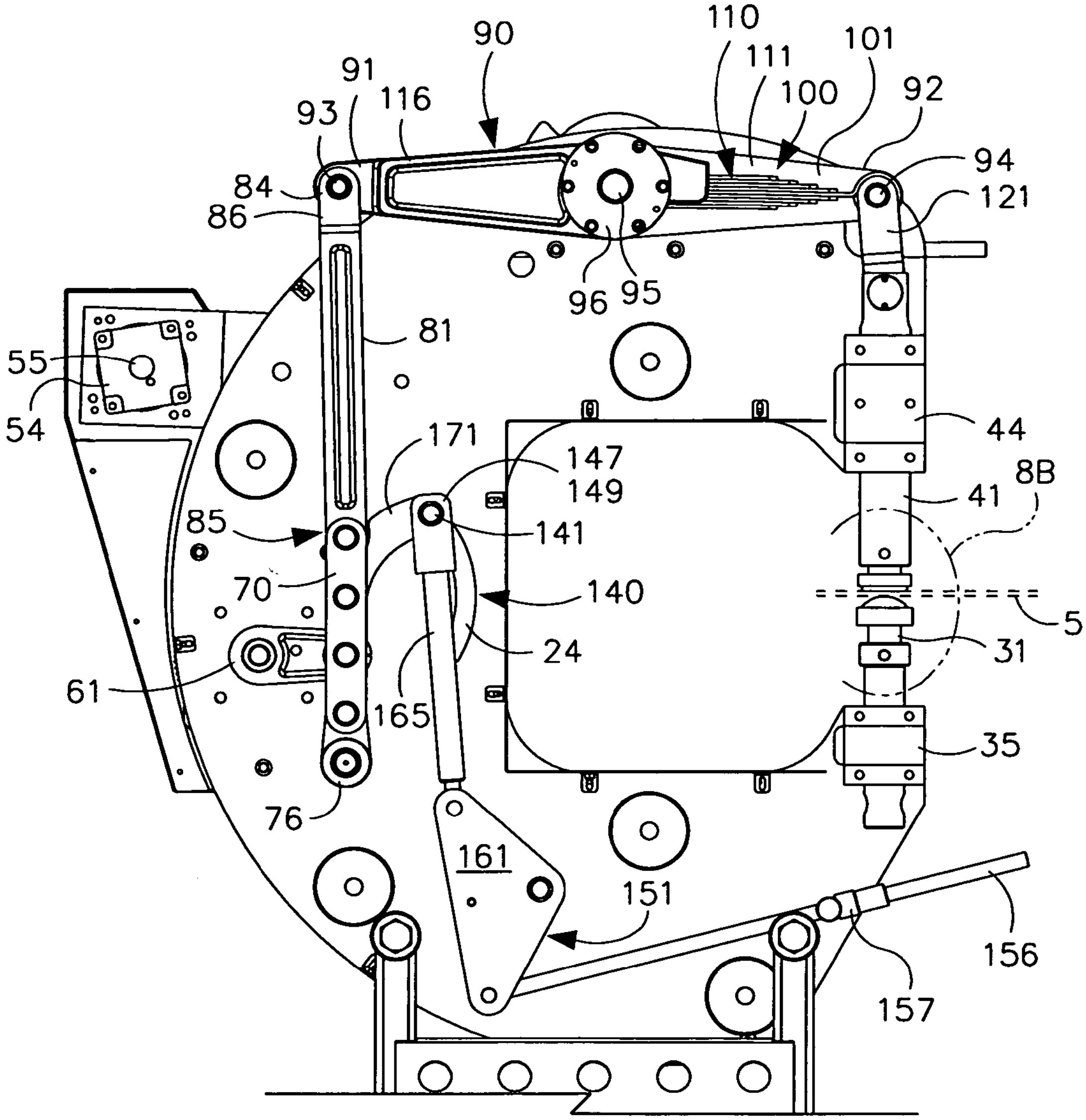


FIG. 8A



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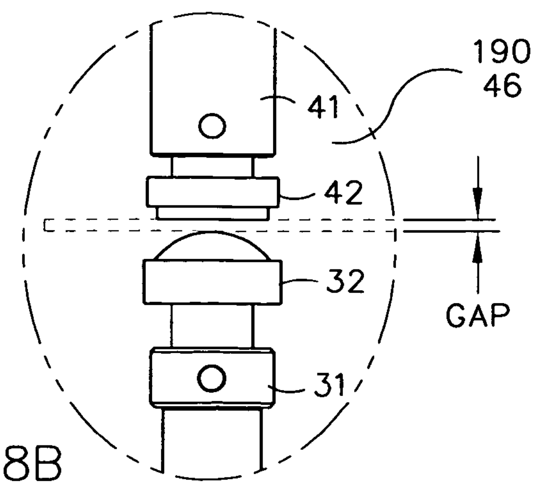

190
46
41
42
32
GAP
31

FIG. 8B

MULTI-MODE HAMMERING MACHINE

TECHNICAL FIELD OF THE INVENTION

This invention relates to a hammering machine for shaping sheet metal that operates in a rigid-stroke mode, a flexible-stroke hammering mode, and a rigid-stroke machine press mode, and where the ram stroke length and tool gap adjustment mechanisms are independently adjustable during operation.

BACKGROUND OF THE INVENTION

Sheet metal shaping, hammering and pressing machines are well known. These machines typically have a fixed die and a ram that moves toward and away from the die. A metal sheet is placed on the die and the ram is lowered to shape, hammer or press the workpiece. Shaping machines have contoured male and female tools fixed to the die and ram that cause the sheet to take the shape of the tools, but do not compress or hammer the sheet metal. The tools are kept apart a distance or gap equal to the thickness of the sheet metal workpiece. The sheet metal takes on a curved or other desired shape dictated by of the ram and die tools. Hammering machines use the ram to strike the sheet metal with enough force to cause the metal to flow and compress or thin the workpiece. Hundreds of hammer strikes are often needed to properly shape the metal to the desired thickness and shape. A press typically performs a specific task in various localized areas on the workpiece, such as forming holes, notches, slots, crimps or the like into the workpiece. Metal forming machines help alleviate the more strenuous and repetitious shaping, hammering and forming work needed to fabricate various sheet metal products. These machines also increase the consistency of the forces being applied, and free up the hands of the operator so that he or she can better position the workpiece between the ram and die to more accurately and quickly shape the workpiece.

Shaping machines use a rigid ram stroke to contour the workpiece. The drive mechanism raises the ram to a first position above the die tool, and then extends or lowers the ram toward the die to a second position. The ram stroke is set to a desired length, and the ram rigidly moves back and forth between the raised and lowered positions during each stroke or beat of the machine. Conventional machines can cycle the ram about 1,000 beats per minute (bpm). The machine allows the operator to set the gap between the die and the lower most position of the ram. The gap is typically set to the thickness of the material before operating the machine. Adjustments to the gap are not made during the operation of the machine. The motor and rigid stroke drive system are not typically strong enough to compress and reduce the thickness of the metal workpiece. An example of this type of rigid stroke machine is the P5 machine produced by Pullmax of Sweden.

Hammering machines use a flexible ram stroke to produce the power or force needed to get the metal to flow in the sheet metal, and when desired, compress or reduce the thickness of the sheet. Again, the drive mechanism raises the ram to a first position above the die tool, and then extends or lowers the ram toward the die to a second position. Although the ram stroke is set to a desired length, the ram drive has a flexible component that allows a degree of play in the ram stroke length during each beat of the machine. The first stroke of the machine does not necessarily produce all the metal flow or entirely compress the sheet of metal. The ram acts more like a hand held hammer and consecutively drives down the sheet metal. While the first stroke may do the majority of the compression, several subsequent strokes can add to that compression. The flexible drive does not necessarily crush the sheet metal to the set gap thickness after the first stroke. The ram stroke and crushing of the metal can actually exceed the gap setting particularly after several strokes of the ram. Thickness is determined by how many hammer beats a particular area of the sheet metal receives. The flexing components in the machine produce a whipping action that can accentuate the power of the machine and the ram impact forces produced by the machine. Again, the ram can be cycled about 1,000 bpm. The faster the machine operates, the more the flexible component of the ram drive flex. When the operator sets the stroke length, machine speed and flexible action of the ram drive with the springiness of the material, a harmonic effect can occur that increases the ram impact forces produced by the machine. Yet, conventional machines do not allow stroke length and gap adjustments during the operation of the machine. An example of this type of power enhancing machine is the LK90 machine produced by Yoder of Cincinnati Ohio.

Flexible stroke hammering machines give the operator more control over the shape and thickness of the workpiece being shaped. More or less contouring can be generated by more or fewer repeated beats on the same area of the workpiece. Thicker or tougher pieces of metal can be worked by the machine without resetting the gap and stroke length. This type of power hammering machine is particularly suited for making prototypes or custom made parts, such as car and motorcycle body parts. These machines are also known to produce extra impact power given the motor and stroke length of the machine.

A machine press uses the ram and die in conjunction with specifically contoured surfaces to form the metal workpiece into a specific shape or punch a hole or depression into a portion of the workpiece. The press typically strikes a sheet metal part only a single time to perform a specific task. A reciprocating drive mechanism is typically not necessary or desired. Instead, presses typically include a relatively less expensive hand operated drive mechanism with levered mechanical advantage to produce the force needed to work the sheet material.

A problem in the metal forming industry is meeting customer demands to perform a wide variety of metal forming jobs. Because customers and metal forming shops have a wide variety of metal forming needs, each shops must have equipment capable of perform a wide variety of jobs. To meet these demands, shops need ready access to a wide variety of metal forming machines. Because each machine typically performs a specific function different from other machines, each shop must purchase and provide floor space for each machine. Yet, metal forming machines are typically quite expensive. To make matters worse, many customer job orders only require the use of one or two machines. While one machine is being used for a specific type of job, other machines sit idle. In addition, a single shop often needs to two or more of each machine to meet order schedules and work flow requirements, and have a back up when one machine goes down unexpectedly or is out of service for scheduled maintenance.

Combining different metal forming machines is either structurally difficult or commercially impossible. Each machine has a drive mechanism suited for a specific job. The structures of the drive mechanisms are not readily combined, and are not readily switched from one mode of operation to another. Integrating the power systems, drive mechanisms, frame housings and tool movements so a single machine can perform a variety of functions is a significant engineering challenge and usually commercially impossible. This is particularly so for different types of shaping, hammering and press machines with different power systems, ram drive mechanisms and stroke length and gap adjusting mechanisms. Rigid reciprocal drives, power enhancing drives with flexible components and mechanically levered hand operated drives are structurally different mechanisms. Each lacks some components of the other and requires other structurally components not found in the others. As a result, metal forming shops have had to incur the expense of buying and allocating floor space for various shaping, hammering and press machines, or endure the consequences of failing to meet customer expectations.

Another problem with combining rigid reciprocating, flexible power enhancing and press machines is that their drive mechanisms must interface with both a mechanism for adjusting the ram stroke length and a mechanism for adjusting the gap between the ram and die. These stroke length and gap adjustment mechanisms should operate independently of each other and during the operation of the machine. As noted above, this is particularly important for hammering machines to allow the operator to achieve increased ram impact forces.

A further problem with combining rigid reciprocating and flexible power enhancing metal forming machines is that the stroke length and gap should be structures so that each can be adjusted on-the-fly or during the operation of the machine. Again, this is particularly important for hammering machines because the operator must be able to adjust stroke length to find the natural harmonic between the stroke length and the material being shaped. The ram forces produced by the natural harmonic can also require gap adjustment so that the sheet metal maintains a desired thickness.

A still further problem with combining rigid reciprocating and flexible power enhancing metal forming machines is that the forces involved are significant. The orientation of the components during moments of particularly high loading must be arranged so that the components are not over stressed. If this is not done, the components will be prone to brake or accelerated wear and tear, which will increase service costs and short the life of the machine.

A still further problem with combining rigid reciprocating and flexible power enhancing metal forming machines is the shape of the machines. To accommodate and work on projects that require large pieces of sheet metal or extremely curved products, the machines must have a large internal cavity. The larger the internal open area for accommodating a large workpiece, the better the machine will be able to handle such projects. The various drive mechanisms and stroke and gap adjustment mechanisms must extend around the internal work cavity.

The present invention is intended to solve these and other problems.

BRIEF DESCRIPTION OF THE INVENTION

The present invention pertains to a multi-mode hammering machine that operates in a rigid metal shaping mode, a flexible power hammer mode and a machine press mode to form sheet metal products. In all three modes, a ram is linearly stroked toward and away from a fixed die. All three modes use a ram drive assembly with a lever drive assembly and a reciprocating lever to cycle the ram up and down. The lever drive assembly moves in a rigid non-flexing manner. The reciprocating lever includes a rigid mode and a flexible mode. A conversion pin is used to engage one and simultaneously disengage the other. The lever drive assembly includes a control link that interfaces with a stroke adjustment mechanism. The gap adjustment mechanism is located at the fulcrum of the reciprocating lever. Both stroke length and gap are adjusted independently during the operation while the ram is cycling.

An advantage of the present multi-mode hammering machine is that it is three machines in one. The single machine is structured to readily perform three different and distinct metal forming functions that are widely used in the sheet metal forming industry. This three-in-one structure allows a plant to significantly reduce its overhead by reducing both machine costs and floor space requirements. Savings are further multiplied by the fact that a single extra machine provides overflow and back up for all three functions. A plant using the machine can more easily and cost effectively meet order schedules, work flow requirements, and have a back up if one machines goes down unexpectedly or is scheduled for maintenance.

The present multi-mode hammering machine has a drive mechanism structured to suite three different sheet metal forming jobs. The drive mechanisms is structured to easily switch the machine from one mode of operation to another. The power system is the same for both the rigid metal shaping mode and the flexible power hammer mode. The drive mechanism is the same for all three modes. The rigid movement of the ram tool is the same for both the rigid metal shaping and manual press modes. The stroke length and gap adjusting mechanisms are the same for all three modes. The machine combines specific components necessary for one, two or all three machine modes, while disengaging other components that are unnecessary or interfere with other machine modes. As a result, the machine will benefit metal forming shops by reducing machine and floor space overhead costs while meeting a wide array of customer demands and expectations.

Another advantage of the present multi-mode hammering machine is its ram drive assembly. This ram drive assembly includes a rigid lever drive assembly used in all three modes of operation. The rigid lever drive assembly interfaces with a reciprocating lever that is readily converted from a rigid metal shaping mode to a flexible power hammering mode. The lever includes both selectively engagable rigid plates and a selectively engagable spring. The conversion is readily achieved by simply inserting or removing a single conversion pin. The stroke length adjustment mechanisms is integrated into the rigid drive assembly. The gap adjustment mechanism is integrated into the reciprocating lever. The end result is a highly functional and commercially useful hammering machine that provides multiple functions so that machine and floor space costs are kept to a minimum.

A further advantage of the present multi-mode hammering machine is its independent stroke length and gap adjustment mechanisms. Both the stroke length and gap adjustment mechanisms operate independently of each other, and both function while the machine is in use. Both mechanisms operate when the rigid drive mechanisms and reciprocating lever are moving. This is particularly important for the power hammer mode because it allows the operator to adjust stroke length and gap to find the natural harmonic between the stroke length, gap and the material being shaped. The enhanced ram power or impact forces produced by setting the machine to achieve this natural harmonic further increases the versatility of the machine in that it can perform a wider variety of metal forming functions on a wider variety of sheet metal and workpiece thicknesses.

A still further advantage of the present multi-mode hammering machine is its rugged design. The ram drive assembly is specifically structured to handle the significant forces experienced by a hammering machine. The orientation of the components during moments of particularly high loading are aligned so that the components are not over stressed. Drive linkages have an in-line arrangement during moments of heightened or maximum compression that produce the impact between the ram and workpiece. As a result, the machine and its components do not experience excessive wear and tear, or require excessive service, and the machine has a long life.

A still further advantage of the present multi-mode hammering machine is its shape. The machine has a large open interior for easily accommodating a wide variety of workpieces. The ram drive assembly and stroke length and gap adjustment mechanisms extend around and not through this interior opening. Thus, the machine can handle a wide array of sheet metal products and jobs.

Other aspects and advantages of the invention will become apparent upon making reference to the specification, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the inventive hammering machine **10** showing its base **11** and support structure **20**, die **31**, ram **41**, power supply system **50** and exterior portions of its gap adjustment assembly **130**.

FIG. **2**A is a perspective view of the hammering machine **10** with a support plate **22** removed to show the ram drive assembly **60**, the eccentric pivot pin **95** of the lever **90** and gap adjustment assembly **130**, and the stroke length adjustment assembly **140** including its toggle mechanism **151**.

FIG. **2**B is an enlarged cut away view of the crank **61** shown in FIG. **2**A showing the drive shaft **57** and its offset drive crank **62**.

FIG. **3**A is a side plan view of the hammering machine **10** showing its base **11** and support structure **20**, die **31**, ram **41**, power supply system **50** and gap adjustment assembly **130**, and including an enlarged view of its stroke length scale located along curved slot **24**.

FIG. **3**B is an enlarged partial view of FIG. **3**A showing the stroke length adjustment scale adjacent the curved slot **24** with the toggle control pin **141** at its lowest or maximum stroke length position **48**.

FIG. **4** is a front plan view of the hamming machine showing the rotational centerline and maximum upward and downward positions of the lever achieved by the gap adjustment mechanism, and showing the rotational centerline of the crank shaft of the ram drive assembly.

FIG. **5**A is a side plan view of the hammering machine **10** in its rigid metal shaping mode **190** with the conversion pin **105** locked in place, the drive crank **61** in its fully retracted position to angularly displace the control link **70** out of vertical and out of line with the piston rod **81** to draw the piston rod down, the toggle assembly **151** set for maximum stroke length with its control pin **141** at the bottom of curved slot **24**, and the ram **41** in its maximum fully retracted position **48**.

FIG. **5**B is an enlarged partial view of FIG. **5**A showing the ram **41** in its maximum retracted position **48** and its lower surface **42** located 0.550 inches above the top **46** of the gap to produce the maximum ram stroke length SL_{Max} during operation in rigid metal shaping mode.

FIG. **5**C is an enlarged partial view of FIG. **5**A showing the path of travel **63** of the crank **61**, with the crank shifted to the right to its fully retracted position **67**.

FIG. **5**D is an enlarged portion of FIG. **5**A showing the hammering machine in its power hammer mode **200** with the conversion pin **105** removed from the rear **91** of the lever **90** to engage the flex drive **110**, and showing the plates **101** shifted down in phantom lines to further raise the conversion link **121** as the piston rod **81** reaches its lower most position **88** to increase the maximum fully retracted position **48'** and stroke length SL' of ram **41**.

FIG. **5**E is an enlarged portion of FIG. **5**A showing the hammering machine in its power hammer mode **200** with the conversion pin **105** removed from the front **92** of the lever **90** to engage the flex drive **110**, and showing the leaf spring **111** flexing up **204** in phantom lines to further raise the conversion link **121** as the lever **90** reaches its upper most position to increase the maximum fully retracted position **48'** and stroke length SL' of ram **41**.

FIG. **5**F is an enlarged portion of FIG. **5**B showing the hammering machine in its power hammer mode **200** with the ram **41** moving upwardly to a position **48'** beyond the upper most position **48** of the rigid metal shaping mode to increase the stroke length SL' of the ram.

FIG. **6**A is a side plan view of the hammering machine **10** in its rigid metal shaping mode **190** with the drive crank **62** in its fully retracted position **67** to angularly displace the control link **70** and draw down the piston rod **81** as in FIG. **5**A, but with the toggle assembly **151** set for minimum stroke length with its control pin **141** at the top of curved slot **24**, and with the ram **41** in its minimum fully retracted position **49**.

FIG. **6**B is an enlarged portion of FIG. **6**A showing the ram **41** in its minimum retracted position **49** and its lower surface **42** located 0.175 inches above the top **46** of the gap to produce the minimum ram stroke length SL_{Min} during operation in rigid metal shaping mode.

FIG. **7**A is a side plan view of the hammering machine **10** in its rigid metal shaping mode **190** with the conversion pin **105** locked in place with the toggle assembly **151** set for maximum stroke length with its control pin **141** at the bottom of curved slot **24** for maximum piston rod **81** retraction as in FIG. **5**A, but with the drive crank **61** in its fully extended position **68** to vertically and linearly align the control link **70** with the piston rod **81** to push the piston rod up, and with the ram **41** in its fully extended position **46**.

FIG. **7**B is an enlarged portion of FIG. **7**A showing the ram **41** in its fully extended position **46** with the lower surface **42** of the ram at the top of the gap during operation in the rigid metal shaping mode.

FIG. **7**D is an enlarged portion of FIG. **7**A showing the hammering machine in its power hammer mode **200** with the conversion pin **105** removed from the rear **91** of lever **90**, and showing the plates **101** shifting up in phantom lines to further lower the conversion link **121** as of the piston rod **81** reaches its fully extended position **84**.

FIG. **7**E is an enlarged portion of FIG. **7**A showing the hammering machine in its power hammer mode **200** with the conversion pin **105** removed from the front **92** of lever **90**, and showing the leaf spring **111** flexing down **207** in phantom lines to further lower the conversion link **121** as the fixed plates **101** of the lever **90** reach their bottom most position.

FIG. **7**F is an enlarged portion of FIG. **7**B showing the hammering machine in its power hammer mode **200** with the ram **41** moving downwardly to a position **46'** beyond its lowest position **46** in the rigid metal shaping mode to and increase the stroke length SL' of ram and reduce the size of the gap.

FIG. **8**A is a side plan view of the hammering machine **10** in its rigid metal shaping mode **190** with the conversion pin **105** locked in place and the drive crank **61** in its fully extended position **68** to vertically and linearly align the control link **70** with piston rod **81** to push the piston rod up, and with the ram **41** in its fully extended position **46** as in FIG. **7**A, but with the toggle assembly **151** and its control pin **141** set at the top of curved slot **24** for minimum stroke retraction as in FIG. **6**A.

FIG. **8**B is an enlarged portion of FIG. **8**A showing the ram **41** in its fully extended position **46** with the lower surface **42** of the ram at the top of the gap during operation in the rigid metal shaping mode.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While this invention is susceptible of embodiment in many different forms, the drawings show and the specification describes in detail a preferred embodiment of the invention. It should be understood that the drawings and specification are to be considered an exemplification of the principles of the invention. They are not intended to limit the broad aspects of the invention to the embodiment illustrated.

The present invention relates to a multi-mold hammering machine for shaping a workpiece **5** such as a sheet of metal. The multi-mode hammering machine is generally depicted as reference number **10** in FIG. **1**. The machine **10** has a rigid meal shaping mode **190** where its ram has a rigid non-flexible stroke length. The machine **10** is readily switched from this mode to a flexible power hammer mode **200** by removing a conversion pin. In this mode, the ram has a flexible stroke length that varies with machine cycle speed. This power hammer mode utilizes a harmonic force multiplier to produce more significant impact forces by the ram on the workpiece. When the conversion pin is inserted and the motorized drive system is disengaged, the machine **10** can be used in a machine press mode **220**. In this mode, the ram drive assembly is manually operated to lower the ram like a conventional machine press. While the machine **10** is particularly suited for shaping sheet metal **5** as shown in FIGS. **5**A and **5**B, it should be understood that the broad aspects of the invention are not limited to sheet metal.

The hammering machine **10** is mounted on a support frame **11** that includes a rectangular base **12** that rests on the floor of a building. The base **12** has a wide footprint to stabilize the machine and minimize shaking and vibration during operation. The frame **11** has front and rear A-frame supports **13** and **14**. These supports **13** and **14** are rigidly secured to and extend upwardly from the base **12** to elevate a workpiece receiving area **15** of the machine **10** about four feet above the floor to facilitate ease of use and material handling during operation. The A-frames **13** and **14** are spaced apart and rigidly joined by two braces **16**. While structurally strong, these braces **16** also have numerous openings or holes cut through them, so that the braces serve as tool racks to hold the various die and ram tools used during the operation of the machine **10**. The machine **10** is about eight feet tall, has a front to back depth of about five feet, a side-to-side width of about three feet, and weight of about 1,600 pounds for added stability during operation.

The hammering machine **10** has a housing and support structure **20** for securing, supporting and protecting its internal components. This structure **20** includes first and second plates **21** and **22** that are spaced about 3½ inches apart to form an internal compartment that houses many of the working components of the machine **10**. Each plate **21** and **22** is robustly designed and about one inch thick to withstand the significant cyclical loads produced by the machine **10**. The plates **21** and **22** are joined together in spaced registry by a number of internal spacer posts **23**. Each plate **21** and **22** has an accurate slot **24**. Each plate also has a generally round perimeter and a large central opening **25** extending inwardly from the front or mouth **26** of the machine to form a generally C-shaped configuration. The C-shaped housing and support structure **20** defines the upper and lower jaws **27** and **28** located above and below its mouth **26** for receiving a workpiece **5**. The mouth **26** generally forms the working area **15** of the machine **10**. Plates **21** and **22** are generally symmetrical, and aligned so that their slots **24**, openings **25**, and outer perimeters are in substantial registry. Cover plates or shields **29** close the outer edges between the side plates **21** and **22** to prevent inadvertent contact with the moving internal components of the machine **10** and to prevent debris from entering the machine. These shields **29** are located along the outer perimeter of the support plates **21** and **22**, as well as the internal perimeter forming the central opening **25**.

Matched sets of workpiece forming tools **30** are mounted on a die **31** and a ram **41**. Each tool set **30** includes a die tool **32** mounted on the die **31**, and a ram tool **42** mounted on the ram **41**. The die tool **32** has a contoured upper surface **32*a*** designed to shape the workpiece **5** in a desired manner. The die tool **32** is rigidly fixed to one end of an elongated linear mounting shaft **33** by a removable pin or other conventional releasble tool mounting device. The mounting shaft **33** is vertical orientation and rigidly held by a mounting block **35** that is rigidly fixed between side plates **21** and **22** proximal the lower jaw **27**. The shaft **33** and block **35** include cooperating height adjustment holes **37**. The shaft has several space holes along its length. A locking pin rigidly secures the vertically oriented mounting shaft **33** to the mounting block **35**. The locking pin fixes the height of the die **31** during the operation of the machine **10**. The working opening **25** of the machine **10** includes a conventional workpiece support **37** to support the weight and help align the workpiece **5** between the die and ram tools **32** and **42** during the operation of the machine. The workpiece support **37** is rigidly fixed to the support structure **20**, and can also be used as a visual guide or horizontal reference during the operation of the machine **10**.

The ram tool **42** has a lower surface **42*a*** that is flat or contoured to flushly mate or otherwise cooperate with its corresponding die tool surface **32*a***. Similar to the die tool **32**, the ram tool **42** is rigidly fixed to one end of an elongated linear shaft **43** by a removable pin or other conventional releasble tool mounting device. The ram shaft **43** is vertically oriented and held by a linear bearing **44** that allows the ram **41**, tool **42** and shaft **43** to move along a substantially vertical and linear path of travel **45** as shown in FIG. **3**. The linear bearing **44** is rigidly fixed between side plates **21** and **22** proximal the upper jaw **28**. An oil gauge is provided to ensure the bearing **44** is properly lubricated during operation.

The ram or hammer **41** moves cyclically between a bottom position **46** and an upper position **47** as shown in FIGS. **5**A, **5**B, **7**A and **7**B. The distance between the upper surface **32*a*** of the die tool **32** and the lower surface **42*a*** of the ram tool **42** when the ram **41** is at its bottom-most or bottom dead center position **46** constitutes the "gap" between the workpiece forming tools **30**. The linear movement **45** of the ram tool **42** between its bottom dead center **46** and upper position **47** constitutes the stroke length SL of the ram **41**. As discussed more fully below, the size or height of the gap can be adjusted during the operation of the machine **10**. While the die **31** remains fixed during the operation, the bottom dead center position **46** of the ram **41** can be adjusted up or down to increase or decrease the size of the gap. Adjusting the size or height of the gap does not impact the stroke length SL of the ram **41**. Adjusting the gap moves the entire stroke of the ram **41**. Both the bottom **46** and upper **47** positions of the stroke move an equal amount when setting the gap. As is also discussed more fully below, the stroke length SL can be independently adjusted during the operation of the machine **10** by independently adjusting the upper position **47** between maximum **48** and minimum **49** retracted positions, as shown in FIGS. **5**B and **6**B.

The hammering machine **10** includes a power supply system **50** for driving ram **41**. As shown in FIG. **1**, an electric power box **51** is secured to the base **12** of the lower frame **11**. The electric box **51** draws power via an electric cord plugged into a 20 amp, 230 volt electric outlet. The power box **51** includes a variable frequency drive (VFD) that converts the electricity before sending the electric power via cord **53** to an AC electric drive motor **54**. The motor **54** is a standard 2 Hp, variable speed motor capable of rotating its output or drive shaft **55** at a rate of up to about 4,500 rpm. The drive shaft **54** is joined to a drive belt **56** that rotates a crank shaft **57**. There is a 3 to 1 reduction via the belt **56**, so the driven crank shaft **57** spins at a speed of up to about 1,500 rpm. The crank shaft **57** has a rotational centerline **58**. The speed of the motor **54** and its drive shaft **55** determines the cycle speed or beats per minute (bpm) of the ram **41**. The speed of the motor **54** is controlled by a control system, as discussed below.

The crank shaft **57** is held by a linear bearing and support frame secured to support plates **21** and **22**. Both the motor drive shaft **55** and crank shaft **57** are free to rotate, but are otherwise fixed relative to the support structure **20** of the machine **10**. The motor **54**, drive shaft **55**, belt **56** and crank shaft **57** are covered by a removable safety shroud during operation. Although the power supply system **50** is shown and described as a power system with an electric drive motor **54** drawing power from a conventional electrical outlet, it should be understood that the power supply system could be a hydraulic power supply system or other types of power supply system without departing from the broad aspects of the present hammering machine **10** invention.

The motor **54** and crank shaft **57** power a ram drive assembly **60** best shown in FIGS. **2**A, **5**A, **6**A, **7**A and **8**A. The ram drive assembly **60** is held between support plates **21** and **22**, and includes a rotating drive crank **61**, toggle control link **70**, lower rocker **76**, upper piston link **81**, reciprocating lever **90**, linear conversion link **121** and ram shaft **43**. The links, pins, rods, levers and shaft components forming the drive assembly **60** are robustly designed to withstand the sufficient loads generated by the hammering machine **10**. The drive crank **61**, rocker **76** and lever **90** are pivotally secured to these support plates **21** and **22**. The control link **70**, piston rod **81** and linear conversion link **121** are not directly secured to support plates **21** or **22**. The ram is held by its linear bearing **44**.

The drive crank **61** is mounted to a crank **62** on drive shaft **57**, as best shown in FIG. **2**B. The crank **62** is offset from centerline **58** to revolve around the centerline in a circular path of travel **63**, as shown in FIGS. **5**C and **7**C. Although the crank arm **64** revolves with the crank **62**, the crank arm remains facing toward the front of the machine **10** and remains predominantly horizontal. The crank arm **64** has an outer end with a hole that receives a pin that joins it to the control link **70**. The crank arm **64** has an internal weight reducing slot to reduce power loss. The drive crank **61** revolves around its circular path of travel **63**, as the outer end of the crank arm **64** oscillates between a fully retracted position **67** (FIG. **5**A or **6**A) and a fully extended position **68** (FIGS. **2**A, **7**A and **8**A). The outer end of the crank arm **64** oscillates back and forth in a generally curved or actuate path of travel toward and away from the front of the machine **10**.

Proper positioning of the toggled control link **70** controls the stroke length SL of the ram **41**. Control link **70** has four substantially evenly spaced pins **71**-**74** between its opposed ends, and an end pin to end pin length of about nine inches. Each pin is pivotally received in a hole formed in the link **70**. A first pin **71** is inserted through a lower intermediate hole in the link **70**, and pivotally connects the link **70** to the outer end **66** of the oscillating drive crank **61**, as noted above. A second pin **72** is inserted through a hole near the lower end of the control link **70**, and pivotally connects the link **70** to a lower rocker **76**. The third pin **73** is inserted through an upper intermediate hole, and pivotally connects the control link **70** to a toggle arm **131** as discussed below. The fourth pin **74** is inserted through a hole near the upper end of the control link **70**, and pivotally connects the link **70** to an upper piston rod or vertical extension link **81**, as also discussed below.

The lower rocker **76** has an arm **77** with a hole in its outer end for receiving the second pin **72** of the control link **70**. The lower rocker **76** is fixed to a pivot or rocker shaft **79**. The shaft **79** is free to pivotally rotate, but is otherwise fixed to the support plates **21** and **22**. The rocker arm **77** oscillates back and forth as the drive crank **62** and crank arm **64** revolve around path **63**. The lower rocker **76** restricts the movement of the lower end of control link **70**. The oscillating pivotal movement of the lower rocker **76** combines with the revolving movement of the drive crank **61** and toggle arm **131** to determine the position or orientation of the control link **70** and its path of movement.

The elongated piston rod **81** extends upwardly from the control link **70**. The piston rod **81** has opposed ends **82** and **83** and a pin to pin length of about 18 inches. The lower end of **82** of the piston **81** has a hole for pivotally receiving link pin **74** of control link **70**. The upper end **83** of the piston **81** has a hole for receiving a pin of reciprocating lever **90**. The elongated vertical piston link **81** has a weight reducing slot along its length to improve the power and performance of the machine **10** and its ram drive assembly **60**. The rod **81** remains substantially vertically oriented during all modes of operation of the machine **10**. The piston rod **81** extends or elevates the ram drive assembly **60** above opening **25** so that the ram **41** can move up and down relative to the working area **15** of the machine **10**. This length of the rod **81** is sufficient to permit the ram **41** to be raised to its elevated or retracted position **47**, and stroked linearly downward toward the die **31** to its lower or bottom dead center position **46**.

The drive crank **61**, control link **70**, lower rocker **76** and upper piston rod **81** form a lever drive assembly **85** that rigidly drives the reciprocating lever **90**. The components **61**, **70**, **76** and **81** in the lever drive assembly **85** are sized and positioned to cooperatively extend and retract the piston rod **81** and lever **90** as the crank **61** rotates around its path of travel **63**. The piston rod **81** returns its upper end **83** to the same upper most extended position **84** during each cycle of the drive crank **61**, as shown in FIGS. **2**A, **7**A and **8**A. The load bearing components or linkages **61**, **70**, **76** and **81** in the lever drive assembly **85** do not flex or bend. The cyclical movement of the lever drive assembly **85** rigidly drives the piston rod **81** in an up and down motion like the piston of a car engine, except that the stroke length SL of the piston rod **81** can be selectively varied. The lever drive assembly **85** is made of rigid metal components that extend and retract the piston rod **81** and one end of the lever **90** in a rigid, non-flexing movement. Although the stroke length SL of the piston rod **81** is selectively varied by varying its fully retracted position **87** between its maximum **88** and minimum **89** positions (FIGS. **5**A and **6**A, respectively), once the stroke length SL is set to a specific desired stroke length, the drive assembly **85** rigidly maintains that stroke length SL.

The lever drive assembly **85** cyclically moves between an in-line orientation with its load bearing linkages linearly aligned when in a single common fully extend position **86** (FIGS. **2**A, **7**A and **8**A) and an angled orientation with its load bearing linkages angularly aligned when in a selectively variable fully retracted position **87**. (FIG. **5**A or **6**A). The fully retracted position is selectively varied between its maximum **88** and minimum **89** angled positions. When the drive crank **61** is at its full retracted position **67** (FIG. **5**C), the control link **70** has a generally angled orientation relative to the rocker **76** and piston rod **81**. The control link **70** angles in one direction relative to the rocker **76**, and the opposite direction relative to the piston **81**. This angled orientation **87** draws down or retracts the piston rod **81** and lever **90**. When the crank **62** and crank arm **64** are at their full extended position **66** (FIG. **7**C), the control link **70** has a generally in-line or vertical position relative to the rocker **76** and piston link **81** as shown in FIGS. **2**A, **7**A and **8**A. This in-line orientation **86** pushes up or extends the piston rod **81** and lever **90**.

While the lever drive assembly **85** returns to its in-line orientation **86** when the crank **61** is at its fully extended position **66**, the amount of the angle between its components **70**, **76** and **81** when the crank **61** is at its retracted position **67** is selectively varied by the stroke length adjustment assembly, as discussed below. When the machine **10** is set to its maximum stroke length setting as in FIGS. **5**A and **7**A, the lever drive assembly **85** cyclically move between its full extend position **86** and a maximum full retract position **88**. This stroke length setting provides the maximum stroke length SL_{Max} of piston rod **81**. In the preferred embodiment, the maximum stroke length SL_{Max} of the lever drive assembly **85** and its piston rod **81** is about 0.550 inches. When the machine **10** is set to its minimum stroke length setting as in FIGS. **6**A and **8**A, the lever drive assembly **85** cyclically move between full extend position **86** and a minimum full retract position **89**. This stroke length setting provides the minimum stroke length SL_{Min} of piston rod **81**. In the preferred embodiment, the minimum stroke length SL_{Min} of the lever drive assembly **85** and its piston rod **81** is about 0.175 inches. Again, the piston rod **81** returns its upper end **83** to the same upper most extended position **84** (FIGS. **7**A and **8**A) during each cycle of the drive crank **61**, no matter what the stroke length setting.

The reciprocating lever **90** is located at the top of the machine **10**. The lever **90** is about 30 inches long to accommodate and span the central opening **25**, is robustly designed and weighs about 55 pounds. The lever **90** has opposed ends **91** and **92**. The rear end **91** is pivotally joined to the piston rod **81** by first pin **93**. The front end **92** is pivotally joined to the linear conversion link **121** by a second pin **94**. The lever **90** reciprocally pivots about a pivot pin **95** that serves as a fulcrum for the lever. This fulcrum pin **95** is preferably located at or near the center or middle of the lever. The outer ends of the pin **95** are collinear and pivotally held by bearing collars **96**. Each collar **96** is rigidly bolted to one of the side plates **21** or **22**. The collinear ends of the fulcrum pin **95** and the collars **96** form a centerline **97** of the lever **90**. The pin **95** has an eccentric mid section **98** located between plates **21** and **22**. The mid section **98** is offset to allow for adjustments to the gap between the die **31** and ram **41**, as discussed below. The offset mid section **98** forms a rotational centerline or axis **99** for the pivotal movement of the lever **90**.

The ram drive assembly **60** has both a rigid drive **100** and a flexible drive **110** as shown in FIG. **2**. Both drives **100** and **110** are incorporated into the lever **90**, and each spans the full length of the lever **90** from its rear end **91** to its front end **92**. Both drives **100** and **110** are mounted on the midsection **98** of the fulcrum pin **95**, and pivot about rotational axis **99** during operation. The drives **100** and **110** are not engaged at the same time. When one drive **100** or **110** is engaged, the other is simultaneously disengaged. The hammering extend position **86** and a minimum full retract position **89**. This stroke length setting provides the minimum stroke length SL_{Min} of piston rod **81**. In the preferred embodiment, the minimum stroke length SL_{Min} of the lever drive assembly **85** and its piston rod **81** is about 0.175 inches. Again, the piston rod **81** returns its upper terminal end **83** to the same upper most extended position **84** (FIGS. **7**A and **8**A) during each cycle of the drive crank **61**, no matter what the stroke length setting.

The reciprocating lever **90** is located at the top of the machine **10**. The lever **90** is about 30 inches long to accommodate and span the central opening **25**, is robustly designed and weighs about 55 pounds. The lever **90** has opposed ends **91** and **92**. The rear end **91** is pivotally joined to the piston rod **81** by first pin **93**. The front end **92** is pivotally joined to the linear conversion link **121** by a second pin **94**. The lever **90** reciprocally pivots about a pivot pin **95** that serves as a fulcrum for the lever. This fulcrum pin **95** is preferably located at or near the center or middle of the lever. The outer ends of the pin **95** are collinear and pivotally held by bearing collars **96**. Each collar **96** is rigidly bolted to one of the side plates **21** or **22**. The collinear ends of the fulcrum pin **95** and the collars **96** form a centerline **97** of the lever **90**. The pin **95** has an eccentric mid section **98** located between plates **21** and **22**. The mid section **98** is offset to allow for adjustments to the gap between the die **31** and ram **41**, as discussed below. The offset mid section **98** forms a rotational centerline or axis **99** for the pivotal movement of the lever **90**.

The ram drive assembly **60** has both a rigid drive **100** and a flexible drive **110** as shown in FIG. **2**. Both drives **100** and **110** are incorporated into the lever **90**, and each spans the full length of the lever **90** from its rear end **91** to its front end **92**. Both drives **100** and **110** are mounted on the midsection **98** of the fulcrum pin **95**, and pivot about rotational axis **99** during operation. The drives **100** and **110** are not engaged at the same time. When one drive **100** or **110** is engaged, the other is simultaneously disengaged. The hammering machine **10** is easily switched from one drive **100** or **110** to the other by selectively inserting or removing a conversion pin **105**, as discussed below.

The rigid drive **100** is formed by a load bearing rigid assembly that rigidly joins the lever drive assembly **85** to the ram **41**. The rigid assembly is formed by two spaced rigid, metal plates **101** that span the length of the lever **90**. The plates **101** are located between and coplanar with each other and the support plates **21** and **22**. Each plate weighs about 12 pounds. The rigid drive **100** is engaged when the rear **91** and front **92** ends of the plates **101** are pivotally pinned **93** and **94** to piston rod **81** and linear conversion link **121**, respectively. The plates **101** rigidly join the piston rod **81** and conversion link **121** about a common pivot axis **99** so that each **81** and **121** moves in rigid unison with the other. The ends **91** and **92** move in an arced path about the rotational axis **99** of the pivot pin **95**. Because the pivot pin **95** is preferably located at the center of the lever **90**, the rigid drive **100** converts upward movement of the piston rod **81** into a substantially equal downward movement of the conversion link **121** and ram **41**, and visa versa. When the rigid drive **100** is engaged, the stroke length SL of the piston rod **81** is substantially the same as the stroke length of the conversion link **121** and ram **41**. For example, when the drive assembly **85** and piston rod **81** are set to a maximum stroke length SL_{Max} of about 0.550 inches (FIGS. **5**A and **5**B), so is the ram **41**. Similarly, when the drive assembly **85** and piston rod **81** are set to a minimum stroke length SL_{Min} of about 0.175 inches (FIGS. **7**A and **7**B), so is the ram **41**.

The flexible drive **110** is formed by a load bearing spring assembly **110***a* that flexibly joins the lever drive assembly **85** to the ram **41**. The spring assembly includes a leaf spring **111** and a rigid torsion arm **116**. The torsion arm **116** firmly grips, supports and provides leverage to flex or torque the leaf spring **111**. The spring assembly **110***a* and its components **111** and **116** are located between or sandwiched by the plates **101** of the rigid drive **100**. The leaf spring **111** is preferably located toward the front end **92** of the lever **90**, and the rigid torsion arm **116** is preferably located toward the rear **91**. In rigid mode, when the plates **101** are pinned at both ends **91** and **92** via pins **93** and **94**, the leaf spring **111** and torsion arm **116** move in unison with the plates **101**. The flexible drive **110** is effectively inoperative as the load is transmitted through the plates **101** of the lever **90**. The flexible spring **111** and torsion arm **116** are rigidly connected to each other, but are not welded, bolted or otherwise directly or integrally fastened to the rigid plates **101**. Selectively removing one of the outer pinned connections **93** or **94** disengages the rigid drive **100**, and simultaneously engages the flexible drive **110**.

The leaf spring **111** spans about half the length of the lever **90**, and has a wide central end **112** and narrow outer end **113**. The wide end **112** is formed by several individual spring plates, and is rigidly secured to torsion lever **116**. The narrow end is formed by a single spring plate. The conventional leaf spring **111** flexes up and down, but does not generally flex from side-to-side or twist about its longitudinal axis. The leaf spring **111** has a rated stiffness or K value of about 1,000. The end **113** of the central plate of the leaf spring **111** forms a circular loop. The looped end **113** has a diameter of about two inches and is shaped to flushly and securely receive a first polyurethane sleeve **115**.

The torsion arm **116** spans about half the length of the lever **90**, and has central and outer ends **117** and **118**. The central end **117** is secured to the midsection **98** of the pivot pin **95** and pivots with the leaf spring **111** about axis **99**. The central end **117** has a pocket **117***a* to receive the spring **111** that extends about five inches out from axis **99** over the spring. The upper portion of the pocket **117***a* pushes down on the top of the spring **111** during the down stroke of the ram **41**. The torsion arm **116** is rigid and does not flex. The arm **116** rigidly holds the wide central end **112** of the spring **111**. The central end **112** of the spring **111** does not rotate relative to or slide in and out of the torsion arm **116**. The outer end **118** of the support forms a two inch diameter hole that is shaped to flushly and securely receive a second metal sleeve **119**. The upper end of the piston rod **81** is pivotally joined to the outer end **118** of the torsion arm **116** and can be pinned to the rigid plates **101** via pin **93**.

The polyurethane sleeve **115** is slightly compressible and serves as a shock absorber. Both the polyurethane and metal sleeves **115** and **119** have a one inch diameter opening. The loop **113** of the spring **111** is pivotally joined to the linear conversion link **121** during all modes of operation. Similarly, the outer end **118** of the torsion arm **116** is pivotally joined to the piston rod **81** during all modes of operation. The ends of the sleeves **115** and **119** are flush with the sides of the outer ends **113** and **118**, respectively. The outer end **118** of torsion arm **116** is pivotally joined to the rigid plates **101** by the pivot pin **93**. The loop **113** of the spring **111** is pivotally joined to the rigid plates **101** by the pivot pin **94**. The pins **93** and **94** are flushly received by the sleeves **115** and **119** and are free to rotate in ends **113** and **118**, but otherwise remain fixed inside and directly joined to their respective end. The pins **93** and **94** are longer than the width of the support and spring ends **113** and **118**. The pins **93** and **94** have a length of about four inches, and are longer than their respective sleeve **115** or **119**. When inserted into their sleeve **115** or **119**, the pins **93** and **94** extend through the aligned holes in the rigid plates **101**. The ends of the pins **93** and **94** are flushly received by and extend through aligned holes in the plates **101**.

The linear conversion link **121** transitions the pivoting motion of reciprocating lever **90** into the linear motion of ram **41**. During rigid mode operation, the rigid lever plates **101** remain substantially horizontal, but pivot about ½° to 2° in either direction. During flex mode operation, the lever plates **101**, spring **111** and torsion arm **116** pivot about ½° to 5° in either direction. The lower end of the conversion link **121** holds the pin **122** for pivotally joining the conversion link to the upper forked end of the ram shaft **43**. The upper end of the conversion link **121** is pivotally joined to the outer loop end **113** of the spring and can be pinned to the rigid plates **101** via pin **94**.

A conversion pin **105** is inserted in to one of the two ends **91** or **92** of the lever **90** to engage the rigid drive **100** and disengage the flexible drive **110**. The conversion pin **105** can be either the pin **93** located at the rear end **91** of the lever **90**, or the pin **94** located at the front end **92**, as shown in FIG. **2**A. The pin **105** is a bolt is threaded at one end, and secures or locks the pin in place by a pair of cooperating nut and washer. The pin **105** also serves as a shear pin to prevent overloading the ram drive assembly **60** during rigid mode operation. In the preferred embodiment, the conversion pin **105** is the pin **93** at the rear end **91** of the lever **90** as in FIGS. **5**D and **7**D. When the pin **94**, **105** is removed to engage the flexible drive **110**, the outer end **118** of the torsion arm **116** disengages from the rigid plates **101**. The spring **111** flexes during both the up and down strokes of the ram and piston rod **81**. During the up stroke of the piston rod **81** (down stroke of the ram **41**), the spring pocket **117***a* of the torsion arm **116** press down into the top of the spring **111**, and causes the spring and spring assembly to flex in what is believed to be a bowed manner.

In another embodiment, the conversion pin **105** is the pin **94** at the front end **92** of the lever **90** as in FIGS. **5**DE and **7**E. When the pin **94**, **105** is removed to engage the flexible drive **110**, the spring **111** extends from its secured wide end **112** in a cantilevered manner. The cantilevered extension of the spring **111** preferably starts at a location proximal the fulcrum pin **95**, and continues to its terminal or flex end **113** formed by the central plate of the spring. The conversion pin **105** is inserted into sleeve **115** or **119** to place the machine **10** in a rigid reciprocating mode **190** and is removed from that sleeve to place the machine in a flexible power hammer mode **200**, as discussed below. As the ram **41** is stroked up and down, the spring **111** and spring assembly flex in a cantilevered manner.

A gap adjustment assembly **130** is provided to set the "Gap" between the surface **32***a* of the die tool **32** and the surface **42***a* of the ram tool **42** when the ram **41** is at its lower most position **46** during rigid mode. The gap adjustment assembly **130** includes the eccentric pivot pin **95** of the lever **90**. While the pin **95** is secured to the plates **21** and **22** at its outer ends via bearing collars **96**, the rigid lever plates **101** and spring torsion arm **116** are secured to its eccentric midsection **98**. The rotational centerline **99** of the midsection **98** is offset about ½ inch from the centerline **97** of the fulcrum pin **95**. As the pin **95** rotates about its centerline **97**, the rotational or pivot axis **99** of the eccentric mid section **98** moves between a maximum and minimum gap positions **132** and **133**, as shown in FIG. **4**. The gap adjustment assembly **130** allows for continuous adjustment of the Gap, so the Gap can be set to any of an infinite number of positions between positions **132** and **133**. The eccentric mid section **98** produces about a plus or minus one inch difference in height at the front end **92** of the lever **90** that is joined to the linear conversion link **121**. The conversion link **121** and ram **41** move twice as much as the eccentricity of the pin **95** due to the fact that the rear end **91** of the lever **90** returns to the same point **84** when the lever drive assembly **85** is at its full extended position **86**, and the fact that the pivot pin **95** is located at about the middle of the lever **90**.

One end of the pivot pin **95** extends outwardly from plate **21** to rigidly join a rotation plate **134** and gear **135**. A wheel assembly **136** with a threaded shaft **137** is used to rotate the gear **135** and eccentric pivot pin **95**. The wheel assembly **136** includes a threaded mounting block **138** and turn wheel **139**. By rotating turn wheel **139**, an operator can rotate the eccentric pivot pin **95**. Again, the rotation of the pivot pin **95** about its centerline **97** moves the axis **99** of its eccentric midsection **98** between maximum and minimum gap positions **132** and **133**. This motion is used to raise and lower the ram **41** to set its bottom dead center position **46**. The gap setting assembly **130** can be operated to set or adjust the gap when the machine is running, and operates independently of the stroke length adjustment assembly **140**.

The stroke length adjustment assembly **140** sets the stroke length "SL" of the ram **41**. The adjustment assembly **140** sets the variable lever drive retraction position **87** between the maximum **88** and minimum **89** lever drive retraction positions. The stroke length SL is selectively set by moving a control pin **141** received by the curved slot **24** of the support plates **21** and **22**. The control pin **141** is positioned at the top **149** of the slot **24** for minimum rigid mode stroke length SL_{Min} as in FIG. **1**, and at the bottom **88** of the slot **24** for a maximum rigid mode stroke length SL_{Max} as in FIG. **3**A. The maximum rigid mode stroke lengths SL_{Max} is preferably about 0.550 inches. The minimum rigid mode stroke length SL_{Min} is preferably about 0.175 inches as shown on the scale best seen in FIG. **3**B. It should be noted that the broad aspects of the invention are not limited to these particular maximum SL_{Max} and minimum SL_{Min} rigid mode stroke lengths. The stroke length adjustment assembly **140** allows for continuous adjustment of the stroke length SL, so the stroke length can be set to any of an infinite number of lengths between positions **88** and **89**.

The adjustment assembly **140** selectively sets the variable ram retraction position **87** of the lever drive assembly **85**, but has little or no effect on its full ram extension position **86**. When the machine **10** is in its rigid metal shaping mode **190**, the positions **86**, **87**, **88** and **89** of the lever drive assembly **85** directly correspond to the positions **46**, **47**, **48** and **49** of the ram **41**, respectively. When the machine **10** is in its flexible hammer mode **200**, the positions **86**, **87**, **88** and **89** of the lever drive assembly **85** are related to but do not necessarily directly correspond to the positions **46**, **47**, **48** and **49** of the ram **41** due to the flexing of spring **111** caused by the cyclical motion of the ram **41** and impact forces against the workpiece **5**.

The stroke length adjustment assembly **140** uses a toggle mechanism **151** to set the lever drive retraction position **87**, and thereby the rigid mode variable ram position **47**. Toggle mechanism **151** is operable when the machine **10** is running and the ram **41** is cycling. The toggle mechanism **151** includes a turn wheel assembly **155** and a threaded positioning shaft **156** that is rotationally secured to a threaded mount **157** that is rigidly secured between **21** and **22** of the support structure **20**. A turn wheel **158** is rotated to turn its threaded shaft **156**. The threaded shaft **156** is joined to a triangular plate **161** via a pivot pin **162**. Turning the wheel **158** draws pin **162** up or down the length of the shaft **156**. The triangular plate **161** pivots about a pin **163** that is rigidly held by plates **21** and **22** of the support structure **20**. Triangular plate **161** includes a third pin **164** that is pivotally joined to a slot arm **165**.

Slot arm **165** is elongated with a first end secured to triangle **161** via pin **164**, and a second end joined to the control pin **141**. Control pin **141** is movingly received in the curved slots **24** of plates **21** and **22** so that the pin **141** will follow the path of the curved slot. Control pin **141** is pivotally joined to toggle arm **171** at one end. The other end of the toggle arm **171** is pivotally joined to the third pivot pin **73** of the control link **70**. Rotating hand wheel **158** pivots triangle plate **161** to raise and lower slot arm **165** and control pin **141** along curved slot **24**, to thereby position the third pivot pin **73** of the control link **70** at a desired location corresponding to the desired ram retraction position **87**. Stroke length SL is set by setting the angular position of the control link **70** when the crank **61** is at its fully retracted position **67**. The position of the control link **70** dictates the upper most position **47** and the stroke length (SL) of the ram during the rigid sheet metal shaping mode **190**.

The hammering machine **10** includes a control system **180** that controls the speed or revolutions per minute (rpm) of the motor **54** and cycle speed or beats per minute (bpm) of the ram **41**. The control system **180** includes a control panel **181** with an on/off switch **182** and a BPM limit knob **183**, and a foot pedal **185**. The panel **181** and pedal **185** are in electrical communication with the motor **54**. The motor **54** and ram **41** speed are controlled or varied in two ways. First, the BPM limit switch **183** allows the operator to set the upper rotation speed of the motor **54** and corresponding cycle speed of the ram **41**. While the AC motor **54** is capable of producing 2,000 bmp, the limit knob **183** can set the upper limit of the motor to a value at or less than 2,000 bpm. For example, the limit knob **185** can be set to 10 bpm, 100 bpm, 1,000 bpm or 2,000 bpm depending on the type of work being performed. Second, the foot pedal **185** allows the operator to control the motor **54** speed and ram **41** cycle speed between zero and the set upper level set by knob **183**. Setting the limit switch **183** to a lower upper level (e.g., about 10 to 100 bpm) allows the operator greater control over the cycle speed of the ram **41** via the foot pedal **185**. Setting the limit switch **183** to a higher upper level (e.g., about 1,000 to 2,000 bpm), allows the operator to rapidly shape a workpiece **5** by depressing the foot pedal **185** to attain a rapid ram speed.

As noted above, during the rigid reciprocating or sheet metal shaping mode **190**, the ram **41** and linear conversion link **121** move rigidly in unison with the lever drive assembly **85**, via the rigid drive plates **101**. As the front end **92** of the lever **90** moves up and down a set predetermined distance, the ram **41** is rigidly stroked up and down substantially the same distance. This set distance is the desired stroke length SL of the ram **41**. In the rigid reciprocal or rigid sheet metal shaping mode **190**, the stroke length SL is set by the stroke length adjustment assembly **140**. Stroke length SL is not a function of the cycle speed of the ram **41**. Increasing or decreasing the cycle speed or bpm of the ram **41** does not effect the stroke length SL of the ram **41**.

In the rigid reciprocating mode **190**, conversion pin **105** is inserted into the sleeve **115** or **119**. The insertion of this pin **105** pivotally and rigidly joins the piston rod **81** to the linear conversion link **121** and ram **41** via the rigid lever plates **101** to rigidly hold the stroke length of the ram, thereby bypassing the use of the leaf spring **111**. The load generated by motor **54** is transmitted through the ram drive assembly **60** and cycles ram **41** through its linear up and down path of travel **45**. Tight pin connections in this drive assembly **60** dictate that the position of the lower surface **42** of the ram **41**, which directly correspond to the rotation of the drive crank **61** and the oscillation of the outer end of its arm **64**.

The hammering machine **10** is readily converted from its rigid metal shaping mode **190** to a flexible power hammer mode **200** by removing the conversion pin **105**. When the conversion pin **105** is removed, the flex drive **110** of lever **90** is activated and spring **111** is free to flex, which flexibly join the lever drive assembly **85** to the conversion link **121** and ram **41** to flexibly hold the stroke length of the ram, as discussed below. Load now passes through the flexible drive **110** and spring **111**, and no longer passes through the rigid plates **101**. As noted above, the conversion pin **105** is preferably the rear pin **93** of the lever **90**, but can also be the front pin **94** or even both pins. When the rear pin **93** is the conversion pin **105**, the change in momentum and cyclical acceleration of the ram **41**, lever **90** and link **121** masses, apply a force to the spring **111** and cause it to flex a particular distance so as to store energy. When the front pin **94** or both pins **39** and **94** are removed, only the mass and acceleration of the ram **41** and link **121**, apply force to the spring **111**. The ram **41**, lever **90** and conversion link **121** weigh about 17, 55 and 4 pounds, respectively, for a total of about 76 pounds. The amount the spring **111** flexes is a function of the cycle speed of the ram **41**. The faster the speed of the ram drive assembly **60** and ram **41**, the greater the cyclical acceleration of the components and the more the spring **111** will flex.

During flex mode **200**, the speed of the motor **54** is preferably set so that the energy stored in the spring **111** releases as the ram **41** strikes the workpiece **5**. The characteristics of the workpiece (e.g., elasticity, thickness, shape, etc.) as well as the stroke length and gap settings have an effect on when the spring releases. Controlling the machine cycle speed and stroke length and gap settings so that the spring releases energy on impact with the workpiece **5** increases the impact force of the ram **41** against the workpiece and the effective power of the machine **10**. During the power hammer mode **200**, the flexible drive **110** and leaf spring **111** also give the lever **90** a degree of flexibility that tends to increase the stroke length SL of the ram **41**. This increase in stroke length can also increase the impact forces of the ram **41** against the workpiece **5** and the effective power of the machine **10**.

Removing rear pin **93**, **105** eliminates the rigid connection between the piston rod **81** and the rigid lever plates **101**. The piston rod **81** remains pivotally joined to the rear end **118** of spring torsion arm **116**. During operation, as the piston rod **81** moves down to its retracted position **87** as shown in FIG. **5**D, the mass and upward momentum of the ram **41** and conversion link **121** and the mass and rotational momentum of the plates **101** cause the spring **111** to flex **204** which is seen by the downward shift **202** of the rear end of plates **101** relative to the piston rod **81** and torsion arm **116**. While the lever drive assembly **85** and spring torsion arm **116** start to reverse their direction (begin moving upwardly) so as to begin pushing the ram down, the ram **41** and conversion link **121** continues moving upwardly. This flexes or loads the spring **111**, which now stores releasable energy. The flexing of the spring **111** allows the upward stroke of the ram **41** to continue to a point **47'** beyond the rigid mode retracted position **47** as shown in FIG. **5**F. This spring flex also increases the stroke length SL of the ram **41**. The polyurethane sleeve **115** at the front **113** of the lever **90** is believed to compress to allow the spring **111** to flex. As the cycle continues and the ram **41** moves along its down stroke toward the die **31**, the spring **111** maintains its upward flex **204** and the rear end of the plates maintain their downward shifted **202** relative to the piston rod **81** and spring torsion arm **116** as the lever **90** is still driving or pushing the ram down.

As the piston rod **81** and spring support **111** reach the fully extended position **84** and ram **41** approaches its rigid mode fully extended position **46** as in FIG. **7**D, the mass and momentum of the ram **41**, plates **101** and conversion link **121** cause the spring **111** to transition and flex down **207**, which is seen in the upward shift **205** of the rear end of the plates **101** relative to the piston rod **81** and torsion arm **116**, which remain pinned together. The spring flex **207** allows the ram **41**, front end of the plates **101** and the conversion link **121** to shift down or extended or lowered position **205**. Again, the polyurethane sleeve **115** at the front **113** of the lever **90** is believed to compress to allow the spring **111** to flex. The transition and reverse spring flex **207** allows the ram **41** to continue moving to a point **46'** beyond the bottom most position **46** of the rigid mode as shown in FIG. **7**F. When no workpiece **5** is present, the ram **41** actually extends into the Gap of the rigid mode to further increase the stroke length SL' of the ram **41**. This transition unloads the spring **111** and releases the stored energy in the spring **111**.

When the workpiece **5** is placed on the die **31** and fills all or a part of the rigid mode Gap, the workpiece absorbs the impact of the ram **41** resulting from the energy released by the spring **111**. The workpiece **5** stops the ram **41** from continuing into the gap all the way to its new flex mode bottom most position **46'**, and the ram bounces off the workpiece **5**. The cyclical loading and unloading of the spring **111** begins anew each cycle as the piston rod **91** approaches its retracted position **87** and as in FIG. **5**D. The power mode **200** can be used to create significantly greater hammering power against a workpiece **5** by adjusting the SL and bpm depending on the reaction between the ram and the workpiece **5** so that a harmonic multiplier is achieved on the down stroke of the ram **41**.

Removing the front pin **94**, **105** produces a similar power mode **200** operation. Removing the front pin **94**, **105** eliminates the rigid connection between the linear conversion link **121** and the rigid lever plates **101**. The loop end **113** of the spring **111** remains pivotally joined to the conversion link **121**. As the ram **41** reaches its fully retracted position **47** and lever **90** and conversion link **121** reach their retracted or raised position **202** as shown in FIG. **5**E, the upward momentum of the ram **41** and conversion link **121** cause the spring **111** to flex up **204** relative to the plates **101**. As before, this upward spring flex **204** of the spring **111** throws the ram **41** or allows its stroke to continue to a point **47'** beyond retracted position **47** as shown in FIG. **5**F, which increases the stroke length SL of the ram. The upward spring flex continues during the down stroked of the ram **41** toward the die **31**. The spring **111** is now pushing the ram **41** and conversion ling **121** down. As the ram **41** reaches its fully extended position **46** and lever **90** and conversion link **121** reach their extended or lowered position **205** as in FIG. **7**E, the downward momentum of the ram **41** and conversion link **121** tend to cause the spring to flex down **207** relative to the front end **92** of plates **101**. As before, this transition and reverse flexing of the spring **111** throws the ram **41** or allows its stroke to continue to a point **46'** beyond the bottom most position **46** of the rigid mode, as in FIG. **7**F.

The power mode **200** allows the operator to control the amount of shaping performed on the workpiece **5**, such as via plannishing, stretching (thinning) or shrinking (thickening) the workpiece. For example, when the gap is set to about ¼ inch, the cycle speed is set to a higher speed (about 1,000 bpm or more) and before the workpiece **5** is inserted, the flexing of the lever **90** and spring **111** will allow the surface **42***a* of the ram tool **42** to engage or contact the surface **32***a* of the die tools **32** at the flexed bottom most position **46'** of the ram. By leaving a portion of the workpiece **5** engaged between the ram **41** and the die **31** for a longer or shorter time or number of ram cycles, the operator can control the amount the workpiece is shaped. When the workpiece **5** is left between the ram **41** and die **31** for several ram beats, the workpiece will shrink or thin an amount approaching the flexed bottom most position **46'** of the ram. (FIG. **7**F). Conversely, when the workpiece **5** is only left between the ram **41** and die **31** for one or two ram beats, the shrinking of the workpiece will be less sever and may exceed the thickness of the gap setting. The amount of shaping performed by each ram beat depends on the properties of the workpiece **5** such as its hardness and toughness.

During the power mode **200**, the gap is typically set so that the downward movement or stroke of the ram **41** is stopped by its impact against the workpiece **5**. The workpiece **5** is held against the surface of the die **31**. This impact force causes the workpiece **5** to compress and the ram **41** to bounce up off the workpiece **5**. As noted above, the amount of the bounce is believed to be a function of the gap, stroke length and material properties of the workpiece **5**, such as its elasticity and compressibility, as well as the surface area of the workpiece being compressed between the die **31** and ram **41**. The bouncing effect can be harmonically matched with the cycle speed or bpm of the ram **41** to further increaser the upward flexing **204** of the spring **111** in its raised position **202**. When cycle speed and material properties are harmonically matched, the energy stored in the spring **111** via its upward flexing **204** is released during the down stroke at the moment of impact of the ram **41** against the workpiece **5** to increase the impact force between them. This increase in impact force or force multiplier effectively increases the power of the machine **10**.

The hammering machine **10** includes a manual ram positioning hand wheel **222**. The hand wheel **222** does not grip or rotate with the crank shaft **57** when the shaft is driven by motor **54** for safety reasons. The hand wheel **222** engages and grips crank shaft **57**. The hand wheel **222** is used for a variety of purposes, such as to raise the ram **41** to its upper most position **47** to allow the machine operator to change tools **32** or **42**, or to disengage the ram **41** from the workpiece **5** to remove the workpiece. The hand wheel **222** engages to the crank shaft **57** to achieve a one-to-one turn ration. One complete revolution of the hand wheel **222** turns the crank shaft **57** one complete revolution.

The ram positioning hand wheel **222** also allows the hammering machine **10** to be used as a press. The machine **10** is set to its rigid reciprocating or sheet metal shaping mode **190** by inserting the conversion pin **105**. The machine operator then sets the gap to the desired size or height. The height of the gap is less than the thickness of a selected workpiece **5**. The gap size determines the amount of compression of the ram **41** into the workpiece **5**. The hand wheel is rotated to raise the ram **41** to its upper most position **47**. Then a one half or 180° turn of the hand wheel **222** lowers the ram **41** to its bottom most position **46** to compress the workpiece **5** in a manner similar to a conventional machine press. The wheel **222** is then further rotated a second half turn or 180° to raise the ram **41** up and away from the workpiece **5**.

An optional DC servo motor can replace of the AC motor **54**. The DC servo motor allows the motor powered reciprocating mode **190** to deliver a single hit or blow to the workpiece **5**. The BPM limit switch **185** can also be set to a relatively low value such as below 30 bpm or less to use the machine **10** as a press.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the broader aspects of the invention.

I claim:

1. A multi-mode hammering apparatus for shaping a workpiece such as sheet metal, said multi-mode hammering apparatus comprising:

a die secured to a support structure, said die and support structure being adapted to receive the workpiece;

a ram cyclically movable along a path of travel toward and away from said die between fully extended and fully retracted ram positions that define a stroke length of said ram;

a ram drive assembly including a motor, lever drive assembly and lever, said motor cyclically driving said lever drive assembly at a selectively variable rate of speed between fully extended and fully retracted drive positions, said lever being pivotable about a pivot axis, joined to said lever drive assembly on a first side of said pivot axis and joined to said ram on a second side of said pivot axis, said lever further including a rigid drive and a flexible drive, said rigid drive having at least one load bearing rigid member rigidly joining said lever drive assembly to said ram, and said flexible drive having at least one load bearing flexible member flexibly joining said lever drive assembly to said ram, said ram drive assembly cyclically moving said ram between said fully extended and a fully retracted ram positions; and,

wherein said ram drive assembly operates in a rigid reciprocating mode when said rigid drive is engaged and a flexible power hammer mode when said flexible drive is engaged, said stroke length of said ram being rigidly held by said ram drive assembly when in said rigid reciprocating mode, and said stroke length of said ram being flexibly held by said ram drive assembly and increasing with said speed of said motor when in said power hammer mode.

2. The multi-mode hammering apparatus of claim **1**, and wherein said lever has first and second ends and a predetermined length, and said ram drive assembly includes a linear conversion link pivotally joined to said ram;

said at least one load bearing rigid member includes a plate with first and second ends and extends said length of said lever, said first end of said plate being pivotally joined to said lever drive assembly and said second end of said plate being pivotally joined to said linear conversion link; and,

said at least one load bearing flexible member includes a spring assembly with first and second ends and extends said length of said lever, said first end of said spring assembly being pivotally joined to said lever drive assembly and said second end of said spring assembly being pivotally joined to a linear conversion link.

3. The multi-mode hammering apparatus of claim **2**, and wherein said spring assembly includes a leaf spring and a rigid torsion arm that rigidly holds one end of said leaf spring, said leaf spring extending from about said center of said lever to said second end of said lever, and said torsion arm extending from said first end of said lever to about said center of said lever.

4. The multi-mode hammering apparatus of claim **3**, and wherein one of said first and second ends of said lever includes a selectively removable conversion pin, said conversion pin pivotally pinning one of either said first and second ends of said plate to one of either said lever drive assembly and said conversion link, and wherein said flex drive is engaged and said rigid drive is simultaneously disengaged by selectively removing said conversion pin, and said flex drive is disengaged and said rigid drive is simultaneously engaged by selectively inserting said conversion pin.

5. The multi-mode hammering apparatus of claim **4**, and wherein said first end of said lever includes said conversion pin, and said conversion pin pivotally pins said first end of said plate to said lever drive assembly.

6. The multi-mode hammering apparatus of claim **4**, and wherein said second end of said lever includes said conversion pin, said conversion pin pivotally pins said second end of said plate to said linear conversion link.

7. The multi-mode hammering apparatus of claim **2**, and wherein said pivot axis is substantially centrally located on said lever, and said plate and spring assembly each pivot about said centrally located pivot axis.

8. The multi-mode hammering apparatus of claim **1**, and further including a stroke length adjustment assembly joined to said lever drive assembly, said stroke length adjustment assembly being operable to selectively set said fully retracted drive position within a range of positions between maximum and minimum fully retracted drive positions, and wherein said stroke length adjustment assembly is operable to correspondingly selectively set said fully retracted ram position within a continuous range of positions between maximum and minimum fully retracted ram positions to selectively adjust said stroke length of said ram.

9. The multi-mode hammering apparatus of claim **8**, and wherein said stroke length adjustment assembly includes a toggle mechanism with a control pin selectively movable in a continuous manner between maximum and minimum fully retracted adjustment positions to selectively set said fully retracted drive position within a continuous range of positions between maximum and minimum fully retracted drive positions.

10. The multi-mode hammering apparatus of claim **9**, and wherein said lever drive assembly has an in-line orientation when in said fully extended position and an angled orientation when in said fully retracted position.

11. The multi-mode hammering apparatus of claim **10**, and wherein said lever drive assembly includes a drive crank, rocker arm, control link and piston rod, said control link is pinned at spaced locations to each of said drive crank, rocker arm and piston rod, and said rocker arm, control link and piston rod are in said in-line orientation when in said fully extended position, and said rocker arm, control link and piston rod are in said angled orientation when in said fully retracted position.

12. The multi-mode hammering apparatus of claim **11**, and wherein said control link is located between said rocker arm and piston rod, and said stroke length adjustment assembly is pivotally joined to said control link.

13. The multi-mode hammering apparatus of claim **9**, and wherein said support structure includes spaced rigid C-shaped support plates that form a large central opening and mouth with upper and lower jaws adapted to receive the workpiece, said ram drive assembly and stroke length adjustment assembly being held between said C-shaped support plates and extending around said central opening.

14. The multi-mode hammering apparatus of claim **13**, and wherein said range of positions of said stroke length adjustment assembly is defined by a slot in said rigid support plates, a first end of said slot defining said maximum fully retracted adjustment position and a second end of said slot defining said minimum fully retracted adjustment position, and said control pin travels in said slot, said control pin being selectively movable in said slot between its said first and second ends by said toggle mechanism.

15. The multi-mode hammering apparatus of claim **8**, and further including a gap adjustment assembly connected to said lever, said gap adjustment assembly selectively moving said pivot axis of said lever within a range of positions between maximum and minimum pivot positions to selectively set a gap between said die and ram when said ram is in its said fully extended position.

16. The multi-mode hammering apparatus of claim **15**, and wherein said gap adjustment mechanism includes an eccentric pivot pin with collinear ends that define a central axis and an eccentric midsection that defines said pivot axis, said pivot pin being rotatably mounted by its said collinear ends to a support structure, and a gear, rod and hand wheel assembly for selectively rotating said eccentric pivot pin about its said central axis to selectively move said eccentric midsection and pivot axis within a continuous range of positions between said maximum and minimum pivot positions.

17. The multi-mode hammering apparatus of claim **15**, and wherein said piston rod has an upper terminal end joined to said lever and said upper terminal end returns to an upper most position when said lever drive assembly is in it said fully extended position, and said upper most position is substantially unaffected by adjustments made by said gap and stroke length adjustment assemblies.

18. The multi-mode hammering apparatus of claim **17**, and wherein said stroke length adjustment assembly and gap adjustment assembly are independently operable and operable while said ram drive assembly cyclically moves said ram to maximize impact force of said ram against the workpiece during power hammer mode.

19. The multi-mode hammering apparatus of claim **1**, and the wherein said motor is a variable speed motor operable at a selectively variable rate of speed, and said apparatus includes an electric control system with a limit knob and foot pedal for controlling said rate of speed of said motor and said cycle speed of said ram drive assembly and ram.

20. The multi-mode hammering apparatus of claim **1**, and wherein said die is selectively movable between higher and lower positions, but remains fixed during operation.

21. The multi-mode hammering apparatus of claim **1**, and wherein the ram drive assembly includes a hand wheel, said hand wheel being rotatable to manually drive said ram drive assembly in a machine press mode.

22. A multi-mode hammering apparatus for shaping a workpiece such as sheet metal, said multi-mode hammering apparatus comprising:

a die secured to a support structure, said die being adapted to receive the workpiece;

a ram cyclically movable along a path of travel toward and away from said die between fully extended and fully retracted ram positions that define a stroke length of said ram;

a ram drive assembly including a motor, a lever drive assembly and a lever, said ram drive assembly being held by said support structure, said motor cyclically driving said lever drive assembly, said lever drive assembly having a control link and said lever having a pivot axis, said lever drive assembly being cyclically movable between a fully extended drive position and a filly retracted drive position, said control link being in-line with other links in said lever drive assembly when in said filly extended drive position and being angled relative to those said other links when in said fully retracted drive position, said lever being pivotable about said pivot axis, joined to said lever drive assembly on one side of said pivot axis and joined to said ram on said second side of said pivot axis, said lever further including a rigid drive and a flexible drive, said rigid drive having at least one load bearing rigid member to rigidly join said lever drive assembly to said ram, and said flexible drive having at least one load bearing flexible member to flexibly join said lever drive assembly to said ram;

a gap adjustment assembly connected to said lever, said gap adjustment assembly selectively moving said pivot axis of said lever to a position between maximum and minimum pivot positions to selectively set a gap between said die and ram when said ram drive assembly moves said ram to a said fully extended position;

a stroke length adjustment assembly joined to said lever drive assembly, said stroke length adjustment assembly being operable to selectively set said fully retracted drive position within a continuous range of positions between maximum and minimum fully retracted drive positions, and wherein said stroke length adjustment assembly is operable to correspondingly selectively set said fully retracted ram position within a continuous range of positions between maximum and minimum fully retracted ram positions to selectively adjust said stroke length of said ram; and,

wherein said multi-mode hammering apparatus operates in a rigid metal shaping mode when said rigid drive is engaged and a flexible hammer mode when said flexible drive is engaged, said gap and stroke length being rigidly maintained by said ram drive assembly when in said rigid metal shaping mode, and said gap and stroke length being flexibly maintained when in said flexible hammer mode, said stroke length adjustment assembly and gap adjustment assembly being independently operable while said ram drive assembly cyclically moves said ram.

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