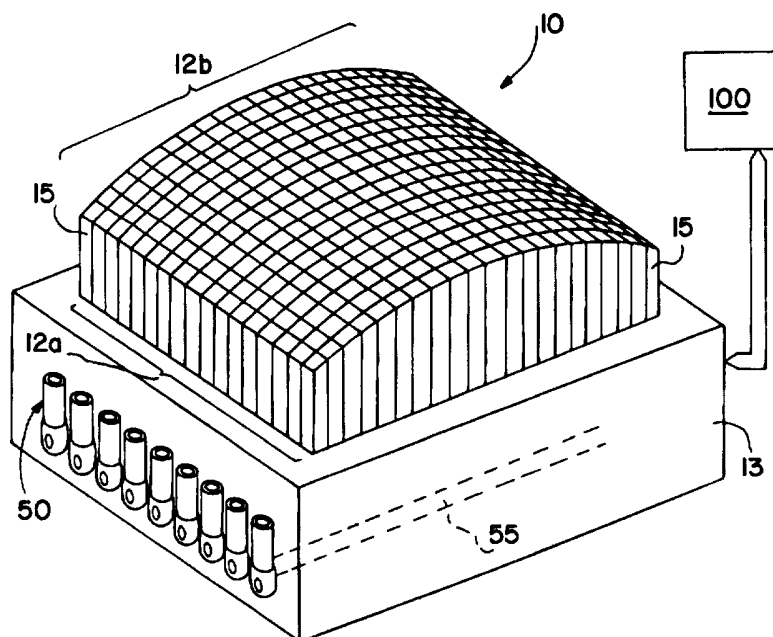




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B21B 37/24, B30B 15/26, B21D 37/02, 37/14, B21C 51/00	A1	(11) International Publication Number: WO 96/17697 (43) International Publication Date: 13 June 1996 (13.06.96)
(21) International Application Number: PCT/US95/15423 (22) International Filing Date: 27 November 1995 (27.11.95) (30) Priority Data: 08/349,434 5 December 1994 (05.12.94) US (71) Applicant: GRUMMAN AEROSPACE CORPORATION [US/US]; 1111 Stewart Avenue, Bethpage, NY 11714-3580 (US). (72) Inventors: HAAS, Edwin, G.; 3953 Marilyn Drive, Seaford, NY 11783 (US). KESSELMAN, Martin; 39 Glenmere Lane, Commack, NY 11725 (US). (74) Agents: DiGIGLIO, Frank, S. et al.; Scully, Scott, Murphy & Presser, 400 Garden City Plaza, Garden City, NY 11530 (US).		(81) Designated States: European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>

(54) Title: ADJUSTABLE FORM DIE



(57) Abstract

This invention details a computer controlled self adjusting sheet metal forming die (10) which can provide rapid contour changes. It eliminates the need to manufacture, store, and change individual forming dies for forming different contours, and comprises a computer control device (100) which sends appropriately timed signals to translate each contour element so that a three dimension surface is formed by a discrete matrix of individual pins (15). This self adjusting sheet metal forming die is used on a sheet metal press wherein sheet metal can be formed by pressing or stretch forming the metal against the contoured surface.

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ADJUSTABLE FORM DIE

The present invention relates to adjustable form dies and specifically to a computer controlled self-adjusting form die comprising a plurality of pins that are height adjustable to form a controlled three dimensional surface for forming sheet metal products and the like.

The usual tooling process begins once the sheet metal product contours have been described and are finalized. The typical process requires the manufacture of a contoured form die, followed by a testing phase (often known as tool "prove-out") to assure that the form die imparts the proper contour to the sheet metal product. Should changes to the contour of the die be required (for example, to make springback adjustments) then rework of the existing die or re-manufacture of a new die becomes necessary in order to achieve the appropriate contour changes.

Presently, predesigned and specifically designed form dies are utilized to achieve contoured surfaces for sheet metal product and the like. Manufacturers usually maintain and store sets of specifically designed form dies and, depending upon the application, will retrieve the appropriate die depending upon the surface contour desired to be achieved. This is not a cost-effective method since a new form die has to be manufactured for each new application, not to mention the attendant costs of testing and storing the new form die.

1 The present invention relates to a self-adjusting form die that is computer controlled for imparting proper contours to a sheet metal product.

5 The instant invention to provide can provide an adjustable form die that permits virtually instant contour changes to the forming tool by computer control without the need to manufacture templates, molds, and without having to remove the die from the metal forming press when changing surface contours.

10 Furthur, the present invention relates to an adjustable form die that obviates the need for a manufacturing facility to fabricate, store, and retrieve specially designed forming dies for each contour surface application. The present invention
15 also reduces the costs of individual form die production, inventory, and storage, by allowing rapid prototyping and rapid "tweaking" of finished parts during tool prove-out process.

20 The present invention further relates to an adjustable form die that is capable of changing its contour in real time when real time shape adjustments are required.

25 The instant invention also relates to an adjustable form die that includes a computer means having memory and for contour storage and retrieval and an adjustable form die that includes a multi-pin design with feedback controlled multi-motor pin positioning.

30 More specifically, the present invention is directed to a self-adjusting die for forming a three-dimensional contoured die surface comprising:

1 a) a plurality of individual pin means
defining a matrix of pin rows and pin columns, each
said pin means independently movable in an extended
and retracted position along a single axis;

5 (b) control means for generating desired
positional information for each of said plurality of
individual pins of said matrix; and

 (c) drive means responsive to said
positional information generated by said control means
10 for providing simultaneous and independent axial
movement of each said pin means of said matrix along
each respective said single axis to form said three
dimensional contoured die surface.

 The present invention is further directed to
15 a method for forming a tool die having a plurality of
pins arranged in a matrix comprising a plurality of
rows/columns, said die including drive means for
independently driving each individual pin of said
plurality to an extended or retracted position along a
20 single axis, said method comprising the steps of:

 (a) generating pin extension information for
each pin of said matrix necessary to form a desired
three-dimensional contoured surface:

 (b) transferring each said pin extension
25 information to a data storage means corresponding with
each said pin means;

 (c) actuating said drive means to drive each
pin means of said matrix to its desired extended
position, while

30 (d) simultaneously comparing the actual
position of each said pin means with the desired pin

1 position information stored in its respective data
storage means; and

(e) terminating the motion of a said pin
means when the actual position of that pin means is
5 equal to the desired position stored in said data
storage means.

FIG. 1 is a perspective view of the
adjustable form die of the instant invention.

FIG. 2 is a schematic diagram of the
10 mechanical layout of the adjustable form die showing
several pins adjusted to different heights.

FIG. 3 illustrates an isometric breakaway
view of adjustable form die pin layout.

FIG. 4 is a circuit diagram illustrating the
15 computer control system for controlling the adjustable
form die of the instant invention.

FIG. 5 is a circuit diagram illustrating the
control logic for operating the clutch and power-off
brake mechanism of a single pin of the adjustable form
20 die.

FIG. 6 illustrates a second embodiment of
the computer control system for controlling the
adjustable form die of the instant invention.

As illustrated in Figure 1, the form die
25 apparatus 10 comprises a frame 13 for housing several
rows 12a and columns 12b of adjacently positioned pins
15. In the preferred embodiment, each pin is a hollow
square, approximately one inch in width and is spaced
apart from each adjacent pin at a distance of one inch
30 (center to center). Alternatively, as will be
appreciated by one skilled in the art, pins 15 may be

1 solid and even cylindrical in shape and having a one
inch diameter. It is understood that the pin spacing
distance is merely a design choice depending upon the
configuration and thickness of the pins. One skilled
5 in the art would recognize that adjacently located
pins must be placed at a distance from each other
sufficient to accommodate the movement of various
mechanical components such as the electric drive
motors 50 for adjusting the vertical translation of
10 each pin as shown generally in Figure 1.

All pins, plates, and frame materials
described hereinbelow are formed of heavy steel to
assure that the die is rugged and will maintain
15 maximum tool rigidity. Only the minimum amount of
material is removed from the heavy steel die plates
77, 87, 30 and 35 (Figure 3) so that maximum tool
rigidity is retained. These plates are built up
progressively so that disassembly for maintenance or
20 repair is facilitated. Pin faces are spherically
ground from hardened tool steel and made removable for
easy replacement. Additionally, all parts may be
specially coated with materials, for instance, PTFE,
to minimize friction. As shown in Figure 2, a hard
25 rubber (or other elastomeric material) material 16 is
placed on top of the pins 15 to protect the formed
parts and ensure that bumps from the individual pin
heads are not transmitted to the sheet metal product.

As shown generally in Figures 1 through 3,
30 vertical translation of the pins 15 occur using
electric motors which drives a rotating threaded shaft

1 or "lead screw" 25 for each pin located at each row
12a or column 12b of a matrix of pins. In the
preferred embodiment, the pins 15 are hollow and
square-shaped, so that they are unable to rotate
5 within the form die frame 13. As mentioned above,
each of the pins may be solid and/or shaped in a
variety of ways that are largely determined by the
types and thicknesses of material that are to be
formed in a particular pressing application.
10 Preferably, the pins 15 are permanently attached or
welded to nuts 26 at the pin end 15a, and are drilled
so that the inside diameter of the pin 15 closely fits
the outside diameter of the rotating threaded shaft
25. One skilled in the art should recognize that the
15 hollow pin 15 may alternately be of a one-piece semi-
or fully threaded configuration for extending or
retracting movement along rotating threaded shaft 25.
The threaded pins 15 are each supported within frame
13 which reacts the pin side loads. The axial pins 15
20 loads are reacted by thrust bearings 28 which transfer
axial loads when the pins are extending or retracting
along their respective vertical axes to the forming
machine's bed or platten.

As shown in Figures 2 and 3, each threaded
25 shaft 25 is connected to the output side of an
electric clutch 60. The electric clutch 60, when
actuated, engages torque from a drive shaft 56 to
rotate each pin's threaded shaft 25. When the clutch
60 is de-actuated, torque from the drive shaft 56 will
30 be disengaged from the pin's threaded shaft 25 and
rotation of that shaft will terminate. A spur or

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1 pinion gear 65 located at the end of each drive shaft
56 assures constant torque to the drive shaft as long
as it's respective motor (not shown) is turning. The
spur or pinion gear 65 receives its torque via a worm
5 gear 55a from a rotating worm gear shaft 55 which is
provided for each row (or column) of pins and mounted
at right angles to a row (or column) of pinion gears
65 and directly connected to an electric motor 50.
Each worm gear shaft 55 has a plurality of worm gears,
10 such as worm gear 55a shown in Figure 3, that are
spaced one inch apart (center to center distance)
along the shaft 55 and associated with a respective
pin 15 for engaging a respective right angle pinion
gear 65. As shown in Figures 2 and 3, each worm gear
15 shaft 55, drive shaft 56, pinion gear 65, and electric
clutch 60 are housed in gear drive plate 87. Each
worm gear shaft 55 is appropriately supported within
the gear drive plate 87 by capped precision bearings
88 that are strategically placed at each drive shaft
20 location to assure proper alignment, smooth operation,
and long life. The capped bearings are fastened to
the gear drive plate by fasteners 89.

As shown in Figures 2 and 3, a rotary
optical encoder 75 is mounted within encoder housing
25 plate 77 and provided for each pin 15 to provide
positional feedback information for the control system
100 as will be explained in greater detail below. A
power-off brake 85 associated with each pin is also
provided within frame 13 for ensuring additional
30 stability to the pin. When the clutch associated with
that pin is de-actuated the pin has reached its final

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1 extended or retracted position. As will be explained
in greater detail below in further view of Figures 4
and 5, the clutch 60 and power-off brake 85 are
simultaneously controlled by control system 100
5 utilizing positional feedback information generated by
rotary encoder 75; the brake being turned off when the
clutch is engaging the threaded screw shaft 25 to
enable axial movement of said pin.

In operation, an electric motor 50 drives a
10 worm gear shaft 55 that has worm gear tap-off points
at each pin location along its length. The motor is
preferably bi-directional in that it could be powered
to drive the worm gear shaft 55 in both forward and
reverse directions; the forward direction when
15 increasing vertical movement of the pin relative to a
predetermined set of "home" position is desired, and,
reverse direction when pin positioning needs to be
tweaked or altered to allow for springback
adjustments. As shown in Figure 4, a suitable motor
20 controller 114 and motor power device 116 is provided
for each motor 50; the motor controller 114 receiving
instructions from the computer controller 99 via line
112 for directional and speed information. The worm
gear shaft 55 driven by each motor is long and can
25 power a complete line of pins in a row/column. For
example, given that each pin occupies 1 square inch of
space, a form die that is four feet by six feet is
configured with 48 pins in a line, and 72 lines
yielding 3456 pins total. A worm gear shaft 55 could
30 conceivably power either the 48 pin line or the 72 pin
line depending upon motor torque considerations and

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1 cost. In the preferred embodiment, the motors 50 are
stagger mounted on opposite sides of the frame to
allow sufficient side clearance space for the motor
housings. The concept is applicable to any number of
5 pins per line and any number of lines.

As shown in Figures 1 and 2, each reversible
motor 50 is linked directly to each pinion drive shaft
56 so that all the worm gears on each individual shaft
turn together when it's respective motor is activated.
10 The computer control system 100 sorts through the
positional data that has been previously input,
simultaneously enables each motor to drive its
respective worm gear shaft and pins, and then
individually addresses each "power-off" brake 85 and
15 clutch unit 60 in the manner described below. The
computer activates the appropriate brake/clutch unit
to allow translational movement of its respective pin
until the rotary encoder 75 has counted the required
number of displacement pulses for its respective lead
20 screw shaft. At that time, electrical power is
withdrawn from that particular clutch and the brake,
thus stopping the pin 15 in it's desired location
while permitting it's driving spur gear and drive
shaft to spin freely. The drive shaft 56 (located
25 between the pinion gear 65 and clutch 60) and the
threaded screw shaft 25 (located between the pin and
the clutch), are not solidly connected until the
electrical clutch 60 is activated. The "power off"
brake 85 on each pin assures that there will be no
30 relative pin movement during forming and provides

1 positive locking in the event of electrical power
loss.

As shown in Figure 4, the computer control
system 100 comprises a computer/controller 99, a
5 switch system 102 comprising clutch control logic for
every pin, motors 50 including motor controllers 114,
and a clutch 60 for controlling the drive to each pin.
The control logic for an individual pin of the
adjustable die operates in the preferred embodiment as
10 follows: Computer/controller 99 retrieves from memory
storage, or, is input with a three-dimensional array
of information representing the positions of each pin
of the matrix of pins necessary to describe a three
dimensional surface. The computer 99 is programmed to
15 determine the extension required of each pin 15 of the
die, and controls each individual switching system
102a as depicted in Figure 5. Pin extension
information, which may comprise a number representing
the amount of count pulses necessary to achieve the
20 desired translation of that pin relative to a zero
(fully retracted) or "home" position, is transferred
to a storage register 125 associated with that
particular pin. It should be understood that with
appropriate software programming, individual pin
25 position information may consist of a number
representing the amount of count pulses necessary to
achieve a desired translation of that pin relative to
any predetermined position and not necessarily a zero
or fully retracted position.

30 Preferably, a data storage register 125 is
provided for each pin 15 of the die. The data is

1 transferred to the register 125 from the computer 99
via any appropriate data transfer
configuration/protocol known to those skilled in the
art. As illustrated in Figure 5, pin extension data
5 is provided to the storage register 125 on data bus
129. Pin address information is likewise provided to
an address decoder 131a on data address bus 139. The
decoder 131a addresses the particular data storage
register in which information is to be stored. After
10 the pin extension data and address location have been
presented to the pin data storage register, the
computer 99 issues a STORE command line 127 to the pin
data register to initiate the transfer of pin
extension information to the addressed storage
15 register 125. It is understood to those skilled in
the art that additional circuitry, such as AND gates
133a,b may be needed for writing data to the register
125 or for reading data from the digital counter 135,
as will be explained below.

20 In a similar manner as described above, pin
address information is also provided to address
decoder 131b on data address bus 139. The decoder
131b addresses a counter 135 that is used to count the
lead screw position/turns for the addressed pin.
25 Counting the turns of the pin drive shaft 56 is
accomplished by the rotary shaft encoder 75 which
simply provides a count pulse for each turn of the
lead screw engaged thereto. The count of each shaft
for each pin may be reset to zero upon initialization.
30 The number of pulses are counted by up/down counter
135 to determine the total amount of pin drive shaft

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1 56 rotations and this number is communicated to a
first input A of a digital comparator 141 via count
bus 149. The current value of the count number is
compared with the pin extension count value data value
5 for that particular pin which is communicated to a
second input B of the digital comparator 141. The
comparator 141 will generate an appropriate logic
level output signal 145 depending upon either of three
conditions: $A=B$, when the current count value is equal
10 to the programmed pin extension value; $A<B$, where the
current count value is less than the programmed pin
extension value; and $A>B$, when the current count value
for the selected pin is greater than the programmed
pin extension value. The output 145 generated by
15 comparator 141 is used to control a switch 147 that
activates/de-activates the clutch 60 and the brake 85
corresponding to the addressed pin. For instance, if
the current count value of the rotary encoder 75 at
input A is less than the programmed count value for
20 the extension limit of the pin at input B, i.e., if $A < B$, then the clutch is activated and the drive shaft
will engage the lead screw for that particular pin as
it is being driven to its desired position. If the
current count value of the rotary encoder 75 at input
25 A is equal to or greater than the programmed value for
the extension limit of the pin, i.e., if $A \geq B$, then
the clutch will be deactivated and the drive shaft
will no longer engage the lead screw for that
particular pin. Simultaneously, when the condition A
30 $< B$ is true, the power-off brake 85 for that
particular pin will be deactivated as power is being

1 supplied thereto. When the condition $A \geq B$ is
reached, the power flow to brake 85 will be
interrupted, and the brake will provide a stop to the
pin at its programmed position.

5 Limit switches (not shown) may be provided
with precise, repeatable "on-off" triggers to provide
a "home" position in either the fully extended or
fully retracted pin positions. The individual rotary
encoders 75 may then provide incremental positioning
10 information for communication to the computer control
system 100 relative to either a "home" position, or
from any other known position so that the contoured
surface formed by the face of the pins can be modified
slightly without having to return to a "home"
15 position. The final coordinates of the positioning of
each vertical pin location (relative to a "home"
position) can be stored magnetically for future use.

As previously mentioned, a pin may be moved
up/down to make minor corrections to a desired forming
20 mold, for example, when "tweaking" or making
springback adjustments. Motion of the pin 15 in both
directions can be achieved by reversing the drive
motor and activating alternate logic for the digital
comparator 141. Thus, the computer 99 may generate
25 drive signal 143 representing forward or reverse
(extension or retraction) of the pin drive. As shown
in Figure 5, this forward/reverse signal 143 is tied
to a forward/reverse logic circuit 148, so that the
clutch may actuate/de-actuate properly when the pin is
30 being retracted. Additionally, forward/reverse signal
143 is provided to the counter 135 so that the counter

1 135 may count down from its current value when a pin
is being retracted. For instance, during tool prove-
out, if a particular pin has to be retracted an
incremental amount after reaching its desired
5 position, new positional information has to be loaded
within pin data register 125. This value provided to
input B will necessarily be less than the current
value of the counter 135 provided to input A of the
comparator 141. If the current count value of the
10 rotary encoder 75 at input A is greater than the
programmed count value for the extension limit of the
pin at input B, i.e., if $A > B$, and the
forward/reverse signal 143 indicates reverse motion of
the pin, then the clutch is activated and the drive
15 shaft will engage the lead screw for that particular
pin as it is being retracted to its desired position.
If the current count value of the rotary encoder 75 at
input A is equal to or less than the programmed value
for the retraction limit of the pin, i.e., if $A \leq B$,
20 and the forward/reverse signal 143 indicates reverse
motion of the pin, then the clutch will be deactivated
and the drive shaft will no longer engage the lead
screw for that particular pin. Simultaneously, when
the condition $A > B$ is true, and the forward reverse
25 signal 143 indicates pin retraction, then the power-
off brake 85 for that particular pin will be
deactivated as power is being supplied thereto. When
the condition $A \leq B$ is reached, then power flow to
brake 85 will be interrupted, and the brake will
30 provide a stop to the pin at its programmed position.

1 System timing is largely governed by the
time necessary to drive the pins to full extension to
create a new metal forming mold, and, is primarily
determined by the response time of the clutch. The
5 resolution required must not be exceeded during the
clutch de-actuation time to assure accurate pin
positioning. Thus, the drive motor speed, and the pin
speed are determined by the gearing ratios, the
resolution, and the activation/de-activation time of
10 the clutch. It is understood that each pin 15 of
the adjustable form die 10 is provided with its own
control circuitry 102a and logic thereby permitting
all pins to be simultaneously driven. Thus, as shown
in Figure 4, there will be seventy-two (72) switching
15 systems 102, each comprising forty-eight (48)
individual control circuits 102a (Figure 5).
Alternatively, depending upon the design of the die
and the number of pins thereof, there may be forty-
eight (48) switching systems 102 for the adjustable
20 form die, each comprising seventy-two (72) individual
control circuits 102a.

In an alternative embodiment of the
invention, and in view of Figure 5, the adjustable
form die 10 is completely controlled by a
25 computer/controller 99 with only a system of clutch
switches 147 and a drive motor 50 as hardware
elements. In this embodiment, the computer 99 selects
each pin clutch in sequence and then determines the
motion required for that pin. The motor will drive
30 the worm gear shaft and that motion will be sensed
with the appropriate sensors as described above so

1 that the CPU will simultaneously compare the current
shaft position with programmed pin motion criteria.
Through program control, the computer may then
activate/deactivate all of the clutches 60 via
5 switches 147. Shaft position could be fed to the
computer with a shaft encoder, as described above, or,
the motor could be of the stepping variety that will
accurately and definitively move precise amounts in
response to command pulses. As shown in Figure 4,
10 stepping motor/controller 114 is utilized and the
computer 99 will generate the motor advance pulses.
Motion can be provided for forward and reverse
operation with appropriate pulse lines and
commercially available motor controllers which
15 provides a very high torque, precise angular motion,
and virtually no accumulation of errors. It is
desirable that the holding torque is also high, and as
long as the motor is not overloaded or driven too
fast, the position of the pin is accurately known as a
20 function of the number of pulses/counts presented to
the controllers. Since the computer 99 generates the
pulse count information, it is available to control
each clutch switch 147 as described above.

 An option to the above described alternative
25 embodiment, which uses a computer for control and
switching, is to further distribute the computing
load. In this embodiment, as shown in Figure 6, the
main computer/controller 99 would do the surface
computations, and determine the required pin extension
positions. The pin extension information is
30 transferred to a number of smaller

1 microcomputers/controllers 99a₁ to 99a_n as shown in
Figure 6 that would replace the switching system 102
described above. The smaller
microcomputer/controllers are loaded with a program
5 that could control the motor drive 50 for a single
line of pins. The controller, for e.g., 99a₁, would
scan the array of pin locations, determine the
clutches 60a₁ through 60a_m that should be activated,
broadcast appropriate control bits to activate them,
10 and, drive the motor to the first position requiring a
change to the clutch actuation conditions.
Appropriate changes would be made to clutch actuation,
and the motor would then be driven to the next
location (pin distance), and the cycle repeated. In
15 this way the microcontrollers need to provide motor
control codes to position the pins, in addition to
appropriate codes for actuating the clutches. The
motors could be moved at high speed from one clutch
activation change location to another, and dwell for
20 only the time required for the clutch to change state.
Since there are a limited number of clutches in each
line the dwell time required for each line of pins is
minimized, and the controller can slew the pins to the
required positions as quickly as a position servo
25 system will permit. This will reduce the total amount
of time required to set the pins in the system. The
pin lines are operated in parallel and are
independently controlled as in the method of the
invention. Thus, distributing the computing power can
30 improve the system response time by permitting clutch
control under software control instead of hardware

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1 control, and slewing at high rates with a minimum of
stops to change clutch actuation signals.

Although shown and described in what we
believed to be the most practical and preferred
5 embodiments, it is apparent that departures from the
specific methods and designs described and shown will
suggest themselves to those skilled in the art and may
be made without departing from the spirit and scope of
the invention.

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1 WHAT IS CLAIMED IS:

1. A self-adjusting die for forming a three-dimensional contoured die surface comprising:

5 a) a plurality of individual pin means defining a matrix of pin rows and pin columns, each said pin means independently movable in an extended and retracted position along a single axis;

10 (b) control means for generating desired positional information for each of said plurality of individual pins of said matrix; and

(c) drive means responsive to said positional information generated by said control means for providing simultaneous and independent axial movement of each said pin means of said matrix along each respective said single axis to form said three dimensional contoured die surface.

2. The self-adjusting die as claimed in Claim 1 wherein said drive means includes a torque engaging means corresponding to and operatively connected with each pin of said matrix, each said torque engaging means engaging said drive means to provide said independent axial movement of its corresponding pin means in response to said control means.

25 3. The self-adjusting die as claimed in Claim 1 or 2 wherein said drive means includes a drive motor for each row/column of said matrix of pins, each said drive motor rotating a first drive shaft having a plurality of worm gears rotating therewith and spaced apart at each pin location for imparting translational movement to each pin positioned in that row/column.

1 4. The self-adjusting die as claimed in
Claim 3 wherein said drive means further includes a
plurality of rotatable second drive shaft means, each
second drive shaft means associated with a
5 corresponding worm gear and operatively connected
therewith for receiving rotational motion therefrom,
said rotatable second drive shaft means being threaded
at an end for connection with a corresponding pin
means.

10 5. The self-adjusting die as claimed in
Claim 4 wherein each said torque engaging means is
responsive to a first control signal generated from
said control means for engaging said first drive shaft
means with said second drive shaft means to provide
15 axial movement of said pin to a desired extended or
retracted position, or, responsive to a second control
signal for disengaging said first drive shaft means
from said second drive shaft means to terminate axial
movement of said pin means.

20 6. The self-adjusting die as claimed in
Claim 5 wherein each said torque engaging means
includes a switch means responsive to said first
control signal for enabling engagement of said first
and second drive shaft means or, responsive to said
25 second control signal for enabling disengagement of
said first and second drive shaft means.

 7. The self-adjusting die as claimed in
Claim 4 wherein each said second drive shaft means is
positioned substantially perpendicular to its
30 respective first drive shaft means.

1 8. The self-adjusting die as claimed in
Claim 4 wherein each said pin means includes means for
converting rotational motion of said second drive
shaft means into extending or retracting movement of
5 its pin means along said single axis.

 9. The self-adjusting die as claimed in
Claim 8 wherein each said converting means of said pin
means includes a hollow, threaded interior for
receiving said second drive shaft means.

10 10. The self-adjusting die as claimed in
Claim 3 wherein each said first drive shaft means
rotates about an axis substantially perpendicular to
said single axis of said pin means.

 11. The self-adjusting die as claimed in
15 Claim 5 wherein each said pin means includes a braking
means for actuating a positive stop of said pin means
when said pin has reached a desired extended or
retracted position.

 12. The self-adjusting die as claimed in
20 Claim 11 wherein said control means simultaneously
enables said braking means to actuate said positive
stop and said torque engaging means to disengage each
said pin from continued axial movement thereof.

 13. The self-adjusting die as claimed in
25 Claim 11 wherein said control means enables said
braking means to maintain the desired extended or
retracted position of its respective pin in response
to said second control signal generated by said
control means.

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1 14. The self-adjusting die as claimed in
Claim 6 wherein said control means includes a data
storage means associated with each pin for storing
desired positional information for that pin.

5 15. The self-adjusting die as claimed in
Claim 14 wherein said control means further includes
rotary encoder means associated with each individual
pin means and connected with each said second drive
shaft means for counting the number of rotations of
10 said second drive shaft means, wherein each rotation
of said second drive shaft indicates movement of said
pin means along said single axis, said rotary encoder
means generating a pulse signal for each detected
rotation of said second drive shaft means.

15 16. The self-adjusting die as claimed in
Claim 15 wherein said control system further includes
a counter means associated with each said pin means of
said matrix and communicating with said rotary encoder
means for counting the number of pulse signals
20 generated thereby, said counter means generating a
counter output signal representing the current axial
positioning of its associated pin means.

 17. The self-adjusting die as claimed in
Claim 16 further including a comparator means
25 associated with each individual pin means, wherein
said current counter output signal of a respective pin
means is input to a first input of said comparator,
and said stored desired positional information for
that pin means is input to a second input of said
30 comparator, said comparator comparing a difference
between said first and second inputs thereof and

1 generating said first or second control signals
indicating whether said pin means has reached its
final extended or retracted position.

5 18. The self-adjusting die as claimed in
Claim 17 wherein said switch means associated with
each said pin means is responsive to said second
control signal for deactivating said torque engaging
device to terminate movement of said pin means when
said first and second inputs are equal.

10 19. The self-adjusting die as claimed in
Claim 17 wherein said switch means associated with
each said pin means is responsive to said first
control signal for activating said torque engaging
device to enable movement of said pin means when said
15 first and second inputs are not equal.

20 20. The self-adjusting die as claimed in
Claim 14 wherein said control means further includes a
computer device for inputting desired positional
information for one or more pin means into respective
data storage means associated with said one or more
pin means.

25 21. The self-adjusting die as claimed in
Claim 3 wherein each said drive motor enables forward
or reverse rotation of said first drive shaft means,
each said pin means moving toward an extended position
along said single axis when said first drive shaft
means rotates in a forward direction and moving in a
retracted position when said first drive shaft means
rotates in a reverse direction.

30 22. The self-adjusting die as claimed in
Claim 14 wherein said control means calculates desired

1 positional data for changing the position of a said
pin means relative to a predetermined home position.

23. The self-adjusting die as claimed in
Claim 22 wherein said predetermined home position
5 corresponds to a position wherein each said pin means
are in a fully retracted position.

24. The self-adjusting die as claimed in
Claim 22 wherein said predetermined home position
corresponds to a position wherein each said pin means
10 are in a fully extended position.

25. A method for forming a tool die having a
plurality of pins arranged in a matrix comprising a
plurality of rows/columns, said die including drive
means for independently driving each individual pin of
15 said plurality to an extended or retracted position
along a single axis, said method comprising the steps
of:

(a) generating pin extension information for
each pin of said matrix necessary to form a desired
20 three-dimensional contoured surface:

(b) transferring each said pin extension
information to a data storage means corresponding with
each said pin means;

25 (c) actuating said drive means to drive each
pin means of said matrix to its desired extended
position, while

(d) simultaneously comparing the actual
position of each said pin means with the desired pin
30 position information stored in its respective data
storage means; and

1 (e) terminating the motion of a said pin
means when the actual position of that pin means is
equal to the desired position stored in said data
storage means.

5 26. The method for forming a tool die
according to Claim 25 wherein said tool die further
includes a torque engaging means associated with a
respective pin means and operatively connected
therewith for engaging said drive means to drive each
10 said pin means to an extended or retracted position
or, disengaging said drive means to disable motion of
said pin means, the comparing step (d) further
including the step of generating a first control
signal for enabling continuous engagement of said
15 torque engaging means with said drive means when said
actual position of said pin means has not reached the
desired pin position.

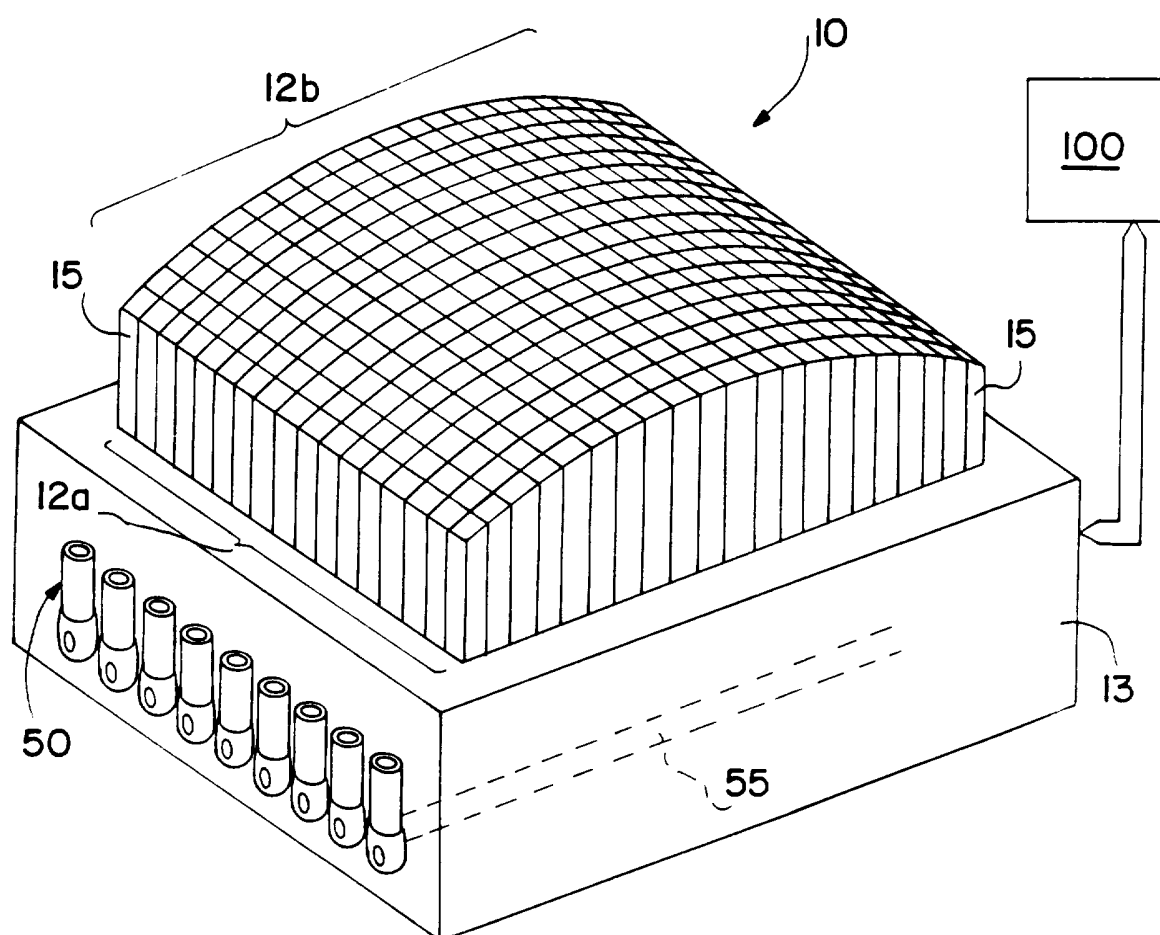
20 27. The method for forming a tool die
according to Claim 25 wherein said step (d) further
includes the step of generating a second control
signal for disengaging said torque engaging means with
said drive means when said actual position of said pin
means has reached its desired pin position.

25 28. The method for forming a tool die
according to Claim 27 wherein said step (d) further
includes the step of actuating a positive stop by a
braking means to prevent further movement of said pin
means upon receipt of said second control signal.

30

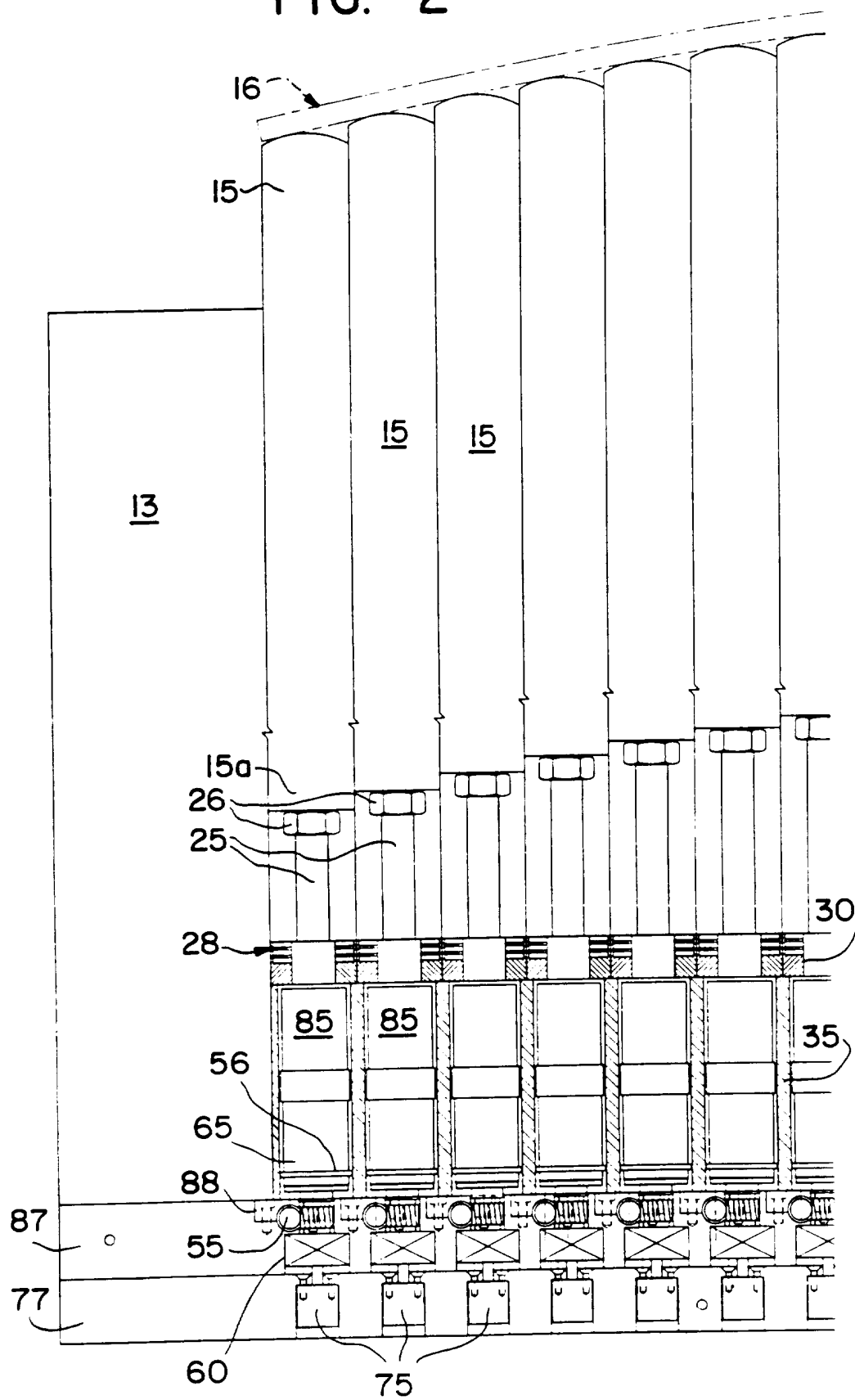
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FIG. 1



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FIG. 2



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FIG. 3

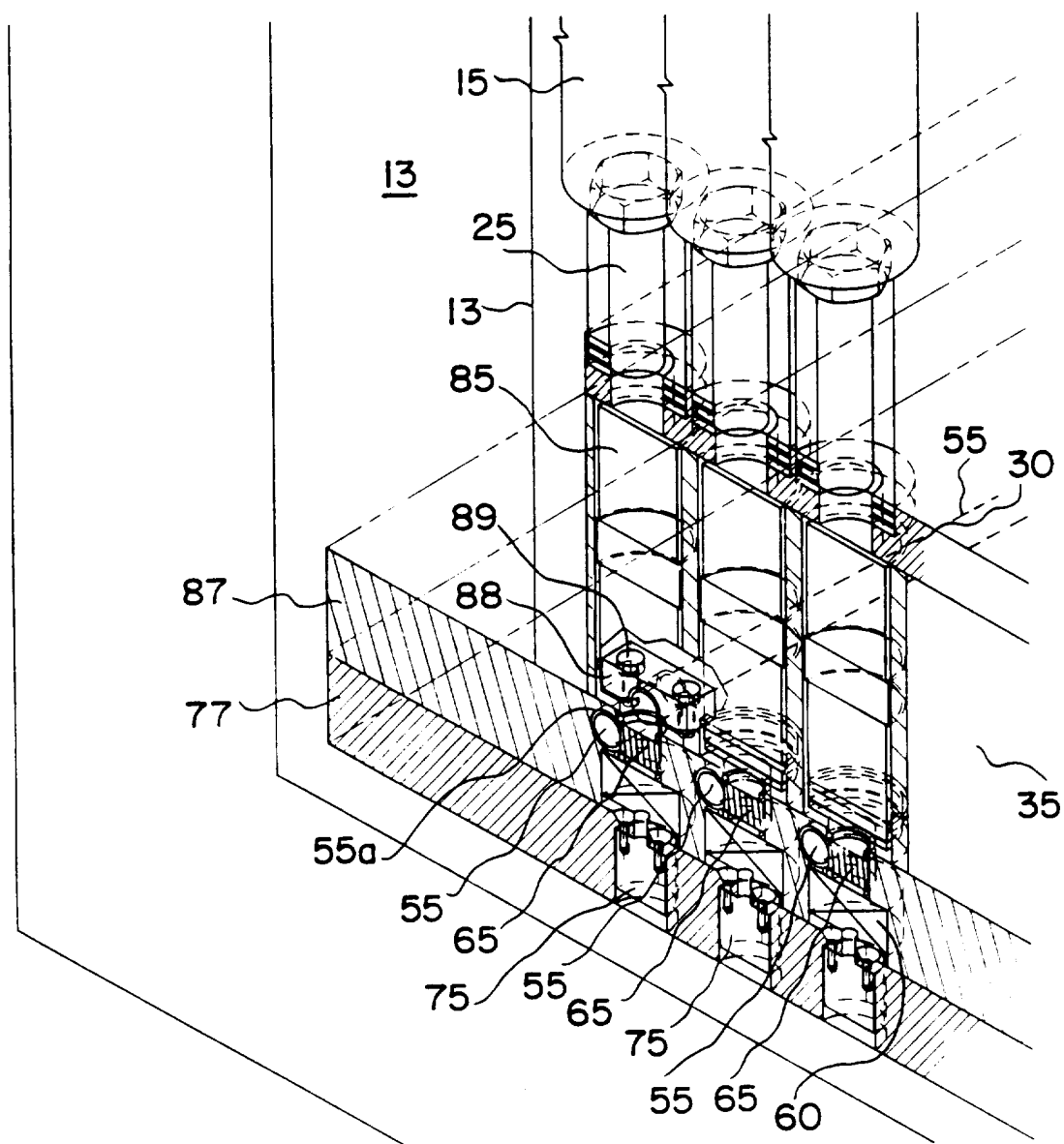


FIG.4

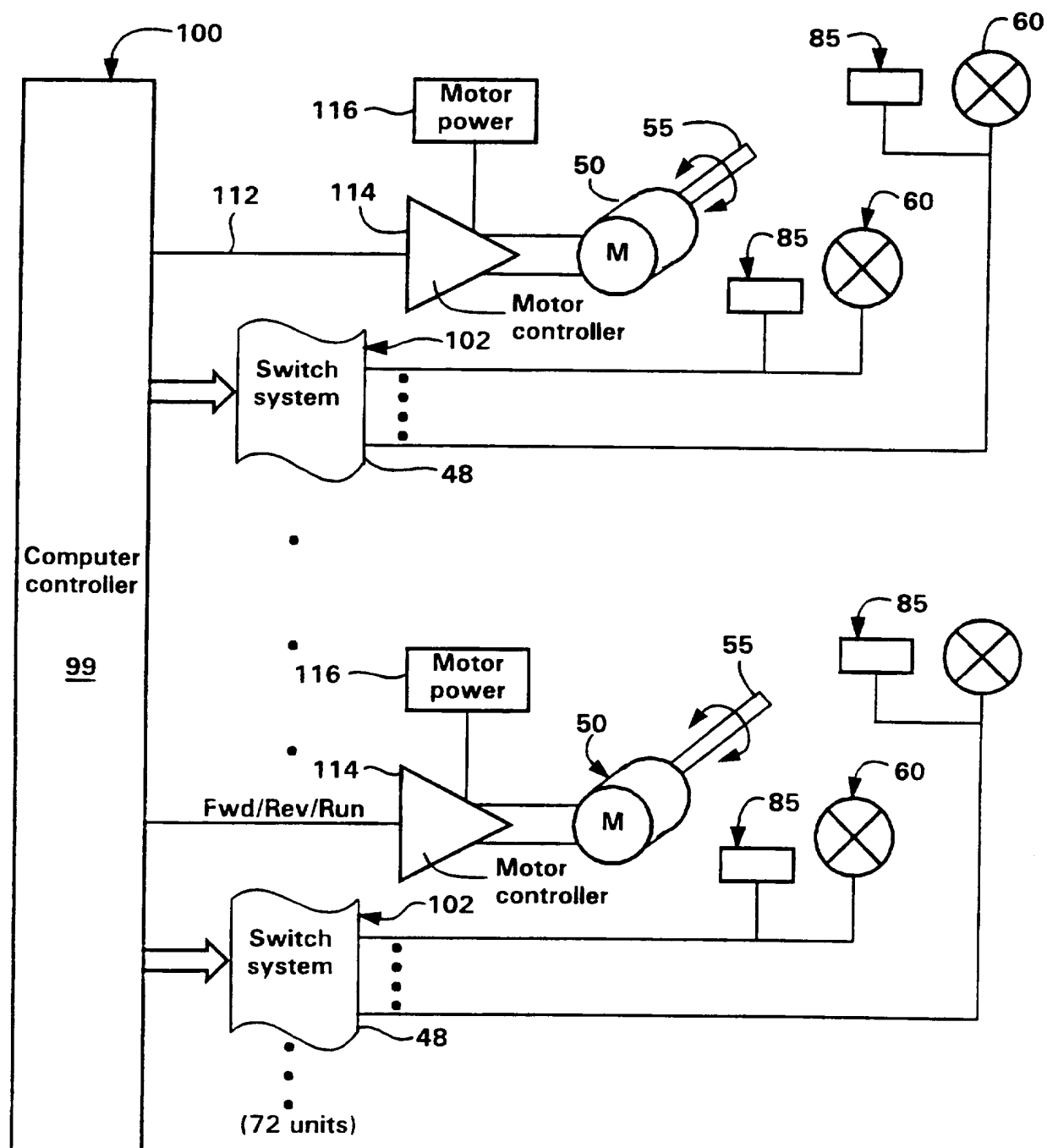


FIG. 5

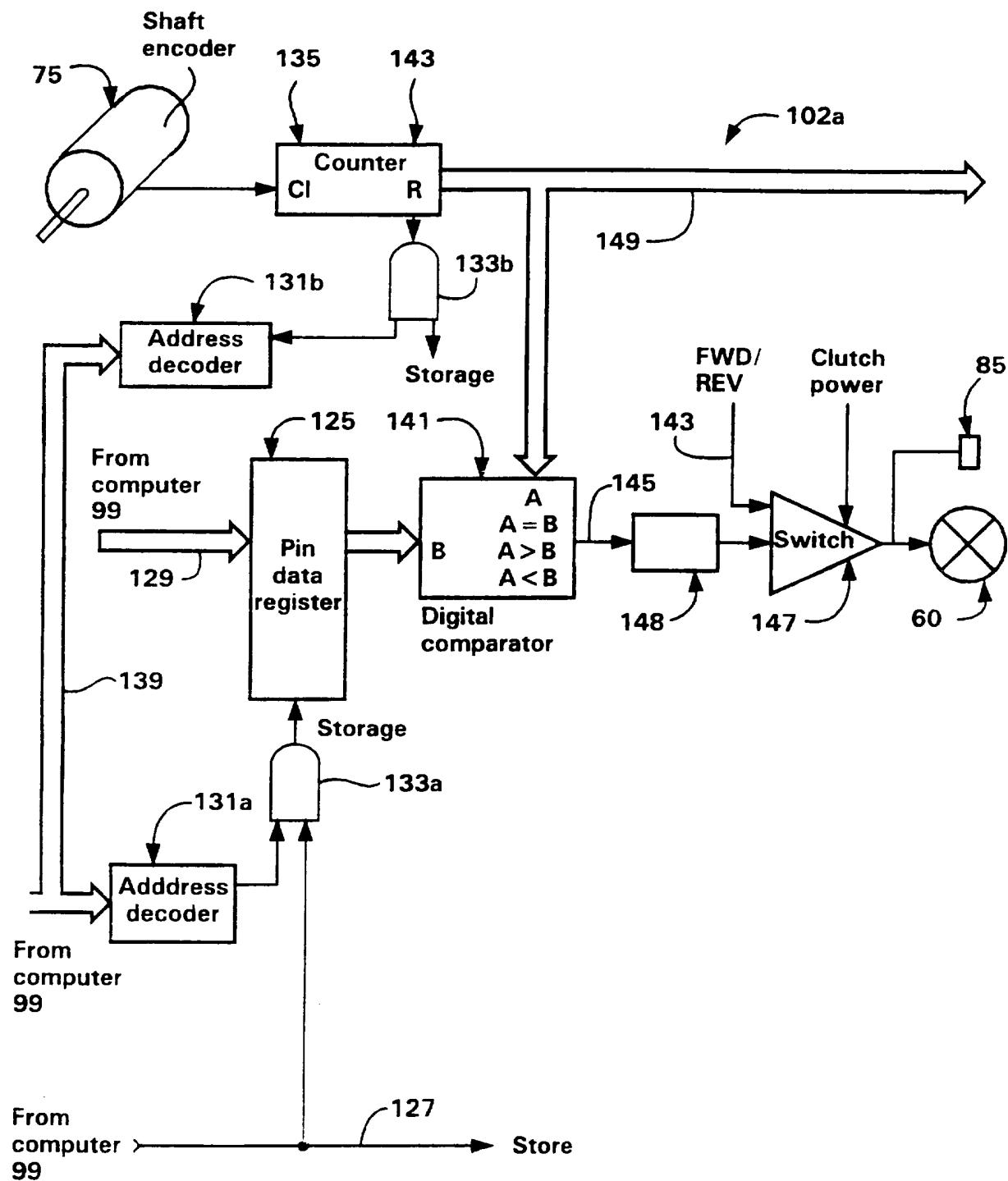
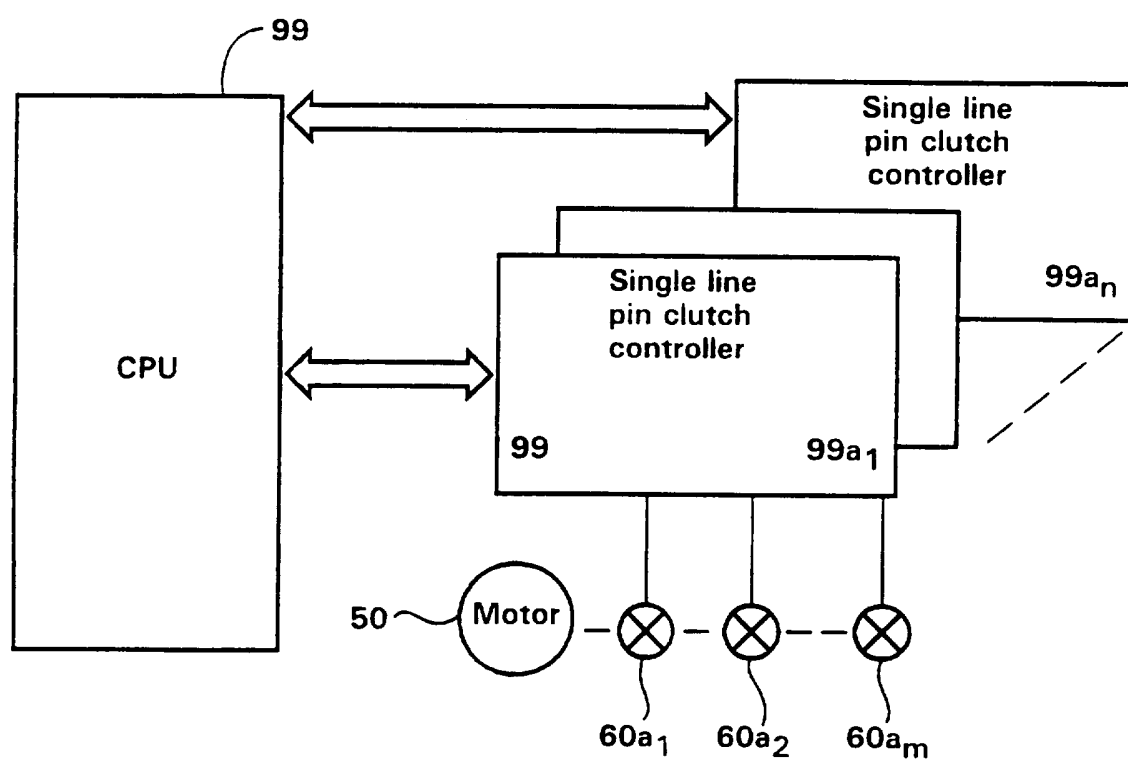


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/15423

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : B21B 37/24; B30B 15/26; B21D 37/02; B21D 37/14; B21C 51/00

US CL : 72/7,31,413,473,478

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 72/7,31,413,473,478

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US, A, 4,212,188 (PINSON) 15 July 1980, See entire document.	1 ----- 2-28
Y	US, A, 5,187,969 (MORITA) 23 February 1993, col. 7, lines 3-34.	2-14 & 20-28
Y	US, A, 4,131,003 (FOSTER ET AL) 26 December 1978, col. 5, line 39-48.	15-19
A	US, A, 4,548,065 (VYHNAL) 22 October 1985.	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

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

"Y"

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

"&"

document member of the same patent family

Date of the actual completion of the international search

06 JANUARY 1996

Date of mailing of the international search report

30 JAN 1996

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