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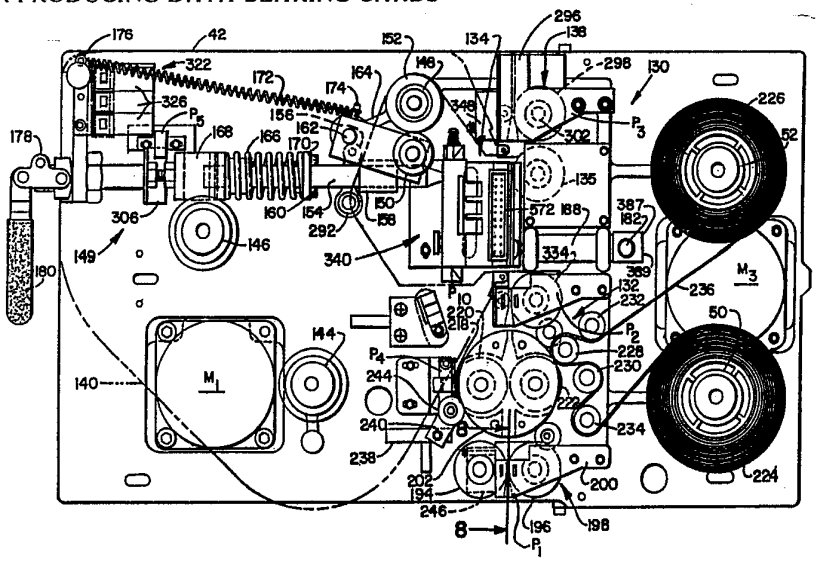

(57) Abstract

An apparatus and method for printing a graphic design on a hard plastic workpiece such as a credit card blank includes a thermal printing element which is supported by a head assembly that has been designed a single link, to have low mechanical compliance in a horizontal plane and yet to allow the print head to align with a print roller. A cleaning assembly is further provided which includes a pair of cleaning rollers having an adhesive coating; and a novel arrangement for stripping particulate matter away from the cleaning rollers after a predetermined number of cards have been cleaned. A number of stepper motors are provided to perform the cleaning and printing functions. The stepper motors are controlled by a local control system which monitors a number of sensors provided on the cleaning and printing stations and is subservient to an overall system controller. The invention further includes a novel method of operation, a cassette for use with the printing station and a novel thermal printing foil.

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System for Producing Data Bearing Cards

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a system and method for producing plastic data bearing cards such as credit cards. More particularly, the present invention relates to a system and method for producing information bearing cards having a graphic design printed thereon which may be varied according to input from a system controller.

2. Description of the Prior Art

A great demand exists in contemporary society for information bearing plastic cards such as credit cards or magnetically encoded cards for use with automatic teller machines (ATMs). Many such cards come with a standardized design thereon which is modified by individual banking institutions, who often seek to place their logos or other identification thereon. These are but only a few of the many examples of the need for being able to transfer images to such items.

Various systems and methods have heretofore existed for transferring images to relatively thick, flexible, non-porous materials such as plastic cards. One example is the use of offset lithography, which is most commonly used in forming the initial design of the cards. Yet another method is the use of hot stamping in conjunction with embossing foils. In addition to other problems, these methods are not sufficiently flexible, because it is very time consuming and expensive to re-tool these systems so as to be able to transfer a different or modified image to the surface of an item.

While thermal printers have been used to create graphics images on paper and the like, they have not been very efficient in transferring images to relatively thick, flexible and non-porous items such as plastic cards. See for example for U. S. Patent No. 4,695,850 which is commonly assigned with the present application,

and U. S. Patent No. 4,650,350 to Dorner. Commonly assigned pending applications, Serial Nos. 235,830 and 937,602 filed August 18, 1988 and December 3, 1986, respectively, disclose thermal printers for printing on plastic items. Serial No. 235,830 is a continuation of Serial No. 905,288, which was filed September 8, 1986.

Numerous problems encountered by these various thermal printers when printing on plastic cards include the lack of uniformity in the transfer of ink to the surface of the plastic card, which results in a non-uniform image. The images so derived are often not satisfactory for graphics purposes. The present invention solves these problems and other problems associated with existing systems.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an apparatus which is capable of printing a graphic design on a hard plastic workpiece such as a credit card blank.

It is further an object of the present invention to provide an improved cartridge assembly for use with a thermal printer head which is effective at guiding a thermal printing foil along a planar printing path and storing used foil after printing.

It is further an object of the present invention to provide an apparatus for removing particulate matter from hard plastic workpieces such as credit card blanks prior to printing a graphic design thereon. It is a secondary object of the present invention to provide a device for stripping such particulate matter off of the cleaning apparatus when it becomes overloaded.

A yet further object of the present invention is to provide an improved thermal printing foil for use in a thermal printing system.

In order to achieve the above objects, the

present invention provides a system for producing magnetically encoded plastic cards having a graphic design thereon, comprising structure for supplying a series of blank plastic cards; structure for encoding magnetic strip on the cards; structure for separating loose particles from the cards; structure for placing a graphic design on the cards; structure for embossing a number of alphanumeric characters on the cards; and structure for collecting the cards after the cards have passed through the installing structure, the separating structure, the design placing structure and the embossing structure.

According to the invention, the structure for placing a graphic design on the cards comprises structure for feeding the cards along the work feed path; structure positionable adjacent the work feed path for printing a pattern on the cards; structure for precisely aligning the printing structure with respect to the feeding structure so that the printing structure is adapted to bear against the cards at a constant pressure; and structure for controlling the feeding structure and the printing structure to print a predetermined design on the cards.

According to the invention, the structure for separating particulate matter from the cards comprises cleaning structure having at least one engaging surface adapted for engaging the surface of the cards to be cleaned; structure on the engaging surface for attracting loose particles from the corresponding surface of the cards to be cleaned; structure adapted for feeding a workpiece to the cleaning structure; and structure for removing collected particles from the cleaning structure. According to the invention, a cartridge assembly is further provided for use with a thermal printer or the like, comprising an outer casing having an inside and an outside surface; a length of thermal printing foil disposed substantially within the

casing; first capstan structure for storing an unused portion of the printing foil; second capstan structure for storing a used portion of the printing foil; structure for rotatably supporting the first and second capstan structure within the outer casing; and structure for guiding the printing foil from the first capstan structure to a guide path line within a printing plane and for guiding the foil from the printing plane path to the second capstan structure.

According to the present invention, a method of printing a graphic design on a hard plastic workpiece comprises feeding the workpiece along a work feed path to a position adjacent a resistance type thermal printer; precisely aligning a printing surface of the thermal printer with the surface of the workpiece which is to be printed upon; controlling the printer to print on the desired workpiece surface while continuing to feed the workpiece past the printer; and moving the workpiece away from the printer.

The invention also provides a method for removing particulate matter from at least one surface of a workpiece at a cleaning station, comprising detecting the presence of a workpiece before the workpiece reaches the cleaning station; feeding the workpiece into the cleaning station; engaging the surfaces of the workpiece to be cleaned with a corresponding number of particle attracting elements; removing the workpiece from the cleaning station; determining the total number of workpieces that had been cleaned responsive to the detecting step; and removing particles that have collected on the particle attracting elements whenever the total number of workpieces cleaned exceeds a predetermined number.

These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better

understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and described a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a perspective view of a system constructed according to the instant invention, with portions cut away for clarity;

FIGURE 2 is a block schematic diagram depicting the control system for the system illustrated in FIGURE 1;

FIGURE 3 is a top plan view of the graphic station illustrated in FIGURE 1, with a printer foil cartridge illustrated in broken lines;

FIGURE 4 is a bottom plan view of the assembly illustrated in FIGURE 3;

FIGURE 5 is an exploded perspective view of the assembly illustrated in FIGURE 3;

FIGURE 6 is a side elevational view of the graphic station assembly illustrated in FIGURE 3;

FIGURE 7 is a fragmentary top plan view of a portion of the assembly illustrated in FIGURE 3, taken in cross-section generally along lines 7-7 in FIGURE 6;

FIGURE 8 is a fragmentary cross-sectional view taken along lines 8-8 in FIGURE 3;

FIGURE 9 is a view similar to FIGURE 7 showing the stripper assembly of the invention in operation;

FIGURE 10 is a view similar to FIGURE 7 and 9, with additional parts broken away for clarity;

FIGURE 11 is a view similar to FIGURE 7 and 9, with the stripper assembly shown in a second stripping position;

FIGURE 12 is a top plan view similar to that illustrated in FIGURE 3, with the printer head

illustrated in its released condition;

FIGURE 13 is a top plan view similar to that illustrated in FIGURE 12, with a cartridge illustrated in its operative position, with parts broken away for clarity;

FIGURE 14 is an exploded perspective view of a cartridge assembly according to the invention;

FIGURE 15 is a fragmentary view of an indicating system on the cartridge assembly illustrated in FIGURE 14;

FIGURE 16, is an exploded elevational view of the printer head assembly of the invention;

FIGURE 17 is a cross-sectional view taken along lines 17-17 in FIGURE 12;

FIGURE 18 is a cross-sectional view taken along lines 18-18 of FIGURE 13;

FIGURE 19 is a cross-sectional view similar to FIGURE 18 with the printer head shown in its released position;

FIGURE 20 is an isolated elevational view of a printing surface of the printer head of the invention;

FIGURE 21 is a cross-sectional view taken along lines 21-21 of FIGURE 20;

FIGURE 22 is a detailed schematic block-type diagram of a portion of the control system illustrated in FIGURE 2 for controlling the graphic station illustrated in FIGURE 3;

FIGURE 23 is a schematic block-type diagram detailing a portion of the control system illustrated in FIGURE 22;

FIGURE 24 is a depiction of a card image buffer according to the control system of the invention;

FIGURE 25 is a temperature response diagram according to the control system of the invention;

FIGURE 26 is a representative depiction of the logic used by the print processor of the invention; and

FIGURE 27 is a profile of a resistive dot

element according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring to Figure 1, a system 10 for producing magnetically encoded embossed plastic cards having a graphic design printed thereon is illustrated. System 10 includes a graphic input terminal 12 having a CRT 14 and a keyboard 16. System 10 further has a card hopper input 18 for holding blank plastic cards prior to processing, a magnetic stripping station 20 for encoding a magnetic strip on a plastic card and a novel graphics station 22 for printing a graphic design on at least one face of the card. In addition, system 10 includes embossing stations 24 for embossing alphanumeric characters into a desired portion of the plastic card or cards. A foil topper station 26 is further provided for coating portions of the card or cards which were raised in embossing stations 24. The system 10 is further provided with an output stacker 28 for storing cards that had been processed at the previously mentioned stations. In the illustrated embodiment, hopper input 18 feeds a blank card to magnetic encoding station 20; the card is then forwarded to the graphic station 22. After processing at graphic station 22, the card is forwarded to the embossing stations 24 which, in turn, pass the card to the foil topper 26. After processing by foil topper 26, the card is passed to output stacker 28 where it may then be removed from the system 10.

Referring now to Figure 2, the broad system 29 which is used for controlling card producing system 10 is depicted. System 29 includes a system controller 30 which is in communication with alphanumeric input terminal 12, as is shown in Figure 2. System controller 30 is further in communication with a CPU or card 32 for magnetic stripping station 20, and with a graphics control CPU or card 34 for graphic station 22. Graphics CPU 34, is preferably in communication with a print

engine 502, as will be described further below. Separate CPU's or cards 38 are preferably also provided for embossing station 24, which also is in communication with system controller 30. A further CPU or card 40 may further provide for additional steps or modules as may be required.

As is illustrated in Figure 2, control system 29 is in communication with input hopper 18, foil topper 26 and output stacker 28. In operation, system controller 30 controls the passage of a card through the various above-described stations in a manner that will be hereinafter described.

Referring to Figures 3-6, the structure and operation of graphic station 22 will now be described. Graphic station 22 includes a main frame member 42 which is securable to the chassis of card producing system 10. Mounted to frame member 42 are a number of stepper motors M_1, M_2, M_3, and M_4. Referring briefly to Figure 5, motor M_1 is securable to frame member 42 within a mounting recess 68 by a plurality of mounting screws 44. Stepper motor M_2 is likewise mounted within a recess provided on frame 42 by a plurality of mounting screws 46. Motor M_3 is mounted within a recess 56 by a plurality of mounting screws 48. In like fashion, mounting screws 49 secure motor M_4 to frame 42.

Referring to Figure 3, graphic station 22 is formed of a printing unit 130 which is adapted to print a graphic design on a plastic card, and a cleaning unit 132 which is for cleaning loose particles off a plastic card before the card is fed into printing unit 130. In operation, a plastic card is guided along a linear work feed path through cleaning unit 132 and printing unit 130. In order to guide each card along the work feed path, the apparatus is provided with a first top edge guide member 62 for guiding a card into cleaning unit 132, a second top edge guide member 64 for guiding a card from cleaning unit 132 to printing unit 130 and a

third top edge guide member 66 for guiding the card out of printing unit 130 and into a subsequent station. In order to facilitate control of the system in a manner that will be described below, first, second and third top edge guide members 62, 64, 66 are each respectively provided with a photosensor P1, P_2 and P_3 for detecting the presence of a card in a guide slot defined in each of the respective guide members.

Referring to Figures 3 and 4, a first stripper tape spindle 50 and second stripper tape spindle 52 are arranged to extend upwardly in a direction normal to an upper surface of frame 42 and are each connected to shafts which extend through frame 42. Spindle 52 is mounted for rotation on frame 42 by a one-way bearing which allows the spindle 52 to move only counterclockwise as viewed in Figure 7. In this way, the second stripper tape spindle 52 is arranged to rotate with a pulley 54 which is provided beneath frame 42, as is shown in Figure 4. In like fashion, first stripper tape spindle 50 is arranged to rotate with a serrated disk 120 which is provided beneath frame 42. Serrated disk 120 is adjacent to a photosensor P_7 and forms therewith a stripping tape payout motion sensor 118 which is monitored by the control system, as will be below described.

Printing unit 130 is provided with first and second foil drive spindles 144, 146 which each extend through frame 42. Second foil drive spindle 146 is connected for rotation with a pulley 114, and first printer foil spindle 144 is connected for rotation with a serrated disk 124 which together with photosensor P_6 forms a motion sensor 122 that is monitored by the control system, as will be described hereinafter. First and second feed rollers 194, 196 are provided at the entrance to cleaning unit 132 and are connected for synchronous rotation. Second feed roller 196 is connected for rotation with a feed roller input pulley

80 provided beneath frame 42. As is illustrated in Figure 3, a stripper roller 228, a first stripper guide roller 230, a second stripper guide roller 232 and a third stripper guide roller 234 extend vertically from the top surface of frame 42. First and second stripper guide rollers 230, 232 are connected for rotation, respectively, with a first stripping tape guide roll input pulley 82 and a second stripping tape guide roll input pulley 86 which extend beneath frame 42. Cleaning unit 132 further includes a turret body 202 which is arranged to rotate with a turret input pulley 72 that extends beneath frame 42. Stepper motor M_1 is connected to an output pulley 60 that extends beneath frame 42. A first timing belt 70 engages M_1 output pulley 60 and the turret input pulley 72 so as to turn the turret body 202 in non-slipping fashion when motor M_1 is instructed to turn by the control system. Similarly, stepper motor M_2 is provided with an output pulley 74 which is arranged to rotate the feed roller input pulley 80 and a first portion of input pulley 82 by means of a second timing belt 84, as is best shown in Figure 4. A second pulley portion of first input pulley 82 and a second pulley portion of input pulley 86 are connected for synchronous rotation by a third timing belt 88. Pulley 82 is provided with a one-way clutch between the first and second pulley portions thereof which allows clockwise relative movement of the second pulley portion relative to the first pulley portion as viewed in Figure 4.

For a purpose that will be described later, printer unit 130 is provided with a cam shaft 182 which is connected for rotation with a cam shaft input pulley 90 arranged beneath frame 42. Cam shaft input pulley 90 is adapted to be rotated by an output pulley 58 which is connected to stepper motor M_3 by a fourth timing belt 94, as is shown in Figure 4. Briefly referring to Figure 12, printing unit 130 is provided with a first printer feed roll pair 334, 336. Roller 334 is connected for

rotation with a first printer feed roll input pulley 78 which extends beneath frame 42, as is shown in Figure 4. Printing unit 130 further includes a second print feed roller pair 138, which, as illustrated in Figure 5, includes a first pair of rollers 298, 300 adapted to rotate with a drive shaft 302 and a second pair of smaller diameter rollers 308 adapted to rotate with a support shaft 310. Referring again to Figure 4, drive shaft 302 for the second print feed roller pair 138 is connected to a pulley 108 which extends beneath frame 42. Output pulley 74 for step motor M_2 drives first printer feed roll pulley 78 and second printer feed roll pulley 108 by means of an eighth timing belt 116. In addition, second stripper tape spindle pulley 54 is driven by a first pulley portion of the second stripping tape guide roll input pulley 86 by means of a fifth timing belt 92. In this way, stepper motor M_2 performs the dual function of driving all of the feed roll pulleys 80, 78, 102 as well as the first and second stripping tape guide rolls input pulleys 82, 86 and the second stripper tape spindle pulley 54, in a manner that will be described further below.

Referring again to Figure 4, stepper motor M_4 is provided with an output pinion 100 which engages a reduction gear 102. Reduction gear 102 is connected for rotation with an M_4 output pulley 104. Referring briefly to Figure 3, printing unit 130 includes a first capstan roller guide 148 for guiding a printer tape during the printing process. First capstan roller guide 148 is connected for rotation with a capstan roller guide input pulley 112 which, in turn, is connected for rotation with M_4 output pulley 104 by a sixth timing belt 106. In addition, capstan roller guide input pulley 112 is constrained to rotate with the pulley 114 for the second foil drive spindle 146 by a seventh timing belt 110. Printing unit 130 is provided with a printer roller 135, for purposes which will be clarified below. Printer

roller 135 is constrained for rotation with M_4 output pulley 104. In this way, M_4 controls the rotation of print roller 135, the first capstan guide roller 148 and the second printer foil drive spindle 146.

Also provided beneath frame 42, as viewed in Figure 4, is a cam shaft position sensor 96 which includes a photosensor P_8 and a cam shaft flag 98 mounted on the cam shaft input pulley 90. The cam shaft position sensor 96 allows the control system to monitor the position of the cam shaft at any given time.

Also mounted beneath frame 42 is an air supply plenum 126 which is connected to a central air supply duct for the overall card producing system 10. Plenum 126 communicates with a box-shaped manifold 128 which, in turn, is in communication with a passage 342 through frame 42 to allow air from the manifold 128 to cool selected areas of the printing unit 130 during operation.

Referring again to Figure 3, printing unit 130 includes a printing head assembly 134 including a printing head 340, the printer roller 135 and first and second print feed roller pairs 136, 138. A thermal printing foil 142 is provided in a cartridge 140 and guided when the cartridge is position through a printing plane which extends between printing head 340 and print roller 135. In order to secure cartridge 140 in its proper position on printing unit 130, and to properly orientate printing head 340, a positioning mechanism 149 is provided which includes a plunger 154 movable by a toggle linkage 178 and handle 180 from a first open position as is shown in Figure 12 to a second closed position, as is shown in Figure 3. In the closed position, plunger 154 is urged against a pivot plate 344 of the printer head assembly 134 to urge printing head 340 and specifically a thermal print line 374 thereon against print roller 135. In the closed position, as illustrated in Figure 3, plunger 154 is biased against

pivot plate 344 by a compression spring 166 which is interposed between a spring seat 168 attached to the toggle actuation mechanism and a spring stop 170 on plunger 154. As shown in exploded Figure 5, spring seat 168 is attached to the overall toggle-handle mechanism 330 by a threaded rod 328; and a flag member 306 is interposed between threaded rod 328 and the toggle-handle linkage 330. A photosensor P_5 is mounted on an upwardly extending mounting surface 304, which is part of frame member 42, so as to be positioned to detect movement of flag 306. As a result, the control system can monitor the position of plunger 154 during operation of the printing unit.

Referring again to Figure 3, the first stationary capstan guide roller 148 is provided with an outer resilient surface 152 and is mounted on a structural support grip 164 provided on frame 42 so as to rotate about an axis stationary relative to frame 42. A second capstan guide roller 150 is provided to rotate about a pin extending through a pivot block 156, as is shown in Figure 3. Pivot block 156 is mounted to pivot about a pivot shaft 162 which extends upwardly from a pivot support bearing and structural support rib or boss 164. A tension type spring 172 is stretched between a first mounting screw 176 provided on frame 42 and a second mounting screw 174 provided on pivot block 156 so as to urge pivot block 156 in a counterclockwise direction, thereby forcing second capstan guide roller 150 against the outer resilient surface 152 of first capstan guide roller 148. Pivot block 156 is further provided with a cam pin and bushing 160 and a bearing block guide roller 292 which are adapted to bear against a bearing block 158 provided on plunger 154.

When the overall handle-toggle linkage 330 is opened to withdraw plunger 154 to the position illustrated in Figure 12, cam pin 160 is forced rearwardly by bearing block 158, thus causing pivot

block 156 to pivot in a clockwise direction about pivot shaft 162, thereby separating first capstan guide roller 148 from the second capstan guide roller 150. In this position, a cartridge 140 may be easily inserted into the printing unit 130 by aligning a pair of circular recesses 262 which are provided in the cartridge 150 with the first and second foil drive spindles 144, 146 so that printing foil 142 stretches between the separated capstan guide rollers 148, 150.

At the same time, printing head 340 is allowed to pivot rearwardly toward plunger 154 by a torsion spring 348 which urges pivot plate 344 in that direction, so that the printing foil 142 may be stretched between the printing head 340 and print roller 135. After the cartridge 140 has been so positioned on printing unit 130, toggle-handle linkage 330 may be closed, which causes plunger 154 to urge the printing head 340 toward printer roller 135 and causes the first and second capstan guide rollers 148, 150 to be urged together in a printing foil driving position.

Referring briefly to Figures 18 and 19, the invention also includes structure for urging the printer head assembly 134 away from the work feed path of a card 192 against the resilient biasing provided by plunger 155 and compression spring 166 responsive to instructions provided by the control system. As was stated above in reference to Figure 4, a stepper motor M_3 drives a cam shaft 182 through a pair of pulleys 58, 90 and a fourth timing belt 94. As shown in Figure 18, cam shaft 182 extends upwardly through frame 42 and includes a first cam surface 386 and a second cam surface 388. First cam surface 386 is supported within a first cam housing 387 and second cam surface 388 is supported within a second cam housing 389. A first retractor rod 382 is supported for reciprocation within a first retractor rod housing 188 and a second retractor rod 384 is likewise supported for reciprocation within a second

retractor rod housing 398. The first and second retractor rod housings 188, 398 each are provided with a threaded external surface 404, 406, respectively. Frame 42 includes an upstanding support member 390 having a first trunnion like extension 394 and a second trunnion like extension 396. Each of the first and second extensions 394, 396 have a pair of threaded holes defined therein adapted to receive the threaded outer surfaces 404, 406 of first and second retractor rod housings 188, 398. As shown in Figure 18, the first and second retractor rod housings 188, 398 are adjoined to the first and second cam housings 387, 388, respectively.

Each of the first and second retractor rods 382, 384 are provided with a cam follower surface 383, 385, respectively, for engaging the first and second cam surfaces 386, 388 on cam shaft 182. Each of the retractor rods 382, 384 further have an adjustable contact tip 392 at an opposite end thereof for engaging corresponding contacts 402 which are provided on the printer head assembly 134. In actuality, contacts 402 are surfaces of mounting screws 360, which will be described hereinbelow.

In operation, when the control system instructs stepper motor M_3 to turn the cam shaft 182, the first and second retractor rods 382, 384 and their corresponding follower surfaces 383, 385 are cammed by the first and second cam surfaces, 386, 388 on cam shaft 182, thereby forcing retractor rods 382, 384 toward the printer head assembly 134. As a result, adjustable contact tips 392 of the respective retractor rods 382, 384 bear against the contacts 402 on the printer head assembly 134 and thereby urge the printer head assembly rearwardly against the bias of compression spring 166, as is shown in Figure 19. At the same time, the position of cam shaft 182 may be monitored by the cam shaft position sensor 96 which is illustrated in Figure 4 and has

previously discussed.

Referring now to Figures 16, 20, 21 and 27, the structure of printer head assembly 134 will now be discussed. As is best shown in Figure 16, printing head 340 includes an aluminum heat sink portion 370 which is coated on one side thereof with a ceramic substrate 371. Referring briefly to Figure 20, the front surface of the printing head 340 includes a thermal print line 374 which has a multiplicity of thermal print resistive elements 376 therein which may be heated according to a predetermined algorithm, which will be discussed hereinafter, in order to induce printing foil 142 to produce the desired graphic pattern upon a workpiece. The ceramic substrate 371 is coated with a partial glaze along the print line 374 to give the thermal print line 374 an elevated shape of .001 to .003 inches. On top of this glazed portion, a resistive material 570 (0.9 micron thick) is deposited and a number of conductive leads 568 (1.0 micron thick) corresponding to the number of thermal print elements 376 are deposited upon the glazed portion. The area is then coated with a wear layer 372 of silicon carbide or silicon nitride and a print head drive electronics module 366 is bonded directly onto the ceramic substrate 371 with its connections made directly to the conductive leads for the microresistors. Upper and lower external electronic connectors 572 are interfaced to the ceramic substrate 371 which includes gold coated leads via flex circuit leads 368 and a compliant silicon rubber block 574 which is clamped by members 359 and 358. A lower card guide 358 and a clamping member 359 are then secured to the printing head 340 by means of a number of mounting screws 360, as is shown in Figure 16.

Referring again to Figure 16, a novel mounting structure for the printing head 340 includes a backing block 352 having a plurality of heat dissipating fins 353 thereon which is secured to printing head 340 by a number of mounting screws 410.

In order to ensure even pressure distribution across the printing line 374, the mechanism supporting the print head has been designed to have low mechanical compliance in the horizontal plane and yet allow the print head to align with the print roller 135. Accordingly, the support mechanism in the printer head assembly 134 has been designed as a single link which allows the assembly to be pivoted away from the print roller 135 for foil replacement and also allows the printing head 340 to pivot and follow the minor imperfections of the print roller 135 and minor workpiece thickness variations. This link reacts to horizontal moments and forces which are caused by bearing spacing and tolerance deviations of components in the link. In order to ensure acceptable printing quality, total mechanical deflection of the print head assembly 134 must be less than 10% of the physical size of one printed dot, which is approximately .0004 inches.

In order to correct for tolerance deviations in the printing head 340, which may be slightly warped, the invention includes a novel prestressing arrangement 412, which is best shown in Figure 21. According to the invention, backing block 352 is provided with a multiplicity of threaded holes 414 which extend toward the interface with heat sink 370 of the printing head 340. Heat sink 370 has a lesser number of threaded holes 416 defined therein which are aligned with a chosen number of the threaded holes 414 in backing block 352. In the illustrated embodiment, backing block 352 is provided with a total of five such threaded holes 414, and heat sink 370 is provided with three threaded holes 416 which are aligned with alternating holes 414. Three adjustment bolts 418 are inserted into those holes 414 which are aligned with a hole 416, and are threadable within the holes 416 to tension the bolts 418, which draws heat sink 370 and backing block 352

together at those discrete points. In those threaded holes 414 which are not aligned with corresponding holes and heat sink 370, adjustment studs 420 are insertable which bear against a rear surface of heat sink 422 and are tightenable thereagainst so as to exert a compressive force, thereby urging heat sink 370 away from backing block 352 at those discrete points. By suitably adjusting mounting screws 410 and adjustment studs 420, deviations in tolerance of the printing head 340 obtained from a supplier may be corrected for, thereby improving the alignment of the printing head with print roller 135.

Backing block 352 is securely fixed to a support block 350 by a thumb screw knob connection 354, as is shown in Figure 16. Support block 350 is pivotally mounted with respect to pivot plate 344 by a bearing 356. Pivot plate 344 is pivotally mounted with respect to frame 42 by a pivot plate bearing shaft 346 and is torsionally biased with respect to frame 42 by torsion spring 348, as has been previously described. Thus, a single link is achieved which allows the print head assembly to be pivoted away from the print roller for foil replacement and also allows the print head assembly to pivot and follow the minor imperfections of the print roller and minor card thickness variations.

As has been previously discussed, print roller 135 is mounted for rotation upon a shaft which is connected to the output pulley 104 of stepper motor M_4. Print roller 135 is aligned with thermal print line 374 and preferably has an outer resilient layer capable of supporting a workpiece against deflection relative to the thermal printing line during printing. In the preferred embodiment, print roller 135 is made of a 90 shore A durometer elastomer that has good friction characteristics and yet has some ability to allow for minor card thickness variations along the print head axis. This construction of print roller 135 in

conjunction with the above-discussed measures for ensuring the alignment of printing head 340 results in a total mechanical deflection of the print head assembly relative to print roller 135 which is less than the critical value of approximately 0.0004 inches.

As previously discussed, the printing unit 130 includes a first set of printer feed rollers 334, 336 which are rotated by stepper motor M_2 through the first printer feed roller pulley 78 and eighth timing belt 116. As is may be seen in Figure 12, printer feed roller 334 has a resilient outer surface and is larger than roller 336, which has a vinyl or other high friction outer surface. Resilient roller 334 is mounted for rotation with pulley 78, and roller 336 is by rotated by friction applied by roller 334. Rollers 334 and 336 are biased together by a spring arrangement 338 which acts upon a bearing block in which the smaller roller 336 is constrained to rotate. A second pair of rollers similar in shape to rollers 334 and 336 are provided on the same shafts which support those rollers, but are positioned beneath the work feed path and serve the purposes of aiding alignment and driving of the two shafts. The shafts supporting rollers 334, 336 are mounted in one-way pulley clutch bearings in a manner similar to the mounts for rollers 194, 196 so that the workpiece is driven at the speed of the fastest feed roller or print roller. The second feed roller pair 138 is likewise so mounted.

Referring now to exploded Figure 5, a second set of printer feed rollers 138 includes a first upper print feed roller 298 having a resilient outer surface and a second upper print feed roller 308 having a vinyl or other high friction surface and a smaller diameter than roller 298. First upper print feed roller 298 is constrained to rotate with drive shaft 302, which also has a lower print feed roller 300 mounted thereon and is adapted to engage a second roller portion 308 on support

shaft 310 which supports roller 308 for rotation therewith. Drive shaft 302 for the first upper print feed roller 298 is connected to a pulley 108 which is adapted to be driven by stepper motor M_2 in a manner previously described. When M_2 turns drive shaft 302 responsive to an instruction from the control system, the first upper print feed roller 298 turns to help feed a workpiece out of the printer unit 130 and into the next station. At this time, second upper feed roller 308 and support shaft 310 turns due to friction of the workpiece or to friction between lower printer feed roller 300 and the lower roller 308 on shaft 310. Rollers 298 and 308 are biased toward each other by a compression spring 316 which is secured on a bearing guide 314 by a retaining ring 318 and acts against a bearing block 312 within which support shaft 310 is constrained to rotate. A lower print assembly card guide 296 is provided beneath rollers 298, 308 for ensuring straight passage of the workpiece along the work feed path.

Referring to Figures 13-15, the construction of the printing foil tape cartridge according to the invention will now be described. As shown in the exploded view provided in Figure 14, cartridge 140 includes a styrene outer casing 256 having an outer surface 258 and an inner surface 260. A pair of circular recesses are provided in both sides of outer casing 256 for receiving the first and second foil drive spindles 144, 146. Circular recesses 262 are preferably spaced so that their central axes are approximately three and one-half inches apart, as is shown in Figure 14. A slot 264 is defined in outer casing 256 for receiving a photo detector P_{10}, which is best illustrated in Figure 3. Each sides of the inner surface 260 of outer casing 256 have a pair of circular seating surfaces 266 defined therein for receiving first and second cylindrically shaped capstan members 268, 270, as

is shown in Figure 14. Each of the capstans 268, 270 have an inwardly extending rib 272 which is adapted to engage an outwardly extending projection on the respective foil drive spindles 144, 146. As is shown in Figure 14, unused printing foil 142 is wrapped around first capstan 268 for storage purposes. Preferably, a transparent warning leader is spliced to printing foil 142 on the end of the supply wrapped around capstan 268. When the printing foil 142 is nearly exhausted, the transparent leader will pass by photosensor P_{10}, which will report the exhaustion of printing foil to the control system, as will be described below.

A first guide post 274 and a second guide post 276 are provided for guiding the printing foil 142 along a printing plane which is constructed for positioning between the thermal printing line 374 and print roller 135. A third guide post 278 is provided to guide foil 142 from first capstan 268 to the first guide post 274. Likewise, a fourth guide post 280 is provided for guiding foil 142 from the second idler 276 to the second capstan 270, where the used printing foil is stored. As is shown in Figure 14, all of the guide posts 274, 276, 278, 280 are constructed as thin hollow cylinders which are supported by studs which extend from the inner surface 260 of the outer casing 256.

Referring to Figure 15, an indicating system for indicating what type of printing foil is contained in a cartridge is illustrated. Indicating system 290 includes a first tab 284, a second tab 286 and a third tab 288 which may be selectively punched out to encode such parameters as the printer energy level which corresponds to a particular type of printing foil. The provision of the three tabs 284, 286, 288 create a total of eight different combinations which may be read either manually or by a corresponding number of photosensors or switches.

Referring to Figure 5, a switch assembly 322 is illustrated which includes three switches 326 adapted to

detect which of the tabs 284, 286, 288 have been punched out of the outer surface 258 of a cartridge assembly 140. Switch assembly 322 is supported by a switch bracket 324 and is arranged to signal the control system as to the type of printing foil 142 contained in the cartridge, so that the appropriate power level or the like may be set automatically by the control system.

Printing foil 142 is preferably constructed of a first carrier layer, a backing layer on the carrier layer for contacting the thermal print line 374 and a pigmentation layer on the side of the carrier layer opposite the backing layer. According to the invention, the carrier layer may be formed of either polyester also referred to as polyethylene terephalate. The backing layer is preferably formed of a cross-linked silicon. The pigmentation layer includes a thermal transfer ink of the type which reacts exothermically to heat applied by the thermal print line 375, whereby printing may be effected without melting any portion of the printing foil. A back coated printing foil is sold by Coding Products of Michigan, under the product designation TTR-59CM.

Referring now to Figures 3 and 7, the cleaning unit 132 of graphic station 122 will now be described. As was previously described, a first feed roller 194 and second feed roller 196 are mounted for synchronized rotation beneath a first top edge guide member 98 and are biased toward each by a feed roller biasing spring 246, as is shown in Figure 10. Second feed roller 196 is rotated by stepper motor M_2 through second timing belt 84 and the feed roller input pulley 80. A second gear 208 is mounted to rotate with second feed roller 196 and feed roller input pulley 80 and is intermeshed with a first gear 206 which is in turn mounted for rotation with the first feed roller 194. Accordingly, rotation of the first feed roller 194 is synchronized with the second feed roller 196. Turret body 202 is supported

for rotation with a turret body shaft 204 that is connected with turret input pulley 72. As a result, turret body 202 may be rotated by stepper motor M_2 as has previously been described.

A first cleaning roller 220 and a second cleaning roller 222 are mounted for rotation on turret body 202, as is clearly shown in Figure 7. A third gear 210 is mounted for rotation with first cleaning roller 220, and a fourth gear 212 is likewise mounted for rotation with the second cleaning roller 222. Fourth gear 212 and third gear 210 intermesh so as to ensure synchronization between the first and second cleaning rollers 220, 222. The shafts supporting rollers 194, 196 are mounted in one-way pulley clutch bearings which allow the rollers to turn only in the feed direction, and allow the rollers to be driven in the feed direction at a speed greater than provided by their shaft, so the workpiece will be driven at the speed of the fastest roller. Turret body 202 further supports a transfer gear 214 which intermeshes with both second gear 208 and fourth gear 212 when the turret is in the position illustrated in Figure 7, which is the normal work feed position. As a result, cleaning rollers 220, 222 will be synchronized with the first and second feed rollers 194, 196 when a card workpiece is being fed through the cleaning unit 132, and share the one-way clutching action described above.

In order to monitor the rotational position of turret body 202, a turret position detector 216 is provided which consists of a turret flag 218 extending radially from the turret body 202 and a photosensor P_4 for detecting the position of the turret flag 218. Photosensor P_4 is monitored by the control system in a manner that will be described below.

In order to remove particulate matter which has collected on the cleaning rollers 220, 222 during use, a stripper system 223 is provided. Stripper system 223

includes a length of stripper tape 236 which is arranged in a first stripper tape supply reel 224 and a second stripper tape stores reel 226. First stripper tape supply reel 224 is adapted to be non-rotatably received over the first stripper tape spindle 50, and second stripper tape reel 226 is adapted to be non-rotatably received over second stripper tape spindle 52. As has been previously described, a stripper roller 228, a first stripper guide roller 230, a second stripper guide reel 232 and a third stripper guide reel 234 are provided in cleaning unit 132. First stripper guide roller 230 has an outer diameter of 0.500 inches and second stripper guide roller 232 has an outer diameter of 0.510 inches. It is important that the diameter of the second roller be greater than the first roller so that the tension is maintained in the stripping tape during cleaning. As may be seen in Figure 7, stripper tape 236 is guided from supply reel 224 over the third stripper guide roller 234, back around the first stripper guide roller 230, so that it winds around stripper roller 228, and then curves around second stripper guide roller 232 on its way to the second stripper tape reel 226.

In order to remove particulate matter from a card passing through the cleaning unit 132, cleaning rollers 220, 222 are provided with an adhesive coating and are preferably made from 20 to 30 durometer shore A urethane rubber. As the card passes between the rollers, the debris accumulates on the surface of the rollers and must be removed by the stripper system 223. To effect this, stripper tape 236 has one surface thereof coated with a substance that is more adhesive than the surface of cleaning rollers 220, 222. The adhesive surface of stripper tape 236 is arranged to face away from stripper roller 228, so that it is facing the cleaning rollers 220, 222.

In order to provide stability to the turret

body 202 as it is rotated about shaft 204, a plurality of turret support bearings are provided. For example, as may be seen in Figure 3, a bearing support block 240 is fixably mounted to a structural support 238 and has a turret support bearing 244 rotatably mounted thereon which abuts a circumferential side surface of the turret body 202. In the illustrated embodiment, three such bearings are provided which give a great deal of stability to the turret body 202.

Referring to Figure 10, first top card guide 62 includes a pair of ramped slots 248 which center a workpiece card entering the cleaning unit 132. Second top card guide 64 likewise has a ramped top slot 250 provided therein for similar purposes. As may be seen in Figure 10, photosensors P_1 and P_2 are built into the first and second top card guides 62, 64, respectively. Referring to Figure 8, the first top edge guide 62 has a chamfered leading edge 378 which engages the front surface of a workpiece card entering therein. Second and third top edge card guides 64, 68 likewise are provided with a chamfered edge. When a card 192 enters beneath one of the top edge guides 62, 64, 68, the cantilevered arm supporting the top edge guide deflects upwardly, thereby exerting a downward bias onto the card which keeps the card in a proper position. For example, first top edge guide 62 exerts a downward bias onto card 192 which presses the card firmly onto bottom edge guide 380, as is shown in Figure 8.

Referring to Figures 2 and 22-26, the control system for graphic station 22 will now be described. As is shown in Figure 22, system controller 30 is in two-way communication with a print engine 502 via a communications bus 500. Print engine 502 includes the above-described print head structure including printing head 340 and the above-discussed drive electronics 366. Print engine 502 of the preferred embodiment applies card image data to the plastic cards through the use of

fixed array thermal transfer technology. The print engine 502 is equipped with a custom thermal print head 340, as described above, providing a single "column" of dot or thermal print elements 378 which are vertically oriented with respect to the printing surface. The dots 378 are resistive elements that, when turned on, heat up a foil and transfer ink from a carrier coating. The dot elements remain off at areas left blank. Each dot element is controlled by a binary digit supplied to the print head 340, wherein a binary "1" means the corresponding dot element 378 is turned on and a binary "0" means the corresponding dot element is turned "off".

The thermal print head 340 is the most vulnerable component in the print engine 502, so steps which increase the life span of the print head 340 increase the cost effectiveness of the print engine 502. The goals of the present invention, therefore, are to (1) optimize print quality and consistency while (2) minimizing the electric and thermal stress on the print head 21.

Figure 22 is an overall schematic depiction of the print engine 502. Cards are delivered to the print engine 502 by the upstream cleaning unit 132. The card is first moved to the print position by the feed rollers 334, 336 and during printing the card is moved by the print roller 135, as is described above. Upon completion, the card is moved out of the print engine 502 by the feed rollers. The progress of the card through the system is monitored by sensors P_1, P_2 and P_3, as is represented in Figure 23. The print head 340 is brought into contact with the plastic card at the column dictated by a "starting column" value sent by the system controller 30. The card image is printed until the "ending column" value is reached, which value is also transmitted from the system controller. The starting column and ending column quantities have default values of column No.1 and No. 810, respectively. Figure 24

depicts a card image 528. A column consists of 512 bits numbered 0-511, wherein bit 0 represents the lower left corner of the image and bit 511 represents the upper left corner of the image. A row consists of 810 columns numbered 0-809, wherein column 0 begins on the left side of the card image buffer 528.

A graphics interface CPU 504 converses directly with the system controller 30 when the system controller 30 wishes to print a card image. The graphics interface CPU 504 stores the card image in a RAM buffer, and converses with the print engine 502 via cable 507 and an interface 508. The interface 508 delivers data and commands from the system controller 30 to the print engine 502. The interface 508 is concerned with five elements: the transfer request message; the transfer acknowledge message; input FIFO 510 buffer selection; a write strobe; and an 8-bit parallel data interface. The transfer request message is sent by the print engine 502 to the graphics interface CPU 504 to request the current column of data and the previous three columns of data. The graphics interface CPU 504 responds with the data and a transfer acknowledge message. The interface 508 is responsible for loading the input FIFO 510 properly. This requires that the first 256 bits of each column of data be written to the first buffer in the input FIFO 510. Next, the interface 508 de-selects the first buffer, selects the second buffer, and transmits the remaining 256 bits of each column of data into the input FIFO 510. This is repeated for each column of data. The write strobe signal strobes the 8-bit parallel data into the chosen input FIFO 510 buffer.

The print head 340 is driven by two separate buffers in an output FIFO 520. Each buffer is loaded separately and serially by the print processor 514 which reads the data from the input FIFO 510. In terms of card progress through the system, the print engine 502 waits until the card has reached sensor P_2 and then

requests three consecutive columns from the graphics interface CPU 504. This action buffers data in the input FIFO 510 and the output FIFO 520. The timing and control processor 512 is responsible for synchronizing the print head 340 with the cards position, based upon the sensor and stepper motor signals 518. The sensor and stepper motor signals 518 first indicate that the card is positioned at the print head 340. The timing and control processor 512 monitors subsequent signals 518 indicating each column advance of the card, and interrupts the print processor 514 which activates the print head strobe 522 accordingly. Once card printing begins, subsequent data is requested on a column-by-column basis from the graphics interface CPU 504. The interface 508 is responsible for keeping pace with the printing process. As mentioned herein earlier, during the printing of a card image, each column requires that the three previous column of data, as well as the current column of data, be sent to the print engine 502. The print processor 514 uses this historical data to provide thermal hysteresis control for each dot element in the print head 340. The past history of each dot element for the previous print cycles is used to calculate the exact energy necessary to the raise the dot element temperature to the ideal printing temperature. The energy supplied to the print head 340 is controlled by dividing the print head strobe 522 into five mini-phases. These five mini-phases are: 1) the transparent phase; 2) three compensation phases; and 3) the preheat phase. The Boolean algebra that describes the logic for determining when a mini-phase is "on" is in the lower portion of Figure 26, generally identified by reference numeral 550. The transparent phase is the first data loaded into the print head 340 by the print processor 514 and the longest print head strobe 522 by the print processor 514. This data, loaded into the output FIFO 520, is the current column of data read from

the input FIFO 510. The compensation phases are of equal time duration and yield active dot elements within the print head 340 depending upon the past history of each dot element. Whether a dot element is turned "on" during a compensation phase depends on whether the transparent phase is "on" for the current column and whether the dot element was "off" during the previous columns printed. The dot element is turned "on" for the first compensation phase if it was "off" during the first prior column (i.e., one column earlier). The dot element is turned "on" for the second compensation phase if it was "off" during the first and second prior columns (i.e., one and two columns earlier). The dot element is turned "on" for the third compensation phase if it was "off" during the first, second, and third prior columns (i.e., one, two, and three columns earlier).

The preheat phase is used to reduce the differential temperature stress on a dot element. The preheat phase occurs if a dot element is "off" for the entire hysteresis (i.e., if the dot element is "off" in the current column and it was "off" during for all three prior columns). A preheat phase is required because the transfer temperature of the foils utilized in the preferred embodiment are higher than the typical thermal media. This higher transfer temperature, coupled with the need to eliminate density variations as a function of ambient temperature, dictates the need for methods of preheating dot elements in the print head 340 to further reduce the differential temperature stress. Preheating dot elements in the print head 340 also reduces the need to vary the applied energy within the print pulse as a function of the ambient temperature, as discussed herein later.

Figure 26 provides an example of the logic used by a print processor 514 to determine how many mini-phases should be generated. At the top of Figure 26 is

an example "past history" for a dot element, generally identified by reference numeral 546. Beginning on the left side of the diagram, the printer begins from a cold start. For the next 11 print cycles after a cold start, the example dot element is "on" for one cycle, "off" for two cycles, "on" for one cycle, "off" for one cycle, "on" for two cycles, and "off" for four cycles.

Underneath each cycle indicator of "on" or "off" is a reference numeral, 552-566 and 576-580. These reference numerals correspond to the timing diagrams in Figure 26, generally identified by reference numeral 548. The first timing diagram illustrates the print head strobe 522, which is an inverted signal. The following timing diagrams illustrate the mini-phases for each print cycle.

In timing diagram 552, the first print cycle after a cold start, the current column is "on" resulting in an active transparent phase 530. Because there are no prior columns of data to be used in determining how many mini-phases should be generated, three "initialization" columns are transferred by the graphics interface CPU 504, wherein each column consists of all "off" dot elements. Therefore, the transparent phase 530 is concatenated with compensation phases 532, 534 and 536.

In timing diagram 554, the second print cycle after a cold start, the current column is "off" resulting in an off transparent phase 530. Compensation phases 532, 534 and 536 are "off" because the transparent phase 530 is "off". The preheat phase 34 is "off" because the first prior column was "on".

In timing diagram 556, the third print cycle after a cold start, the current column is "off" resulting in an "off" transparent phase 530. Compensation phases 532, 534 and 536 are "off" because the transparent phase 530 is off. The preheat phase 34 is "off" because the second prior column was "on".

In timing diagram 558, the fourth print cycle after a cold start, the current column is "on" resulting in an active transparent phase 530. Compensation phases 532 and 534 are "on" because the first and second prior columns were "off". The preheat phase 538 is "off" because the current column is "on" and the third prior column was "on".

In timing diagram 560, the fifth print cycle after a cold start, the current column is "off" resulting an "off" transparent phase 530. Compensation phases 532, 534 and 536 are "off" because the transparent phase 530 is "off". The preheat phase 538 is "off" because the first prior column was "on".

In timing diagram 562, the sixth print cycle after a cold start, the current column "on" resulting in an active transparent phase 530. Compensation phase 532 is "on" because the current column is "on" and the first prior column was "off". The preheat phase 538 is "off" because the current column is "on" and the second prior column was "on".

In timing diagram 564, the seventh print cycle after a cold start, the current column is "on" resulting an active transparent phase 530. Compensation phases 532, 534 and 536 are "off" because the first and third prior columns were "on". The preheat phase 538 is "off" because the current column is "on" and the first and third prior columns were "on".

In timing diagrams 566, 576, 578 and 580, the eighth through eleventh print cycles after a cold start, all current columns are "off" resulting in an off transparent phase 530. Compensation phases 532, 534 and 536 are "off" because the transparent phase 530 is off. In timing diagram 580, the preheat phase 538 is "on" because the current column is "off" and all three prior columns were "off".

The print processor 514 is responsible for controlling the width of each print head strobe 522.

Whenever one to three additional mini-phases are concatenated to the first mini-phase, based upon the past print history as described above, the concatenation results in very high electrical duty cycles. The print rate cannot be reduced to maintain a constant duty cycle in the face of dynamically changing individual pulse widths. The worse case can occur with a "cold dot" (i.e., a dot which has been "off" for the four print cycles of the hysteresis algorithm) where the transparent phase plus all three compensation phases are concatenated together to produce the print pulse. The danger is that the "cold dot" can create a peak dot temperature because of the dramatic increase in the duty cycle, which results from the mini-phase concatenation within a fixed overall print rate. The problem is exacerbated in the preferred embodiment because the high temperature transfer characteristics of the foil require higher energy than standard thermal media.

To overcome this problem, the invention allows the duty cycle, or pulse width, of individual mini-phases to be established and varied by the timing and control processor 512. The pulse width is initially determined by the thermal transfer characteristic of the foil being used. In an alternative embodiment, a foil type signal characterizing the thermal transfer temperature of the foil being used is input to the print processor 18. In an alternative embodiment, the foil type signal is used in conjunction with the thermistor 22 voltage to index into an extended look-up table. Different foils would have different thermal transfer characteristics requiring different energy levels. For example, different ink color will typically result in a foil having a different thermal transfer temperature. During printing, the temperature of the print head 340 is continuously monitored by the print processor 514 using thermistor 524. Thermistor 524 produces a voltage which varies with the temperature of print head 340.

The print processor 514 uses the voltage in a compensation algorithm, indexing into a look-up table to retrieve values indicating the desired width of the print head strobe 522. The look-up table is created on the basis of empirical evidence. As a result, the print head strobes 522 associated with the mini-phases discussed above are adjusted by the print processor 514. Thus, the required foil transfer temperature can be reached while avoiding dangerously high peak temperatures by effectively integrating or time-multiplexing the power applied to the print head 340.

The print processor 514 computes all five mini-phases for the next column during the printing of the present column. The significance of this approach is that it decouples the minimum width of a mini-phase from the execution time required to generate a mini-phase. This is especially important given that the cycle time for a mini-phase is shortened at high temperatures, to the point where the cycle time can be less than the execution time for computing the mini-phase.

The temperature response of each dot element due to the mini-phases is illustrated in Figure 25 by the four pulses, generally referred to by reference numeral 540. Pulse 530, associated with the transparent phase, raises the dot element temperature above the required foil transfer temperature 544. However, pulse 530 does not provide enough energy to raise the dot element temperature above the peak dot temperature 542. When pulse 530 ends, the temperature of the dot element begins to drop. After a predetermined amount of time, pulses 532, 534 and 536 associated with the three compensation phases, are generated to keep the dot element temperature from falling below the required foil transfer temperature 544 or from rising above the peak dot temperature 542. In this way, the invention maintains the temperature of the dot element above the required foil transfer temperature 544, but below the

peak dot temperature 542, thereby optimizing print quality but minimizing thermal stress. Although not shown in Figure 25, the width of the preheat pulse 538, can also very as a function of the print head 340 substrate temperature. Thus, during printing, the print processor 514 is able to uniquely establish the appropriate print pulse for each individual dot.

The final factor used in controlling print quality in thermal stress is preheating the print head 340. The resistance of the print head 340 to variations in the ambient temperature can be accomplished through the use of self-regulating thermistor heaters 526 which are mounted to the print head heat sink and spaced so as to provide even heat distribution. The print processor 514 receives signals from thermistor 524 indicating the substrate temperature of the print head 340, and, in turn, generates signals to the thermistor heaters 526 in an attempt to maintain the print head 340 at a constant optimal temperature. As a result, print head 340 is physically preheated to a constant background temperature, which allows the invention to operate in a more stable overall environment.

The system for controlling the various mechanical elements of cleaning unit 132 and printing unit 130 will now be described. As a card is introduced to cleaning unit 132 from a previous station such as the magnetic stripping station 20, photocell sensor P_1 reports the entry of the card to timing and control processor 512, which, in turn, informs system controller 30 via interface 508, cable 506, the graphics interface CPU 504 and communications bus 500. Timing and control processor 512 then instructs stepper motor M_1 to turn first and second feed rollers 194, 196 in order to feed the card through the first and second cleaning rollers 220, 222, which are rotated in synchronization with rollers 194, 196 in a manner described above. At this time, timing and control processor 512 and system

controller 30 monitor the status of photocell sensor P_4 to verify that cleaning turret body 202 is in its home position. As the card is advanced through the cleaning station, timing and control processor 512 continues to monitor the status of photocell sensor P_1. If timing and control processor 512 determines that P_1 remains blocked for too long a time given the rotation of feed rollers 194, 196, the timing and control processor 512 will determine that the passage of the card has been blocked, which is a fatal error. In the case of a fatal error, timing and control processor 512 reports back to system controller 30, which ceases operation of the entire card producing system 10.

As the card continues to advance through the cleaning station, photocell sensor P_2 is monitored by timing and control processor 512, which instructs stepper motor M_1 to advance the card to an initial printing position responsive to signals received from P_2. At the time photocell sensor P_2 is no longer blocked by the card, timing and control processor 512 records passage of the card through the cleaning station. Timing and control processor 512 keeps count of the number of cards which have passed through the cleaning system since the occurrence of the last cleaning sequence. The cleaning event is triggered by the processed card count and this is estimated to be between 20 and 1000 cards, depending upon the anticipated cleanliness of the cards. At the time the processed card count reaches its predetermined limit, timing and control processor 512 instructs stepper motor M_2 to rotate the cleaning turret 202 by 30 degrees in a counterclockwise direction as viewed from the top of the turret body 202. Figure 9 depicts turret body 202 in this position. This places the cleaning roller 222 in position to be cleaned by the stripper tape. At this time, the stepper motor M_1 is instructed to reverse in direction by timing and control processor 512 to run for

a 720 degree rotation. This action drives the stripper tape past the cleaning roller 222 and removes particulate matter from cleaning roller 222. After this is completed, stepper motor M_2 is instructed by timing and control processor 512 to drive the turret body 202 330 degrees in the counterclockwise direction, which returns the turret body 202 to its home position. Timing and control processor 512 further monitors photocell sensor P_4 to verify that turret body 202 has indeed returned to the home position. At this time, timing and control processor 512 instructs stepper motor M_1 to feed another card through the cleaning rollers 220, 222. After this next card has been passed through photocell sensor P_2, timing and control processor 512 instructs stepper M_2 to rotate turret body 202 150 degrees in the clockwise direction, which places cleaning roller 220 in a position to have particulate matter removed therefrom. Timing and control processor 512 then instructs stepper motor M_1 to reverse direction and run for a 720 degree rotation, which drives the stripper tape past first cleaning roller 220. After this is completed, timing and control processor 512 causes stepper motor M_2 to rotate the turret 150 degrees in a counterclockwise direction, which returns turret body 202 to its home position. When timing and control processor 512 learns through photocell sensor P_4 that turret body 202 has returned to the home position, stepper motor M_1 is then instructed to drive a new series cards through cleaning rollers 220, 222.

As a card is moved into printing position, timing and control processor 512 checks photocell sensor P_{10} to verify that printing foil is available. If printing sensor P_{10} indicates that printing foil has been exhausted, timing and control processor reports back to system controller 30, which ceases operation of the entire card producing system 10 until which time timing and control processor 512 reports that the supply of

printing foil has replenished.

Assuming sensor P_{10} indicates that printing foil is available, timing and control processor 512 instructs stepper motor M_3 to rotate cam shaft 182 in the manner described above, to cause the thermal print head and printing line 374 to be biased against printing roller 135 by the compression type compression spring 166 and plunger 154. At this time, timing and control processor 512 monitors the cam shaft position photocell sensor P_8 to verify that cam shaft 182 has indeed moved off of its home position. Timing and control processor 512 then instructs stepper motor M_4 to drive the first and second foil printer spindles 144, 146 and the printer roller 135. At this time, timing and control processor 512 instructs print process 514 to begin the print algorithm in the manner described above. Timing and control processor 512 simultaneously monitors the movement sensor P_6 which is connected to first foil drive spindle 144 in order to verify that printing foil is indeed being fed. If motion sensor P_6 indicates that the first printer foil spindle 144 is not, in fact, moving during the printing process, timing and control processor 512 instructs system controller 30 that a fatal error has occurred, and the entire card producing system 10 is shut down. Timing and control processor 512 further monitors the toggle position photocell sensor P_5 during the entire printing process to ensure that plunger 154 is properly engaged against the pivot plate 344. If sensor P_5 indicates that the toggle mechanism is not properly positioned, timing and control processor 512 reports this back to system controller 30 which shuts down operation of the entire card producing system until which time timing and control processor 512 indicates to system controller 30 that the toggle mechanism is properly positioned.

When printing is completed, timing and control processor 512 instructs stepper motor M_4 to advance an

additional 0.2 inches of printing foil to make sure that the printing foil separates from the card, and instructs stepper motor M_3 to advance cam shaft 182 to its home position. The cam shaft photosensor flag P_8 is monitored by timing and control processor 512 to verify that cam shaft 182 has indeed returned to its home position.

In addition, photosensor P_3 is monitored by timing and control processor 512 during the printing process to verify that it has been blocked by the card at the proper time during printing. If photocell sensor P_3 does not so indicate, timing and control processor 512 assumes that jamming has occurred, and reports a fatal error back to the system controller 30, which shuts down operation of the entire card producing system 10. After printing the card, the timing and control processor 512 instructs M_2 to drive the card from the printer roller 135 through second print feed roller pair 138. As the card clears P_3, the processor notifies system controller 30 that processing of the card has been completed.

It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

WHAT IS CLAIMED IS:

1. An apparatus for printing a graphic design on a hard plastic workpiece, comprising:

means for feeding the workpiece along a work feed path;

means positionable adjacent the work feed path for printing a pattern on the workpiece;

means for precisely aligning said printing means with respect to said feeding means so that said printing means is adapted to bear against the workpiece at a constant pressure; and

means for controlling said feeding means and said printing means to print a predetermined design on the workpiece.

2. Apparatus according to claim 1, wherein said feeding means comprises a first pair of printer feed rollers; a second pair of printer feed rollers aligned with said first pair of printer feed rollers along the work feed path; and means for driving said first and second pairs of printer feed rollers.

3. Apparatus according to claim 2, wherein said feeding means further comprises printer backup guide means positioned opposite the work feed path from said printing means for supporting the workpiece against deflection resulting from contact with said printing means.

4. Apparatus according to claim 3, wherein said backup guide means comprises a driven print roller having a resilient outer surface.

5. Apparatus according to claim 2, wherein said feeding means further comprises means secured to said printing means for supporting and guiding a lower edge

of the workpiece.

6. Apparatus according to claim 2, wherein said driving means comprises a stepper motor having a timing pulley connected thereto, additional timing pulleys connected to one roller of each of said first and second printer feed roller pairs, respectively, and a timing belt operatively connecting said three pulleys.

7. Apparatus according to claim 2, wherein said feeding means further comprises means for guiding a top edge of the workpiece along the work feed path.

8. Apparatus according to claim 7, wherein said feeding means further comprises means for guiding a bottom edge of the workpiece along the work feed path.

9. Apparatus according to claim 8, wherein said feeding means further comprises means for biasing said top edge guide means downwardly, whereby the workpiece is securely positioned between the top edge guide means and bottom edge guide means.

10. Apparatus according to claim 2, wherein said feeding means further comprises means for biasing said printer feed rollers of each of said printer feed roller pairs toward each other, respectively.

11. Apparatus according to claim 1, wherein said printing means comprises a resistance-type thermal printer.

12. Apparatus according to claim 11, wherein said thermal printer comprises a print head element positionable adjacent the work feed path and having a thermal print line thereon facing the work feed path; and means for feeding a thermal printing foil between

said thermal print line and the work feed path.

13. Apparatus according to claim 12, wherein said thermal printing foil has a first carrier layer, a backing layer on said carrier layer for contacting said thermal print line and a pigmentation layer on the side of said carrier layer opposite said backing layer.

14. Apparatus according to claim 13, wherein said carrier layer is formed of polyester.

15. Apparatus according to claim 13, wherein said carrier layer is formed of polyethylene terephalate.

16. Apparatus according to claim 13, wherein said backing layer is formed of cross-linked silicone.

17. Apparatus according to claim 13, wherein said pigmentation layer includes a thermal transfer ink of the type which reacts exothermically to heat applied by said thermal print line, whereby printing may be effected without melting any portion of said printing foil.

18. Apparatus according to claim 12, wherein said thermal print line has a multiplicity of resistive elements therein which are selectively actuatable by said controlling means to print a predetermined design on the workpiece.

19. Apparatus according to claim 12, wherein said feeding means comprises means for supplying said thermal printing foil; means for storing said foil after use; and means for guiding said foil from said supplying means to a path between said thermal print line and the work feed path and into said storing means.

20. Apparatus according to claim 19, wherein said feeding means further comprises cassette means for housing said supplying means and said storing means.

21. Apparatus according to claim 20, wherein said supplying means comprises a first capstan on said cassette means about which unused printing foil is wound and said storing means comprises a second capstan on said cassette means about which used printing foil is wound.

22. Apparatus according to claim 21, wherein said guide means comprises idler means on said cassette means for guiding said foil along the path between said thermal print line and the work feed path.

23. Apparatus according to claim 22, wherein said idler means comprises a pair of idler guides, said idler guides being positioned on opposite sides of said print head element.

24. Apparatus according to claim 21, wherein said guide means includes means for guiding used printer foil into said second capstan.

25. Apparatus according to claim 23, wherein said guide means includes means for guiding used printer foil from one of said idler guides into said second capstan.

26. Apparatus according to claim 25, wherein said means for driving used printer foil comprises a pair of driven guide rollers.

27. Apparatus according to claim 26, wherein said feeding means further comprises means for turning both said second capstan and said driven guide rollers in a timed relationship.

28. Apparatus according to claim 27, wherein said workpiece feeding means includes a backup roller positioned opposite the work feed path from said printing means, and said turning means further is for turning said backup roller in timed relationship to said driven guide rollers and said second capstan.

29. Apparatus according to claim 21, wherein said supplying means further comprises separate means for engaging said first and second capstans so as to be rotatably fixed with respect thereto.

30. Apparatus according to claim 29, wherein said supplying means further comprises friction clutch means for frictionally retarding rotation of said first capstan, whereby tension is maintained in said printing foil during feeding.

31. Apparatus according to claim 20, wherein said cassette means includes means for indicating the type of printer foil contained therein, whereby a proper energy level may be provided to the printing means.

32. Apparatus according to claim 31, wherein said cassette means includes a hard plastic casing, and said indicating means comprises tabs formed on said casing which may be broken off to indicate the type of printer foil.

33. Apparatus according to claim 32, wherein there are three of said tabs.

34. Apparatus according to claim 31, wherein said controlling means includes means for determining the status of said indicating means.

35. Apparatus according to claim 11, wherein said thermal printer comprises a print head element which is positionable adjacent the work feed path and has a thermal print line thereon, and further comprising frame means for supporting said feeding means, said printing means and said aligning means.

36. Apparatus according to claim 35, wherein said aligning means comprises a support block; a pivot plate; means for pivotally mounting said pivot plate to said frame means; means for pivotally connecting said support block and pivot plate; and means for securing said print head element to said support block.

37. Apparatus according to claim 36, wherein said securing means comprises a rigid backing block, means for fastening said backing block to said support block, means for fastening said backing block to said print head element and means on said backing block for prestressing said print head element so that thermal print line is as flat as possible.

38. Apparatus according to claim 37, wherein said means for fastening said backing block to said support block comprises a hand-manipulable thumbscrew.

39. Apparatus according to claim 37, wherein said means for fastening said backing block to said print head element comprises a plurality of mounting screws.

40. Apparatus according to claim 37, wherein said prestressing means comprises at least one compressive-type jackscrew for urging said print head away from said backing block at selected points.

41. Apparatus according to claim 37, wherein said prestressing means comprises at least one tension-type jackscrew for urging said print head toward said backing block at selected points.

42. Apparatus according to claim 36, wherein said aligning means further comprises means for pivotally resiliently biasing said pivot plate away from the work feed path.

43. Apparatus according to claim 36, wherein said aligning means further comprises releasable means for biasing said pivot plate toward the work feed path.

44. Apparatus according to claim 43, wherein said releasable biasing means comprises a plunger rod means for releasably positioning said plunger rod proximate said pivot plate, and means for biasing said plunger rod against said pivot plate when said plunger rod is positioned proximate said pivot plate.

45. Apparatus according to claim 44, wherein said releasable positioning means comprises a toggle linkage connecting said plunger rod to said frame means, and handle means for selectively positioning said toggle linkage between a first released position and a second engaging position.

46. Apparatus according to claim 44, wherein said biasing means comprises a compression-type spring interposed between said plunger and said frame means.

47. Apparatus according to claim 12, wherein said aligning means comprises means for resiliently biasing said print head element toward the work feed path.

48. Apparatus according to claim 47, further comprising means for selectively urging said print head element away from the work feed path against said resilient biasing means responsive to said controlling means, whereby wear on said print head element is reduced.

49. Apparatus according to claim 48, wherein said urging means comprises at least one retractor rod; a cam shaft having at least one cam surface for contacting said retractor rod(s); and means for rotating said cam shaft responsive to said controlling means.

50. Apparatus according to claim 49, wherein said cam shaft rotating means comprises a stepper motor.

51. Apparatus according to claim 2, wherein said controlling means comprises first and second means for sensing the presence of a workpiece along the work feed path before and after said printing means.

52. Apparatus according to claim 51, wherein said controlling means further comprises means for operating said driving means responsive to a signal received from said first sensing means.

53. Apparatus according to claim 52, wherein said aligning means comprises means for selectively urging said printing means away from the work feed path, and said controlling means further comprises means for actuating said urging means responsive to said first sensing means, whereby said printing means may be caused to contact the workpiece once the workpiece has moved to a proper position.

54. Apparatus according to claim 53, wherein said controlling means further comprises means for

determining the position of said urging means, and means for discontinuing operation of the apparatus if said determining means indicates said urging means is in an improper position.

55. Apparatus according to claim 19, wherein said controlling means comprises means for sensing when said supplying means has been exhausted of foil; and means for discontinuing operation of the apparatus responsive to said sensing means.

56. Apparatus according to claim 55, wherein said controlling means further comprises means for resuming operation of the apparatus when said sensing means indicates said supplying means has been replenished.

57. Apparatus according to claim 21, wherein said controlling means includes means for sensing movement of said first capstan, and means for discontinuing operation of the apparatus if said sensor does not detect movement when said printing means is in operation.

58. Apparatus according to claim 1, wherein said controlling means comprises means for monitoring the temperature of said printing means, and means for discontinuing operation of the apparatus if said temperature exceeds a predetermined value.

59. Apparatus according to claim 43, wherein said controlling means comprises means for monitoring the position of said releasable biasing means, and means for discontinuing operation of the apparatus if said releasable biasing means is not in its biasing position.

60. A method of printing a graphic design on a hard plastic workpiece, comprising:

(a) feeding the workpiece along a work feed path to a position adjacent a resistance-type thermal printer;

(b) precisely aligning a printing surface of the thermal printer with the surface of the workpiece which is to be printed upon;

(c) controlling the printer to print on the desired workpiece surface while continuing to feed the workpiece past the printer; and

(d) moving the workpiece away from the printer.

61. A method according to claim 60, wherein step (a) is performed along a substantially linear work feed path.

62. A method according to claim 60, further comprising the step of detecting the presence of the workpiece prior to step (b) and wherein step (b) is performed responsive to the detection of the workpiece.

63. A method according to claim 60, wherein said aligning step further comprises:

mounting the thermal printer on a backing block; and selectively pulling or pushing predetermined portions of the backing block with respect to corresponding portions of the thermal printer, whereby irregularities in the printing surface of the thermal printer are corrected for.

64. A method according to claim 60, wherein said aligning step further comprises:

releasably biasing the thermal printer toward the workpiece.

65. A method according to claim 64, wherein said aligning step further comprises the step of selectively urging the thermal printer away from the work feed path.

66. A method according to claim 65, further comprising the step of detecting the presence of the workpiece prior to step (b); and performing said urging step responsive to said detecting step.

67. A method according to claim 63, wherein said aligning step further comprises:

releasably biasing the thermal printer toward the workpiece.

68. A method according to claim 67, wherein said aligning step further comprises the step of selectively urging the thermal printer away from the work feed path.

69. A method according to claim 68, further comprising the step of detecting the presence of the workpiece prior to step (b); and performing said urging step responsive to said detecting step.

70. A method according to claim 65, wherein said urging step is performed by a cam arrangement, and further comprising the steps of:

monitoring the position of the cam arrangement; and

discontinuing performance of the method if the cam arrangement is in an improper position.

71. A method according to claim 60, wherein the thermal printer includes a supply of printing foil, further comprising the steps of:

monitoring the thermal printer foil supply; and

discontinuing performance of the method if the supply is exhausted.

72. A method according to claim 71, including the additional steps of:

continuing to monitor the thermal printer foil supply after performance of the method has been discontinued; and

resuming performance of the method if said continued monitoring indicates replenishment of the foil supply.

73. A method according to claim 60, wherein the thermal printer includes a first reel and capstan for supplying thermal printing foil, and a second reel and capstan for storing used thermal printing foil, further comprising the steps of:

sensing whether the first capstan is moving during said printing step; and

discontinuing performance of the method if the capstan is not moving.

74. A method according to claim 60, further comprising the steps of:

monitoring the temperature of the thermal printer during the printing step; and

discontinuing performance of the method of the monitored temperature exceeds a predetermined value.

75. A method according to claim 64, wherein said biasing step is performed by a spring-biased releasable plunger, further comprising the steps of:

monitoring the position of the plunger; and

discontinuing performance of the method if the plunger is in a released position.

76. A cartridge assembly for dispensing a thermal printing foil or the like, comprising:

an outer casing having an inside and outside

surface;

first capstan means adapted for storing unused printing foil;

second capstan means adapted for storing used printing foil;

means for rotatably supporting said first and second capstan means within said outer casing; and

means adapted for guiding printing foil from said first capstan means to a guide path lying within a printing plane and adapted for guiding the foil from the printing plane path, to said second capstan means.

77. Apparatus according to claim 76, wherein said outer casing is formed of hard styrene.

78. Apparatus according to claim 76, wherein said first and second capstan means each comprise a hollow cylindrically-shaped member having an outer surface and an inner surface, said inner surface having means thereon adapted for engaging a separate spool member.

79. Apparatus according to claim 78, wherein said engaging means comprises at least one inwardly protruding member which extends toward the central axis of said cylindrically-shaped member.

80. Apparatus according to claim 79, wherein said inwardly protruding member is formed as a rib extending axially along the length of said inner surface.

81. Apparatus according to claim 78, wherein said supporting means comprises a pair of circular seating surfaces defined in said surface of said casing for rotatably supporting each of said first and second capstan means.

82. Apparatus according to claim 76, wherein said guiding means comprises a first guide post and a second guide post rotatably supported by said outer casing, said first and second posts being positioned so that the guide path is tangent to each of said rollers.

83. Apparatus according to claim 82, wherein said guiding means further comprises a guide post adapted for guiding the foil from said first capstan means to said first guide post.

84. Apparatus according to claim 82, wherein said guiding means further comprises a fourth guide post adapted for guiding the foil from said second guide post to said second capstan means.

85. Apparatus according to claim 78, wherein the axes of said cylindrically-shaped members are approximately three and one-half inches apart.

86. A cartridge assembly for use with a thermal printer or the like, comprising:

an outer casing having an inside and an outside surface;

a length of thermal printing foil disposed substantially within said casing;

first capstan means for storing an unused portion of said printing foil;

second capstan means for storing a used portion of said printing foil;

means for rotatably supporting said first and second capstan means within said outer casing; and

means for guiding said printing foil from said first capstan means to a guide path lying within a printing plane and for guiding the foil from the printing plane path to said second capstan means.

87. Apparatus according to claim 86, wherein said thermal printing foil has a first carrier layer, a backing layer on said carrier layer adapted for contacting a thermal print element and a pigmentation layer on the side of said carrier layer opposite said backing layer.

88. Apparatus according to claim 87, wherein said carrier layer is formed of polyester.

89. Apparatus according to claim 87, wherein said carrier layer is formed of polyethylene terephalate.

90. Apparatus according to claim 87, wherein said backing layer is formed of cross-linked silicone.

91. Apparatus according to claim 87, wherein said pigmentation layer includes a thermal transfer ink of the type which reacts exothermically to heat applied by said thermal print line, whereby printing may be effected without melting any portion of said printing foil.

92. Apparatus according to claim 86, wherein said outer casing is formed of hard styrene.

93. Apparatus according to claim 86, wherein said first and second capstan means each comprise a hollow cylindrically-shaped member having an outer surface and an inner surface, said inner surface having means thereon adapted for engaging a spool member.

94. Apparatus according to claim 93, wherein said engaging means comprises at least one inwardly protruding member which extends toward the central axis of said cylindrically-shaped member.

95. Apparatus according to claim 94, wherein said inwardly protruding member is formed as a rib extending axially along the length of said inner surface.

96. Apparatus according to claim 93, wherein said supporting means comprises a pair of circular seating surfaces defined in said inside surface of said casing for rotatably supporting each of said first and second capstan means.

97. Apparatus according to claim 86, wherein said guiding means comprises a first guide post and a second guide post rotatably supported by said outer casing, said first and second guide posts being positioned so that the guide path is tangent to each of said rolls.

98. Apparatus according to claim 97, wherein said guiding means further comprises a third guide post adapted for guiding the foil from said first capstan means to said first idler roll.

99. Apparatus according to claim 97, wherein said guiding means further comprises a fourth guide post adapted for guiding the foil from said second guide post to said second capstan means.

100. Apparatus according to claim 93, wherein the axes of said cylindrically-shaped members are approximately three and one-half inches apart.

101. An apparatus for removing loose particles from at least one surface of a workpiece, comprising:

cleaning means having at least one engaging surface adapted for engaging the surfaces of the workpiece to be cleaned;

means on said engaging surface for attracting loose particles from the corresponding surface of the

workpiece to be cleaned;

means adapted for feeding a workpiece to said cleaning means; and

means for removing collected particles from said cleaning means.

102. Apparatus according to claim 101, wherein said cleaning means comprises at least one cleaning roller having an outer surface for engaging the surfaces of the workpiece to be cleaned.

103. Apparatus according to claim 102, wherein said cleaning means comprises two of said cleaning rollers.

104. Apparatus according to claim 103, wherein said two cleaning rollers are opposed so as to engage opposite surfaces of the workpiece.

105. Apparatus according to claim 102, further comprising means for driving said cleaning roller(s), thereby aiding propulsion of the workpiece.

106. Apparatus according to claim 105, wherein said driving means drives said cleaning rollers in timed relationship to said feeding means.

107. Apparatus according to claim 106, wherein said driving means is powered by said feeding means.

108. Apparatus according to claim 102, wherein said attracting means comprises an adhesive layer formed on said outer surface.

109. Apparatus according to claim 102, wherein said roller(s) are formed of a resilient material.

110. Apparatus according to claim 109, wherein said resilient material is a butyl rubber having a shore durometer value of 25-30.

111. Apparatus according claim 101, wherein said feeding means comprises first and second work feed rollers; and means for turning said work feed rollers.

112. Apparatus according to claim 111, wherein said turning means comprises a stepper motor, means for connecting said stepper motor to said first work feed roller, and means for synchronizing said first and second work feed rollers.

113. Apparatus according to claim 112, wherein said synchronizing means comprises a first gear on said first work feed roller and a second gear on said second work feed roller which is meshed with said first gear.

114. Apparatus according to claim 101, further comprising means for controlling at least one of said cleaning means, said feeding and said particle removing means.

115. Apparatus according to claim 102, wherein said particle removing means comprises a stripping element having stripping means thereon for stripping particles from said cleaning roller(s), and means for selectively causing engagement between said cleaning roller(s) and said stripping means.

116. Apparatus according to claim 115, wherein said stripping element comprises a stripping tape having an adhesive surface thereon for stripping particles from said outer engaging surface of said cleaning roller(s).

117. Apparatus according to claim 116, wherein said attracting means comprises an adhesive layer formed on said outer surface, said adhesive surface being more adhesive than said adhesive layer.

118. Apparatus according to claim 116, wherein said stripping element further comprises first means for storing unused stripping tape and second means for storing used tape.

119. Apparatus according to claim 118, wherein said first and second means comprise, respectively, a first stripper tape spindle and second stripper tape spindle for rotatably supporting said unused stripping tape and said used stripping tape.

120. Apparatus according to claim 118, wherein said stripping element further comprises a stripper roller about which said stripping tape is wound between said first and second storing means.

121. Apparatus according to claim 120, wherein said means for selectively causing engagement between said cleaning roller(s) and stripping means comprises turret means for rotating said cleaning rollers about a central turret axis to at least one stripping position so that said roller(s) are engageable by said stripping tape at the point said stripping tape winds around said stripper roller.

122. Apparatus according to claim 121, wherein said turret means comprises a turret body, and reversible means for selectively rotating said turret body.

123. Apparatus according to claim 122, wherein said reversible means comprises a step motor and means for connecting said step motor to said turret body.

124. Apparatus according to claim 122, further comprising gear means on said turret body for engaging said feeding means for driving said cleaning rollers in timed relationship with said feeding means.

125. Apparatus according to claim 124, wherein said gear means is further for disengaging from said feeding means when said turret means is in one of said stripping positions.

126. Apparatus according to claim 120, wherein said stripping element further comprises stripper guide means for guiding said stripping tape from said first storing means to said stripper roller to said second storing means.

127. Apparatus according to claim 126, wherein said stripper guide means comprises a first stripper guide roller for guiding said stripper tape between said first storing means and said stripper roller; a second stripper guide roller for guiding said stripper tape between said stripper roller and said second storing means; and means for synchronizing said first and second stripper guide rollers.

128. Apparatus according to claim 127, wherein said synchronizing means is arranged so that said second stripper guide roller is to have a slightly higher surface tangential speed than said first stripper guide roller, whereby tension is maintained in said stripper tape around said stripper roller.

129. Apparatus according to claim 127, wherein the diameter of said second stripper guide roller is slightly greater than the diameter of said first stripper guide roller.

130. Apparatus according to claim 114, wherein said controlling means comprises means for detecting a workpiece prior to said cleaning means and for counting the number of workpieces passing through said detecting means.

131. Apparatus according to claim 122, further comprising means for controlling said cleaning means, said feeding means and said particle removing means.

132. Apparatus according to claim 131, wherein said controlling means comprises means for detecting a workpiece prior to said cleaning rollers and for counting the number of workpieces passing through said detecting means.

133. Apparatus according to claim 132, wherein said controlling means is further for rotating said turret body from a cleaning position to a first position to cause a first cleaning roller to engage said stripper tape when a predetermined number of workpieces have passed through said detecting means.

134. Apparatus according to claim 133, wherein said controlling means is further for returning said turret body to said cleaning position after said first cleaning roller engages said stripper tape, and for turning said turret body to a second position to cause a second cleaning roller to engage said stripper tape when a second predetermined number of workpieces have been counted by said detecting means.

135. Apparatus according to claim 134, wherein said controlling means includes means for sensing motion of said first storing means and means for discontinuing operation of the apparatus if no motion is sensed while

one of said cleaning rollers is in contact with the stripper tape.

136. Apparatus according to claim 131, wherein said controlling means comprises means for monitoring the position of said turret body.

137. A method for removing loose particles from at least one surface of a workpiece at a cleaning station, comprising:

(a) detecting the presence of a workpiece before the workpiece reaches the cleaning station;

(b) feeding the workpiece into the cleaning station;

(c) engaging the surfaces of the workpiece to be cleaned with a corresponding number of particle attracting elements;

(d) removing the workpiece from the cleaning station;

(e) determining the total number of workpieces that have been cleaned responsive to detecting step; and

(f) removing particles that have collected on the particle attracting elements whenever the total number of workpieces cleaned exceeds a predetermined number.

138. A method according to claim 137, wherein the particle attracting elements comprise a pair of adhesive cleaning rollers mounted on a turret which is constructed to rotate about a central axis, and wherein step (c) is performed by passing the workpiece between the adhesive cleaning rollers.

139. A method according to claim 138, wherein the particle removing step is performed by an adhesive stripping tape having a stripping surface that is more adhesive than the surface of the cleaning rollers, and

the particle removing step comprises engaging the surface of a first cleaning roller with the stripping surface.

140. A method according to claim 139, wherein said engaging is effected by rotating the turret about the central axis.

141. A method according to claim 140, wherein the turret is rotated approximately thirty degrees in a counterclockwise direction from a cleaning position to a first stripping position to effect said engaging.

142. A method according to claim 141, wherein said particle removing step further comprises returning the turret to its cleaning position.

143. A method according to claim 142, wherein said particle removing step further comprises rotating the turret approximately one hundred and fifty degrees in a clockwise direction to a second stripping position so that a second cleaning roller engages the stripping tape.

144. A method according to claim 143, wherein said particle removing step further comprises returning the turret to its cleaning position.

145. A system for producing magnetically encoded plastic cards having a graphic design thereon, comprising:

means for supplying a series of blank plastic cards;

means for encoding a magnetic strip on the cards;

means for separating loose particles from the cards;

means for placing a graphic design on the cards;

means for embossing a number of alphanumeric characters on the cards; and

means for collecting the cards after the cards have passed through said installing means, said separating means, said design placing means and said embossing means.

146. A system according to claim 145, further comprising a central system controller means for controlling said installing means, said separating means, said design placing means and said embossing means.

147. A system according to claim 145, wherein said embossing means receives the cards after said design placing means.

148. A system according to claim 145, wherein said design placing means receives the cards after said separating means.

149. A method for producing magnetically encoded plastic cards having a graphic design thereon, comprising:

(a) supplying a series of blank plastic cards;

(b) encoding an encodable magnetic strip which is on the cards;

(c) separating loose particles from the cards;

(d) placing a graphic design on the cards;

(e) embossing a number of alphanumeric characters on the cards; and

(f) collecting the cards after the cards have been processed by steps (a) through (e).

150. A method according to claim 149, wherein said embossing step is performed after said design placing step.

151. A method according to claim 149, wherein said design placing step is performed after said separating step.

152. A system for producing encoded plastic cards having a graphic design thereon, comprising:

means for supplying a series of blank plastic cards;

means for separating loose particles from the cards;

means for placing a graphic design on the cards; and

means for collecting the cards after the cards have passed through said separating means and said design placing means.

153. A system for producing encoded plastic cards having a graphic design thereon, comprising:

means for supplying a series of blank plastic cards;

means for separating loose particles from the cards;

means for placing a graphic design on the cards;

means for controlling said separating means and said design placing means; and

means for collecting the cards after the cards have passed through said separating means and said design placing means.

154. Apparatus according to claim 153, wherein said design placing means comprises:

means for feeding each card along a work feed

path;

means positionable adjacent the work feed path for printing a pattern on the card;

means for precisely aligning said printing means with respect to said feeding means so that said printing means is adapted to bear against the workpiece at a constant pressure; and

said controlling means also for controlling said feeding means and said printing means to print a predetermined design on the workpiece.

155. Apparatus according to claim 153, wherein said separating means comprises:

cleaning means having at least one engaging surface adapted for engaging the surfaces of a card to be cleaned;

means on said engaging surface for attracting loose particles from the corresponding surface of the card to be cleaned;

means adapted for feeding a card from said supplying means to said cleaning means; and

means for removing collected particles from said cleaning means.

156. Apparatus according to claim 154, wherein said feeding means comprises a first pair of printer feed rollers; a second pair of printer feed rollers aligned with the said first pair of printer feed rollers along the work feed path; and means for driving said first and second pairs of printer feed rollers.

157. Apparatus according to claim 154, wherein said printing means comprises a resistance type thermal printer.

158. Apparatus according to claim 157, wherein said thermal printer comprises a print head element

positionable adjacent the work feed path and having a thermal print line thereon facing the work feed path; and means for feeding a thermal printing foil between said thermal print line and the work feed path.

159. Apparatus according to claim 158, wherein said thermal printing foil has a first carrier layer, a backing layer on said carrier layer for contacting said thermal print line and a pigmentation layer on the side of said carrier layer opposite said backing layer.

160. Apparatus according to claim 159, wherein said pigmentation layer includes a thermal transfer ink of the type which reacts exothermically to heat applied by said thermal print line, whereby printing may be effected without melting any portion of said printing foil.

161. Apparatus according to claim 158, wherein said thermal print line has a multiplicity of resistive elements therein which are selectively actuatable by said controlling means to print a predetermined design on the card.

162. Apparatus according to claim 158, wherein said feeding means comprises means for supplying said thermal printing foil; means for storing said foil after use; and means for guiding said foil from said supplying means to a path between said thermal print line and the work feed path and into said storing means.

163. Apparatus according to claim 162, wherein said feeding means further comprises cassette means for housing and supplying said supplying means and said storing means.

164. Apparatus according to claim 155, wherein said cleaning means comprises at least one cleaning roller having an outer surface for engaging the surfaces of the card to be cleaned.

165. Apparatus according to claim 164, further comprising means for driving said cleaning rollers, thereby aiding propulsion of the card.

166. Apparatus according to claim 164, wherein said particle removing means comprises a stripping element having stripping means thereon for stripping particles from said cleaning rollers, and means for selectively causing engagement between said cleaning rollers and said stripping means.

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FIG. 1

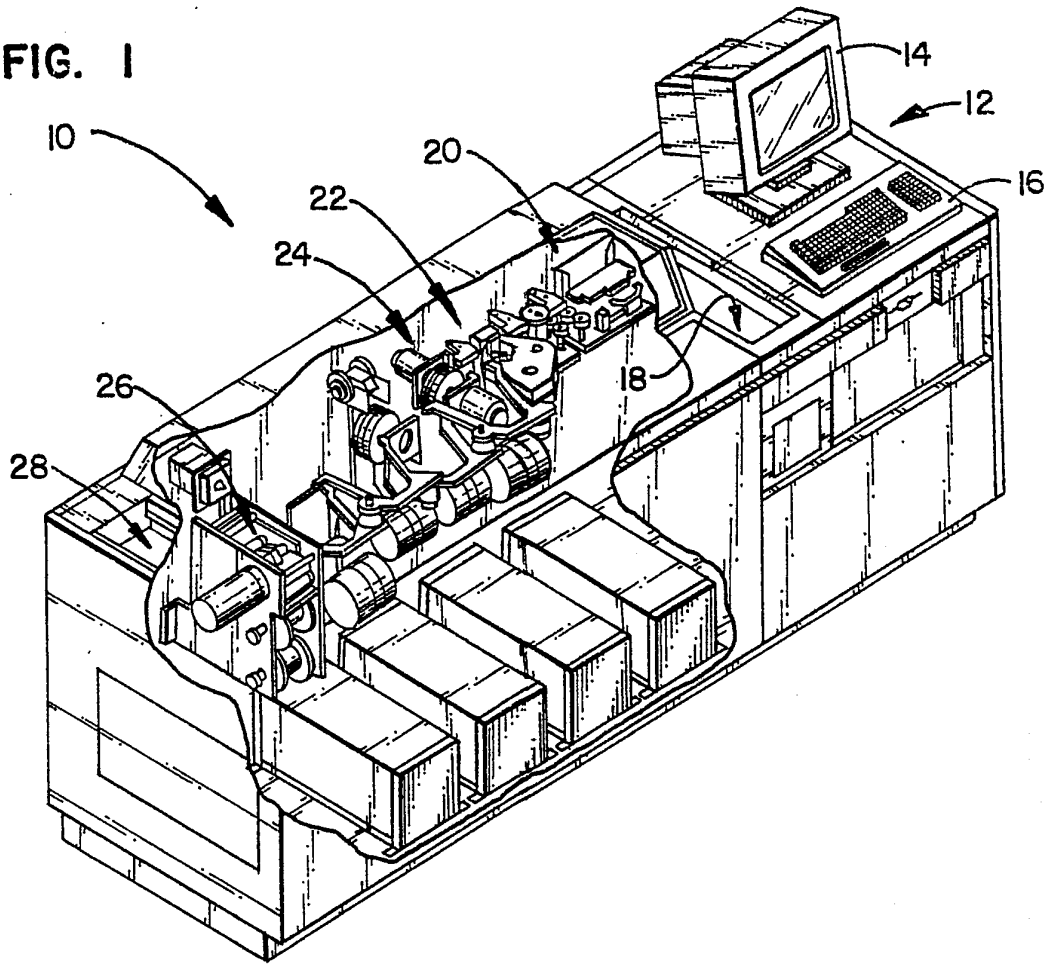
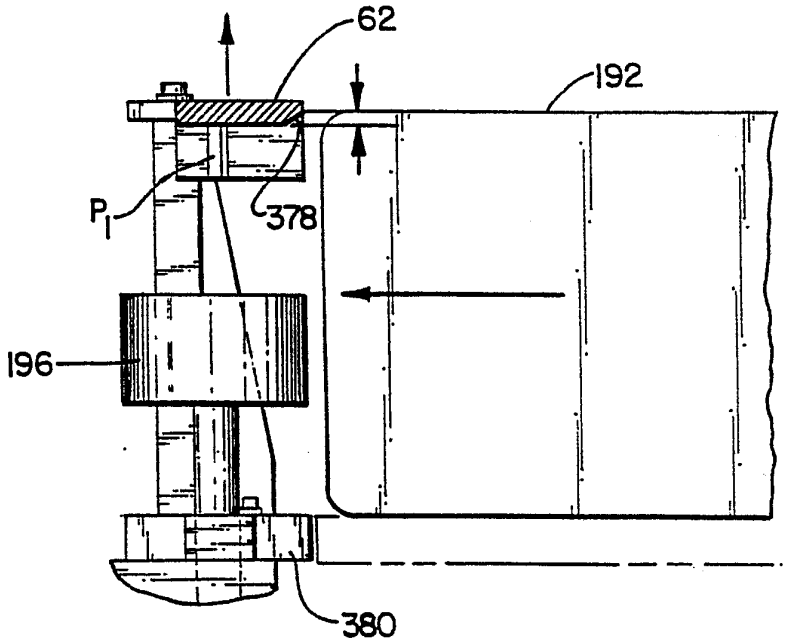


FIG. 8



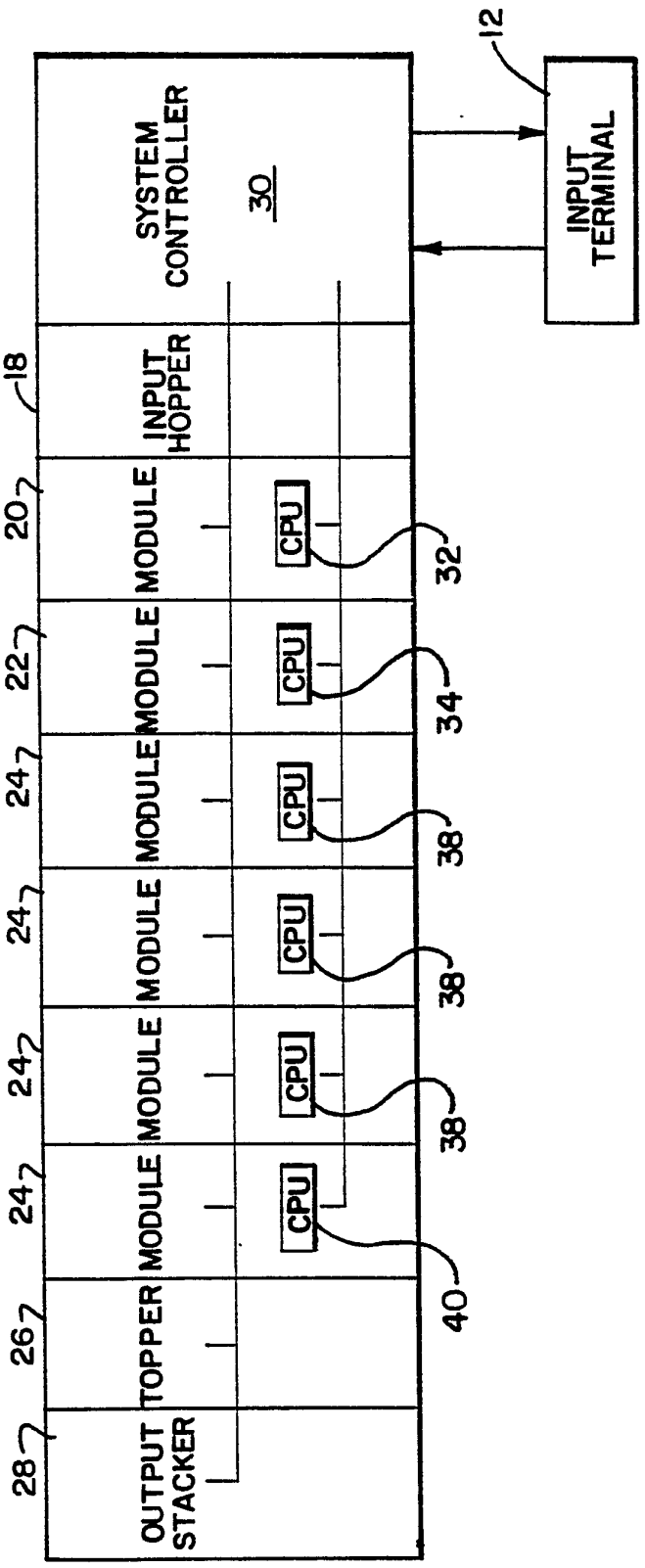

SYSTEM CONTROLLER
30
12
INPUT TERMINAL
18
INPUT HOPPER
20
MODULE
22
MODULE
24
MODULE
24
MODULE
24
MODULE
24
MODULE
26
TOPPER
28
OUTPUT STACKER
CPU
32
34
38
38
38
40

FIG. 2

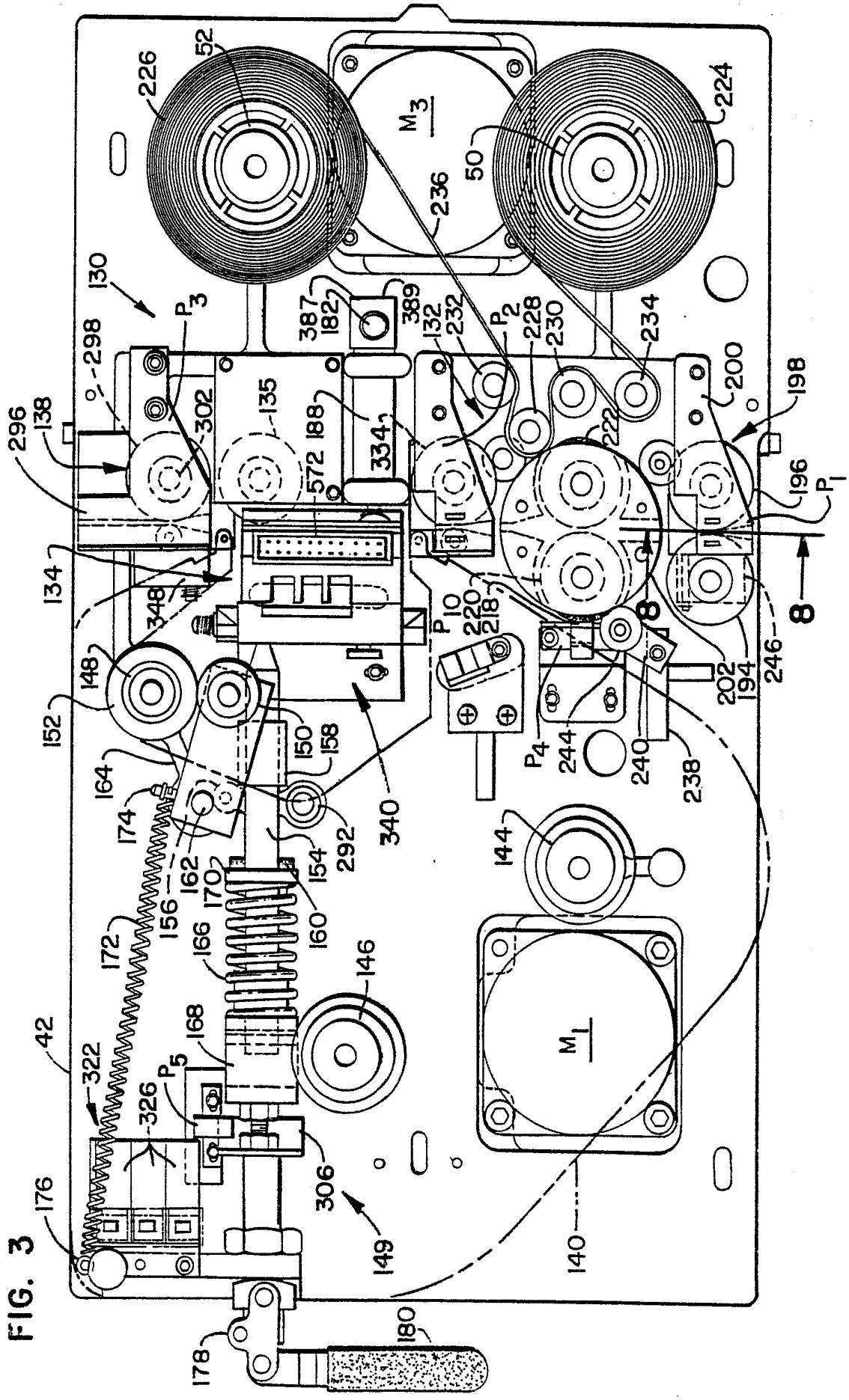

52
226
224
50
236
M_3
130
P_3
P_2
387
182
389
132
232
228
230
234
200
198
298
296
138
302
135
188
334
572
222
196
P_1
134
348
P_{10}
220
218
8
246
148
152
150
158
164
174
162
154
292
340
P_4
244
240
238
202
194
144
156
170
160
172
166
146
168
42
322
P_5
326
306
149
M_1
140
176
178
180

FIG. 3

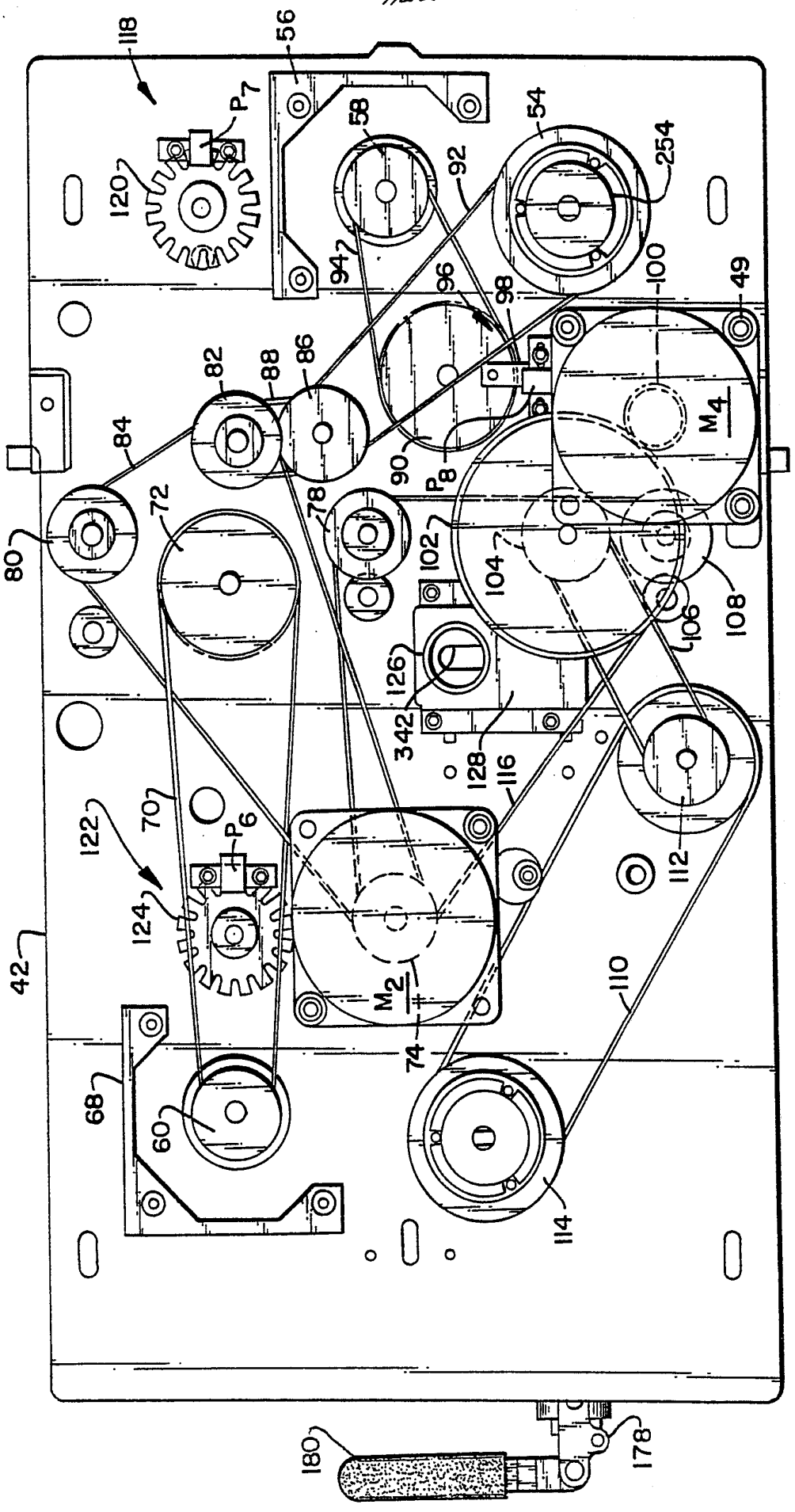

118
56
58
54
254
92
120
94
96
98
100
49
82
88
86
84
90
80
72
78
102
104
108
106
126
342
128
116
122
70
112
124
42
110
74
68
60
114
180
178
P_7
P_6
P_8
M_2
M_4

FIG. 4

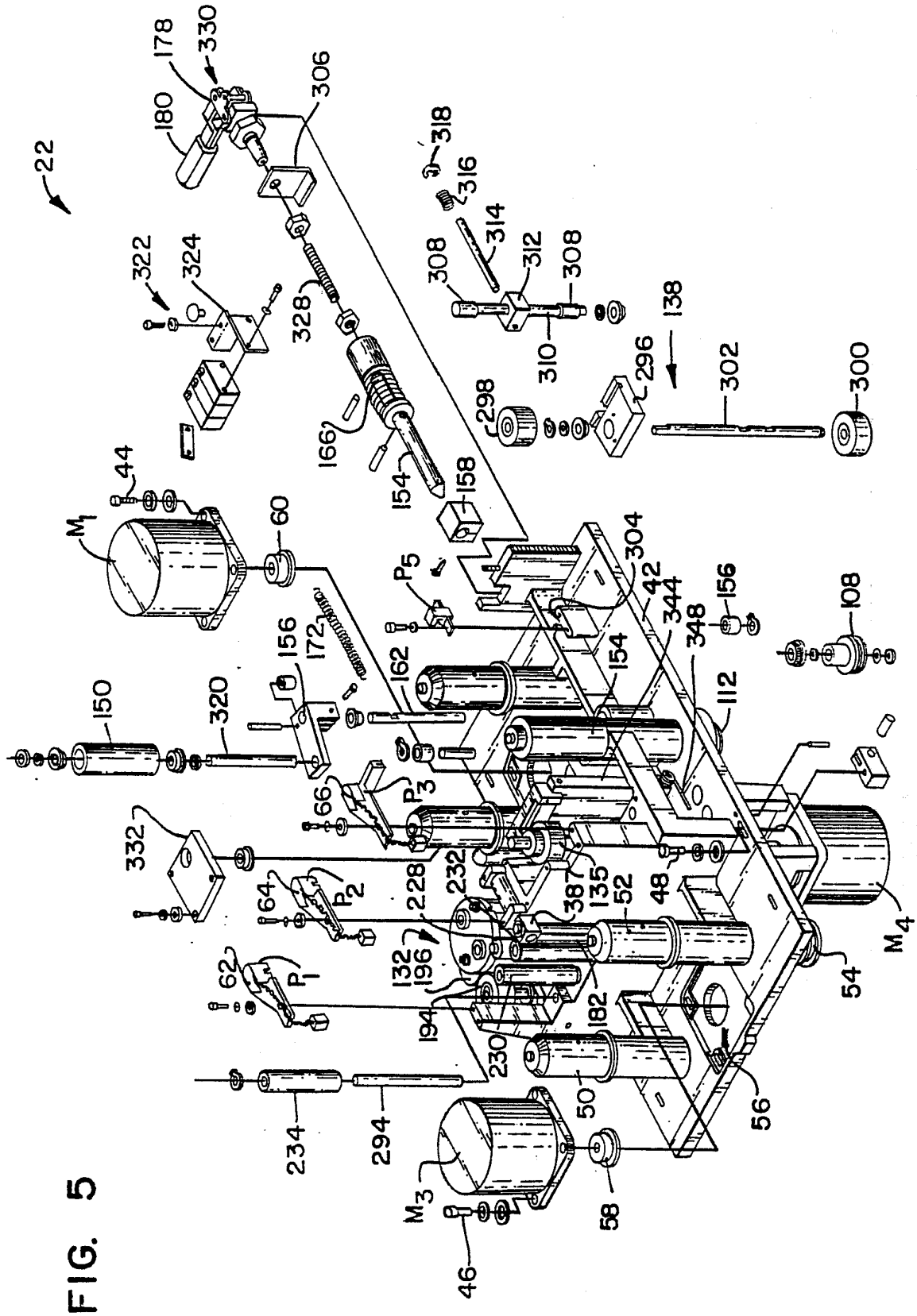

22
178
330
306
180
318
316
314
308
312
322
324
328
138
310
296
302
300
298
166
154
158
44
M1
60
304
P5
42
344
156
108
172
162
348
112
150
320
P3
66
332
232
228
P2
64
387
135
52
48
M4
132
196
62
P1
182
194
230
54
50
56
234
294
58
M3
46

FIG. 5

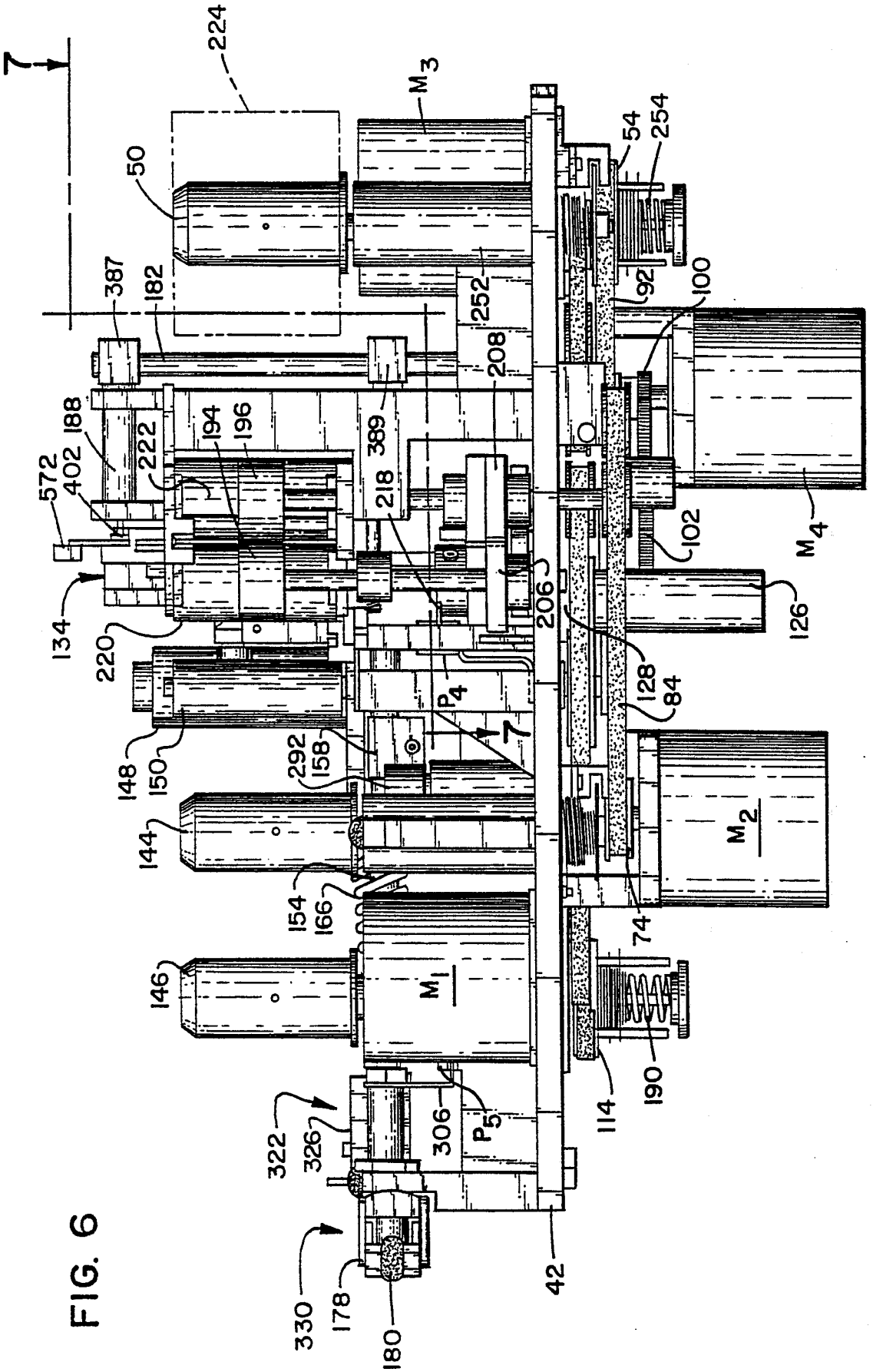

7
224
M3
50
54
254
387
182
252
92
100
208
188
222
194
196
389
218
572
402
206
102
M4
134
220
126
128
84
P4
148
150
292
158
144
M2
154
166
74
146
M1
190
114
322
326
306
P5
330
178
180
42

FIG. 6

FIG. 7

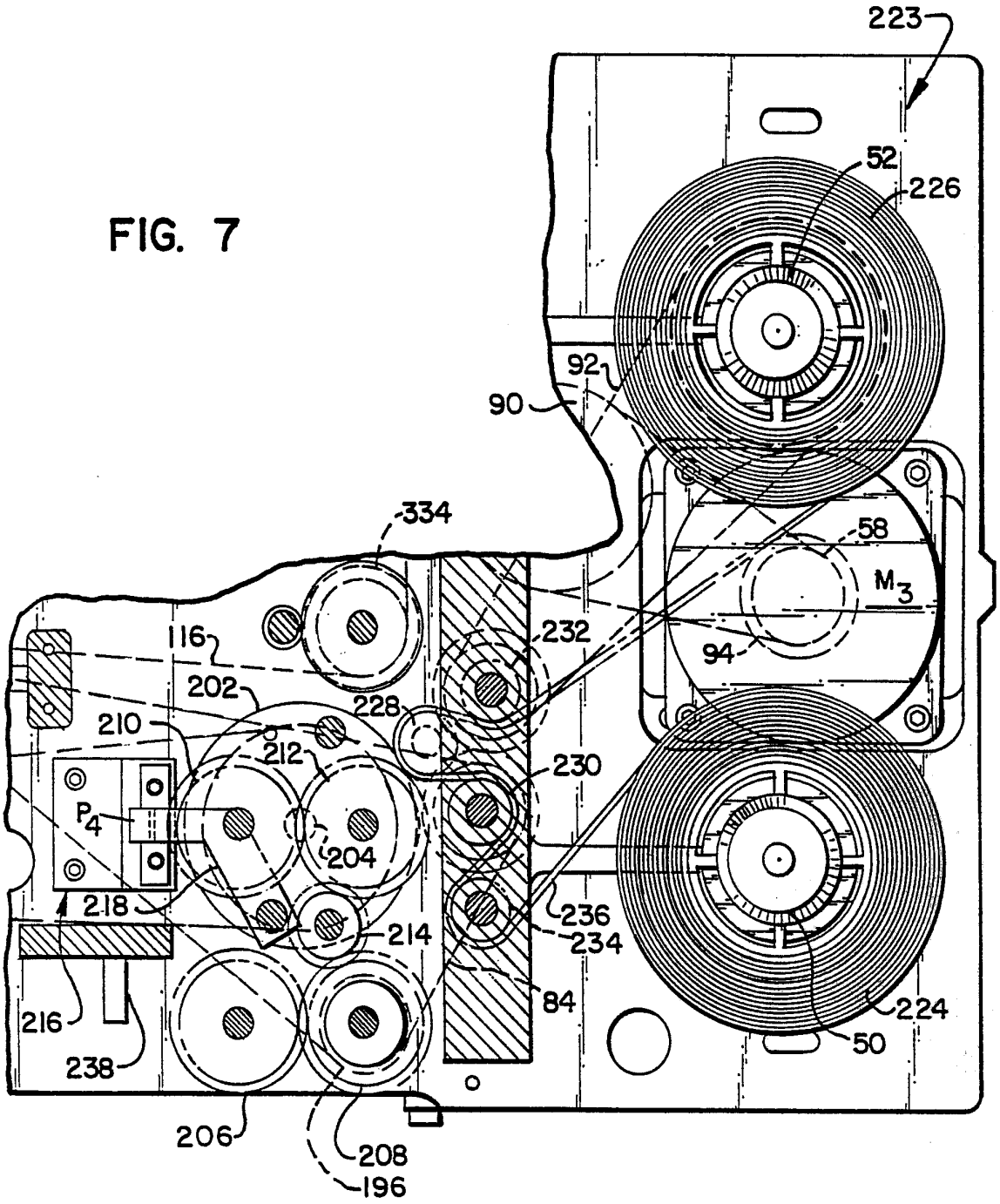
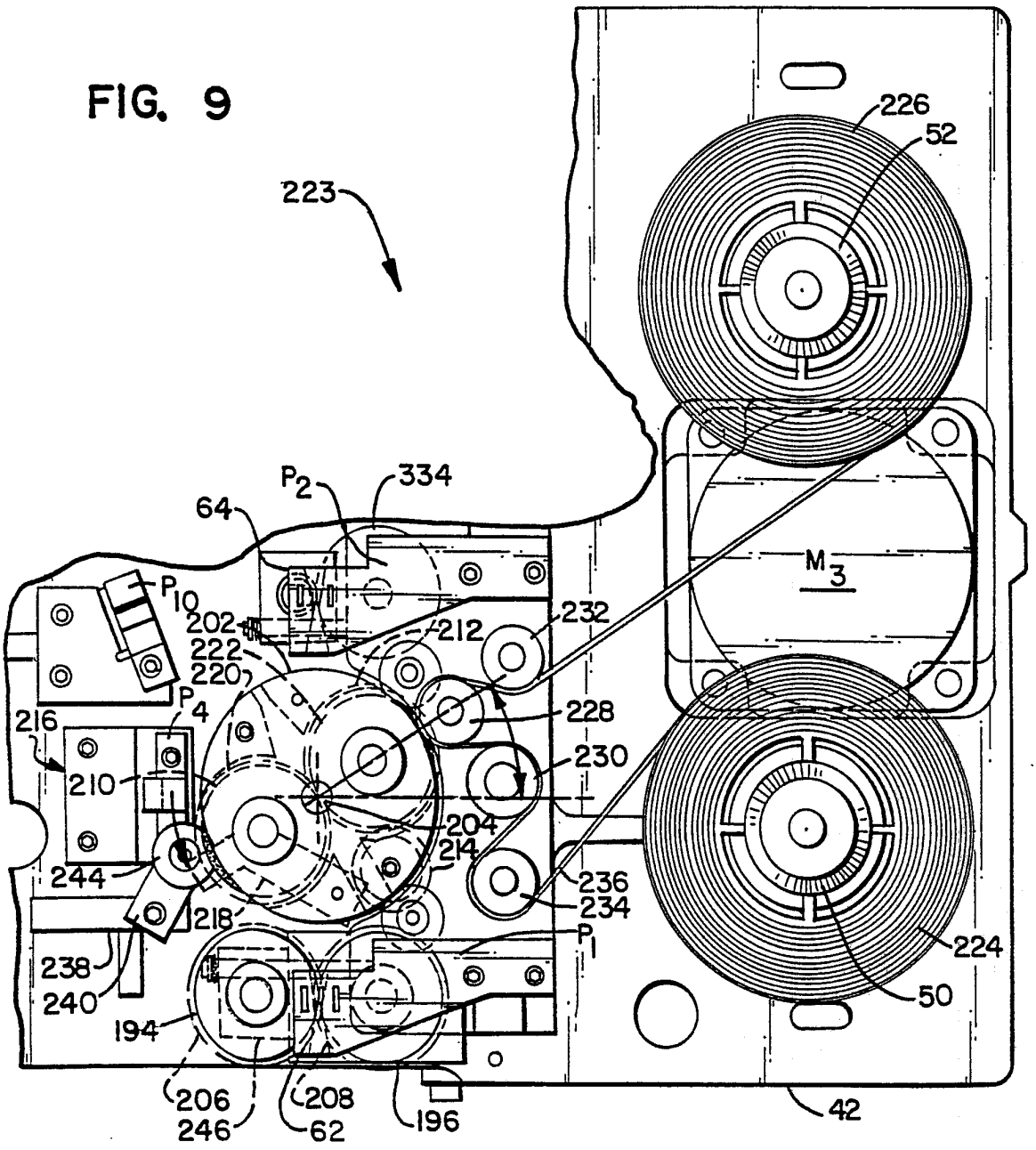

223
52
226
92
90
334
58
M3
232
94
116
202
228
210
212
230
P4
204
218
214
236
234
84
224
216
238
50
206
208
196

FIG. 9


223
226
52
M3
P2
334
64
P10
202
222
220
212
232
228
230
P4
216
210
204
214
244
218
236
234
P1
238
240
194
206
246
208
62
196
224
50
42

9/22

FIG. 10

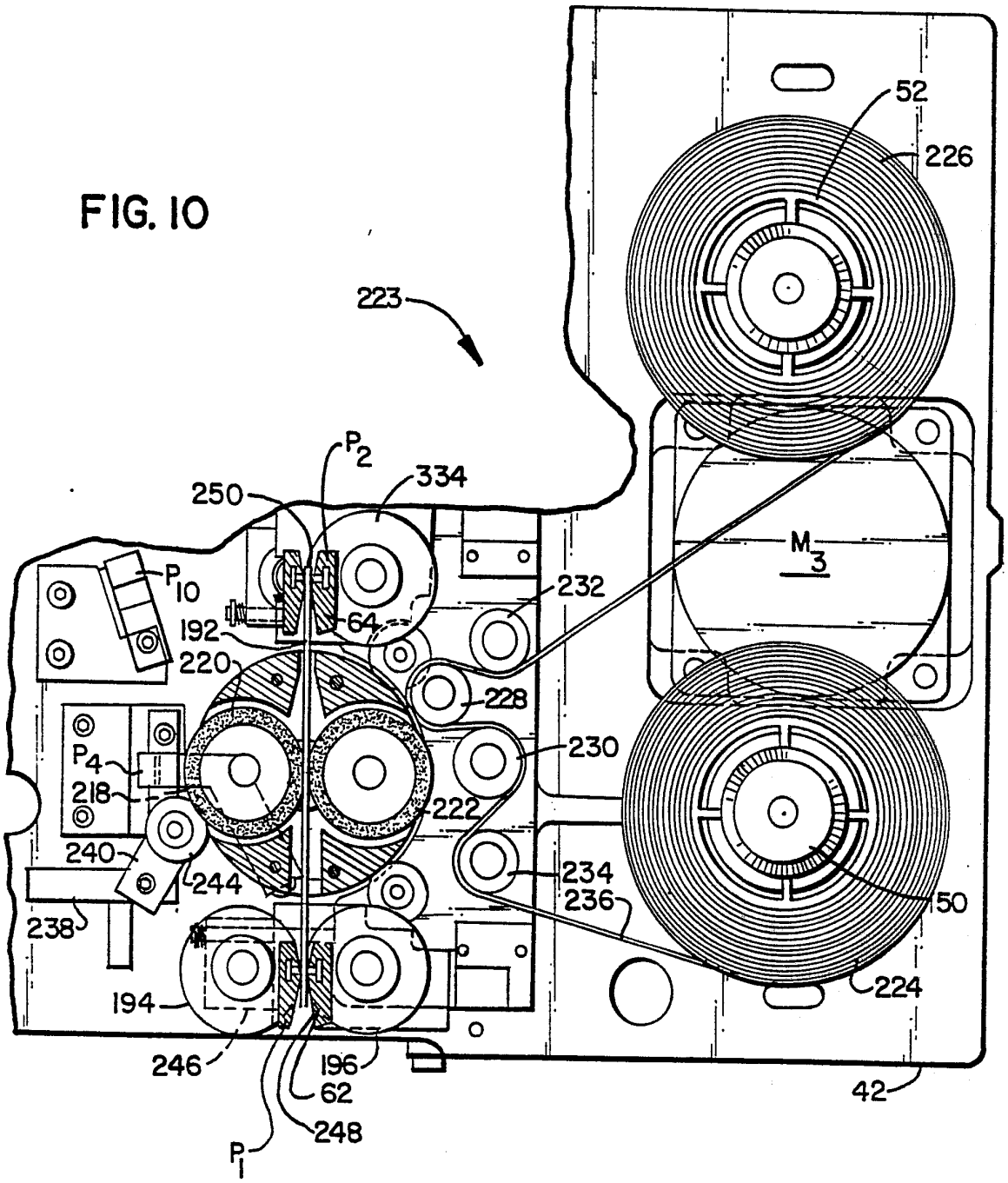
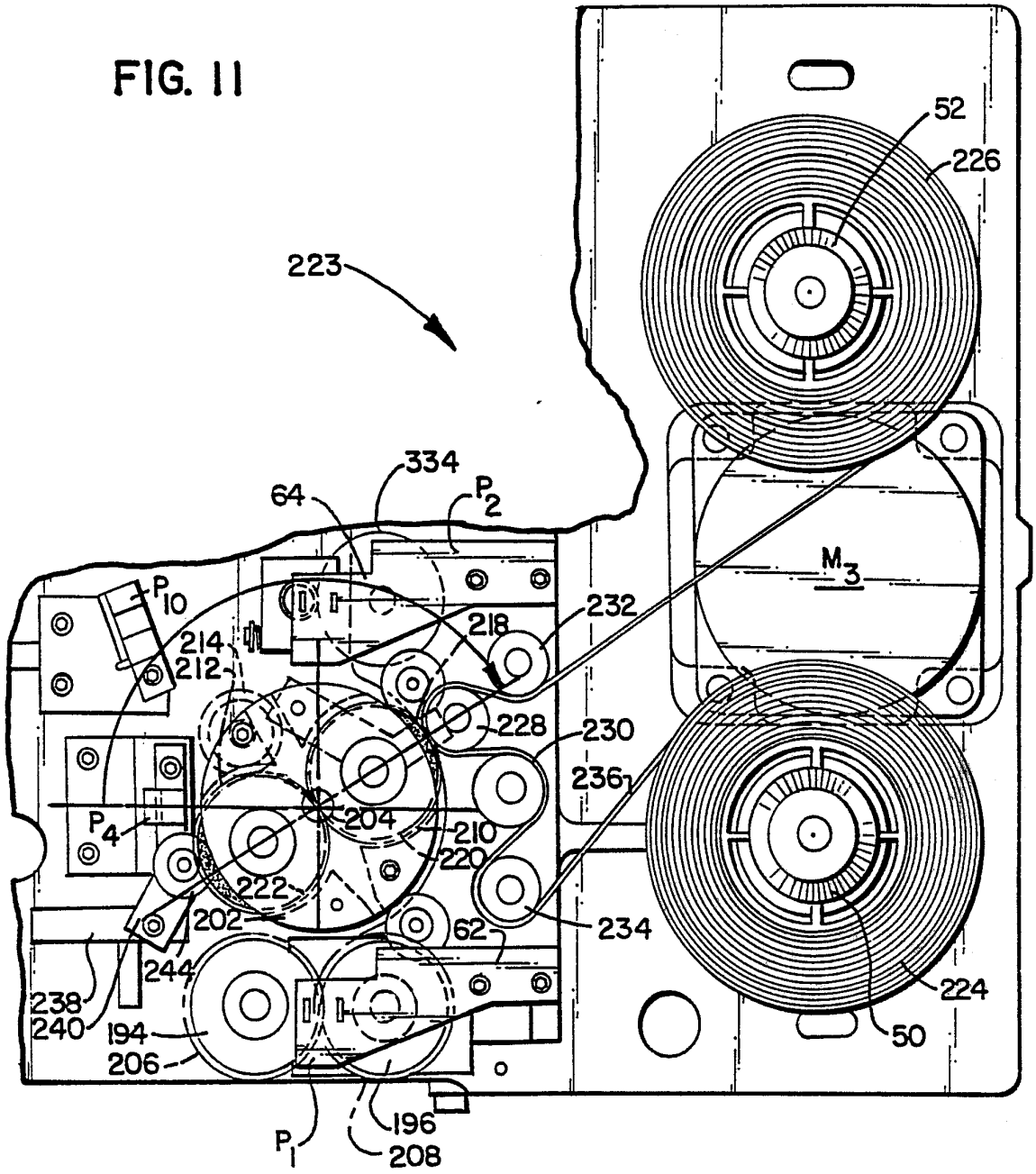

223
52
226
P_2
334
250
P_{10}
192
64
220
232
228
230
P_4
218
222
240
244
234
236
238
50
224
194
246
196
62
248
P_1
42
M_3

FIG. 11


223
52
226
334
64
P_2
M_3
P_{10}
214
212
218
232
228
230
236
P_4
204
210
220
222
202
62
234
244
238
240
194
206
224
50
196
208
P_1

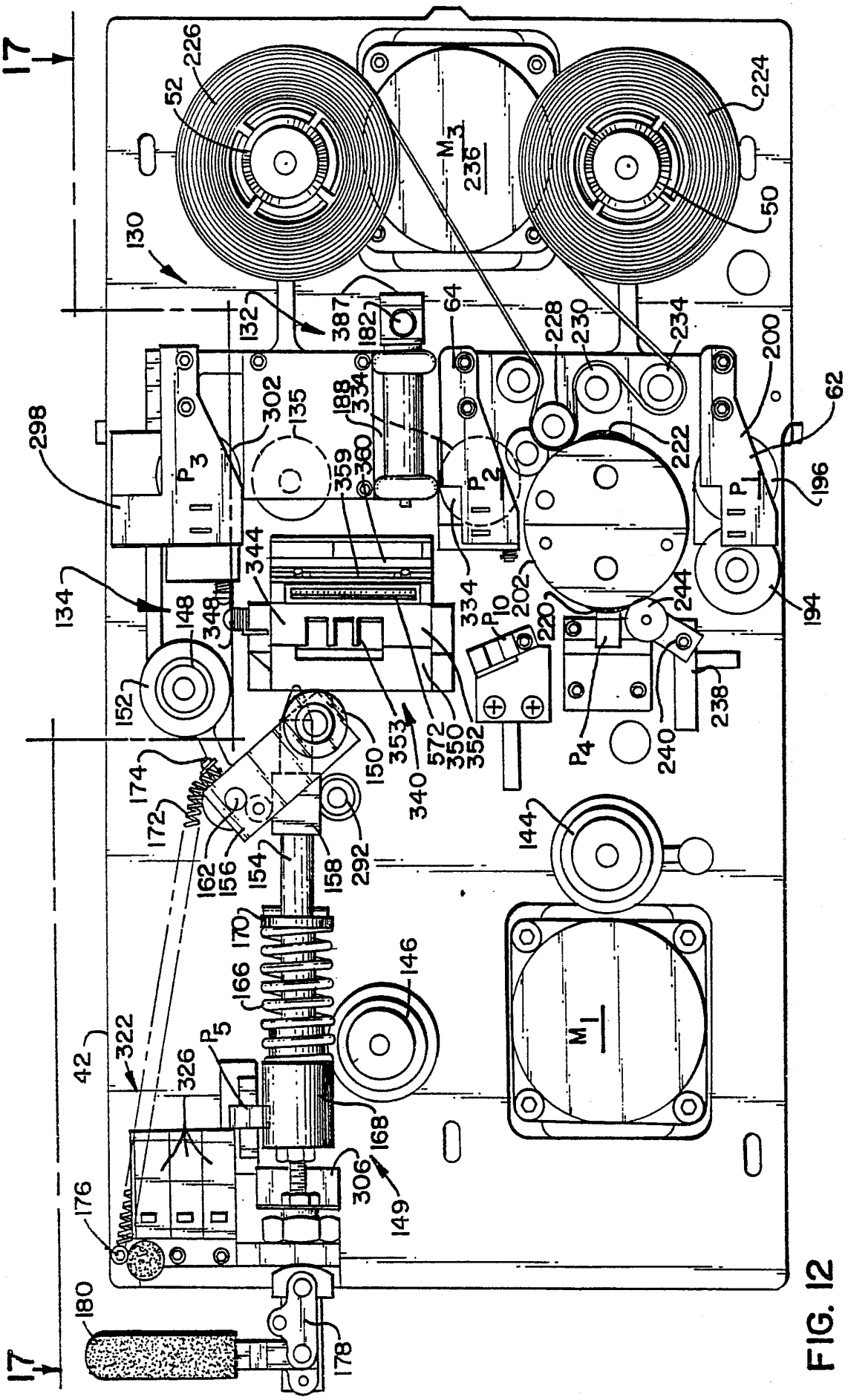

17
17
52
226
224
M_3
236
50
130
132
387
182
64
228
230
234
200
62
298
302
135
188
334
P_3
359
360
P_2
222
P_1
196
344
334
134
148
348
P_{10}
202
220
244
194
152
353
572
350
352
150
340
P_4
240
238
174
172
162
156
154
158
292
144
170
166
146
M_1
322
42
326
P_5
168
306
149
176
180
178

FIG. 12

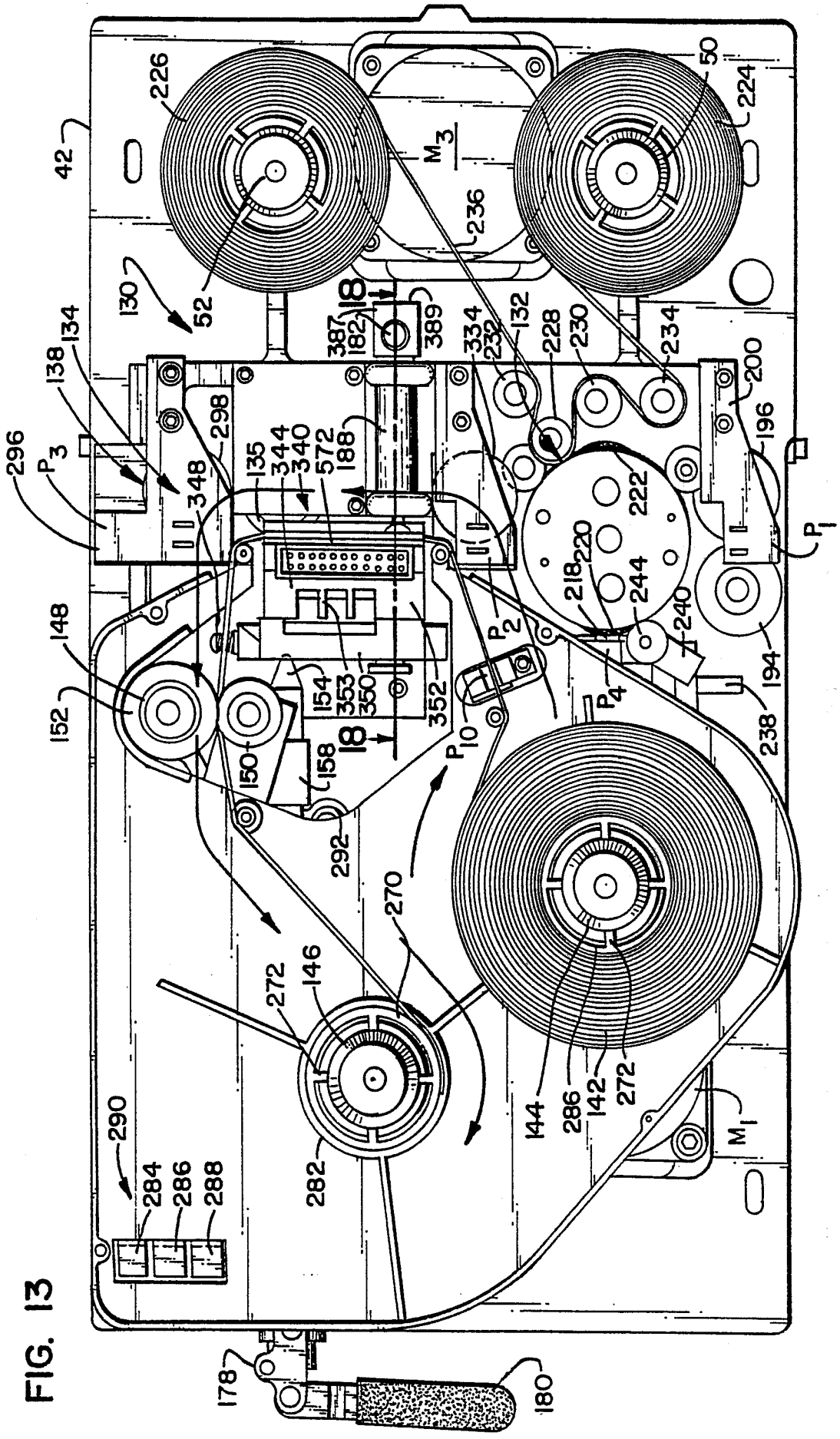

42
226
50
224
M_3
236
130
52
18
387
182
389
334
232
132
228
230
234
200
196
138
134
298
296
P_3
348
135
344
340
572
188
222
220
218
244
240
P_1
P_2
148
152
154
353
350
352
194
P_4
238
150
158
18
P_{10}
292
270
272
146
144
286
142
272
M_1
290
284
286
288
282
178
180

FIG. 13

FIG. 14

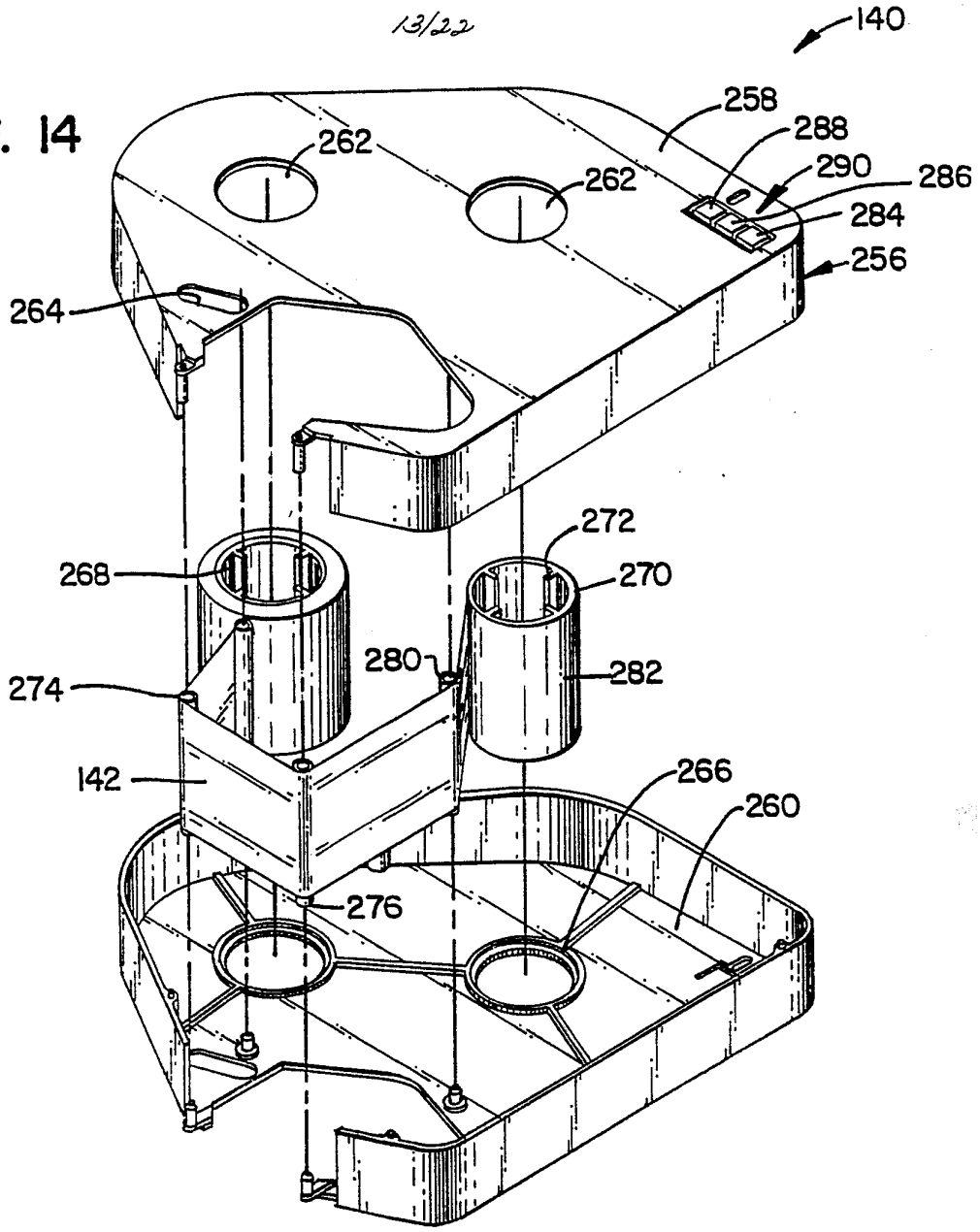
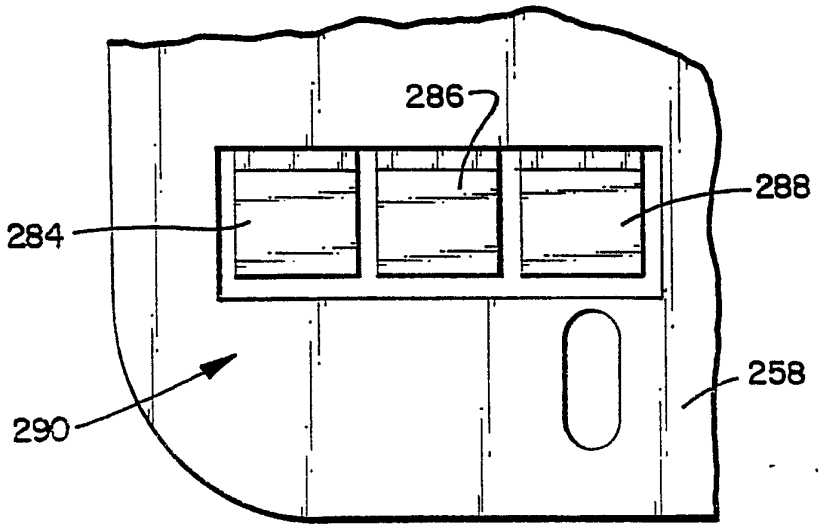

140
258
288
290
286
284
256
262
262
264
272
268
270
280
282
274
142
266
260
276

FIG. 15


286
288
284
290
258

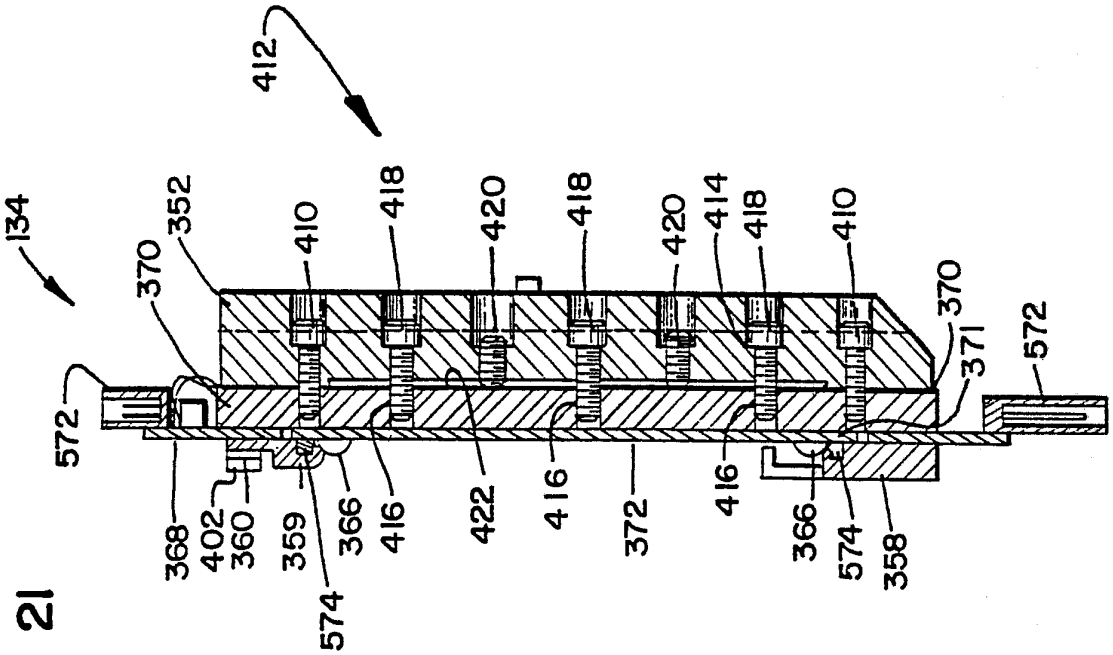

412
134
352
370
410
418
420
418
420
414
418
410
370
371
572
572
368
402
360
359
366
574
416
422
416
372
416
366
574
358

FIG. 21

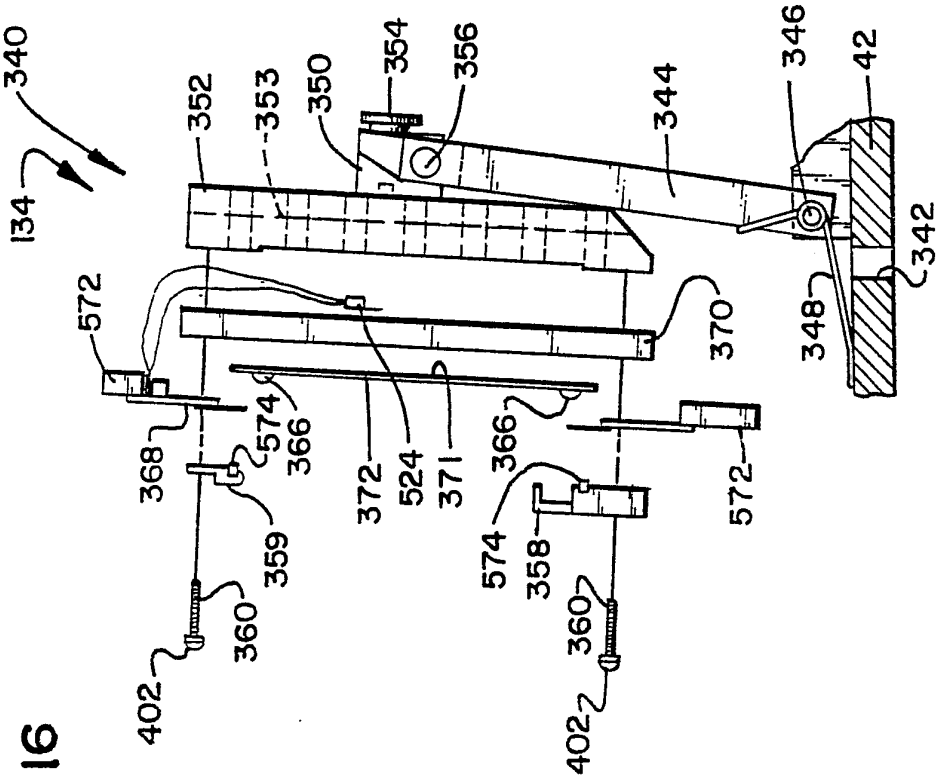

340
134
352
353
350
354
356
344
346
42
342
572
370
348
574
366
368
372
524
371
366
572
574
358
359
360
402
360
402

FIG. 16

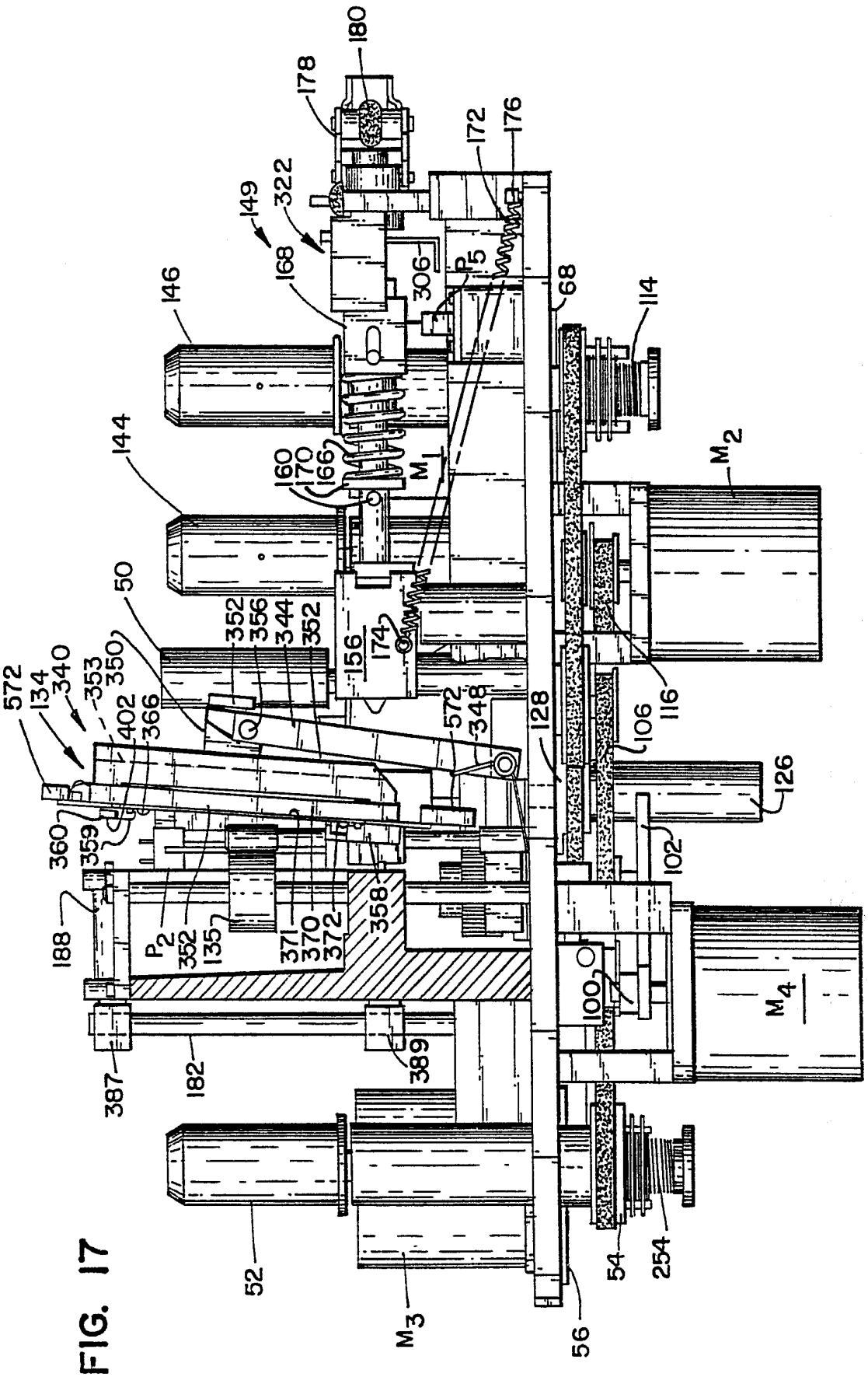

180
178
172
176
149
322
168
306
P5
68
114
146
144
160
170
166
M1
M2
50
352
356
344
352
156
174
572
134
340
353
350
572
348
128
106
116
402
366
Q
126
360
359
102
188
P2
352
135
371
370
372
358
100
M4
387
182
389
52
M3
56
54
254

FIG. 17

FIG. 18

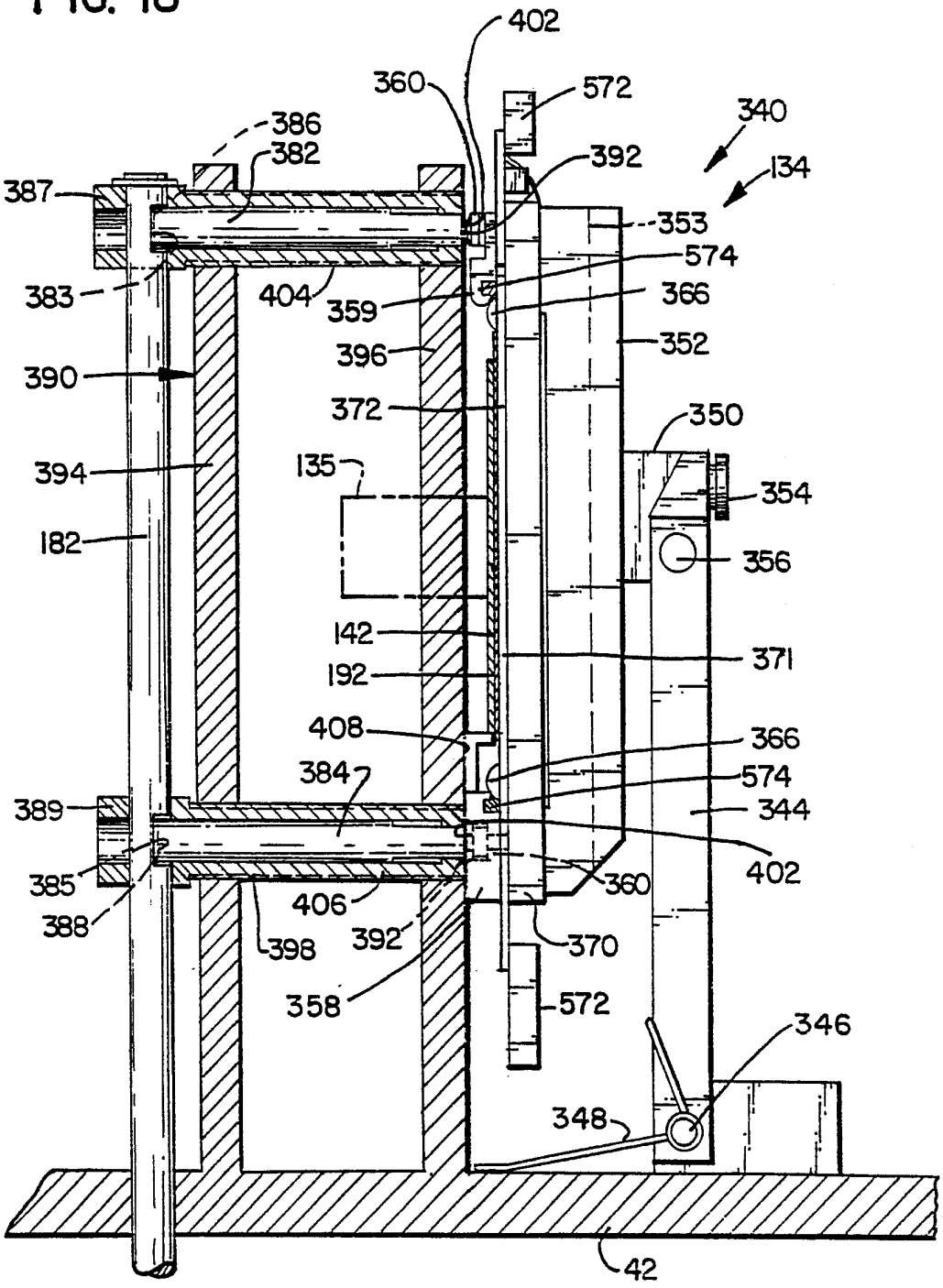

402
360
572
340
386
382
392
134
387
353
574
383
404
359
366
352
396
390
372
350
394
135
354
182
356
142
371
192
408
366
384
574
389
344
402
385
360
406
388
398
392
370
358
572
346
348
42

FIG. 19

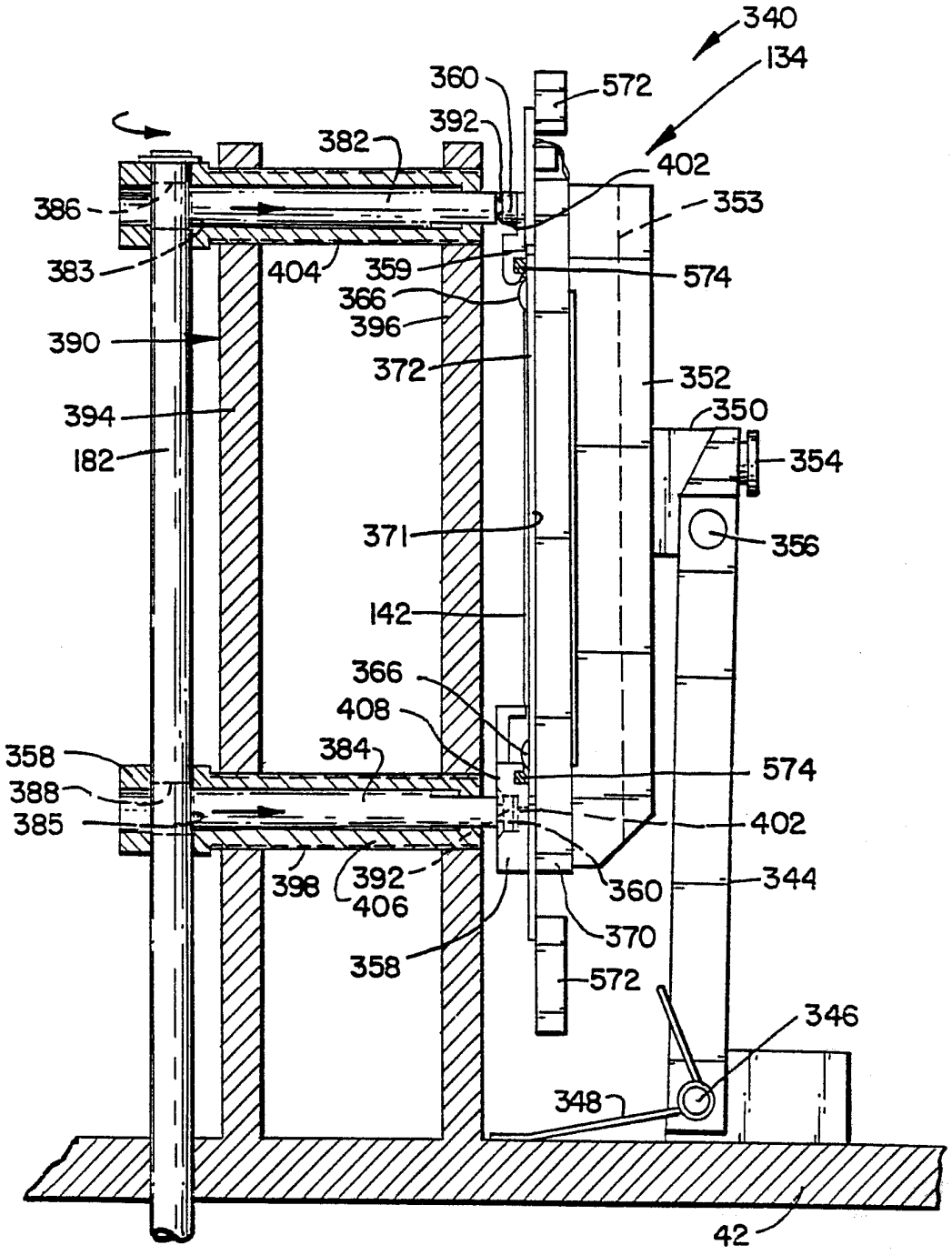

340
134
360
572
392
382
402
386
353
383
404
359
574
366
396
390
372
352
394
350
182
354
371
356
142
366
408
358
384
574
388
385
402
398
392
406
360
344
370
358
572
346
348
42

FIG. 20

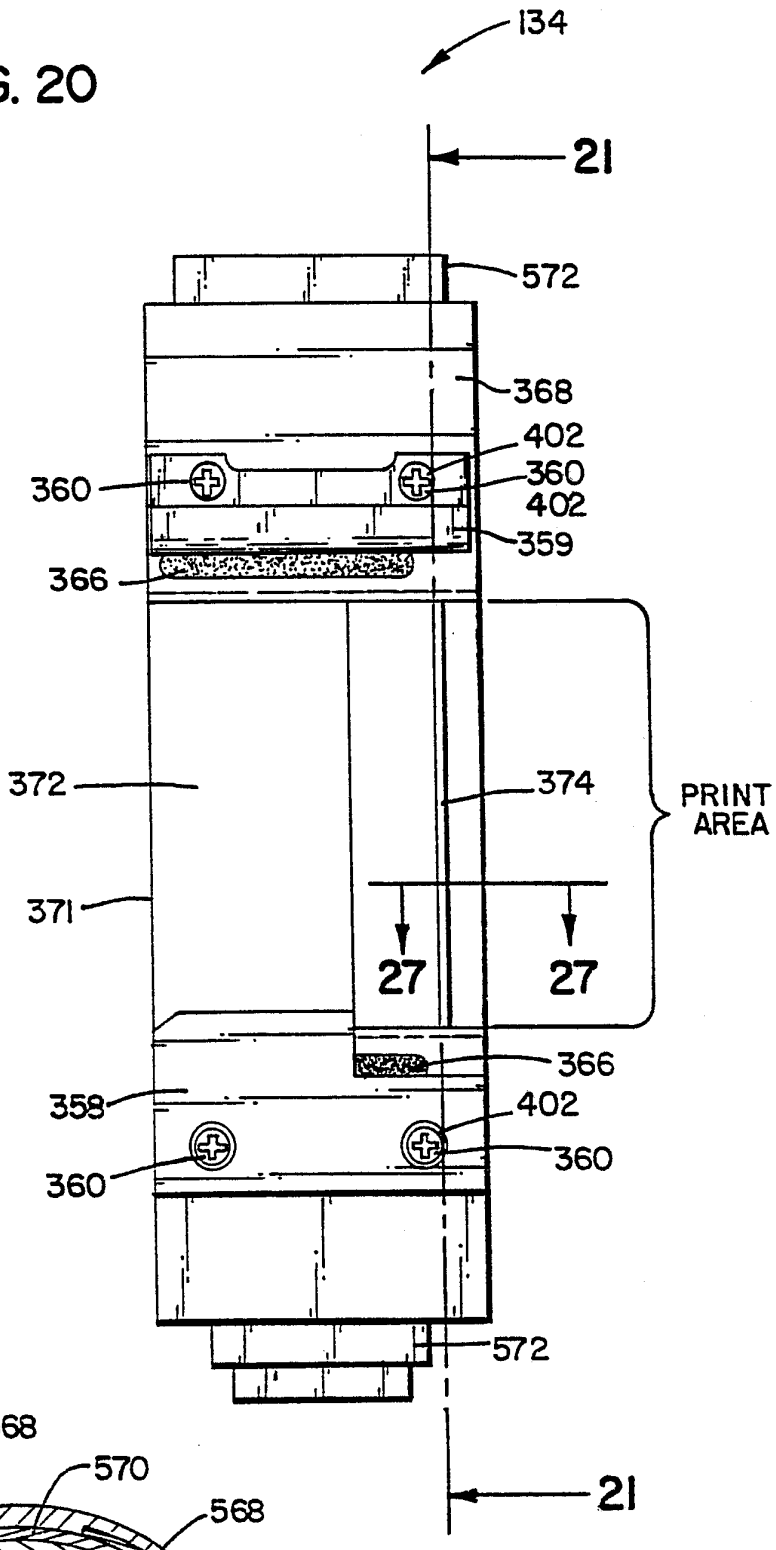
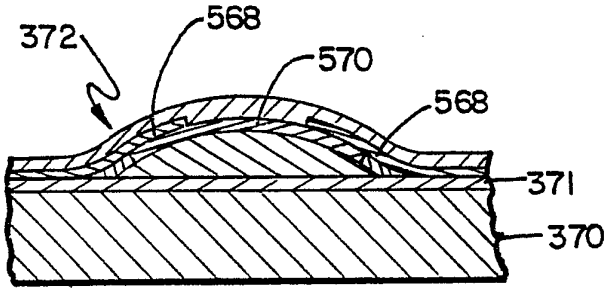

134
21
572
368
402
360
360
402
359
366
372
374
PRINT AREA
371
27
27
366
358
402
360
360
572
21

FIG. 27


372
568
570
568
371
370

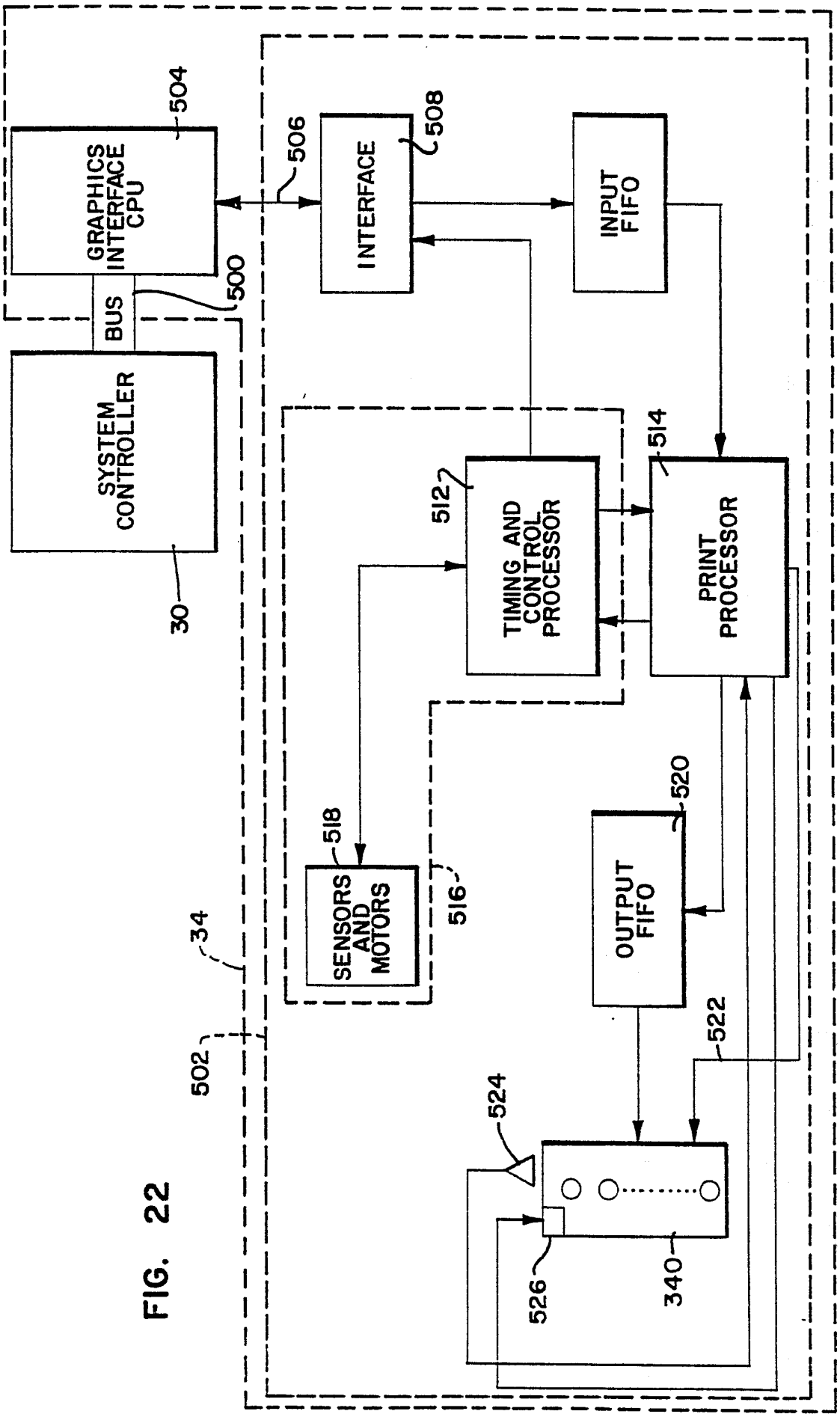

GRAPHICS INTERFACE CPU
504
506
INTERFACE
508
INPUT FIFO
BUS
500
SYSTEM CONTROLLER
30
512
TIMING AND CONTROL PROCESSOR
514
PRINT PROCESSOR
518
SENSORS AND MOTORS
516
520
OUTPUT FIFO
34
502
522
524
526
340

FIG. 22

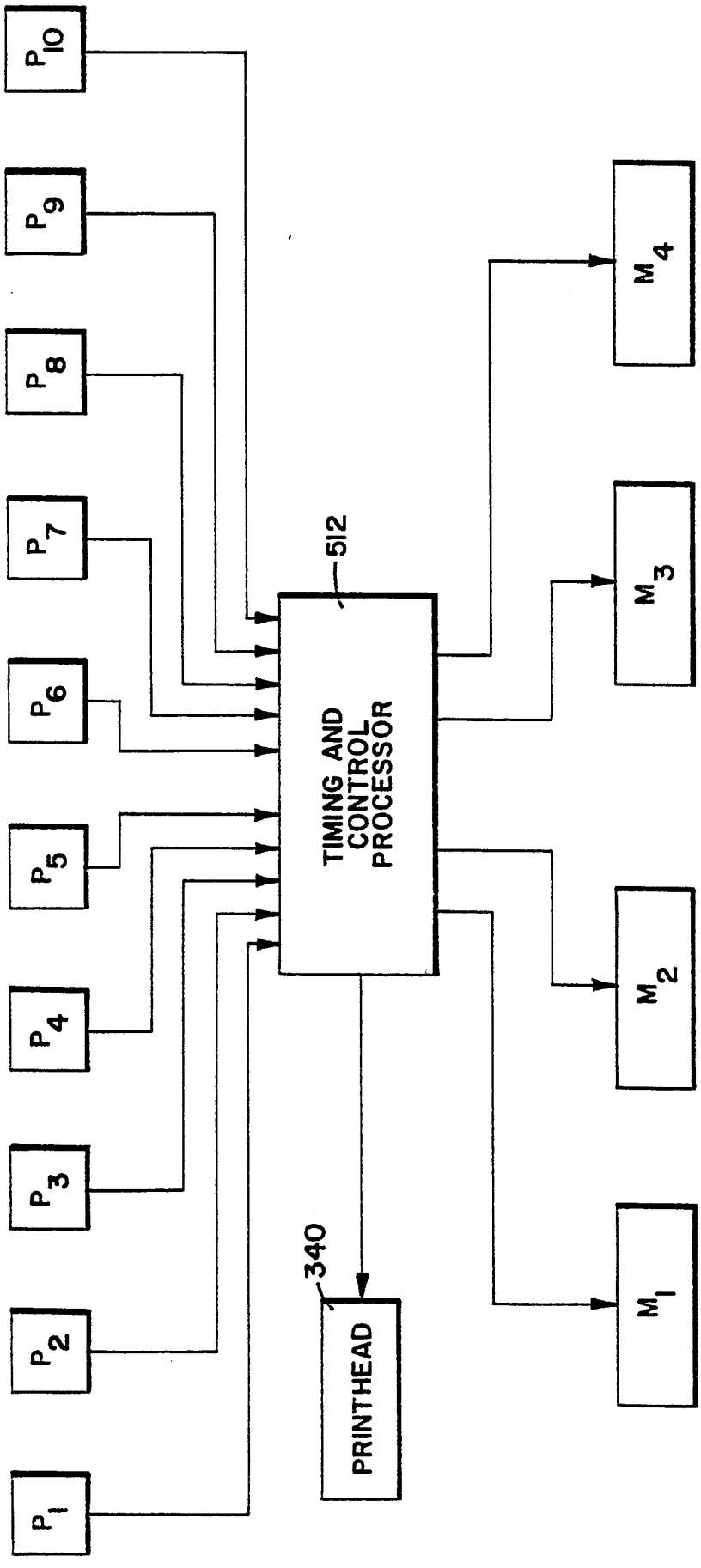

P10
P9
P8
P7
P6
P5
P4
P3
P2
P1
512
TIMING AND CONTROL PROCESSOR
340
PRINTHEAD
M4
M3
M2
M1

FIG. 23

FIG. 24

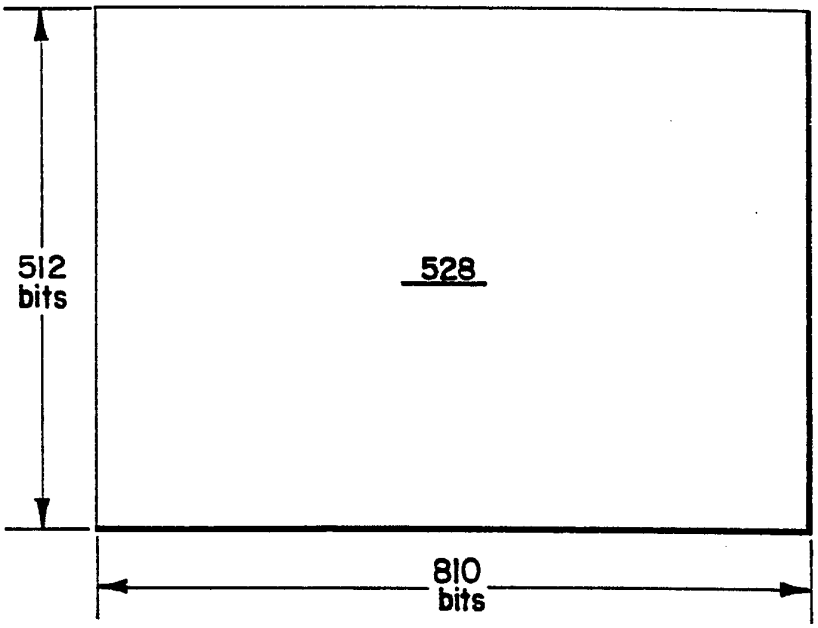

512
bits
528
810
bits

FIG. 25

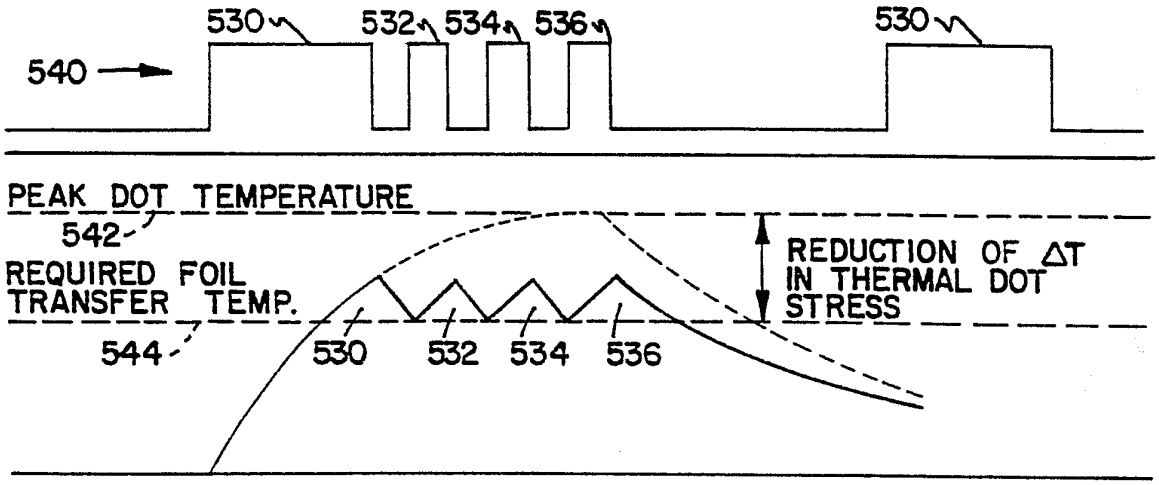
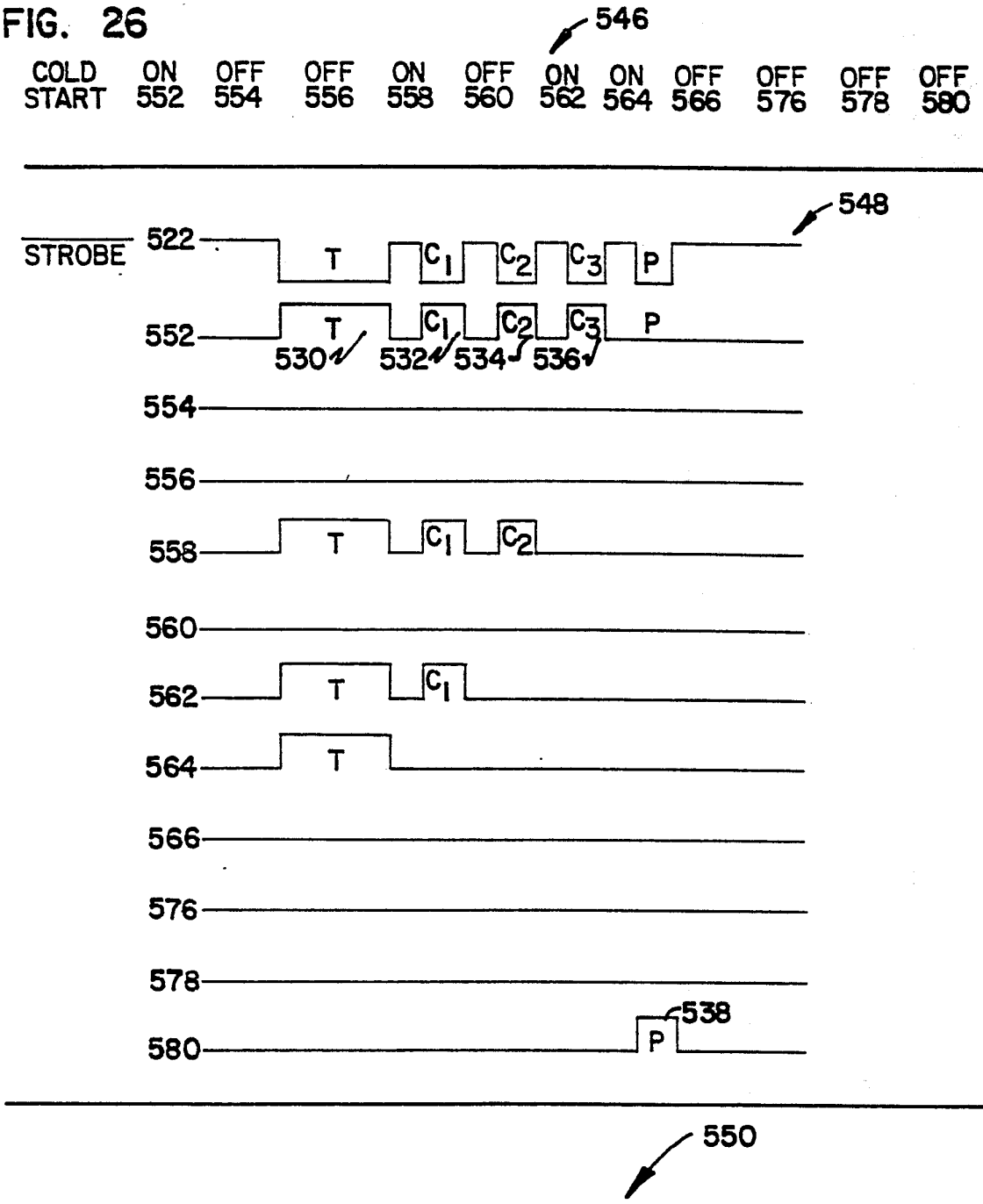

530
532
534
536
530
540
PEAK DOT TEMPERATURE
542
REQUIRED FOIL
TRANSFER TEMP.
544
530
532
534
536
REDUCTION OF ΔT
IN THERMAL DOT
STRESS

FIG. 26



550

T = DATA

C_1 = DATA AND $\overline{\text{DATA} -1}$

C_2 = DATA AND $\overline{\text{DATA} -1}$ AND $\overline{\text{DATA} -2}$

C_3 = DATA AND $\overline{\text{DATA} -1}$ AND $\overline{\text{DATA} -2}$ AND $\overline{\text{DATA} -3}$

P = $\overline{\text{T}}$ AND $\overline{\text{DATA} -1}$ AND $\overline{\text{DATA} -2}$ AND $\overline{\text{DATA} -3}$

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/03994

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

US CL: 400/120, 208, 241; 101/425; 15/256.5 IPC(5): B41J 3/20 35/38 B41F 35/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US CL	400/54, 120, 130, 131, 175, 208, 225, 234, 236, 236.1, 236.2, 241, 241.2, 249 618,692,701, 702, 702.1;101/162, 416.1, 417, 418, 423, 425; 219/216PH; 346/76PH; 15/100,102,256.5,256.51,256.52;198/494,496;355/296,298;360/90

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US,A, 4,009,047, LINDSAY 22 FEBRUARY 1977. (COLUMN 4 LINES 20-35).	101-109,111,114-120, 126,127
Y		110,112,113,137, 139,153-156,164-166
Y	IBM TECHNICAL DISCLOSURE BULLETIN, VOLUME 21, NO. 12, PP. 4959-60 "THERMAL PRINT HEAD SUSPENSION", SCHWEIGS ET AL, MAY 1979.	37-39,41
Y	US,A, 4,272,202, SCHROEDER ET AL, 09 JUNE 1981. (COLUMN 4 LINES 41-48).	30
Y	US,A, 4,321,286, SCOTT ET AL, 23 MARCH 1982. (ABSTRACT, COLUMN 5 LINES 24-25).	13-17,87-91,159, 160
Y	JP,A, 57-150588, MORIGUCHI, 17 SEPTEMBER 1982.	39,40
Y	JP,A, 58-14792, IWASKI, 27 JANUARY 1983.	35,47,48,53,65,67, 68
Y	JP,A, 59-26774, MATSUYAMA, 13 FEBRUARY 1983.	130-137
Y	JP,A, 59-36276, MATSUYAMA, 28 FEBRUARY 1983.	130-137
Y	JP,A, 59-222374, ISAWA, 14 DECEMBER 1984.	45,59,75

* Special categories of cited documents: [10]

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

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

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

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

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

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

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

"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

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
06 February 1990	22MAR 1990
International Searching Authority	**Signature of Authorized Officer**
ISA/US	David A. Wiecking

Form PCT/ISA/210 (second sheet) (Rev.11-87)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	JP,A, 60-2391, WATANABE, 08 JANUARY 1985.	35,47,48,51-53,62, 65-69
Y	JP,A, 60-165281, KONDOU, 28 AUGUST 1985.	55-57,71-72,135
Y	JP,A, 61-79688, WATANABE, 23 APRIL 1986.	128,129
Y	JP,A, 61-274971, NAKADA, 05 DECEMBER 1986.	31-34
Y	US,A 4,651,166, KATSURAGI, 17 MARCH 1987, (COLUMN 1, LINES 12-29).	58,74
Y	JP,A, 62-83166, HISAIE, 16 APRIL 1987.	36,42-44,46,47
Y	US,A, 4,675,746, TEIRICK ET AL, 23 JUNE 1987, (COLUMN 5, LINES 33-51).	145-148
Y	JP,A, 62-202780, SUZUKI, 07 SEPTEMBER 1987.	55-57,71-73
Y	JP,A, 62-208957, TSUMURO, 14 SEPTEMBER 1987.	50
X	US,A, 4,695,850, NUBSON, 22 SEPTEMBER 1987.	1,11-14,17-30,35, 47,60,61,64, 145-159
X Y	WO,A, WO88/01941, WEIZEL ET AL, 24 MARCH 1988.	1-5,7,8,10-13,19-28,35,60,61 6,29,30,51,52,62, 145-158,161-163
Y	US,A, 4,747,716, VAN DER EIKEL, 31 MAY 1988. (FIGURES 3A, 3B; COLUMNS 5 AND 6).	55-57,71-73,135
X Y	US,A, 4,755,069, LAMANNA ET AL, 05 JULY 1988.	1 9,145-154
Y	US,A, 4,764,041, BIERHOFF, 16 AUGUST 1988, (COLUMN 4, LINE 5).	77,92
X,P Y,P	US,A, 4,776,714, SUGIURA ET AL, 11 OCTOBER 1988, (FIGURE 7, COLUMN 5 LINE 48-COLUMN 7 LINE 9).	76,78-84,86,93-99 19-25,29,30,85,100 162-163
Y,P	US,A, 4,855,756, GLUCK ET AL, 08 AUGUST 1989. (FIGURE 6, COLUMN 7 LINE 6-COLUMN 8 LINE 20).	47-49,53,54,64,65, 67,70

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

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

1. ☐ Claim numbers . because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

3. ☐ Claim numbers_____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

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

I. Claims 1-75, drawn to a method and apparatus for printing a graphic design on a hard plastic workpiece.

II. Claims 76-100, drawn to a cartridge assembly.

III. Claims 101-144, drawn to an apparatus and method for removing loose particles from a workpiece.

Continued on second sheet.

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

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

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

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

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

☐ No protest accompanied the payment of additional search fees.

VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING. [2]

IV. Claims 145-151, drawn to a system and method for producing a magnetically encoded credit card, including cleaning and encoding steps.
V. Claims 152-166, drawn to a system and method for producing a magnetically encoded credit card.

The inventions are distinct, each from the other, because of the following reasons: Inventions II and III are related as subcombinations disclosed as useable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately useable. In the instant case, invention II has separate utility such as with any printer which does not have means for cleaning the workpiece. Also, invention III as claimed has no use for a cartridge as claimed in invention II.

Inventions I and II are related as combination and subcombination.

In this case the combination as claimed does not require the particulars of the subcombination for patentability because the existance of claims 1-20 and 31-75 is evidence that the printer/cassette combination does not require the specific details of the cassette as recited for example in claims 76, 86 or 21. Additionally, the subcombination has separate utility such as with any thermal printer, not necessarily one which includes the details of group I.

Inventions I and III are related as subcombinations disclosed as useable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately useable. In the instant case, invention III has separate utility such as for cleaning any workpiece, not necessarily one which is to subsequently receive printing. Also, invention I does not need a workpiece cleaner having the specifics of invention III, or indeed any cleaner, to operate.

Inventions V and III are related as combination and subcombination.

VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING.

In this case, the combination as claimed does not require the particulars of the subcombination for patentability because the existance of claims 152-154 and 156-163 are evidence that the printer/cleaner combination does not require the specific details of the workpiece cleaner as recited for example in claims 101 or 155. Additionally, the subcombination has separate utility such as cleaning workpiece not intended to receive printing.

Inventions IV and I are related as combination and subcombination.

In this case, the combination as claimed does not require the particulars of the subcombinations for patentability because the means for feeding the workpiece, the means for printing being positioned adjacent this feed path; and the means for precisely aligning these elements are not recited in the subcombination and are therefor not necessary. Additionally, the subcombination has separate utility such as printing a design on a workpiece without encoding a magnetic strip thereon.

Inventions II and IV are related as subcombinations disclosed as useable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately useable. In the instant case, invention II has separate use such as in a printer using a cartridge in which the printer does not encode a magnetic strip. Also note that the printer/encorder combination does not need a cartridge to perform its printing process.

Inventions III and IV are related as subcombinations disclosed as useable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately useable. In the instant case, invention III has separate utility such as in a printer using a workpiece cleaner which does not encode a magnetic strip. Also note that the printer/encoder combination does not need a cleaner to perform its printing process.

Inventions IV and V are related as subcombinations disclosed as useable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately useable. In the instant case, invention IV has separate utility such as printing and encoding "dirty" credit cards. In addition, the printer/cleaner combination

can be used without a magnetic encoder.

Inventions V and II are related as combination and subcombination.

In this case, the combination as claimed does not require the particulars of the subcombination for patentability because the existance of claims 152-161 and 164-166 is evidence that the printer/encoder does not need the cassette of Group II to hold the print foil. Additionally, the subcombination has separate utility such as in any printer, not necessarily the printer/encoder recited in Group IV.

Inventions V and I are related as combination and subcombination.

In this case, the combination as claimed does not require the particulars of the subcombination for patentability because the means for feeding the workpiece, the means for printing being positioned aligning these elements are not recited in the subcombination and therefore not necessary. Additionally, the subcombination has separate utility such as printing a design on a workpiece without cleaning it first.