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(54) **System for setting date wheels in a postage meter**

(57) A postage meter that has value wheels (22) and date wheels (24), each value wheel (22) being adjustable by a linkage (26) that moves through a range of positions sufficient to select any of the ten print indicia thereof. Several of the linkages (26) are able to move further, beyond the positions for the ten indicia of the value wheels. When such a linkage (26) moves to said further position, it moves a pawl (39) that ratchets a corresponding date wheel (24) to its next position. The linkages (26) may include rack elements (26) that move along the axis of the print rotor (500).

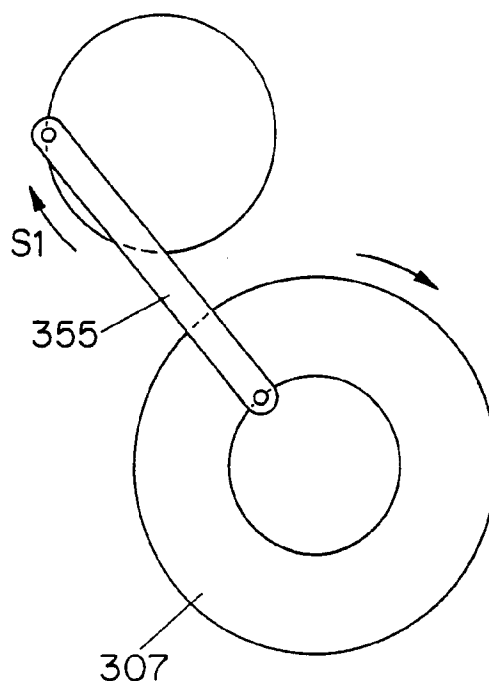


FIG. 5A

EP 0 737 942 A2

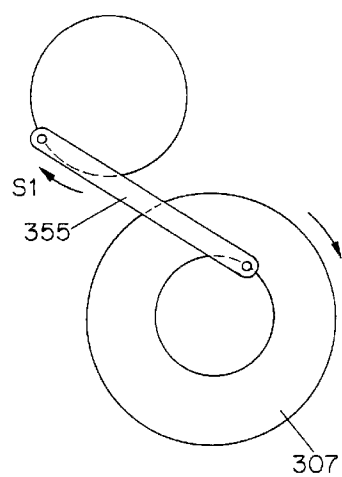


FIG. 5B

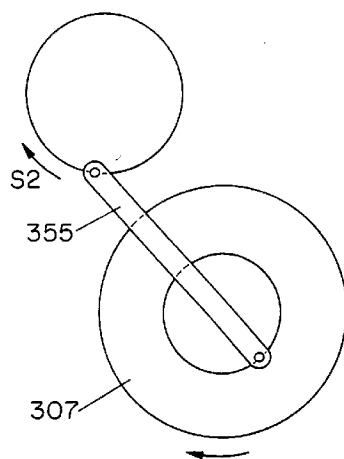


FIG. 5C

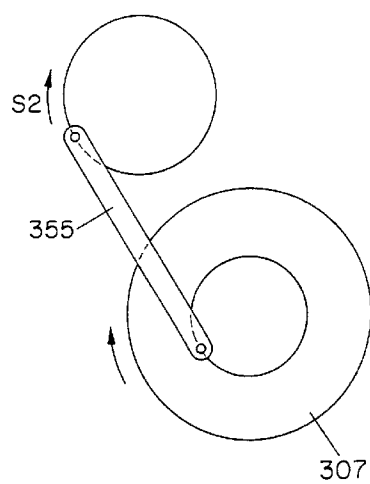


FIG. 5D

Description

The present invention relates generally to postage meters or franking machines, and relates specifically to the setting of date wheels in such machines.

The designer of a postage meter (or franking machine, the terms being used synonymously here) faces many competing and conflicting design requirements.

First and foremost the design has to satisfy the requirements of PTTs (postal authorities such as the U.S. Postal Service) around the world. The postal service is understandably fixated on the danger that a poor meter design might permit someone to print postage for which the postal service is not paid. Closely related to this is the concern that the design of the meter be such that any tampering with the meter will be readily apparent to relatively untrained postal service personnel during periodic meter inspections or during the activity of resetting a meter to contain more postage value. As a practical matter the manufacturer of the postage meter must also guard against the other direction, namely loss by the user of postage value for which the postal service has already been paid; the design features addressing the former generally also address the latter.

To satisfy the requirements of the postal service it is generally necessary to have a secure housing within which information is stored as to the amount of postage remaining to be printed or that has been printed. In the United States, for example, the storage location is called a descending register and it indicates the amount of postage remaining to be printed; in such countries the postage is prepaid. In other countries the storage location may be called an ascending register and indicates the cumulative amount of postage that has been printed; the postal customer pays after mailing.

It is also generally necessary to use a print rotor to print postage, rather than any of numerous other printing technologies that might be employed, since the postal authorities are comfortable with the notion of partially enclosing the print rotor within the secure housing. Partially enclosing the print rotor within the secure housing permits the printing dies to be protected from misuse during nearly all phases of meter operation. The postal authorities are also comfortable with the notion of the print rotor being a pure mechanical device even if the main body of the postage meter contains some electronics. The comfort comes from the notion that tampering with the rotor, if it is purely mechanical, will be easy to detect through visual inspection. One of the most difficult aspects of designing a postage meter is figuring out how the rotor will be interconnected with the rest of the postage meter, as will be discussed further below.

Postal authorities generally require that the meter be capable of printing user-selected postage amounts, and require that the meter be capable of printing the date on the mail piece as well. Depending on the mail class (also called "mail type") the postal authorities may require that the meter print information indicative of the class of service being used (e.g. first class, fourth class, presorted Zip+4, etc.). In a pure mechanical print rotor, this requires that there be print wheels for postage value (also called value wheels), print wheels for the date, and movable dies for such things as the class of service.

As mentioned above, the postal authorities require that the design of the meter reduce to an absolute minimum the possibility of postage being printed for which payment has not been made. This requires a reliable linkage between the value wheels of the rotor and the ascending or descending register mechanism or electronics of the main body of the meter. Such a linkage has to satisfy many requirements. The value wheels have to be under complete control at all times; there cannot be any times when they are free-wheeling and thus subject to intended or accidental mispositioning. Despite this, the rotor has to be capable of rotating through hundreds of thousands of franking operations. Enormous amounts of engineering time and money have been expended to explore ways to link the value wheels and other moving parts with the main body of the meter. One approach to rotor linkage is set forth in US-A-4639581, assigned to the same assignee as that of the present invention. That patent is directed to an H-shaped rotor shaft having racks along the length of the shaft. The racks move axially to adjust the positions of the value wheels. Pinions in the main body of the meter engage with the racks, and the orientation of the pinions and racks is chosen to permit the rotor to rotate when necessary. When the rotor begins to rotate the pinions and racks come out of engagement, and when the rotor completes a revolution the pinions and racks come back into engagement.

Those skilled in the art will appreciate that numerous other requirements also present themselves besides the above-mentioned requirements for the rotor linkage. The weight and size of the meter cannot be too great. The design should be mechanically robust against unintentional and intentional abuse, and should be reliable after many hundreds of thousands of operations. In general, it is desirable to reduce the parts count of the postage meter, since parts have to be fabricated and assembled and can break. Finally, it is desirable to offer a rich mix of features to the user.

The limited space for moving parts, the fact that the rotor has to be able to rotate, the requirement that the value wheels be locked when the rotor is rotating, the fact that the total parts count and complexity of the meter must not be too high, the imperative that the meter be extremely reliable, and the collective experience of mechanical designers in the postage meter art, all lead to the realization that there is a sort of a "control budget", a limit on how much interaction there can be between the main body of the meter and the print rotor. In the vast majority of postage meter models in service the entirety of the control budget is entirely spent on the mere control of the value wheels; there is little or no control budget left over for controlling other moving parts such as the date wheels, the type-of-sending die, the adver-

tising plate, etc.

In many postage meter models, the date wheels are adjusted manually by the user, as are the printing dies indicating class of service and the like. In such a model, the mechanical linkage between the rotor and the main body of the postage meter is as simple as it can be, and is limited to the linkage required to set the value wheels. In such a model, the rotor itself is also about as simple as it can be. Stated differently, if one wanted to minimize the complexity of the interconnection between the rotor and the main body of the meter, and to minimize the complexity of the rotor itself, among the things one would do is to eliminate automatic, mechanical control of as many things as possible, and to leave as many things as possible to be set manually by the user. By far the majority of postage meters in use around the world are meters of just this type. At the start of each new day, the user has to manually adjust the date that will be printed.

Manual date adjustment is not easy for the user. The user has to open a cover, visually inspect the date print wheels, and rotate the wheels. The visual inspection is not easy because the indicia on the wheels present a mirror image. The "8" and "0" indicia look normal but the other digits are reversed. The mirror image is not only problematic because individual digits are not easy to distinguish but for the further reason that the layout of digits is reversed. It is all too easy to set a date of "21" when "12" is meant, for example. Yet another reason the visual inspection is not easy is that the swinging cover typically at least partly obscures the field of view even when it is open.

In the most common postage meter models the way the user rotates the date wheels is by pushing them with a stylus or a ball-point pen. The manipulations are not easy because the swinging cover that is opened to gain access to the rotor partially obscures the access to the date wheels.

A further drawback of manual date adjustment is that the adjustment might be forgotten, in which case anywhere from one to several thousand mail pieces might be franked before the omission is noted and rectified.

It will be appreciated that making a manual date wheel adjustment possible requires providing an openable cover. The cover itself represents further design difficulties, as it cannot simply be a door that opens. It has to be a cover that opens to expose only part of the print rotor, since other parts of the rotor (such as the value wheels) have to be protected, to every extent possible, from tampering. It has to be a cover that is interconnected with other mechanisms of the meter so that (1) the user will not be able to initiate franking while the cover is open; and (2) the user will not be able to open the cover if the rotor somehow stops partway through a franking operation (e.g. due to loss of power). Such a cover has a complicated mechanical interconnection with the main body of the postage meter.

Designers of postage meters thus face pressure in two directions. On the one hand, it would be desirable to have automatically set date wheels. This would provide a meter that offers feature benefits to users, including greatly reduced incidence of accidental franking with an incorrect date. But the limited control budget available in the context of a rotor which rotates relative to a main body makes it desirable to minimize the complexity of the linkage, so that only the value wheels are set automatically, and everything else (including the date wheels) gets set manually.

Some sense of the magnitude of difficulty in designing a suitable mechanism for automatic setting of date wheels may be seen from the great attention that has been paid to sidestepping the problem. See, for example, US-A-4283721, in which a postage meter is turned on at the beginning of a work day. Upon startup, the equipment is prevented from operation in the initialization state, until such time as the date wheel cover is opened and closed at least once. The assumption is that this will prompt the user to set the date wheels as necessary since the date wheel door is open. As another example, see US-A-4347506, in which power is initially applied to a postage meter. When power is applied, operation of the postage meter is inhibited until a date wheel cover is opened and closed at least once. In addition, however, a check date warning override key is provided, upon activation of which the meter enters its operational mode even though the date wheel cover has not been opened and closed. See US-A-4516014, in which a mailing machine is first prepared for operation by turning on a power switch. Upon initial start-up, the processor of the meter causes a check date indicator on the display panel to start flashing for the purpose of warning the operator to check the date that is set at the date wheels. The processor also disables postage printing. The user opens the cover to adjust the date wheels as needed, then presses a button. Pressing the button prompts the processor to extinguish the check date indicator and to enable the printing of postage. As yet another example, see US-A-4635204, in which a postal meter is energized. When the postal meter is energized, the processor causes its display to start displaying and flashing a check date indicator segment. The only way to make the processor stop the flashing is to open the date wheel cover and to press a key, the key being located nearby to the place where date wheels are set. If it were an easy matter to control date wheels automatically, the elaborate reminder strategies just recounted would not have been necessary.

US-A-4852482, US-A-4649489 and US-A-5197042 each talk of setting date wheels, but none of them appears to address setting date wheels in a print rotor.

US-A-3869986 bears mute testimony to the difficulty of finding a way to adjust mechanical print wheels for the date and the postage value. The patent shows a print apparatus for a postage meter in which portions of the print image are by means of a relief printing die, while other portions (i.e. the date and postage value) are printed by an ink jet printer.

US-A-4060720 hypothesizes the user of encoders that are directly engaged with date wheels, the output of which

would provide information as to the present settings thereof. The patent is directed to noting the difference between the actual and desired date wheel positions and adjusting the date wheels accordingly. The system of the patent does not, apparently, contemplate application in a postage meter having a print rotor, since no indication is given as to how numerous encoders would be fitted into a rotor of finite size, nor is there an indication as to how the dozen or more

5 signals from the encoders would be communicated between the rotor (which rotates) and the main body of the meter. US-A-5301116, assigned to the same assignee as the present invention, describes an approach for automatic date wheel setting in a print rotor. When it is desired to adjust a date wheel, the rotor is brought into a particular angular relation with the main body of the meter (here, also called the "stator"). When the angular relation is reached a bevelled shaft engages a slotted shaft, one of which is on the rotor and the other of which is on the main body. Each actuation

10 of the shafts is coupled by a mechanism to the date wheels, so that any desired advancement of the date wheels may be accomplished by a sufficient number of actuations of the shafts. The setting is essentially serial and upwards only. CH 418705, assigned to the same assignee as the assignee of the present application, shows a date wheel indexing mechanism mounted in the rotor and controlled by a hand driver axial cam curve. The wheels are blocked most of the time from movement. The cam, which has two active surfaces, revolves through four phases under hand control. During

15 the first phase, the first active surface actuates a cam follower to unblock the date wheels. During the second phase, the second active surface actuates a cam follower to advance the date by one position, by a ratchet mechanism that is not described in detail. During the third phase, the first active surface blocks the wheels again. US-A-4520725 (counterpart to EP-A-0105424) shows a mechanism for setting date wheels, particularly in Figs. 1-4. To be able to adjust four date wheels, the mechanism calls for six electromagnets and associated linkages and

20 pawls. The electromagnets, linkages and pawls are part of the main body of the postage meter and for successful setting the rotor must be in proper alignment with the linkages; the extent of rotor alignment that permits adjustment of the value wheels does not necessarily assure that the rotor is well enough aligned to permit adjustment of the date wheels. The mechanism of US-A-4520725, with ratchet gears integrally formed with the date wheels, leads to visual gaps between the printed digits to accommodate the ratchet teeth. There is no overlap between the moving parts that

25 accomplish date wheel and value wheel setting, so that the decision to employ the date wheel setting mechanism of US-A-4520725 leads to a very high parts count and allocation of substantial volume and weight to the date-setting mechanism. It will also be appreciated that the mechanism of US-A-4520725 also calls for semiconductor drivers for each of the six solenoids, separate and apart from the drivers needed for the value wheel setting. CH670524, assigned to the same assignee as the assignee of the present invention (counterpart to WO-A-87/03983), describes a system having racks for setting value wheels. One of the value-wheel racks, when extended

30 to an extreme position, permits all the other value-wheel racks to come into engagement with date wheels. When the date-wheel setting is complete, the value-wheel rack that is in an extreme position returns to a normal position and the other racks are no longer engaged with the date wheels. This system assumes that the value-wheel racks can all move independently of each other. A Francotyp-Postalia EFS3000 mechanism is also known in which date wheels and value wheels are set by six

35 racks, each of which has an individual stepper motor. Each of the six stepper motors is individually actuable independently of the other stepper motors. Four of the six racks serve a double purpose, namely controlling respective value wheels and also controlling date wheels. Of the four double-purpose racks, three are used to set (or preload) ratchet conditions for respective date wheels, and a fourth is used to actuate ratcheting of whichever of the three date wheels has been preloaded. The mechanism only adjusts three wheels (month, and units and tens of date). The mechanism

40 requires that racks be independently movable relative to each other. It also has a relatively high parts count and the levers actuated by the racks to preload and ratchet the date wheels are long and take up a lot of space. The mechanism thus has most if not all of the drawbacks of the mechanism of CH 670524, mentioned previously. US-A-5154118 describes a system for setting date wheels in a print rotor. When it is desired to increment the date,

45 a finger in the main body of the meter extends toward the rotor and engages a tooth in a gear positioned to receive the finger. The gear is linked to an escapement much like an automobile odometer, so that actuation of the finger can accomplish advancement of the date. An elaborate mechanical linkage with three times as many gears as there are date wheels, and with numerous cams and truncated teeth, is provided to bring about the desired interrelated move-

50 ments of the day wheel (units and tens), the month wheel, and the year wheel. The mechanism must, of course, be completely changed depending on whether the desired print order is month, day, year (as in the U.S.A.) or day, month, year (as in Europe). The setting is serial and upwards only. US-A-4114533 describes a system for setting date wheels. A large frame is positioned nearby to the date wheels,

55 and contains as many solenoids as there are date wheels. Each solenoid is engaged with a transfer gear also supported within the frame. The frame is pivotally mounted and can rotate between a first position in which the transfer gears and other moving parts of the frame at some distance from the date wheels, and a second position in which the transfer gears all mesh with the date wheels. When it is desired to change the positions of one or more date wheels, a large solenoid causes the frame to rotate from the first position to the second position. Next the transfer gear solenoids are actuated as needed to change the date wheel positions. Then the large solenoid is de-energized and the frame springs

back to its first position.

The mechanical arrangements set forth in US-A-5154118 and US-A-4114533 each has a drawback; each arrangement adds to the list of mechanical elements that have to be properly lined up when the rotor is in position for setting (typically called a "home" position). Stated differently, it would be very helpful if the mechanism used for setting print elements other than the value wheels (e.g. the date wheels) did not increase the number of engaging elements that have to be lined up properly between the rotor and main body, beyond the number of elements that have to be lined up for setting of the value wheels. In the arrangement of US-A-5154118, the concern is that if an attempt were made to actuate the finger at a time when the finger is not correctly lined up with the gear, at the very least the date wheel setting might not achieve its desired result, and there is the danger the finger or some other elements would be damaged in the attempt to actuate the finger. In the arrangement of US-A-4114533, the concern is that if an attempt were made to actuate the transfer gears at a time when they are not correctly lined up with the date wheels, at the very least the date wheel setting might not achieve its desired result, and there is the danger that the transfer gears or some other elements would be damaged in the attempt to actuate the transfer gears.

The arrangement proposed in CH 670524 offers an advantage over US-A-5154118 and US-A-4114533 in that the linkages between the main body and the rotor that are used for the value wheel setting are the same linkages that are used for date wheel setting. Thus, assuming the mechanical designer figures out how to be sure that the rotor is correctly lined up for value wheel setting, then the rotor will also be correctly lined up for date wheel setting.

CH 670524, however, also has a drawback in that, as mentioned previously, it assumes that there are as many stepper motors as there are value wheels to set, and that the stepper motors may be independently moved in varying directions. Among other things, this requires setting aside space for the motors, for their control circuitry, and for their linkages.

It is thus very desirable to have a way to set date wheels that does not require linkages between the main body of the meter and the rotor, in addition to those minimally required for postal-authority-approved setting of value wheels. Such an arrangement desirably has a parts count that does not go far beyond the parts count for a rotor having manual date wheel setting. The arrangement would also desirably be able to count up or down in reasonable periods of time; if it is needed to back up by one day, it is desirable that this be mechanically possible without having to cycle through a year's worth of dates, or through the entire range of all possible dates for the date wheels. Finally, it is desirable that this be accomplished in a rotor of commercially practical size, and in a meter of commercially practical shape and size, and it should not cost too much money.

A further impediment to the designer of a postage meter is that the designer has only limited control over the environment surrounding the date wheels. The date wheels are in the paper path, and thus may pick up debris or lint from mail pieces. If the meter is used in a dusty or hostile environment, then dust and other contaminants may be carried through the air to the date wheels. There is the possibility of over-inking by a user, and the possibility of a user attempting to ink the meter with stale or incorrect ink. The meter might also be exposed to variations in temperature tending to congeal foreign matter between adjacent wheels, thus setting up sticking friction therebetween.

For all these reasons, if a mechanism is provided to adjust date wheels, there is the problem in that it is possible that rotating one date wheel to set its position might drag along a neighbouring date wheel, disturbing the setting of the neighbouring date wheel. The extreme case may be seen if there are, say, four date wheels and if the first and third date wheels are advanced by one position; friction on either or both sides of the second date wheel could result in its being dragged along out of its previous position.

It might be thought that the way to overcome the problem of wheels dragging other wheels is to use stronger and stronger detents. This is unsatisfactory for two reasons. First, strengthening the detents ripples back through the setting mechanism, forcing the designer to apply more force throughout the setting mechanism. This influences many design decisions throughout the meter, potentially requiring the meter to be heavier, more costly, slower, or bulkier, or forcing the designer to compromise on user functionality. Second, experience shows that foreign matter and hostile conditions can lead to sticking friction between date wheels sufficient to overcome any detent, no matter how strong, up to the practical limits for detent strength.

Yet another design approach is to make the date wheel stack more complicated, with non-moving disks located between the date wheels. That way, rotation of one date wheel is not transmitted, by friction, to neighbouring date wheels. This approach is inelegant because it adds to the parts count and complexity of the postage meter, and adds to the assembly time and cost because more parts have to be juggled to assemble the date wheel stack. But more importantly, it adds to the physical bulk of the date wheel stack. Space is always very tight in a print rotor, and making the date wheel stack bigger takes up space in the rotor that might be used for something else, or forces the designer to make the rotor (and thus the postage meter) bigger.

It would thus be highly desirable to have a date wheel setting design that is compact, reliable, and has a small parts count, and that is nonetheless immune from the problem of one date wheel dragging along another.

In accordance with the invention there is provided a greatly improved system for setting date wheels in a postage meter. Each value wheel is adjustable by a linkage that moves through a range of positions sufficient to select any of

the ten print indicia thereof. According to the invention, however, several of the linkages (enough for the date wheels that need setting) are able to move further (to what might be termed an "eleventh position"), beyond the positions for the ten indicia of the value wheels. When such a linkage moves to its eleventh position, it moves a pawl that ratchets a corresponding date wheel to its next position. In one embodiment, the linkages include rack elements that move along the axis of the print rotor. Each rack element has a first rack that is engageable with a gear in the main body of the postage meter (when the rotor is in its "home" position) and a second rack that engages with a value wheel. The engagement between the rack element and the value wheel defines ten linear positions for the rack element, one for each of the digits printable by the value wheel. An eleventh position of the rack element causes the rack element to push a lever, and the lever causes the pawl to move a date wheel to its next position. If only the mechanical parts are considered, the date wheel setting system is "open loop"; there are no sensors that would detect, for example, a date wheel having moved for reasons other than actuation of the ratchet. But a method of operation is provided that permits the postage meter, with the assistance of the user, to accomplish recovery from an incorrect date wheel position.

In keeping with the invention, for each of several settable date wheels on a common axle, there is provided an advancing means disposed to advance its corresponding date wheel by one or more positions. Importantly, the several advancing means are disposed so that relative to the axle, one means advances its date wheel clockwise, the next counterclockwise, and so on in alternation. Since each advancing means not only serves to advance its corresponding date wheel in a predetermined direction but also serves to block its corresponding date wheel from retrograde rotation, it is not possible for a wheel that is being advanced to drag along its neighbour.

The invention will be described with respect to a drawing in several figures, of which:

Fig. 1 is an exterior perspective view of a postage meter according to the invention, including a print rotor shown in phantom;

Fig. 2 is a perspective view of the print rotor, including racks, value wheels, and date wheels;

Fig. 3 is a side view of a portion of the print rotor, showing the value wheel adjustment mechanism including a rack and value wheel as well as part of a date-adjusting lever;

Fig. 4 shows a side view of a portion of the print rotor, showing the date wheel adjustment mechanism including the date-adjusting lever and date wheel;

Fig. 5 shows a cutaway perspective view of most of the moving parts of the print rotor;

Fig. 6 is an axial end view of many of the moving parts of the print rotor;

Fig. 7 is a flow chart of the date-setting method according to the invention;

Fig. 8 shows in perspective view a preferred embodiment of the date wheel setting mechanism;

Fig. 9 shows in plan view the preferred mechanism in its relaxed state;

Fig. 10 shows in plan view the preferred mechanism in its actuated state;

Fig. 11a shows an arrangement of print indicia in a prior art postage meter; and,

Fig. 11b shows an arrangement of print indicia in a postage meter according to the invention.

Fig. 1 is an exterior perspective view of a postage meter according to the invention. Main body 20 may be seen, and a print rotor 21 is shown in phantom. Access to the print rotor 21 may be had by opening a cover 46, although as described below the cover 46 does not need to be opened nearly so often with the meter according to the invention as with many prior art postage meters. A mail piece enters the meter in the direction shown by arrow 47, trips a trigger omitted for clarity in Fig. 1, and the rotor 21 rotates to print postage value on the mail piece. Most of the time, the rotor is in what is defined to be a "home" position. When the trigger is tripped, the rotor rotates through one complete revolution, and stops again at its home position.

Fig. 2 is a perspective view of the print rotor 21, including racks 23, value wheels 22, and date wheels 24. The value wheels 22, of which there are generally four or five, each have ten faces with indicia thereon indicative of decimal digits. The angular positions of the value wheels 22 must be strictly controlled by the mechanisms of the rotor and of the main body of the postage meter, so that there is never any doubt as to the amount of postage value being printed at any particular time. A locking mechanism, omitted for clarity in Fig. 2, holds the value wheels 22 into their positions when the rotor 21 is out of its home position. A cam in the main body of the meter, the cam being omitted for clarity in Fig. 1, releases the locking mechanism when the rotor 21 is in its home position. The locking mechanism serves not only the above-mentioned locking function, but also serves as a detent, tending to urge each value wheel so that its indicium is squarely presented for printing on the mail piece.

The date wheels 24, of which there are typically four, have twelve faces each, with each face bearing an indicium. One wheel prints the month (hence the twelve faces), another wheel prints the year, and the two remaining wheels print the units and tens of the date. The wheels have detent mechanisms, not shown in Fig. 2 for clarity, tending to ensure that each wheel presents one of its twelve faces squarely for printing its indicium on the mail piece.

Fig. 3 is a side view of a portion of the print rotor 21, showing the value wheel adjustment mechanism including a rack 23 and value wheel 22 as well as part of a date-adjusting lever 32. It will be appreciated that all the elements

shown in Fig. 3, save the gear 25, move with the rotor when it rotates. In the view shown in Fig. 3 this movement is out of the page.

The rack member 26 moves to the left and the right in Fig. 3 to set its value wheel 22. The rack member 26 has slots 28 which run on pins 27. The length and position of the slots is selected to permit movement of the rack member 26 so that the entirety of its rack 23 is able to engage the gear 25. The rack 29 engages with a gear portion 30 of the value wheel 22. As will be discussed in more detail below, the range of movement of the rack member 26 is intentionally designed to be greater than would be needed to effect all ten positions of the value wheel 22. The value wheel 22 rotates about a pin 33.

The mechanism just described is repeated several times in the rotor and appears once for each value wheel 22. Thus, if there are five value wheels 22 in the meter, then there are five rack members 26, five racks 23, and five gears 25. The same may be said of Fig. 2, where there are five racks 23 and five value wheels 22.

For most of the rack members 26 (but not necessarily all of them), there is a respective lever 32. Lever 32, which will be described in more detail below, adjusts the position of one date wheel. It is pushed by feature 31 of the rack member 26. The geometry and relative positions for the rack member 26 and the lever 32 are selected so that all of the ten faces of the value wheel 22 may be obtained without the feature 31 touching the lever 32. But if the rack member 26 moves further to the right in Fig. 3, it is able to move far enough to move lever 32 to the right through its range of motion.

The number of levers 32 is selected to match the number of automatically settable date wheels 24, typically four. Thus, if there are four automatically settable date wheels 24 (not shown in Fig. 3), then there are four levers 32, only one of which appears in Fig. 3.

It might appear from Fig. 3 that the rack 23, the rack 29, and the lever 32 are all coplanar. But as will be seen in Figs. 5 and 6, in an exemplary embodiment they are not coplanar. In the exemplary embodiment, lever 32 is in a different plane than rack 29 because the date wheel 24 and value wheel 22 which they respectively control are in different planes.

Fig. 4 shows a side view of a portion of the print rotor 21, showing the date wheel adjustment mechanism including the date-adjusting lever 32 and date wheel 24. The view of Fig. 4 is in mirror image to the view of Fig. 3; movement of lever 32 to the right in Fig. 3 corresponds to movement of lever 32 to the left in Fig. 4. Lever 32 is hinged to pawl 39 at a pivot point 38, detail of which is omitted for clarity in Fig. 4. Return spring 34 accomplishes two results: it urges lever 32 to its extreme counterclockwise position against pin 36, and it urges pawl 39 into uninterrupted contact with the ratchet wheel 40. Ratchet wheel 40 is integral with gear 41, which engages date wheel 24. The teeth of gear 41 and of ratchet wheel 40 may be (but need not absolutely be) twelve in number, matching the number of faces of date wheel 24. A detent mechanism engages dimples 42 to urge date wheel 24 into one of its twelve angular positions, so that one of the faces is squarely presented for printing.

From Fig. 4 it is easy to see what happens when lever 32 moves to the left. When lever 32 moves to the left, which represents clockwise rotation, it pivots about pin 37. That movement causes pivot point 38 to move rightwards, moving pawl 39 rightwards. The pawl 39 engages a tooth of ratchet wheel 40, causing it to move about one-twelfth of a revolution counterclockwise. This causes date wheel 24 to move about one-twelfth of a revolution clockwise, preferably stopping at its next detent position defined by the dimples 42. The detailed geometry of the pawl 39 and ratchet wheel 40 are selected so that when the wheel 24 stops at its next detent position, the pawl 39 is unable to urge ratchet wheel 40 any further, except for a small overstroke to compensate for tolerances. The small overstroke does not lead to a mispositioning of the date wheel because the detent returns the date wheel to its centred position.

It will be recalled that pin 36 and hole 35 defined the maximum clockwise rotation of lever 32. As just described, this maximum clockwise rotation will have caused the date wheel 24 to move almost exactly one-twelfth of a revolution, from one detent position to the next. It is also easy to see what happens when the lever 32 is released. Return spring 34 urges pivot point 38 leftward, which urges pawl 39 leftward and also rotates lever 32 counterclockwise. The movement counterclockwise of the lever 32 halts with the abutment of pin 36 and hole 35. This defines the resting location of the pivot point 38, and that pivot point, together with the point at which pawl 39 touches ratchet wheel 40, completely defines the resting position of pawl 39.

Lever 32 has a hole 35 which surrounds pin 36. A desirable aspect of the mechanism of Fig. 4 is that the hole 35, in cooperation with pin 36, provides stops that define the full clockwise and counterclockwise rotation of lever 32. The geometry of the hole 35 and the other elements of Fig. 4 assure that the pawl 39 reliably and repeatably engages ratchet wheel 40 to the extent of one tooth, no more and no less.

The moving parts just described in Fig. 4 are all preferably coplanar, and the details of the pivot points 37 and 38 confine the movement of the elements 32 and 39 strictly within that plane. As will be more fully appreciated in connection with Figs. 5 and 6, there are other aspects of the design that serve further to constrain the movement of these moving parts within the plane. For example, although it is not shown in Fig. 4, there are other gears 41 stacked on the same pin or axle about which the shown gear 41 rotates. The teeth of the many gears 41 tend to keep the tips of the pawls 39 in place.

Fig. 4 shows the pawls 39 engaging with ratchet teeth on wheels 41, and wheels 41 engage in turn with date wheels 24. This arrangement is thought to be preferable since it permits the date wheels 24 to be closely spaced, and permits most of the width of each date wheel 24 to be devoted to print area. Those skilled in the art will appreciate, however, that without departing in any way from the invention, one could combine the functions of the ratchet wheels and the date wheels. For example, each date wheel could have a ratchet wheel formed integrally with it. The pawls 39 would thus engage directly with ratchet teeth on the date wheels 24. This presents the possible disadvantage that some of the width of each date wheel 24 would be taken away from use for print indicia, and would instead be given over for use in providing the ratchet teeth. This means the printed digits would have gaps between them.

Fig. 5 shows a cutaway perspective view of most of the moving parts of the print rotor 21. The rack members 26 are disposed parallel to each other, collectively mounted on pins 27 which ensure that the rack members 26 move only axially within the print rotor. Features 43 (in Fig. 5) are mounting points for the racks 23 (Fig. 3). The features 43 are splayed to accommodate the racks 23, because each rack 23 is wider than the spacing between the rack members 26. (The splay of the features 43 is also visible in Fig. 6.) The racks 29 are visible, also disposed parallel to each other. The racks 29 are in continuous engagement with the value wheels 22. Locking arms 45 are seen with locking lever 44. Locking lever 44 is pushed downwards, in Fig. 5, by a cam in the main body of the meter, omitted for clarity in Fig. 5. When locking lever 44 is pushed downwards it rotates locking levers 45 and permits value wheels 22 to rotate freely.

The locking arrangement of lever 44 and arms 45 may optionally be that set forth in copending application no. 08/400,335, filed March 7, 1995, which is incorporated herein by reference.

Levers 32 may be seen in Fig. 5, along with return springs 34 and pawls 39. The pawls 39 engage ratchet wheels 40 which turn wheels 41 and thus turn date wheels 24.

The position of the rack members 26 is in the full rightwards extent of possible movement in Fig. 5. Thus, the features 31 are each causing levers 23 to move to their extreme movement, counterclockwise in Fig. 5. (Counterclockwise movement of levers 32 in Fig. 5 corresponds with clockwise movement thereof in Fig. 4.)

Fig. 6 is an axial end view of many of the moving parts of the print rotor 21. Rack members 26 may now be clearly seen in their parallel positions. Pin 27 is also visible, as is locking lever 44 (Fig. 5) and pin 33 (see Fig. 3). Movement of a rack member 26 out of the page in Fig. 6 corresponds to movement to the right in Fig. 5 or to the right in Fig. 3 or Fig. 2. The splayed arrangement of the features 43 (Fig. 5) is also visible.

In Fig. 6, the angular placement of the value wheels 22 and the date wheels 24 within the print rotor is clear. The positions of the wheels are selected to reach the periphery of the rotor, so that as the rotor rotates counterclockwise (in Fig. 6), first the value wheels 22 come in contact with the mail piece, and later the date wheels 24 come into contact with the mail piece. Fig. 6 shows the value wheels 22 upwards for convenience of presentation, but it should be appreciated that the home position of the rotor is preferably such that the date wheels 24 are more or less upwards.

The gears 25 represent a portion of a control means in the main body of the postage meter, coupled in a reliable way with the ascending or descending register of the postage meter. A single motor, together with a number of solenoids, can be used to effect the desired movement of the gears 25 as set forth in copending application no. 08/422,155, filed April 14, 1995, and entitled Single-Motor Setting and Printing Postage Meter, which is incorporated herein by reference. The rotor 21 (Fig. 2) may desirably be the rotor set forth in copending application no. 08/421,900, filed April 14, 1995, and entitled Postage Meter with Hollow Rotor Axle, which is incorporated herein by reference.

It will be appreciated that the linkage according to which control in the main body of the meter is coupled to the value wheels can vary from the particular linkage set forth above. Without departing from the invention, the embodiment could be more generally described as follows. The main body comprises a secure housing, and within the secure housing there is an ascending or descending register of postage value remaining to be printed. If the meter is an electronic meter, then the ascending or descending register is preferably accomplished using one or more nonvolatile memories. Within the rotor are setting members corresponding to respective ones of the value wheels, said setting members operatively coupled with the control means, each setting member having teeth engaging the gear portion of the respective value wheel, each setting member movable to a first respective number of positions, one for each indicium of the respective value wheel. While the exemplary embodiment uses racks and rack members to link the control means and the value wheels, other setting members could be used, including additional gears if desired.

The manner in which the setting members are linked with the date wheels can also vary without departing from the invention. The date lever linkage could more generally be described as comprising a follower portion and a pawl engaging the ratchet wheel of the corresponding date wheel assembly. In the simplest case, as described herein, the pawl engages a ratchet wheel that is integral with a gear that continuously engages a corresponding date wheel. More generally, the ratchet wheel could be mechanically linked to its corresponding date wheel in other ways without departing from the invention.

The manner in which the setting members move to accomplish the setting of value wheels on the one hand, and the setting of date wheels on the other hand, can also vary without departing from the invention. Described more generally, the setting members are movable to any of a first number of positions corresponding with the number of printable digits (preferably ten) and movable to an additional position so as to actuate a follower portion of a corre-

sponding date lever. In the exemplary embodiment, this represents a rack member movable linearly through eleven positions, ten of which are meaningful print positions for value wheels, and the eleventh of which is the position that advances a date wheel. The linear movement could represent, in sequence, print digits 0 through 9 followed by advancement of a date wheel, but could just as well represent digits 9 through 0 or the digits in any other sequence, the correct positioning of which being accomplished in software.

The setting members and value wheels could be and preferably are substantially parallel to each other, but those skilled in the art could select other relative positioning including positioning each element in a plane passing through the axis of the print rotor. The same may be said of the date wheels and the elements mechanically linked thereto.

As was mentioned previously, the cover 46 of the postage meter according to the invention need not be opened very often. Accessible within the cover area are the ink roller, the advertising plate, the lever permitting the user to present or retract the date from printing, and the block that carries optional "mail type" dies, for example stating that the mail is being sent by presorted first class.

The manner in which date wheel setting is accomplished will now be described in some detail.

When the setting members are actuated (by the gears 25, in the exemplary embodiment), this is generally because it is desired to change the value wheel settings, and not to change the date wheel settings. This is for the simple reason that the value wheel settings change many times a day, while the date wheel settings generally change only once a day. In practical terms, this means the gears 25 are actuated so that, most of the time, the setting members (in the exemplary embodiment, the racks) are confined in their movement to the ten positions associated with the ten indicia-bearing faces of the value wheels.

When it is desired to change the positions of the date wheels, this most often occurs because the calendar date has changed. This may arise in any of several different ways.

The postage meter according to the invention will keep track of the date on which it last printed postage, and upon power-up the meter will consult its internal clock/calendar to see whether the date has changed since the date on which it last printed postage. If the date has changed, then depending on the design choice of the meter manufacturer, the meter will either (1) recommend a date setting to the user of the meter, for example by a display of a message, or (2) change the date as shown on the date wheels to reflect the present date.

The postage meter according to the invention will also keep track of the possibility that it may be powered up at a time when a change of the date wheels may be appropriate. For example, the meter may be left powered up around the clock for any of several reasons: the meter may be in active use around the clock, or may simply be left powered around the clock intentionally or through inadvertence. At the very least, the event of midnight passing will desirably prompt updating the date wheels, or at least suggesting to the user that the date wheels be updated.

A more sophisticated plan may also be followed according to the invention, which takes into account the daily routine of those using the postage meter. For example, in the United States, the postal authorities recommend that if metered mail is deposited in a mail box after the last scheduled pickup of the day, the metered date should be the next day when pickup is scheduled. As an example, suppose that the last pickup of the day is 5:00 PM Monday through Friday, and that mail is not picked up Saturday or Sunday. Suppose in addition that it takes fifteen minutes for mail that has been franked to reach the mail box. In this case, it would be desirable to design the meter so that it can be programmed to advance its date (or to suggest advancing its date) at 4:45 PM Monday through Friday. The advance to be performed on Friday would desirably be an advance of three days, so that the printed date would be that of the following Monday.

In a preferred embodiment, an offset may be stored into the postage meter, so that the date wheels will advance not at midnight but at a preset time before midnight. Desirably this offset is not changeable by the user, but is changeable only by authorized field service personnel.

It should also be appreciated that while most date wheel adjustments are expected to be in the forward direction, adjustments in the other direction can be expected from time to time. Some prior art date wheel adjustment mechanisms, as mentioned earlier, only permit automatic adjustment in the forward direction. At least three scenarios may be envisioned wherein retrograde movement of date wheels would be desired.

First, it may happen from time to time that a user may wish to frank some mail pieces today that will not be mailed until some future date. If so, the date wheels would need to be set ahead to the future date for the franking of the mail pieces that are to be mailed on that date, and then the date wheels would need to be restored to their normal date, such as today's date.

Second, in some countries there are mail classes for which it is required that the mailer imprint the month and year, but not the day of the month. In those countries, the date wheels for the day of the month contain not only the digits 0 through 9, but also a character (a blank or a dash) that is used when the day of the month is not to be printed. A date wheel adjustment mechanism that only permitted forward adjustment of dates would not handle well the task of selecting digits, then blanks or dashes, then selecting digits again.

Finally, it is to be assumed that even if it happens only rarely, it will happen from time to time that one or more of the date wheels will be in a position other than the position that the software thinks the date wheels are in. Stated

differently, it is desirable that at all times the software of the meter keep track of the presumed position of the date wheels, based on an initial position and based on keeping close track of all the changes of wheel position performed by the software through the setting means of the meter. Yet because there is no direct mechanical or electrical feedback from the date wheels themselves (in the exemplary embodiment, at least), the software has no direct mechanical or electrical way of knowing the exact positions of the date wheels themselves. The system is, from the electrical and mechanical point of view, an "open-loop" system; there is no electrical or mechanical feedback. So it may occasionally happen that a date wheel has a position other than that recorded by the software.

Such an occurrence is virtually impossible with respect to the value wheels because they are at all times either locked into place or linked in a robust way to setting and sensing mechanisms in the main body of the postage meter. But the date wheels are held into place only by detents and are moved by ratchets. As a consequence it is possible for a date wheel to move under circumstances other than actuation by the setting means of the rotor. To give one example, it may happen that the postage meter loses power at a time when one or more of the date wheels is in contact with a mail piece, in which case efforts by the user to extricate the mail piece might cause a date wheel to change position. To give a second example, the design of the postage meter may give the user access to the date wheels for user-initiated manual adjustment of the date wheels. If so, the user-initiated manual adjustments will lead to differences between the actual date wheel positions and the date wheel positions recorded in software.

In any of these cases it will be desirable, according to the invention, to close the loop by providing feedback regarding the positions of the date wheels. According to the invention this is provided by the user printing a sample mail piece, desirably using a postage amount of zero. The user then reads the date from the mail piece, and enters the digits of the date into the postage meter at a keyboard provided thereon. The date entered by the user is stored in the memory of the postage meter and is used by the software in subsequent calculations regarding suggested or automatic changes in the date wheel positions. It is anticipated that this step by the user will be required only rarely, since all or nearly all changes in date wheel settings will occur under program control rather than through inadvertence. As a consequence, the step of asking the user to key in the date from a sample mail piece, since it will happen only rarely, is not expected to constitute a burden on the user of the postage meter.

As mentioned above, the mechanism according to the invention permits moving dates forward and backward. In this respect the mechanism of the invention offers benefits over many systems in which only forward motion is possible. Stated differently, in many systems for a date to be moved backwards it would be necessary to advance the date by several thousand counts, through all possible dates, until the date wheels "rolled over" rather like the odometer of a car that reaches 100,000 miles or 100,000 kilometres.

But it will also be appreciated that the mechanism according to the invention offers further benefits over many prior art arrangements in that the date wheel adjustment is substantially in parallel rather than serial. To illustrate this, consider the case of a postage meter that was last used on June 1 and goes unused for a month and a half. When the meter is next turned on, it is desired to advance the date from June 1 to, say, July 15.

With some prior art serially set date wheel systems, such as those of US-A-5301116 or CH 670524 as mentioned above, there is a single actuator such as a solenoid which advances the date by one count. A "carry" mechanism is employed so that after the units digit changes from "9" to "0", the tens digit increments, and so that after the tens digit increments past "3", the month changes. With such a system, an advance of the date from June 1 to July 15 requires at least forty-five actuations of the actuator (and with many designs the number of actuations is much more than forty-five, taking into account that dates beyond 31 must be skipped).

With still other serially set date wheel systems, such as that of US-A-4852482 as mentioned above, there is a date actuator which can be moved back and forth to engage the units, or the tens, or the month, or the year. In such a system the time required to perform the date adjustment is the sum of the times required to adjust each of the date wheels together with the times required to move the actuator back and forth.

The system according to the invention, however, never requires more than eleven steps to adjust the date wheels to any desired date (including the year) regardless of the previous setting of the date wheels.

When the feedback loop is closed by user inputs, as it is in the meter according to the embodiment, there is the possibility that a user who wishes to frank mail with a misleading date may accomplish it. For example, as mentioned above when the meter is turned on, one of the first things it will do is ask the user to print a sample mail piece and look to see if the date is right. The user who is very familiar with the postage meter and its operation could answer the question falsely, stating that the date is not right. The user will then be prompted to key in, at the meter keyboard, the date that appeared on the sample mail piece. The user could then type in a date that differs from the date actually printed on the sample piece. The result would be that the meter has been tricked into setting its date wheels to an incorrect position.

To protect against this, the software of the meter is preferably set up so that instances of resetting due to user input are tallied. The meter stores within its memory a record relating to each such user input, each record containing the date and time at which the user input occurred, the values provided by the user that are expected to have been obtained from the sample mail piece, and the difference (negative or positive) between the expected and actual date

wheel settings. If the number of such records is large, this may be an indication that would suggest to postal service personnel that the user has been tricking the meter to print misleading franking dates.

It might also be helpful to maintain statistics derived from the user-input date-change records. For example, if a user input record shows a two-day change in one direction (that is supposedly due to an incorrectly positioned date wheel) resulting in setting the date forward two days, and if a previous user input record shows a two-day change in the other direction (that once again was supposedly due to an incorrectly positioned date wheel) resulted in setting the date back two days, then this pair of records might be an indication of the user trying to trick the meter. So one statistic that might be kept is the number of times that pairs of user inputs occurred that resulted in a move back by a number of days and a move forward by the same number of days.

Ratios would also be helpful, for example, a total could be kept of the number of times the date has changed, and a total of the number of times a user input occurred relating to the date. The ratio of the totals would be helpful for diagnostic purposes and as an indication of possible attempts by a user to trick a meter into setting the wrong date.

It is helpful to keep a certain perspective regarding the detection of user inputs intended to trick a postage meter into printing the wrong date. After all, the vast majority of postage meters in present use have date wheels that are set only by the user, and with these meters there is no way to detect the user's fiddling with date wheels to backdate mail pieces.

Yet another type of statistic is also quite helpful for diagnostic purposes. For example, suppose that a pawl 39 is broken. The result of such breakage would be that the associated date wheel is not correctly set. In the system according to the invention, this would first be noticed when the time came for that date wheel to move. For example, if the pawl 39 that is assumed to have broken is the one for the month wheel, then the breakage would be noticed when the month changes.

From the user's point of view, here is what would happen. The meter would be powered up in the new month. The software would note that the date has changed, and would attempt to advance the date wheels accordingly. The user would be asked to print a sample mail piece and to indicate whether or not the date is correct. The user would respond in the negative, entering in the date from the mail piece at the meter keyboard. The software would again attempt to set the date, this time actuating only the rack (and attempting to actuate only the pawl) for the month wheel. The user would again be asked to print a sample mail piece and to indicate whether or not the date is correct. The user would again respond in the negative, entering in the date from the mail piece at the meter keyboard. After a preset number of attempts, the meter software would abandon the effort to set the date, and would enter a "call service" state, in which it would not be possible to print postage. The software would preferably note in its error log the identification of the particular date wheel (here, the month wheel) that was not set successfully.

One software arrangement usable in the postage meter according to the invention is to ask the user to confirm, after the date wheels have been adjusted, that the date wheels are in the correct position. There are two possible drawbacks to this arrangement.

First, many users will get in the habit that each day, when the meter asks this question, the answer will be unquestionably given in the negative. This may be compared with users who do other things out of habit, such as silencing an alarm clock or pressing a frequently pressed button in an elevator. The drawback with this is that the user will then print numerous mail pieces, perhaps to discover only much later that the date was wrong.

The other possibility is that the user may diligently follow instructions, printing a sample mail piece with a postage value of zero to obtain a print of the date wheel settings. This is likely to prove to be a wasteful habit, assuming the date wheels generally do get set correctly on the first try, as is desired by the designers of the date wheel arrangement according to the invention. This uses up ink, and wastes machine cycles of the franking machine. What's more, if the value wheels are inadvertently left in a non-zero position, the test will result in loss of postage value on the sample piece.

This is shown for example in Fig. 7. Some time after power is applied, the time comes to change the date as shown in box 70. This may occur, as discussed above, because the processor determines that the need for a date change occurred while the meter was powered down, in which case the date resetting desirably happens soon after power-up. On the other hand, this need may arise at a time when the meter is presently powered, in which case the date resetting desirably happens during an idle moment.

In any case, if one or more date wheels has been set, a flag is set in box 71. The meaning of the flag is essentially that a flag has been set and the operator has not yet been asked whether the new date is correct, generally because no franking has taken place.

The broken line between boxes 71 and 72 denoted that a long time might pass between the time a date wheel setting takes place and the next time a mail piece is franked. The passage of a long time could happen because the operator turns on the machine at the beginning of the work day, and does not happen to frank any mail until much later in the work day. Another way the passage of time could be long is if the meter is left powered-on overnight and not used until the next day.

In any event, at box 72 franking begins. Generally this is either because an envelope or card has been passed into the meter, or because a meter strip is printed, indicated at box 73.

In keeping with the invention this is a good time to ask the operator if the date is correct. Thus, at 74, a test is made to determine whether the flag is set. If not, execution proceeds as usual to other meter activities such as printing more postage. On the other hand, if the flag is set, then at 75 the user is asked whether the date is correct. This may be by aural annunciation or by a display at the meter which is noticed by the operator, or by the somewhat less subtle step of blocking the printing of postage until the operator answers the question. In general, since the date setting mechanism is assumed to be highly reliable, the answer at 76 will be in the affirmative. The flag is cleared at box 77 and execution proceeds as usual.

In the case where the user answers in the negative, then the user is asked to enter the printed date at the keyboard (box 78) and the software continues with a recovery from the error condition.

Thus it is desirable, according to the invention, to proceed in a way which is apparently unknown in the prior art, namely to keep track of the event of one or more date wheels having been set, and further to keep track of the event of a first mail piece being franked, which might be long after the event of setting a date wheel. After the second event, it is desirable to annunciate to the user the query whether the date is correct. This avoids the problem of wasted ink and wear and tear for the printing of sample pieces with no postage value in place. In this way a system which appears at first glance to be only "open loop" with no feedback is in fact "closed loop", with feedback, and the feedback path is well integrated into the routine of the human operator.

One skilled in the art will appreciate that for the above-described closed loop date setting system to function, it is necessary that the user be able to communicate to the meter the date that is printing on mail pieces. The user prints an item of postage (which may be either a test piece with a zero postage value or a regular mail piece) and, if the date is wrong, the user communicates the incorrect date to the meter. In a preferred embodiment, this communication takes place by way of numerical entries on the numeric keyboard of the postage meter.

But referring now to Fig. 11a, which shows a prior art print wheel sequence for the units and tens of the day of the month, it will be appreciated that it is not easy for the user to enter all possible printed dates by means of numeric keys. For example, if the printed day were "2-" the user would not necessarily be able to enter this into the meter, as there is no "-" key on a numeric key pad. Likewise there is the potential for ambiguity in that the printed day might include one or more blank spaces (shown as "□" in the figure) and the user could be uncertain how to enter the blank space at the numeric keyboard.

Fig. 11b shows a way to overcome this difficulty. The two digits on the "units" date wheel that might previously have been engraved with a "-" or space are engraved with "9" and "0" as shown. This permits correcting an incorrect date in a maximum of two user interactions. For example, if the printed digit was a "9" and the desired digit was a "4", the software advances the unit wheel by six positions. Depending on which of the "9" faces had been printing, the new wheel position will either be a "3" or a "4". One more user test is performed with a sample mail piece, and if the result was a "3" the wheel is advanced by one more position.

Stated more generally, if the incorrect digit is one that appears more than once on the wheel, so that it is not certain which of the faces bearing that digit is printing, then the wheel is advanced by the smallest number of positions that might leave the wheel in the correct position. The user is asked to print a test piece, and if necessary the wheel is advanced yet again.

The drawing of Fig. 11b suggests that the units wheel and the tens wheel of the day would both advance in the same direction, e.g. both clockwise or both counterclockwise. The portrayal of Fig. 11b is shown in this way only to parallel the portrayal of Fig. 11a, however. In keeping with the invention the units and tens wheels would advance in opposite directions.

As was mentioned above, many proposed mechanisms for setting date wheels of a postage meter have called for ratchet movements. Repeated actuation of the ratchet advances the corresponding date wheel repeatedly. But there is the difficulty that if one date wheel is advanced, one or more of the neighbouring date wheels may be dragged with it as it advances. Space is tight in a postage meter rotor, so there is little room for more parts to solve this problem. For example, placing fixed disks between the rotatable date wheels can keep one date wheel from dragging along a neighbouring date wheel, but at the cost of making the date wheel stack thicker and more complicated.

In keeping with the invention, as shown in Fig. 8 it is preferred to set up the pawl members 90, 91, 92, and 93 in an alternating up and down configuration. As shown in Fig. 8, pawl members 90 and 92 are both "up", meaning that each one advances its respective ratchet wheel 41 clockwise in Fig. 8. This advances the respective date wheel 24 counterclockwise. Pawl member 91 and 93 are both "down", meaning that each one advances its respective ratchet wheel 41 counterclockwise in Fig. 8. This advances the respective date wheel 24 clockwise.

In Fig. 8, the date retraction control 96 is shown. With control 96 in the position shown, the date wheels 24 are held upwards in Fig. 8, in contact with a mail piece during printing. If the user wishes to retract the date wheels 24 so that they do not print, the user rotates control 96 about one-eighth of a rotation clockwise. Pin 97, previously held up by control 96, now drops down into groove 98, urged downwards by spring 95. As pin 97 is fixed to frame member 99 (which has a front counterpart parallel thereto and omitted for clarity in Fig. 8), frame member 99 moves downward, pivoted about pivot point 100, lowering the print wheels 24. Desirably, even if frame member 99 rotates downwards in

this way, the pawl members 90-93 are still capable of advancing the date wheels 24.

If the user wishes once again to have a printable date, the user rotates control 96 counterclockwise in Fig. 8, lifting pin 97 against spring 95, and lifting the date wheels 24.

Omitted for clarity in Fig. 8 are the return springs 34 (see Fig. 9).

One skilled in the art will appreciate that it is desirable to lay out the print indicia on the print wheels 24 to match the setting direction. As shown in Fig. 8, the month wheel rotates counterclockwise to advance from, say, January to February. On the wheel itself, February lies just clockwise from January.

The wheel next to the month wheel is the tens digit of the date. This wheel rotates clockwise to advance the tens digit. On the wheel itself, 3 lies just counterclockwise from 2.

The wheel next in sequence is the ones digit of the date. This wheel rotates counterclockwise to advance the ones digit. On the wheel itself, 3 lies just clockwise from 2.

The wheel next in sequence is the year of the date. This wheel rotates clockwise to advance the date. On the wheel itself, 1995 lies just counterclockwise from 1994.

The sequence of date wheels is, of course, different for example in Europe where the presentation is day, month, and year. In such a configuration, the levers 32 may be in different positions along pivot pin 37. This leaves unchanged the basic teaching which is the desirability of advancing adjacent wheels in opposite directions.

It will be appreciated that one distinctive aspect of the structure shown in Fig. 8 is that the date wheels 24 comprise a "stack" or assembly of wheels with the upwards and downwards arrangement of indicia as described above. This may then be described as a date wheel assembly comprising a plurality of wheels, each with raised indicia thereon, the indicia collectively defining a printable date comprising a year, a month, and a date, an axle, the axle disposed within the wheels such that the wheels each are rotatable thereabout, and detent means urging each of the wheels into any of at least ten positions, further characterized in that the raised indicia are arranged on the respective wheels such that on any two adjacent wheels, the indicia increase in opposite directions. As mentioned above, the sequence of wheels may be month, day, and year, for example for the U.S. market, or may be day, month, and year, for example, for certain European markets, or may be year, month, and day if that sequence is specified by a PTT. The number of wheels will typically be four -- the units of the day, the tens of the day, the month, and the two-digit year. Such an arrangement provides twelve years of date coverage. Alternatively, the number of wheels may be five, with the year split into a wheel for each digit thereof. In that case, the meter has a "perpetual" year; it is not limited to twelve years of coverage.

Turning now to Fig. 9, what is shown are the pawls 90-93 and their positioning relative to the ratchet wheels 41. Superimposed in this view are the "up" pawls 90 and 92 and the "down" pawls 91, 93. Levers 32 are shown in their "home" position, which is fully counterclockwise in Fig. 9. They are urged in that direction by return springs 34, and the limit of movement is set by hole 35 and pin 36. The springs 34 also serve to urge each pawl 90, 92 downward toward the wheels 41 (by the lower springs 34). The springs 34 also serve to urge each pawl 91, 93 upward toward the wheels 41. The mechanism just described is desirably unaffected by the date wheels being retracted or raised by the user, as described above.

If all four of the levers 32 were rotated as part of a setting operation, all four of the pawls 90-93 would move rightwards in Fig. 9. Of the date wheels 24, two would move clockwise and two would move counterclockwise.

Fig. 10 shows the plan view of Fig. 9, but with each of the arms 32 in their actuated (clockwise) position. In this view, the springs 34 are omitted for clarity. The extreme movement of each arm 32 is defined by the hole 35 relative to the pin 36. The geometry of the levers 32 and pawls 90-93 is such that each wheel 41 moves about one-twelfth of a rotation. As a result, each of the date wheels 24 moves about one-twelfth of a rotation. The detents, omitted for clarity in Fig. 10, serve to centre the print faces of the date wheels 24, and also serve to hold each date wheel 24 in place when the pawls 90-93 subsequently drop back into their rest positions.

It will be appreciated that the configuration shown in Fig. 10, where all four of the levers 32 have been rotated, does not occur very often. Most often if a date needs to be set, only one or two of the wheels 24 needs to change, so only the corresponding levers 32 will be rotated.

It will be appreciated that no matter what position the date wheels 24 may have, any desired new date wheel setting could be accomplished by no more than eleven excursions of various of the levers 32.

It will be appreciated that according to the invention what has been described is, in most general terms, a postage meter comprising an ascending or descending register within a secure housing, a value printing means operatively coupled with the an ascending or descending register and disposed for printing of postage value, and a plurality of date wheels located on a common axle, each date wheel having indicia thereon indicative of a component of a date. Coupled to at least two adjacent date wheels are respective advancing means. One advancing means advances its respective date wheel upwards and the next advances its date wheel downwards. Nothing about this description relies on any particular design of advancing means, other than that the advancing means advances its wheel in a particular direction and protects its wheel from backward movement. If there are several settable date wheels, it is desirable that each one have a respective advancing means coupled to it, the advancing means disposed to advance their respective

date wheels in alternating directions.

It will be appreciated that if the advancing means for the date wheels are disposed one upward, the next downward, and so on, then it is desirable that the print indicia on the wheels be arranged accordingly. Thus, one wheel will preferably have indicia increasing clockwise about the wheel, while the next wheel will preferably have indicia increasing counterclockwise.

Those skilled in the art will appreciate that the teaching of the invention to alternate advancing means clockwise and counterclockwise to overcome wheel dragging applies not only to the particular ratchet mechanism described above, but to myriad other date wheel advancing means. For example one could take any of numerous date wheel advancing means from the prior art, heretofore all applied to rotate date wheels in the same direction, and dispose the advancing means alternately upwards and downwards, thus employing the teaching of the invention to yield a mechanism immune from wheel dragging.

As was mentioned above, in some prior art postage meters, the only direction in which the date wheels may be automatically adjusted is in the forward direction. This offers the drawback that if the wheels have been advanced too far forward, it takes a very long time to adjust wheels forward enough that they roll over and approach the correct date from below. But if, on the other hand, the mechanism permits forward and backward adjustment of the date wheels, then there is the danger that a user might take advantage of the forward and backward adjustment capability to print postage that falsely indicates a date of mailing in the past. Such backdating of mail violates postal regulations in some countries, but is easy to do in postage meters that have date wheels that may be manually adjusted by the user.

In the postage meter according to the invention, however, desirably the control program is set up to perform the following method:

- the user requests to be able to change the date as indicated by the print wheels;
- the user indicates a request, namely the desired date to be indicated on the print wheels;
- the control program compares the requested date with the actual calendar date as found in a trusted electronic calendar within the postage meter;
- if the requested date is in predetermined relationship with the actual date, then the stored program causes the date wheels to be adjusted to match the requested date;
- if the requested date is not in predetermined relationship with the actual date, then the stored program does not change the date wheel position but instead displays an error message to the user;
- later, if the user wishes to restore the date to the actual (today's) date, this may be done with the push of just one or two buttons, with no need to enter in all the digits of today's date.

The predetermined relationship is, in compliance with PTT rules, at the very least a requirement that the date can only be set to a date after the present date, not a date in the past. In addition, preferably the stored program is set up so that if a date is set forward, it is set only a limited number of days into the future. The day limit for such setting is a settable parameter, settable by authorized service personnel.

It will be appreciated that this software limitation that dates may only be set forward is quite a different thing than the prior art mechanical limitation of dates only being settable forward. In the prior art meters having the prior art limitation, the automatic mechanism can only advance the date, not change it backwards. Thus it is unworkable from a practical point of view to have the meter change the date forward (for predated mail) and then to have the meter change the date backward (to return to franking of mail with the actual date). In the meter according to the invention, however, the mechanism can equally well change the date forwards or backwards, and it is only a matter of the stored program that the user cannot select dates in the past for franking, but may only select the present date or a limited range of dates in the future.

Those skilled in the art will appreciate that the system according to the invention is closed loop in the sense that the user is able to close the loop by, for example, typing in the present date wheel setting at the keyboard. In response, the control program makes whatever wheel movements as are required to move the wheels to the desired position. It is hoped, however, that in most circumstances the wheels would not be in positions other than the positions that the control program thinks they are in. But it is easy to imagine a circumstance in which it is impossible for the control program to be sure where the wheels are. For example, assume that the setting mechanism being used is the one in which racks are moved forward and back to set value wheels, and in which the manner in which the date wheels are adjusted is by permitting the racks to "over-travel", thereby striking levers that advance the date wheels. In such a system there will preferably be sensors that indicate whether the racks are forward or backward. For example, a setting axle may be rotated forward and back to set the value wheels, and the setting axle is coupled with breakaway clutches to gears associated with each of the racks. The gears are halted at selected positions by the dropping of pawls into sawtooth teeth on the gears; the pawls are dropped by releasing electromagnets. The axle has two sensors on it, one that represents a "home" position for the axle and a second sensor that generates clock pulses indicative of movement of the axle through ten or more angular positions as it moves forward and back. The sensors may be called the "setting

axle home" sensor and the "setting axle clock" sensor, and may be seen in Figs. 9C and 13 as sensors 504 and 503, respectively, in the copending application no. , entitled "Single-motor Setting and Printing Postage Meter", and the specification of which is attached hereto as an appendix.

As will be seen from Fig. 13 in that application and the appendix, in the setting axle home position, signal 504 is high and signal 503 is low. When the setting axle is in its extreme position, signal 504 is again high, and signal 503 is high. In this way, software may distinguish between the axle being in its home or extreme positions.

In the normal case, when power is applied to the meter, the axle is in its axle home position. Sensor 504 is high and sensor 503 is low. It may be reasonably assumed in software that the date wheels are intact -- that they are in the position that they were in before power was lost.

Consider now the case where, upon application of power, the sensor 504 is low. Basically this means that the setting axle is in the middle of the first half of a setting cycle or in the middle of the second half of a setting cycle. Software cannot be sure whether the axle is in the first half of the setting cycle or the second half of the setting cycle. Thus the best course of action is to turn off power to the pawl electromagnets so that the pawls drop into the sawtooth teeth of the setting wheels, and to energize the setting motor until such time as signals 503 and 504 are both high. This means that the setting axle has reached its half-way position. Then the software proceeds as described next for the situation where both signals 503 and 504 are high.

In the case where upon power-up the signals 503 and 504 are both high, it is assumed that the setting axle is in its extreme position (half way through a setting cycle, point 502 in Fig. 13 of copending application no. 08/422,155). In this instance, the electromagnets are energized and the setting motor is turned on. In software, a count is kept of the number of pulses received from sensor 503. If it exceeds some predetermined number (e.g. 15) without the signal 504 going high, then under software control the magnets are de-energized and the pawls drop onto their respective saw-tooth setting wheels. It is assumed in software that this means the value wheel setting is not known to be good, but the date wheels will be unaffected by the actuation of the setting motor.

In this way, the software can recover from the circumstance of power being applied when the setting cycle was in progress, and software is able to know whether or not the date wheel positions have been corrupted, and is able to know whether or not the value wheel positions are known with confidence.

It should be appreciated that those skilled in the art may readily devise obvious modifications and variations from the precise embodiments described herein, all of which are within the scope of the invention, which is defined by the claims which follow.

Attached as an appendix hereto is the text of European patent application no. , filed on the same date as the present application, as mentioned above.

APPENDIXSINGLE-MOTOR SETTING AND PRINTING POSTAGE METER

5 The invention relates generally to postage meters or
franking machines, and relates more specifically to mechanisms
to accomplish the setting of print wheels therein and the
10 printing of postage.

 The designer of a postage meter, also called a franking
machine, faces many competing pressures. First and foremost
15 is the requirement that the design of the meter satisfy the
postal authorities in the country where the meter is to be
used. If a manufacturer has the goal of marketing the meter
in not one but several countries, the practical consequence
20 is that the meter has to satisfy all of the postal authorities
in all of the countries, or must at least be easily and
inexpensively adapted to comply with the requirements in each
25 country. Generally there will be a requirement that critical
portions of the meter (for example, the ascending or
descending register and the printing mechanism) be contained
30 within a single secure housing. The housing has to be made
so that it is easy to detect tampering (and attempted
tampering) by visual inspection. The postage impression
placed on the mail piece by the meter has to be of a printing
35 technology that is not easily counterfeited, replicated, or
altered without detection; this tends to rule out most
printing technologies other than the use of formed metal print
40 elements within a rotating print head or rotor. Indeed the
vast majority of postage meters in use worldwide have print
rotors using metal print elements having raised indicia which
45 receive ink on the raised areas thereof from an ink roller,
and the rotor is rotated so that the indicia come into contact
with the mail piece to form the postage impression on the mail
50 piece. In this way a relief printing impression is
accomplished that is much more difficult to counterfeit than,
say, a pin-matrix or ink-jet impression. The indicia include
55 fixed portions such as the country and meter identification
as well as variable portions such as the date and postage

amount. The variable portions are varied through the use of
print wheels that can be rotated so that particular indicia
5 are positioned for printing.

It will be appreciated that the mechanism for the setting
of print wheels represents a particularly important aspect of
10 the meter design. To be approved by the postal authorities,
the mechanism has to provide a highly reliable linkage between
the print wheels and the ascending and/or descending register,
15 so that it is highly likely that any printing of postage will
result in an accurate debiting of postage value from the
descending register and/or accurate crediting of postage value
to the ascending register. In a pure mechanical postage meter
20 the linkage is, of course, a mechanical linkage between one
or more mechanical registers and the print wheels. In a
postage meter having electronic registers the linkage is
25 accomplished by a blend of hardware and software.

To satisfy postal authorities the linkage between the
print wheels and the registers must not only be highly
30 reliable over hundreds of thousands of postage impressions,
it must also be quite robust against a variety of harms
including abuse by users. Where the linkage is based partly
in software it is typically required that the software monitor
35 the mechanism so that malfunctions are detected and
annunciated.

The linkage between the print wheels and the registers
40 is difficult to design not only because of the above-described
regulatory requirements but also because it has to function
in the context of a rotating print rotor. The rotor has to
45 be capable of rotating a million times or more in the life of
the meter, which emphasizes the fact that the rotor must be
freely rotatable relative to the rest of the meter. Somehow
50 the designer must arrive at a way to accomplish the print-
wheel linkage across the boundary between the rotor and the
rest of the meter. The linkage has to provide its highly
55 reliable function of adjusting print wheels when the rotor is

not moving, and yet has to lock the print wheels during times when the rotor is moving.

5 The patent art is filled with approaches that have been proposed for the linkage between the print wheels and the registers, few of which have been commercially successful.
10 One successful approach is that employed in the F310 postage meter. In that prior art approach, the print rotor has a long axle with an H-shaped cross section. Along the axle and set
15 into recesses of the axle are racks that slide along the axle. Each rack is linked to a respective print wheel in the rotor, so that in a typical rotor with four or five print wheels there will be a corresponding number of racks along the axle.
20 When the rotor is in a "home" position, the racks engage with gears in the main body of the postage meter. When the rotor is out of the home position (generally because a postage
25 printing operation is in progress) the racks are no longer in engagement with the gears in the main body of the postage meter.

30 What has been described thus far is the linkage from the print wheels to gears in the main body of the postage meter. Continuing the account of a prior-art way to link the print
35 wheels to the registers, what will now be described is a prior-art way to link the gears in the main body of the postage meter to the registers. But first it is instructive to review some of the constraints on the designer regarding
40 this part of the linkage. The gears have to be under the complete control of the microprocessor, located in the main body of the postage meter, which maintains and updates the
45 registers. The microprocessor has to be able to actuate electrically controllable elements such as motors and electromagnets to bring about any desired position of the
50 print wheels. It has to be able to receive information from electrical sensors such as Hall-effect sensors, LED-phototransistor pairs, or mechanical electric switches, to
55 have highly reliable information about the positions of the print wheels. All of this has to be accomplished in a highly

reliable way (to satisfy the postal authorities) so that any
of a wide range of failure modes and tampering attempts will
5 be detectable by software so that appropriate action may be
taken, such as disabling the meter or at least logging the
suspicious event. And it has to be accomplished in a way that
10 continues to work properly after several hundred thousand
setting and printing cycles.

Beyond the requirements imposed by the postal authorities
are practical requirements. The manner in which the
15 microprocessor controls the gears (that engage the rotor axle
racks) cannot be too bulky, the parts count cannot be
permitted to be too high, the parts cannot be unduly
20 expensive, and the machine should be easy and fast to
assemble. What's more, from the user's point of view the
setting has to take place fairly quickly.

Conceptually, one way a microprocessor could control such
gears could be as follows. For each gear that needs to be
controlled, a stepper motor is provided. The stepper motor
is linked in a reliable way to the gear, and a position sensor
30 is also linked in a reliable way to the gear. The sensor
could be an encoder, so that its output at all times
communicates the absolute position of the gear. With such an
35 arrangement, when the processor wishes to bring about some
particular setting of a print wheel, the processor simply
reads the output of the encoder, determines whether or not the
40 print wheel is already in the desired position, and drives the
stepper motor as needed until the encoder indicates that the
print wheel is in the desired position.

Such an arrangement is conceptually simple, but it has
45 numerous drawbacks. Where five print wheels are to be
controlled, this arrangement would require five stepper
motors, five resolvers, and all the interface electronics
50 attached thereto. Such equipment takes up a lot of space,
costs a lot of money, and consumes a lot of power in
energizing the motors. Software is also an area of concern.
55 If the software is simple, or if the processor is not very

powerful, then it might be necessary to actuate the five
stepper motors one after the other. Such serial setting might
5 take too long for the user of the meter. Contrariwise, if the
five stepper motors are to be operated simultaneously, then
the processor has to be more powerful and the software more
10 difficult to write and test.

Yet another arrangement that some have proposed is the
user of, say, two motors. A first motor determines which of
15 the five print wheels is to be set, and a second motor does
the setting. In a typical arrangement of this type, the first
motor controls a transmission which selectively connects the
20 second motor to one or another of the gears for the print
wheels. It is all too easy to make mistakes when designing
such a system; for example when one of the gears is being set,
some attention must be given to fixing the positions of the
25 other gears. But at least one such system set forth in the
prior art overlooks this and leaves all the gears (other than
the one being set) free to move in response to any user
manipulation; it would be all too inviting (to the user who
30 is predisposed to misdoing) to attempt to get more postage
than is being paid for by manipulating the print wheels in
such a system.

Another potential drawback to such a serial set system
is that setting of all of the print wheels might take longer
40 than the user would prefer.

Serial setting has been employed in very large so-called
"flatbed" postage meters, used by mailing houses that send out
very large volumes of mail. Typically the meter is not
45 brought to the post office for inspection and resetting, but
instead the user pays an extra fee for the postal employee to
come to the user's location to inspect and reset the meter.
50 Because the meter is not moved very often, its large size and
weight are not seen as a great disadvantage by the user. Most
users of such meters print a large number of mail pieces for
any particular value setting, so the setting of print wheels
55 does not happen very often compared with the number of mail

pieces sent through the machine; as a result even though the setting of print wheels may take a relatively long time, this is not necessarily seen as a great disadvantage. The user who sends out very large volumes of mail is also unlikely to see high cost as a problem so long as the meter franks the mail quickly and reliably.

In either of the two above-described systems, there has to be a way for the microprocessor to sense, with high confidence, the positions of the systems being manipulated. One choice, already mentioned, is the use of position encoders, which provide many-wire signals indicative of the absolute positions being sensed. Another choice is to use much simpler resolvers, which emit simple quadrature signals indicative of relative motion only. Such resolvers are generally used in connection with some sort of absolute indicator such as an end-of-travel switch. The subsystem being controlled (one of the five stepper motors in the five-motor system above, or one of the two motors in the two-motor system above) is caused to move in a direction that will trigger the absolute indicator. From that point onwards, the processor (or some dedicated electronics hardware associated with the resolver) counts pulses from the resolver to keep a running account of the position of the subsystem. It will be appreciated that if such resolvers and end-of-travel switches are used, then it is necessary to run the subsystems to the end-of-travel position from time to time to be sure that everything is in the position that it is supposed to be in; depending on the design of the setting system this may be required during every setting cycle. Such excursions take time and add to the length of time the user has to wait for a setting cycle to finish.

Still another prior-art way for the microprocessor to control the print wheels is set forth in EP-A-0062 376, published October 13, 1982, assigned to the same assignee as that of the present application. As described in that patent, the control of gears associated with print wheels is

accomplished in a way that overcomes many drawbacks of the multiple-motor systems set forth above. The elements controlled by the microprocessor are but a single motor, and several electromagnets, one for each gear. The motor need not be an expensive and difficult-to-control stepper motor but can be an inexpensive DC motor. The sensors monitored by the microprocessor are LED-phototransistor pairs, each coupled to a slotted disk. (Franking is accomplished with the assistance of an additional motor, typically an AC motor, located in a base that is separate from the secure housing of the main body of the meter.)

As set forth in that patent, a single shaft carries several clutches. Each clutch is linked by gearing or other mechanical means to one of the print wheels. The single shaft is controlled by the motor. If the motor is rotated in one direction, the result is that all the print wheels are brought to one extreme position such as zero (that is, the position that would print a "zero" on the mail piece) or a defined position below zero. If the motor is rotated in the other direction, the result is that all the print wheels are brought to another extreme position such as nine (the position that would print a "nine" on the mail piece). A sensor linked to the shaft permits the microprocessor to monitor the position of the shaft and the progress of its movement.

The mechanism described thus far is of interest only to the users whose postage printing needs would consist of repeated characters such as "1111" and "2222". As described in the above-referenced EP-A-0062376, the electromagnets are employed to fix each print wheel when it has reached its desired position. Each electromagnet is associated with one of the print wheels, and has a pawl that, when released, drops into a tooth in the mechanism connecting a clutch to that print wheel. The clutch then "breaks loose", so that the print wheel remains fixed in position by the pawl, even if the axle keeps rotating. The setting cycle is as follows. First the motor is rotated in the direction that brings all the

print wheels to their minimum position. All the
electromagnets are energized. Then the motor is rotated in
the direction that increases the numerical setting of the
print wheels. When a particular print wheel has reached its
desired position, the electromagnet is de-energized. When the
electromagnet is de-energized it releases its pawl, which
halts its print wheel.

The way the microprocessor knows when to de-energize a
electromagnet is that a sensor linked to the associated print
wheel will have emitted signals indicative of the print wheel
reaching its desired position.

Eventually all of the print wheels will have reached
their desired positions, all of the electromagnets will have
been released, and the motor can stop moving. The setting
process has been accomplished.

The clutches used in this arrangement have to satisfy
several requirements. In the direction that brings the print
wheels to their lowest position (the first part of the setting
cycle), each clutch has to have a positive engagement that,
without fail, returns each print wheel to its lowest position,
despite whatever drag may exist due to friction and the like.
In the direction that increases the position of the print
wheels (the second part of the setting cycle), each clutch has
to maintain positive engagement until such time as its
associated electromagnet releases and drops its pawl. At the
point that the pawl blocks movement of the print wheel, the
clutch has to "break away" so that the two parts of the clutch
rotate relative to each other and are no longer fixed
together. The breakaway must not impose too great an impulse
load onto the pawl, or the pawl and the teeth with which it
engages could be damaged. After the breakaway has occurred,
the clutch cannot impose too great a frictional load on the
axle, since the axle has to be able to continue its movement
so that other print wheels may be moved to their desired
positions.

5 The arrangement just described, and set forth in
EP-A-0062376, offers many advantages over the prior art. It
is not very bulky compared to a system with two, four, or five
motors, does not consume much power, and is fairly easy for
the processor to control. It is much faster to set than most
10 serial setting systems.

But none of the systems discussed heretofore fully
satisfies all the competing requirements that face the
15 designer. For example, each of the systems discussed thus far
has a paper path through which a mail piece passes; the paper
path has numerous moving parts that require a relatively
powerful motor for actuation. Generally an AC motor is used.
20 But AC motors are heavy and take up a lot of space. From time
to time it is necessary for the main body of the postage meter
(the part within the secure housing) to be transported to a
post office, for resetting with additional postage value or
for a periodic check (in which the meter is examined for signs
25 of tampering). To keep down the weight and size of the main
body that is to be transported, some of the parts of the
postage meter, such as the large AC motor, are placed in a
meter base. The meter base is moved relatively rarely (i.e.
30 when the meter is installed) and the base and the main body
of the meter are designed so that the main body is readily
removed from the base for the trip to the post office. Thus
even if the base is heavy and bulky, this is not too great a
40 problem since it does not have to move very frequently.

But the decision to apportion the moving parts of the
meter into a base portion and a removable main body has
45 drawbacks of its own. Dozens of moving parts have to be added
to the design to facilitate mechanical linkages that are made
and broken when the main body is placed on the base or removed
50 from it. Each place in the main body of the meter where
something connects to the base represents a place where
someone might try to tamper with the meter to obtain free
55 postage. Thus many additional moving parts have to be added
to the design to protect against such tampering. The postage

meter prior art is filled with all manner of shutters,
interposers, sliding covers, and locks that exist solely to
5 protect against what someone might try to do when the main
body of the meter is separated from the meter base. These
moving parts contribute to the parts count of the meter, and
10 to its assembly cost and complexity. These moving parts also
affect, in a negative way, the reliability of the postage
meter.

15 In the face of all these difficulties and drawbacks it
might be thought that those working in the postage meter art
would long ago have devised ways of making a one-piece meter
that is light and small enough to take to the post office, and
20 that also satisfies all the other demands placed on a postage
meter to secure regulatory approval. Such is not the case.

According to a first aspect of the present invention,
25 there is provided a postage meter, the meter comprising: a
secure housing; a microprocessor system including an
accounting register within the secure housing; a print rotor
and a platen opposed thereto, both within the secure housing,
30 the print rotor being rotatable about an axis and comprising
a plurality of print wheels, each print wheel having indicia
thereon defining digits of a printed postage amount, the rotor
and the platen defining a paper path; a sensor in the paper
35 path and communicatively coupled to the microprocessor; an
electric motor within the secure housing, the electric motor
being engaged with first and second opposed one-way clutches,
40 the electric motor controllably coupled with the
microprocessor; the first one-way clutch being engaged with
45 the print rotor to cause angular movement thereof; the second
one-way clutch being engaged with a setting means causing
rotation of the print wheels; whereby rotation of the electric
50 motor, under microprocessor control, in one direction brings
about rotation of the print wheels, and whereby rotation of
the electric motor, under microprocessor control in response
55 to communication from the sensor, in the other direction
causes angular movement of the print rotor.

According to a second aspect of the present invention, there is provided a postage meter, the meter comprising: a secure housing; a microprocessor system including an accounting register within the secure housing; a print rotor and platen opposed thereto, both within the secure housing, the print rotor rotatable about an axis and comprising a plurality of value print wheels, date print wheel, and a mail class die, each value print wheel having indicia thereon defining digits of a printed postage amount, each date print wheel having indicia thereon defining digits of a printed date, and the mail class die having indicia thereon, each indicium defining a class of mail, the rotor and platen defining a paper path; a sensor within the secure housing in the paper path and communicatively coupled to the microprocessor; printing means within the secure housing controllably coupled with the microprocessor and engaged with the print rotor to cause angular movement thereof; setting means within the secure housing controllably coupled with the microprocessor disposed to cause selective rotation of the value print wheels, the date print wheels, and the mail class die; whereby under microprocessor control any possible combination of printed postage amount, printed date, and class of mail may be set for printing.

According to a third aspect of the present invention, there is provided a breakaway clutch, the clutch comprising a first part and a second part; the first part being shaped to receive a non-round axle rotating on an axis, and to rotate fixedly therewith about the axis thereof; the second part being shaped to rotate in relation to the first part and to the axle about the axis thereof; the second part having rack teeth for engagement with a rack, said rack teeth being disposed about a portion of the periphery of the second part, the rack teeth portion comprising more than one-eighth and less than one-half of the periphery; the second part further having ratchet teeth for engagement with a pawl, said ratchet teeth being disposed about a portion of the periphery of the

second part, the ratchet teeth portion comprising more than one-eighth and less than one-half of the periphery; the second
5 part further having light barriers for engagement with a light-emitting diode and phototransistor, said barriers being disposed about a portion of the periphery of the second part,
10 the barrier portion comprising more than one-eighth and less than one-half of the periphery.

The present invention also includes a clutch stack
15 including a plurality of clutches as described above.

According to a fourth aspect of the present invention, there is provided a postage meter, the meter comprising: a
20 secure housing; a microprocessor system including an accounting register within the secure housing; a print rotor and a platen opposed thereto, the rotor being within the secure housing, the print rotor being rotatable about an axis
25 and comprising a plurality of value print wheels, date print wheels, and a mail class die, each value print wheel having indicia thereon defining digits of a printed postage amount, each date print wheel having indicia thereon defining digits
30 of a printed date, and the mail class die having indicia thereon, each indicium defining a class of mail, the rotor and platen defining a paper path; a sensor in the paper path and communicatively coupled to the microprocessor; a motor controllably coupled with the microprocessor; a helical gear
40 about the periphery of the print rotor; and, a worm gear engaged with the helical gear, the worm gear being driven by the motor; whereby actuation of the motor by the microprocessor rotates the worm gear, which causes rotation
45 of the print rotor.

In a preferred embodiment, in keeping with the invention, what is shown is a postage meter that is self-contained; it
50 does not have a base separable from a main body. The single secure housing contains everything that would be in the main body of a prior art postage meter and everything that would be in a prior art meter base. Despite containing all these
55 things, the single secure housing is small enough and light

enough in weight to permit the entire meter to be readily transported to the post office for inspection or resetting.

5 Within the single secure housing are the print rotor with value wheels, all the mechanisms for setting the print wheels, the accounting register or registers and associated

10 microprocessor, and all the mechanisms for transport of the mail piece through the meter. According to the invention, only a handful of controlled elements are required, chiefly

15 a single inexpensive DC motor for franking and value wheel setting and a few electromagnets. Two one-way clutches are used so that rotation of the motor in one direction accomplishes a setting cycle for the value wheels and rotation

20 of the motor in the other direction accomplishes a printing (franking) cycle. The setting cycle uses a four-bar linkage to rotate a setting axle in one direction and in the other

25 direction. Clutches on the setting axle permit selective transmission of setting movement to the value wheels, mediated by pawls which are controlled by electromagnets. Power consumption is small and the meter is reliable. Despite the

30 relatively low bulk and parts count, the design satisfies simultaneously the demands of the postal authorities and the needs of the users.

35

The invention is described with reference to a drawing in several figures, of which:

40 Fig. 1 is a cross sectional view of a postage meter according to the invention;

Fig. 2 shows the print rotor in perspective view, surrounded by some of the parts that interact with it;

45 Fig. 3 shows in rearranged section view some of the gears of the postage meter as well as the motor;

50 Fig. 4A shows the gears of Fig. 3 in a plan view taken in the plane of the gears;

Fig. 4B shows the gears of Fig. 4A in a different embodiment of the invention;

55 Figs. 5A, 5B, 5C and 5D show the geometry of the "four-bar" linkage at four different times;

Fig. 6 is a stylized cross sectional view showing all the moving parts relating to one value print wheel;

Fig. 7 shows in plan view the pawl and electromagnet arrangement for one of the breakaway clutches;

Fig. 8 shows in plan view the preferred embodiment of the breakaway clutch;

Fig. 8A shows an alternative embodiment for the breakaway clutch;

Figs. 9A and 9B are perspective views of the clutch stack and Fig. 9C is a cross sectional view of the clutch stack;

Fig. 10 shows in schematic form the microprocessor and some of its connections;

Fig. 11 shows in functional block diagram form the flow or transfer of motive power in the postage meter according to the invention;

Fig. 12 shows in cross section a ridge and shroud relative to the rotor;

Fig. 13 shows some of the timing relationships in a simple value wheel setting cycle;

Fig. 14 shows some of the timing relationships for adjustment of a date wheel; and,

Fig. 15 is a perspective view showing the setting mechanism for the mail class die.

The postage meter according to the invention is shown in a cross section in Fig. 1. A mail piece enters the postage meter from the left in Fig. 1, along a paper path M directed rightwards in Fig. 1. The arrival of the mail piece in the paper path it sensed by sensor 430, which may be an optical sensor or a mechanical sensing lever actuating an electrical switch. The particular choice of sensor employed forms no part of the invention. When the sensor 430 senses arrival of the mail piece (assuming that the meter is ready to print postage) then the microprocessor 431 (omitted for clarity from Fig. 1) causes a printing or franking cycle to begin. The print rotor 500 is caused to rotate counterclockwise in Fig. 1, as shown by arrow P. Platen 429 is caused to rotate

clockwise in Fig. 1, also shown by arrow P. The print rotor 500 may desirably be the rotor set forth in copending application no. 08/421,900, filed April 14, 1995, entitled Postage Meter with Hollow Rotor Axle, which is incorporated herein by reference. The paper path may be improved in the manner set forth in U.S. Appl. No. 08/403,461 filed March 14, 1995, incorporated herein by reference.

As rotor 500 rotates, various relief (raised area) indicia pass by ink roller 410 and come into pressure contact with the mail piece against platen roller 429. Each raised area picks up ink which is then transferred to the paper in a relief fashion. The indicia include postage amount 411, date 412, mail type (class of service or type of sending) 413, and an advertising plate 428. It will be appreciated that depending on the class of service and the country, one or more of the date or mail type may be omitted, and that the ad plate 428 is optional with the user. An optional mechanism, omitted for clarity in Fig. 1, permits the user to raise and lower the date indicia so that a date will or will not be printed.

Ejection rollers 432, 433 are optionally provided which urge the mail piece quickly to the right in Fig. 1 to eject a franked mail piece out of the postage meter and into an optional receiving hopper. A mechanism omitted for clarity in Fig. 1 provides mechanical linkages between the rotor 500, the platen 429, and the ejection rollers 432, 433 so that the rotor 500, which is driven by a motor, omitted for clarity in Fig. 1, drives the ejection roller 433 as needed to move the mail piece through the paper path.

In most prior art postage meters, the meter is physically separable into a base containing the platen 429 and ejection roller 433, and a main body comprising a secure housing, containing the print rotor 500, ejection roller 432, and the accounting register or registers. In the meter according to the invention, however, all the items shown in Fig. 1, including the platen 429 and the ejection roller 433, are in the secure housing of the meter. This is possible only

because of reductions in size and weight of the meter described further below. Including all the items of Fig. 1 within the secure housing of the meter permits substantial simplification of the linkages between the rotor 500, the platen 429, and the ejection rollers 432, 433, which saves complexity and cost, and improves reliability.

Those skilled in the art will appreciate that in some countries, the register upon which the PTT places great importance is the descending register. In other countries the accounting for postage places greatest importance on the ascending register. Still other countries place importance on both registers. Herein, the general term "register" or "accounting register" will often be used interchangeably with "descending register" to denote the particular register or registers that are considered important in a particular country.

Including all these items within the secure housing also improves meter security from the point of view of postal authorities, as will now be explained. In a prior art rotor-type postage meter, the secure housing only contains the items above the paper path in Fig. 1. The secure housing, also called the main body of the postage meter, is separated from the meter base when the meter is to be taken to the post office for inspection or resetting. The meter base, in such prior art postage meters, contains the items below the paper path in Fig. 1. Those skilled in the art will appreciate that when the main body of the meter is separated from the base, the underside of the print rotor is exposed. If the rotor happens to be in the "home" position shown in Fig. 1 then the exposure of the underside of the rotor is of little concern. But if the rotor happens to have been halted while printing postage (for example due to an inadvertent or intentional loss of electrical power) with the value wheels 411 downwards, it is of concern to the postal authorities that a user might attempt to tamper with the value wheels 411. But in the meter according to the invention, as was just mentioned, everything

above and below the paper path, including the platen 429, is in the secure housing. This reduces substantially the opportunity for tampering with the value print wheels 411.

As will be described in great detail below, an important feature of the postage meter according to the invention is that all of the indicia 411, 412, and 413 are completely controllable and settable by the microprocessor 431.

Turning briefly to Fig. 2, the print rotor 500 is seen in perspective view, surrounded by some of the parts that interact with it. In this view the paper path M appears at the right, directed upwards and to the left. When postage printing (franking) takes place the rotor 500 rotates in the direction shown by the arrow P, with the top of the rotor in Fig. 2 coming toward the viewer and with the bottom of the rotor going away from the viewer. At the same time the ink roller 410 rotates as needed to accommodate the print areas 411, 412, and 413 as they pass by the ink roller 410 on their way to meet the mail piece. As will be shown in more detail below, a helical gear 415 is disposed about the periphery of the rotor 500, and the helical gear 415 is engaged with a worm gear 354. The worm gear 354 is driven (through linkage omitted for clarity in Fig. 2) by motor 353. When the microprocessor 431 (omitted for clarity in Fig. 2) actuates the motor 353 in a particular direction, the result is that worm gear 354 rotates as shown by arrow P, clockwise in Fig. 2. This rotation of gear 354 causes the rotor 500 to rotate for printing of postage. Timing disks 416, 417 have slots that are optically engaged with sensors, omitted for clarity in Fig. 2, which permit the microprocessor 431 to monitor the position of the rotor 500 in the printing cycle. Optionally, rotor movement may be sensed using the arrangement set forth in U.S. Pat. Appl. No. 08/014,658, assigned to the same assignee as the present application, and incorporated herein by reference. Axial and journal bearings of conventional design hold the rotor 500 in position relative to the rest of the postage meter, confining it axially and translationally

so that its only possible movement is rotation about its axis. A knurled, ridged, or rough region 434 is provided on the rotor 500 to assist in drawing the mail piece along its paper path. A gear 414 provides driving force from the rotor 500 to moving parts below the paper path (e.g. rollers 429 and 433 in Fig. 1) during a printing cycle.

One aspect of the postage meter according to the invention that reduces size and weight of the meter is the use of a single motor 353 to drive all meter movements including the printing of postage (franking) as well as the setting of the many print indicia. As shown in Fig. 3, the motor 353 is a DC motor driveable in either of two directions. A planetary reduction gear assembly of conventional design is optionally contained within the motor 353 and omitted for clarity in Fig. 3. The reduced speed output of the motor 353 is available at gear 300. This gear is intentionally selected to be an angled gear to reduce noise. The rotation is passed by idler gear 301 to shaft 302, on which are mounted opposed one-way clutches 351, 352.

Rotation in one direction (shown by the arrow P in Fig. 3) seizes clutch 352 so that worm gear 354 rotates; clutch 351 is free-wheeling during such rotation. Such rotation brings about a printing (franking) cycle as described above, through angular motion of the rotor 500.

Rotation in the other direction (against the arrow P in Fig. 3) seizes clutch 351 so that gear 435 rotates; clutch 352 is free-wheeling during such rotation. Such rotation brings about a setting cycle as will be described below. Reduction gears 303, 304, and 306, together with idler 305, bring about a rotation of crank gear 307.

There is, of course, some non-zero level of friction in each clutch 351, 352 when it is free-wheeling. Thus, it might be thought that during a printing cycle the gears 303 through 307 might be drawn backwards due to friction in clutch 351. Likewise, it might be thought that during a setting cycle the gears 354 and 415 (see Fig. 2) might be drawn backwards due

to friction in clutch 352. However, the extreme mechanical
advantage in each of the gear trains 303-307 and 354/415
5 together with the non-zero friction in each gear train ensures
that no backwards movement at all takes place in either gear
train when the other is being operated. Stated differently,
10 the print linkage does not go backwards at all during setting,
and the setting linkage does not go backwards very much if at
all during printing.

15 Turning briefly to Fig. 4B, what is shown is an exemplary
embodiment of the invention including a ratchet 553. The
purpose of the ratchet 553 is to eliminate backwards movement
of the setting linkage during printing. Ratchet 553 is urged
20 by a spring, omitted for clarity in Fig. 4B, in a clockwise
direction. Fig. 4B shows the gear train during a setting
cycle. During the setting cycle, the relieved cam area 550
is not aligned with the cam follower end 554 of the ratchet
25 553. As a result, cam follower 554 is forced away from the
center of gear 307, which rotates the ratchet 553 slightly
counterclockwise. As a further result, the pawl end 552 is
30 held at some distance from the teeth of the gear 304.

When the setting cycle is complete, the relieved cam area
35 550 is aligned with the cam follower 554. This permits
ratchet 553 to have its fullest clockwise rotation as urged
by its spring. This permits pawl 552 to drag on the teeth of
the gear 304. As a result, when printing occurs, which might
40 tend to cause gear 304 to turn counterclockwise, the pawl 552
blocks such movement. This eliminates backlash in the setting
linkage during printing.

45 Fig. 3 shows the gears 300 through 307 as if laid out in
a line; in reality the gears are disposed in a compact
arrangement as shown in the cross section view of Fig. 4A,
50 taken in the plane of the gears. Gear 300 may again be seen,
driven in direction P during printing and in direction S
during setting. Idler 301 transmits the rotation to shaft
302. It will be appreciated that shaft 302 carries the
55 clutches 351 and 352 and the worm gear 354, all omitted for

clarity in Fig. 4A. If the rotation of shaft 302 is in the direction S, then rotation is conveyed (via one-way clutch 351) to reduction gear 303, and thence to reduction gear 304, idler 305, and reduction gear 306. Rotation of reduction gear 306 causes rotation of crank gear 307 in the direction S.

Because of the one-way clutch 351, crank gear 307 either moves in the direction S (clockwise in Fig. 4A) or moves not at all. It never moves against the direction S (counterclockwise in Fig. 4A). Because of the manner in which microprocessor 431 (not shown in Fig. 4A) is programmed, microprocessor 431 actuates motor 353 so as to bring about integral revolutions of crank gear 307; in general the crank gear 307 never rests in any position other than the home position shown in Fig. 4A. One complete revolution of crank gear 307, which defines a single setting cycle, brings about the movement of the arm 308 counterclockwise as shown with arrow S1, and then brings about movement of the arm 308 clockwise as shown with arrow S2.

As shown in Figs. 5A, 5B, 5C and 5D, the geometry of the pivot point 435, the link 355, and the arm 308 are selected so that the range of motion of the arm 308 is about 99°, or slightly more than one-fourth of a circle. This defines a "four-bar" linkage. Arm 308 is fixed to non-round axle 426, so that axle 426 goes through the identical 99° excursion counterclockwise and then clockwise in Fig. 4A. Fig. 5A shows the home or at-rest position of the crank gear 307. Link 355 is at the extreme of its movement in the direction that is upwards and to the left in Fig. 5A. Axle 426, omitted for clarity in Fig. 5A, is in its extreme clockwise position in Fig. 5A.

Approximately one-fourth of the way through a setting cycle, the crank gear 307 has reached the position shown in Fig. 5B. Link 355 has moved downward and to the right in Fig. 5B, shown by arrow S1.

Approximately one-half of the way through a setting cycle, the crank gear 307 has reached the position shown in

Fig. 5C. Link 355 has reached the extreme of its movement in the direction that is downwards and to the right in Fig. 5C. Axle 426, omitted for clarity in Fig. 5C, is in its extreme counterclockwise position in Fig. 5C.

Approximately three-fourths of the way through a setting cycle, the crank gear 307 has reached the position shown in Fig. 5D. Link 355 has moved upward and to the left in Fig. 5D, shown by arrow S2.

At the completion of a setting cycle the crank gear 307 has reached the position shown in Fig. 5A. During the setting cycle, the crank gear 307 has moved uninterruptedly in a clockwise direction, while the axle 426 has moved first counterclockwise about 99° and then clockwise about 99° .

It is now instructive to return to Fig. 2, where crank gear 307 may be seen, rotation of which is in direction S as shown. Link 355 and arm 308 are visible, and the motion of arm 308 in the first half of a setting cycle (S1) and the second half (S2) are shown. Non-round axle 426 is also visible. During a setting cycle, axle 426 rotates first counterclockwise, then clockwise. Breakaway clutch 401a, about which more will be said later, rotates first counterclockwise, then clockwise. Rack follower 402a slides first to the left, then to the right, along fixed rod 420a. Rack teeth 403a slide first to the left, then to the right. Inside the rotor 500 a rack 425a, omitted for clarity in Fig. 2, is fixed to the rack teeth 403a and slides to the left and then to the right. A corresponding value print wheel 411a, engaged to the rack 425a, rotates one way, then the other, as described in more detail below. Racks 425 and related moving parts may be made more secure by means of techniques set forth in copending application no. 08/400,335, filed March 7, 1995, which is incorporated herein by reference.

The value print wheel 411a is fixed in a desired position by the microprocessor 431 by releasing electromagnet 404a at a particular time (during the second half of the setting cycle, as discussed in more detail below), so that the

breakaway clutch 401a breaks away. The value print wheel 411a remains fixed despite continued movement of the axle 426.

5 If a printing cycle follows, then the print rotor 500 rotates as shown by the arrow P. Rack teeth 403a rotate out of engagement with rack follower 402a, and the rack teeth
10 403b, 403c, 403d, 403e, and 403f each come briefly into engagement with rack follower 402a. After the completion of a print cycle, the rack teeth 403a come again into engagement with rack follower 402a.

15 The setting activity with respect to a particular one of the value print wheels is shown in complete detail in the stylized cross section view of Fig. 6. In Fig. 6 all the
20 moving parts relating to one value print wheel are shown as if in a single plane, viewed from the bottom of the postage meter. During a setting cycle, shaft 426 rotates clockwise, then counterclockwise in this view. Breakaway clutch 401 does
25 likewise. Rack follower 402 moves to the left, then to the right. Rack 425, which is rigidly fixed to rack follower 402, does likewise. Cog rack 422, which is rigidly fixed to or
30 integrally formed with rack 425, does likewise. Value wheel 411 has ten indicia 421 thereon, capable of printing Arabic digits 0 through 9. Value wheel 411 rotates about a shaft
35 426. Cogs in the face of value wheel 411 engage with the cog teeth of cog rack 422. Thus the rotation of value wheel 411 is first clockwise, then counterclockwise.

40 The arrangement of the indicia 421 is theoretically arbitrary, but it is desirable (for reasons that will be clearer when the pawls 406 are discussed) that they be
45 arranged so that movement of rack 425 to the right in Fig. 6 leads to the progression 0, 1, 2, 9 in the value wheel 411.

50 It will be appreciated that each rack 425 slides parallel to the axis of the rotor 500, and that the racks 425 are slidably held within the rotor and rotate with it when it
55 rotates.

One of the features of rack 425 is a surface 423 which, when the rack 425 moves to its rightmost extent in Fig. 6, engages and deflects lever 424. Lever 424 increments a position of one of the date print wheels as discussed elsewhere. Surface 423 is preferably at the rightmost end of rack 425, but could be placed elsewhere on rack 425 if desired, with corresponding relocation of lever 424.

Light barriers 408 are provided on breakaway clutch 401, spaced so that they correspond in a direct way with the print faces (indicia 421) of the value print wheel 411. Preferably the correspondence is one-to-one, but those skilled in the art will appreciate that the correspondence could be otherwise and changes could be made to the programming of the microprocessor to bring about the same inventive results without departing in any way from the invention.

Turning now to Fig. 7, the pawl and electromagnet arrangement are described in detail for one of the breakaway clutches 401a, shown in a cross sectional view from above the meter. Breakaway clutch 401 is composed of an inner part 439a and an outer part 438a which sometimes move together and sometimes do not, as described in detail below.

During the first half of a setting cycle (shown by arrow S1), the axle 426 moves counterclockwise. During the first half of the print cycle, the electromagnet 404a is energized by the microprocessor. This pulls pawl 406a against spring 437a, and out of engagement with the ratchet teeth 407a. The bevels on the bottom of the pawl 406a (as shown in Fig. 7) and the top of the ratchet teeth 407a (again as shown in Fig. 7) help urge the pawl 406a rightwards and out of engagement.

The above-mentioned counterclockwise rotation of the axle 426 causes inner part 439a to rotate counterclockwise. At some point during the rotation of inner part 439a it comes into an angular relationship with outer part 438a, and the two parts "snap" together. The two parts move as one through the remainder of the first half of the setting cycle. By the end of the first half of the setting cycle (Fig. 5C) the value

wheel 411a (see Fig. 6) will have been rotated into a predefined "home" position, which is preferably below zero in terms of the print indicium that is in position for printing.

The second half of the setting cycle then begins, with movement of the axle 426 in the clockwise direction. The two parts 439a and 438a move as one with the axle 426 and the barriers 408a permit the microprocessor 431 to monitor the movement of the outer part 438a. (As will be appreciated from Fig. 6, the robust linkage between the clutch 401 and the value wheel 411 means that the barriers 408 provide highly dependable information to the microprocessor 431 regarding the position of the value wheel 411.) The microprocessor monitors the barriers 408a with the light-emitting-diode-phototransistor pair 405a. The microprocessor 431 de-energizes the electromagnet 404a at an auspicious moment, and the pawl 406a drops into the ratchet teeth 407a. This halts rotation of the outer part 438a.

Desirably the processor polls the sensors 405 quite frequently during the second half of the setting cycle, collecting some 500 to 600 data points. The software can then analyze the data points after the setting activity has ceased, and can determine with high confidence what setting activity was accomplished. The software does a sensor debounce and counts the number of times each clock signal rises and/or falls.

The motor 353 is a powerful one, and its rotation enjoys a manifold mechanical advantage through its planetary gears and through the gears 303-307 (Figs. 3 and 4). Were it not for the breakaway clutch described in detail below, the consequence of the pawl 406a dropping into the ratchet teeth 407a would be quite simple -- the teeth would be destroyed or the pawl would be destroyed. But because of the breakaway clutch, pawl 406a brings the teeth 407a to a halt, and brings the outer part 438a of the clutch to a halt. The practical result is that a particular indicium 421 (see Fig. 6) will have been neatly centred for printing.

As will be described further below, there is an electromagnet 404 for each of the racks 425 (see Fig. 6).
5 Thus, the microprocessor releases the several electromagnets one by one, at auspicious times, and the result is that each print wheel 411 is in its desired position for printing.
10 (Date setting and setting the mail type die 413 are discussed below.)

Those skilled in the art immediately appreciate that the electromagnet 404a must not be de-energized too soon or too
15 late. Either extreme leads to the setting of a print wheel 411 to a position other than the desired position. Several factors influence when to de-energize the electromagnet. From
20 the time the microprocessor cuts off power to the electromagnet there is some non-zero time before the magnetic field drops to zero. (That time is partly a function of the
25 inductance of the electromagnet and partly a function of the persistence or remanence of the core pieces channelling the magnetic field to the moving pawl.) When the magnetic field drops to zero, it takes a while for the pawl 406a to move into
30 engagement with the ratchet teeth 407a. (That time is partly a function of the moment of inertia of the pawl 406a about its pivot, and the torque imposed on it by the spring 437a.) The
35 time delay is shown on the time line of Fig. 13 as delay 505.

If a mis-setting occurs it is not, however, catastrophic. It does not lead to the user obtaining more postage than the
40 amount debited from the descending register, for example. The reason it is not catastrophic is that the barriers 408a permit the microprocessor to detect movement of the outer part 438a
45 beyond the desired or expected position. If the outer part 438a has moved too far (so that postage would be printed in too large an amount) the microprocessor simply performs
50 another entire setting cycle. Similarly, if the pawl drops too soon this is also detectable. If need be, the microprocessor can optionally keep historical information
55 about such occurrences and take that into account when determining when to de-energize the electromagnet. If the

historical information has a disturbing trend, the user can be advised to take the meter in for service. This would be the case if the pawl 406a is sticky on its pivot, for example, if one of the ratchet teeth 407a has broken off or worn down, or if the spring 437a has broken.

As shown in Fig. 7, preferably the electromagnets 404 and the sensors 405 are all soldered to a printed wiring board (printed circuit board) 427. This simplifies assembly of the meter.

Fig. 8 shows the preferred embodiment of the breakaway clutch 401. The outer part 438 has a cylindrical cavity with cutouts 444. The inner part 439 has a body 442 with a hole 445 to mate with non-round axle 426. (In the preferred case where axle 426 is square, then hole 445 is square.) Pawls 440 are pivoted to body 442, and each is urged outward by corresponding spring 441. The spring 441, when compressed as shown in Fig. 8, exerts a force of about 11.5 Newtons; the travel of the pawl is about 1 mm. The body 442, pawls 440, and outer part 438 are all preferably made of strong plastic such as high density nylon. The pawls 440 can be Delrin 100, and the outer part 438 and inner part 439 can be Delrin 500P. Fig. 8 also shows the light barriers 408, the ratchet teeth 407, and the gear teeth 409 about the periphery of the clutch. Each of the just-mentioned three features takes up between one-eighth and one-half of the circumference, and preferably just over one-fourth of the circumference, as shown.

Those skilled in the art can devise other breakaway clutch arrangements which differ from that shown in Fig. 8 but which depart in no way from the invention. For example, the breakaway clutch of Fig. 2 of the above-mentioned European Pat. No. 62376 could be used. Alternatively, with appropriate selection of materials, the inner part 439 of the clutch could be a one-piece flexible member 443, as shown in Fig. 8A, providing the function of the above-mentioned items 440, 441, and 442. In this instance, what would be provided is a clutch comprising a one-piece inner part and an outer part, the outer

part having at least two concavities facing radially inward,
and the inner part having arms corresponding in number to the
5 concavities, each arm dimensioned to be in tension with the
inner face of the outer part, and shaped to engage with its
corresponding concavity more easily in one direction of
10 relative rotation than the other. The inner part has a non-
round hole in its center. In an exemplary embodiment, the
inner part has two arms, as shown in Fig. 8A. In other
embodiments, the inner part has three or four or more arms,
15 and importantly the arms are at regular angular spacing, i.e.
the spacing between adjacent arms is $2\pi/N$ where N is the
number of arms. This offers a small parts count and a simple
20 assembly.

Stated differently, what has been described is a
breakaway clutch comprising a first part 439 and a second part
25 438. The first part 439 is shaped to receive a non-round axle
426 rotating on an axis, and it rotates fixedly with the axle
426 about its axis. The second part 438 is shaped to rotate
in relation to the first part 439 and to the axle 426, about
30 the axis of the axle. Formed in the second part 438 are rack
teeth 409 (Fig. 6) shaped to engage with a rack follower 402
(Fig. 6). The rack teeth are disposed about a portion of the
35 periphery of the clutch, the rack teeth portion comprising
more than one-eighth and less than one-half the periphery.
Preferably the rack teeth comprise slightly over one-fourth
40 of the periphery. Also formed in the second part 438 are
ratchet teeth 407 shaped to engage with a pawl 406. The
ratchet teeth 407 are disposed about a portion of the
45 periphery of the clutch, the ratchet teeth portion comprising
more than one-eighth and less than one-half the periphery.
Preferably the ratchet teeth comprise slightly over one-fourth
50 of the periphery. Also formed in the second part 438 are
light barriers 408 shaped to engage with a light-emitting
diode and phototransistor 405. The barriers are disposed
about a portion of the periphery of the clutch 401, the
55 barrier portion comprising more than one-eighth and less than

one-half the periphery. Preferably the light barriers comprise slightly over one-fourth of the periphery.

5 In the above-described clutch, a predetermined angular relation between the first part 439 and second part 438 defines a home position relative to each other. The clutch
10 401 may be said to have breakaway means disposed between the first and second parts. When the first and second parts are in the home position relative to each other, rotation of the first part 439 in a first direction (the direction of the
15 second half of the setting cycle) causes corresponding rotation of the second part 438 in the first direction in the absence of blockage of movement of the second part 438 (e.g.
20 by the pawl 406). In the presence of blockage of movement of the second part 438, the first part 439 breaks away therefrom and is capable of continued movement unimpeded (except by a modest level of friction) by the motionless part 438. When
25 the first and second parts are in the home position relative to each other, rotation of the first part 439 in a second direction (the first half of the setting cycle) causes corresponding rotation of the second part in the second
30 direction.

What is provided is not just one clutch but a clutch
35 stack. The clutch stack comprises a non-round axle 426 rotating on an axis and a plurality of breakaway clutches 401 stacked on the axle, each breakaway clutch 401 comprising a first part 439 and a second part 438. The clutches are as
40 described above. The clutch stack may also be thought of as including the plurality of electromagnets 404 corresponding to the clutches 401. Each electromagnet comprises a pawl 406
45 movable between a first position in which the pawl engages its corresponding ratchet teeth 407 (the de-energized position), and a second position (the de-energized position) in which the
50 pawl is out of engagement with the ratchet teeth. Each electromagnet preferably has a spring urging its pawl toward the ratchet teeth. The clutch stack may also be thought of as
55 including the plurality of light-emitting-diode-

phototransistor pairs 405 corresponding to the clutches 401,
with each sensor 305 positioned to engage the light barriers
408. The clutch stack may also be thought of as including a
printed wiring board 427 disposed parallel to the axle 426,
to which are soldered the plurality of light-emitting-diode-
phototransistor pairs 405 and the plurality of electromagnets
404.

Returning now to Fig. 2, it will be appreciated that what
has been illustrated and described thus far is the setting of
one particular print indicium of the print rotor 500. Fig.
2 shows one breakaway clutch 401a, for example, the other
breakaway clutches having been omitted for clarity in Fig. 2.
Fig. 9B is a perspective view of part of the meter showing the
breakaway clutches 401a ... 401f in their vertical stack. The
same stack is seen in a different view in Fig. 9A, where rack
followers 402a ... 402f may be seen, each sliding on
corresponding rods 420a ... 420f. This sliding is parallel
to the axis of the rotor 500. It will be noted that the
clutches 401 are stacked in a line, on axle 426 (omitted for
clarity from Fig. 9B), while the rack teeth 403a ... 403f are
disposed along a section of a circle, namely a portion of the
circumference of the rotor 500. The interface between the
rotor, which rotates, and the rest of the meter, which does
not, is along the curved arc presented by the teeth of the
rack followers 402a ... 402f. When the rotor rotates for the
printing of postage, it does so in the direction shown by
arrow P. Importantly, as will be seen from Fig. 9B, no two
of the rack followers 402a ... 402f are identical. Each rack
follower 402 is shaped to take up the difference between (1)
the vertical, straight-line position of its corresponding rack
teeth 409 of its corresponding clutch 401, and (2) the
position of the corresponding rack teeth 403 which are
positioned along a curve. Returning momentarily to Fig. 6,
it will be noted that the teeth engaging the clutch 401 to the
rack follower 402 are preferably gear teeth with bevelled
faces. In contrast the teeth engaging the rack follower 402

with the rack teeth 403 are preferably square or rectangular teeth, with flat faces.

5 Turning now to Fig. 9C, the position of the racks 425a ... 425f within the shaft of the rotor may be seen, together with the rack teeth 403a ... 403f attached thereto. The rack
10 followers 402a ... 402f may be seen in cross section also. Shaft 426 runs vertically in Fig. 9C. Sensors 405a ... 405f are disposed to the right of the figure, connected with
15 printed circuit board 427. At the top are sensors 503, 504 which permit the processor to determine the position of the shaft 426 during the setting cycle.

20 Turning now to Fig. 10, there is shown the microprocessor 431 and some of its connections. The microprocessor 431 is connected to an accounting register 436, and both are within the secure housing. The accounting register can be battery-
25 backed CMOS static RAM, or EEPROM, or a combination of the two as set forth, for example, in PCT pub. no. 89/11134, assigned to the same assignee as the assignee of the present
30 application. The descending register can be protected as set forth, for example, in U.S. Pat. No. 5,276,844, or U.S. Appl. No. 08/002,737, assigned to the same assignee as the assignee
35 of the present application, or copending U.S. Appl. No. 08/422,435, filed April 14, 1995, and entitled Protection System for Critical Memory Information, all of which are incorporated herein by reference. The processor is optionally
40 connected with a modem as shown in Fig. 10 so that meter resetting can take place by telephone, as set forth in U.S. Pat. Nos. 4,807,139 or 5,237,506, assigned to the same
45 assignee as the assignee of the present application, and incorporated herein by reference. The processor is optionally connected to a tax computer or scale, as shown in Fig. 10.
50 Also connected to the processor 431 are a keyboard 437 and a display 438. Inputs are provided to the processor 431 from the decade sensors 405, the rotor sensors 416, 417, the mail
55 piece sensor 430, and other sensors not shown in Fig. 10. Outputs are provided for the processor 431 including control

lines to the electromagnets 404, and to the motor 353. An external servicing device is optionally capable of being connected as set forth in U.S. Appl. No. 07/738,477, assigned to the same assignee as the assignee of the present application, and incorporated herein by reference.

Fig. 11 shows the flow or transfer of motive power in the postage meter according to the invention. Single motor 353 provides all motive power for all meter functions. The power is selectively provided by one of the one-way clutches 351, 352 to other moving parts.

If clutch 352 seizes, then rotation is many times reduced by gears 354, 415 resulting in the rotation of the rotor 500 for the printing of postage (franking). Sensors 416, 417 permit the processor to be apprised of the progress of the printing cycle, and permit stopping the motor 353 so as to stop the rotor 500 in its home position.

If clutch 351 seizes, then rotation is reduced many times and provided to the four-bar linkage including link 355. Movement of the linkage is sensed by sensor 503 (see Fig. 9C). Clutches 401 transmit rotation through to value wheels 411, but rotation is blocked by pawls 406 at particular positions of the value wheels 411. Sensors 405 permit the processor 431 to determine the position of each value wheel 411. Extreme travel of the rotor setting elements triggers advancement of the date wheels 412. One of the clutches 401, and its associated moving parts, sets the mail class die 413.

Returning now to Fig. 9C, recall that the curved region represents the interface between the rotor 500 and the stationary rest of the postage meter. The rack teeth 403a ... 403f are in engagement with respective rack followers 402a ... 402f at the point in time shown in Fig. 9C, but during the printing of postage the rotor 500 rotates in the direction shown with the arrow P. One skilled in the art would appreciate what would happen if, say, the rack teeth 403a were to move axially, that is, into or out of the page, at some point during a printing cycle. The practical result would be

5 severe damage due to a collision with the mating teeth of the
rack follower 402f. The damage could include broken teeth on
the rack teeth 403a, broken teeth on the rack follower 402f,
or both. Rod 420f could get bent. Rack 425a could get bent.
10 Rack teeth 403a might get dislodged from its fixed connection
to rack 425a.

To minimize these harms, two protective measures are
taken. First, referring back to Fig. 2, ridge 419 is formed
15 on the exterior of the rotor 500. This ridge 419 serves,
during rotation of the rotor 500, to captivate the rack
followers 402. The rack followers 402 are thus unable to move
along the rods 420 (into or out of the page in Fig. 12).
20 Referring now to Fig. 12, the ridge 419 may be seen,
subtending so much of the circumference of the rotor 500 as
is not taken up with the rack teeth 403. Ridge 419, as
25 mentioned before, is formed in the exterior of rotor 500 and
rotates with it.

The other protective measure may also be seen in Fig. 12,
30 namely the shroud 418. Shroud 418 has grooves inside,
positioned to engage the rack teeth 403. The shroud 418
subtends so much of the circumference of the rotor 500 as is
not taken up with the rack followers 402. The shroud 418
35 serves, during rotation of the rotor 500, to captivate the
rack teeth 403. The rack teeth 403 are thus unable to move
into or out of the page in Fig. 12. The shroud 418 offers the
40 further benefit of reducing the already quite small likelihood
that a wrongdoer could tamper with the positions of the value
wheels 411 when the rotor 500 is out of its home position.

45 It will be appreciated that even if a wrongdoer were able
to move one of the rack teeth 403 when the rotor is out of its
home position, this would immediately be detected by the
50 microprocessor upon the next setting cycle. As will be
described below, the signals from the sensors 405 are
monitored during the second half of the setting cycle. If one
55 of the rack teeth 403 were disturbed from its position during
a print cycle, the corresponding clutch 401 would be unable

to rotate fully in one direction or the other. The signals from the corresponding sensor 405 would be aberrant and the microprocessor would annunciate the findings.

Fig. 13 shows some of the timing relationships in a simple setting cycle. Line 426, which is basically sinusoidal in shape, represents the angular position of the axle 426. The first half of the curve, denoted S1, represents the first half of the setting cycle S1 as shown, for example, in Fig. 2. The second half of the curve, denoted S2, represents the second half of the setting cycle S2 as shown, for example, in Fig. 2.

Skipping to line 404, what is significant is that the processor 431 energizes the electromagnet 404 at the beginning of the setting cycle. Line 404 rises to the "on" position at the beginning of the setting cycle.

Proceeding downward to line 411, what is shown is a typical position excursion for a value wheel 411 during a setting cycle. This line assumes that the value wheel 411 was previously positioned so that the printing indicium "2" was in place for printing of postage. During the first half of the setting cycle, the value wheel 411 moves to its lowest (slightly below "0") position. Dotted line 501 denotes the fact that depending on the internal friction between the inner and outer parts of the clutch 401, the value wheel 411 may return to its lowest position right away (if friction is large, shown with the dotted line) or may return to its lowest position at the latest possible time (if friction is minimal, shown with the solid line). The latter represents what happens if the inner and outer parts of the clutch 401 reach their relative home position before the outer part of the clutch moves at all. In either case, or if the behaviour of the clutch falls between the extremes, all that matters is that the wheel 411 reaches its lowest position by the end of the first half of the setting cycle. Stated differently, the practical result is that the line 411 reaches its minimum at

a time that is equal to (or no later than) the time the line 426 reaches its minimum.

5 The processor 431 has no difficulty monitoring the position of the value wheel 411 during the first half of the setting cycle, regardless of whether the value wheel 411 reaches its low position slowly or quickly, because the 10 processor 431 is able to count the pulses shown in line 405, which are pulses from the sensor 405. Here the preferred embodiment is shown, in which the excursion from digit 2 down to the position below 0 gives rise to three pulses. An additional sensor 503 (see Fig. 9C) generates pulses 15 indicative of movement of the axle 426. Here again the preferred embodiment is shown, in which the travel during the first half of the setting cycle gives rise to eleven pulses. Yet another sensor 504 (see Fig. 9C) generates a signal 20 indicating that the midpoint of the setting cycle has arrived.

25 The second half of the setting cycle will now be described. In this example, it is assumed that it is desired to set the value wheel 411 to the position "3". The axle 426 reverses direction, moving upwards in Fig. 13 in line 426, denoting motion that tends to rotate wheel 411 to its highest 30 numbered position. The microprocessor monitors the pulses from sensor 405 (or sensor 503; either may be used) and notes the third pulse indicating that the value wheel 411 is nearing its third position. As shown in line 404, the processor 431 cuts power to the electromagnet 404. Some time later the value wheel 411 halts, presumably in position 3. The time 35 delay 505 has already been discussed above.

40 Referring back to Fig. 2, it will be recalled that there is a mail class die 413, with five faces. In prior art rotor-type postage meters this die is generally set manually, for 45 example by a knob rotated by the user. In the meter according to the invention, the number of racks 425 (generally six) exceeds by one the number of value wheels 411 (generally 50 five), leaving an extra rack 425. The extra rack 425, as shown in Fig. 15, is coupled by means of a follower shaft 520 55

having a crown gear 521, to a matching crown gear 522 on the mail class die 413. In this way, linear movement of the extra rack 425 is translated into rotation of the mail class die 413 to one of its five positions.

Also referring to Fig. 2, it will be recalled that there are date print wheels 412. Turning to Fig. 6, it will be recalled that at the end of some of the racks 425 are corresponding levers 424. If the rack 425 is permitted to move rightwards in Fig. 6 beyond the position required to select the last of the indicia of the value wheel 411, the rack 425 strikes lever 424 and moves it counterclockwise in Fig. 6. This advances one of the date wheels 412, by a mechanism set forth in copending Appl. No. 08/421,902, filed April 14, 1995, and entitled System for Setting Date Wheels in a Postage Meter, and incorporated herein by reference. This causal relationship is also shown in Fig. 11, where the four movable date wheels 412 are actuated by respective ones of the racks for the value wheels 411.

The timing relationships for adjustment of a date wheel are shown in Fig. 14. The example assumes that the value wheel 411 was in position "5" before the adjustment of the date wheel 412, and assumes that the desired position of the value wheel 411 will be "5" after the adjustment of the date wheel 412.

The setting cycle begins with the processor energizing the electromagnet 404. The axle 426 begins its downwards excursion at 1, and no later than time 2 the axle "picks up" the value wheel 411. Again, dotted region 501 denotes that value wheel 411 may begin to drag along wheel 411 sooner. In any event, at time 3 the axle 426 has reached its lowest position, as has the value wheel 411. The axle 426 begins its upwards excursion, and the value wheel 411 moves upwards as well. The indicium uppermost on the value wheel 411 goes 0, 1, 2 ... up to 9 at time 4. As the electromagnet 404 remains energized (see line 404 of Fig. 14), the value wheel 411 rotates beyond its highest position. Stated differently (see

Fig. 6), the rack 425 goes fully to the right (in Fig. 6). The rack 425 strikes the lever 424, and (shown at time 5 in Fig. 14) the date wheel 412 is incremented. In this example, the date wheel 412 is incremented from position 2 to position 3.

In a normal setting cycle where the only item being adjusted is a value wheel 411, the motor 353 is halted at time 5. But in the context of a date wheel setting such as is shown in Fig. 14 it is improper to halt the motor 353, for the reason that the value wheel 411 is not in any of its normal ten digit positions. For this reason the motor 353 continues to turn, and the remainder of the date setting cycle takes place. All value wheels 411 are returned to their below-zero positions between times 5 and 6. After time 6, events proceed much as during the second half of a normal setting cycle, that is, much as shown in the second half of Fig. 13. Recall that it was desired to leave value wheel 411 in position 5. To do this, the processor 431 cuts power to electromagnet 404 at time 7 (shown with line 404 in Fig. 14). Shortly thereafter, at time 8, the pawl of electromagnet 404 halts value wheel 411. Time interval 505 is as discussed above. The setting cycle ends at time 9.

It will be seen from Figs. 13 and 14 that the date setting cycle shown there takes twice as long as a value wheel setting cycle. This is not generally a problem because a date setting generally occurs only about once a day.

It might be thought that advancing a date wheel 412 by two positions would take twice as long as the procedure set forth in Fig. 14, but such is not the case. Advancing a date wheel 412 by two positions only takes $1\frac{1}{2}$ times as long; the procedure set forth in Fig. 14 is merely modified by repeating the segment between times 3 and 6. In this way, advancing a date wheel by eleven positions would only take twelve times as long (not 22 times as long) as a value wheel setting cycle.

Since date wheels have twelve faces, this means that in
the worst case (e.g. incrementing from 9 back to 8) only takes
twelve times as long as a value wheel setting cycle.

It will be appreciated that with the foregoing, what has
been provided is a postage meter having a setting means within
the secure housing controllably coupled with the
microprocessor disposed to cause selective rotation of the
value print wheels, the date print wheels, and the mail class
die, whereby under microprocessor control any possible
combination of printed postage amount, printed date, and class
of mail may be set for printing.

APPENDIX CLAIMS (FROM EP APPLN NO. _____)

- 5 1. A postage meter, the meter comprising:
a secure housing;
a microprocessor system (431) including an accounting
10 register (436) within the secure housing;
a print rotor (500) and a platen (429) opposed thereto,
both within the secure housing, the print rotor (500) being
15 rotatable about an axis and comprising a plurality of print
wheels (411), each print wheel (411) having indicia thereon
defining digits of a printed postage amount, the rotor (500)
and the platen (429) defining a paper path (M);
20 a sensor (430) in the paper path (M) and communicatively
coupled to the microprocessor (431);
an electric motor (353) within the secure housing, the
25 electric motor being engaged with first and second opposed
one-way clutches (352,351), the electric motor controllably
coupled with the microprocessor;
30 the first one-way clutch (352) being engaged with the
print rotor (500) to cause angular movement thereof;
the second one-way clutch (351) being engaged with a
35 setting means causing rotation of the print wheels (411);
whereby rotation of the electric motor (353), under
microprocessor control, in one direction brings about rotation
of the print wheels (411), and whereby rotation of the
40 electric motor (353), under microprocessor control in response
to communication from the sensor (430), in the other direction
causes angular movement of the print rotor (500).
45
2. A meter according to claim 1, wherein the setting means
comprises a four-bar linkage (355) between the second clutch
50 (351) and a setting axle (426), whereby the axle (426) moves
from a starting position through an angular displacement and
then back to the starting position in response to rotation of
the second clutch (351) in a single direction;
55

the setting means further comprising a plurality of breakaway clutches (401), one for each print wheel (411), each breakaway clutch (401) having a first part (443, 439) rotating with the axle (426) and a second part (438) coupled with a respective print wheel (411);

the setting means further comprising a plurality of pawls (406), one for each print wheel (411), each pawl (406) being electrically actuatable between a first position engaged with the second part (438) of a respective breakaway clutch in which the pawl blocks movement of the respective print wheel in a first direction, and a second position out of engagement with the second part (438) of the respective breakaway clutch in which the linkage between the axle and the respective print wheel is unimpeded.

3. A meter according to claim 2, wherein the setting means further comprises:

a plurality of rack followers (402), each rack follower corresponding to a breakaway clutch (401) and engaging with the second part (438) thereof, each rack follower being slidable parallel to the axis of the rotor (500);

a plurality of racks (425), each rack (425) corresponding to a rack follower (402) and engaging therewith, each rack (425) being slidable parallel to the axis of the rotor, the racks being slidably held within the rotor and rotating therewith;

wherein each print wheel (411) is engaged with a respective one of the racks (425);

whereby rotation of the axle (426), with each pawl (406) in its second position, causes rotation of the first and second parts of the breakaway clutches, which causes sliding of the rack followers, which causes sliding of the racks, which causes rotation of the print wheels.

4. A meter according to claim 3, wherein the second parts (438) of the breakaway clutches (401) each further comprises

5 ratchet teeth (407) engageable with the pawl (406)
corresponding thereto, and each further comprises barriers
(408) optically engageable with a light-emitting diode and
phototransistor (405).

10 5. A postage meter, the meter comprising:

a secure housing;

15 a microprocessor system (431) including an accounting
register within the secure housing;

20 a print rotor (500) and platen (429) opposed thereto,
both within the secure housing, the print rotor rotatable
about an axis and comprising a plurality of value print wheels
(411), date print wheels (412), and a mail class die (413),
each value print wheel having indicia thereon defining digits
25 of a printed postage amount, each date print wheel having
indicia thereon defining digits of a printed date, and the
mail class die having indicia thereon, each indicium defining
a class of mail, the rotor (500) and platen (429) defining a
paper path (M);

30 a sensor (430) within the secure housing in the paper
path (M) and communicatively coupled to the microprocessor
(431);

35 printing means within the secure housing controllably
coupled with the microprocessor and engaged with the print
rotor to cause angular movement thereof;

40 setting means within the secure housing controllably
coupled with the microprocessor (431) disposed to cause
selective rotation of the value print wheels, the date print
wheels, and the mail class die;

45 whereby under microprocessor control any possible
combination of printed postage amount, printed date, and class
of mail may be set for printing.

50 6. A breakaway clutch, the clutch (401) comprising a first
part (439) and a second part (438);

5 the first part (439) being shaped to receive a non-round axle (426) rotating on an axis, and to rotate fixedly therewith about the axis thereof;

10 the second part (438) being shaped to rotate in relation to the first part (439) and to the axle (426) about the axis thereof;

15 the second part (438) having rack teeth (409) for engagement with a rack, said rack teeth (409) being disposed about a portion of the periphery of the second part (438), the rack teeth portion comprising more than one-eighth and less than one-half of the periphery;

20 the second part (438) further having ratchet teeth (407) for engagement with a pawl, said ratchet teeth (407) being disposed about a portion of the periphery of the second part (438), the ratchet teeth portion comprising more than one-eighth and less than one-half of the periphery;

25 the second part (438) further having light barriers (408) for engagement with a light-emitting diode and phototransistor, said barriers (408) being disposed about a portion of the periphery of the second part (438), the barrier portion comprising more than one-eighth and less than one-half of the periphery.

30 7. A clutch according to claim 6, wherein a predetermined angular relation between the first and second parts defines a home position relative to each other, the clutch further comprising breakaway means (441, 444) disposed between the first and second parts;

35 45 whereby when the first and second parts are in the home position relative to each other, rotation of the first part in a first direction causes corresponding rotation of the second part in the first direction in the absence of blockage of movement of the second part, and in the presence of blockage of movement of the second part the first part breaks away therefrom and is capable of continued movement;

whereby when the first and second parts are in the home position relative to each other, rotation of the first part in a second direction causes corresponding rotation of the second part in the second direction.

8. A clutch stack, the clutch stack comprising a non-round axle (426) rotatable on an axis and a plurality of breakaway clutches (401) according to claim 6 or claim 7, said breakaway clutches (401) being stacked on the axle (426).

9. A clutch stack according to claim 8, further comprising a plurality of electromagnets (404) corresponding to respective ones of the clutches (401), each electromagnet (404) comprising a pawl (406) movable between a first position in which the pawl (406) engages the ratchet teeth (407) corresponding thereto and a second position in which the pawl (406) is out of engagement with the ratchet teeth (407) corresponding thereto.

10. A clutch stack according to claim 9, wherein each electromagnet further comprises a spring (437) urging the pawl (406) thereof into the first position.

11. A clutch stack according to any of claims 8 to 10, further comprising a plurality of light-emitting-diode-phototransistor pairs (405) corresponding to respective ones of the clutches, each pair being disposed to engage the light barriers thereof.

12. A clutch stack according to claim 11, further comprising a printed wiring board (427) disposed parallel to the axle, to which are soldered the plurality of light-emitting-diode-phototransistor pairs (405) and the plurality of electromagnets (404).

13. A postage meter, the meter comprising:

a secure housing;

5 a microprocessor system (431) including an accounting register within the secure housing;

10 a print rotor (500) and a platen (427) opposed thereto, the rotor (500) being within the secure housing, the print rotor (500) being rotatable about an axis and comprising a plurality of value print wheels (411), date print wheels (412), and a mail class die (413), each value print wheel
15 having indicia thereon defining digits of a printed postage amount, each date print wheel having indicia thereon defining digits of a printed date, and the mail class die having indicia thereon, each indicium defining a class of mail, the
20 rotor and platen defining a paper path (M);

a sensor (430) in the paper path and communicatively coupled to the microprocessor;

25 a motor (353) controllably coupled with the microprocessor (431);

30 a helical gear (415) about the periphery of the print rotor (500); and,

a worm gear (354) engaged with the helical gear (415), the worm gear (354) being driven by the motor;

35 whereby actuation of the motor by the microprocessor rotates the worm gear, which causes rotation of the print rotor.

40 14. A meter according to claim 13, further comprising:

setting means within the secure housing controllably coupled with the microprocessor disposed to cause selective
45 rotation of the value print wheels, the date print wheels, and the mail class die, whereby under microprocessor control any possible combination of printed postage amount, printed date, and class of mail may be set for printing.
50

SINGLE-MOTOR SETTING AND PRINTING POSTAGE METERABSTRACT

A self-contained postage meter has a single secure housing which contains everything that would be in the main body of a prior art postage meter and everything that would be in a prior art meter base. Within the single secure housing are the print rotor (500) with value wheels (411), all the mechanisms for setting the print wheels, the descending and/or ascending register and associated microprocessor (431), and all the mechanisms for transport of the mail piece through the meter. A single inexpensive DC motor (353) for franking and value wheel setting and controlling electromagnets (404) are provided in the housing. Two one-way clutches (352,351) are used so that rotation of the motor in one direction accomplishes a setting cycle for the value wheels and rotation of the motor in the other direction accomplishes a printing (franking) cycle.



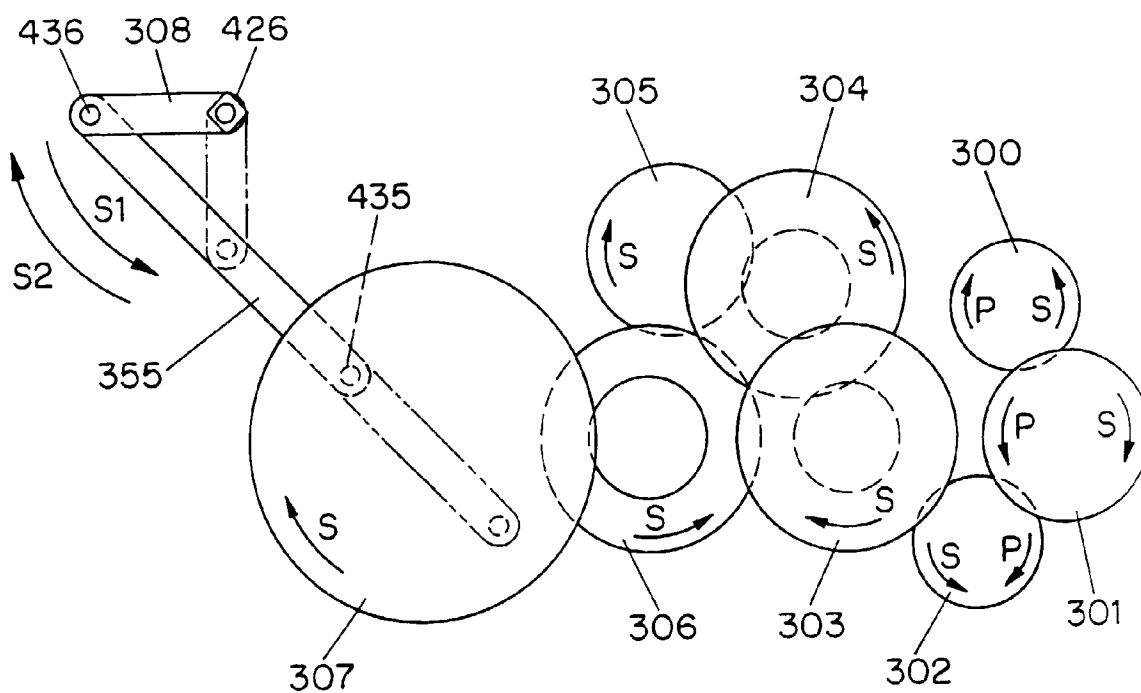


FIG. 4A

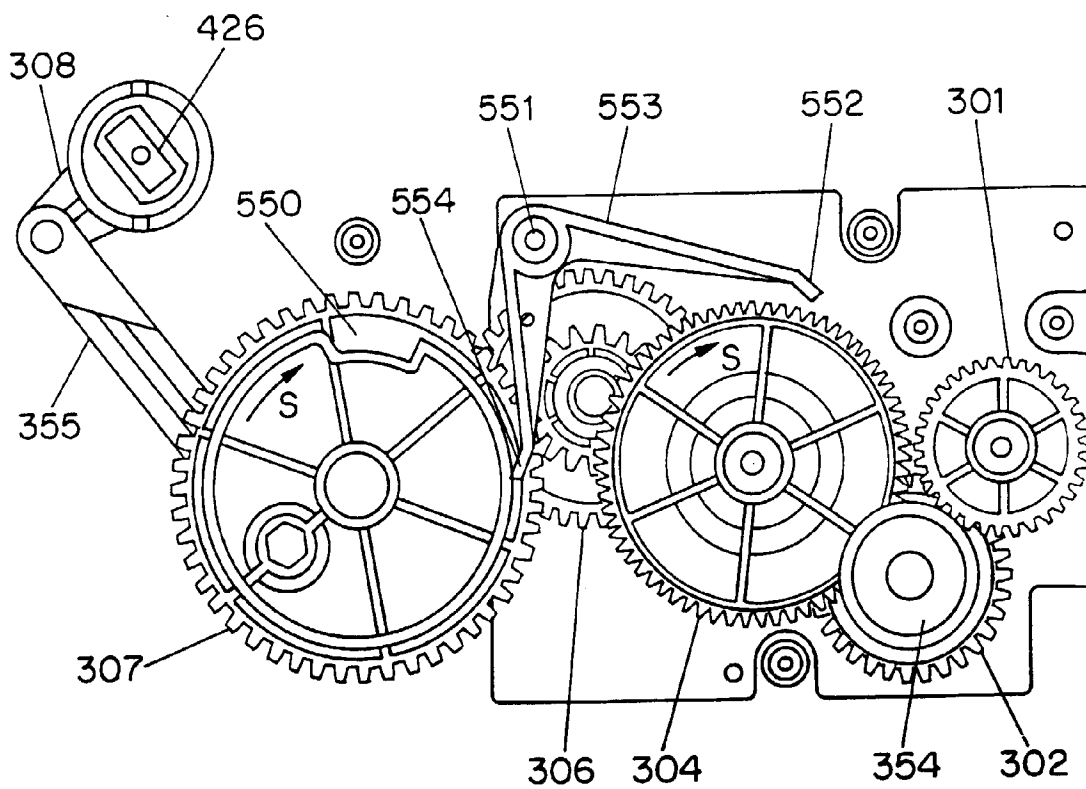


FIG. 4B

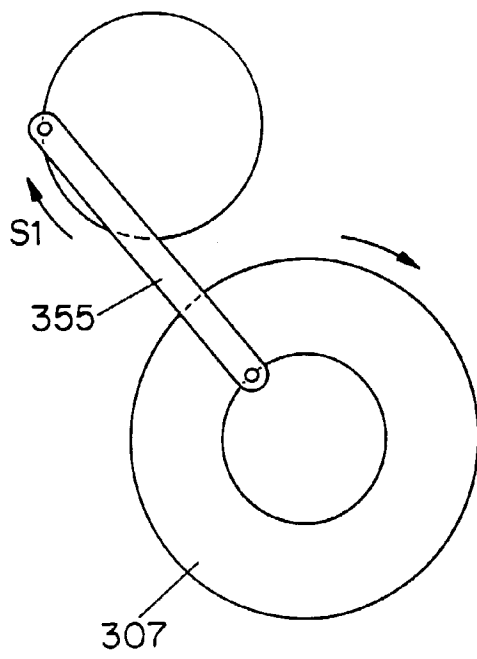


FIG. 5A

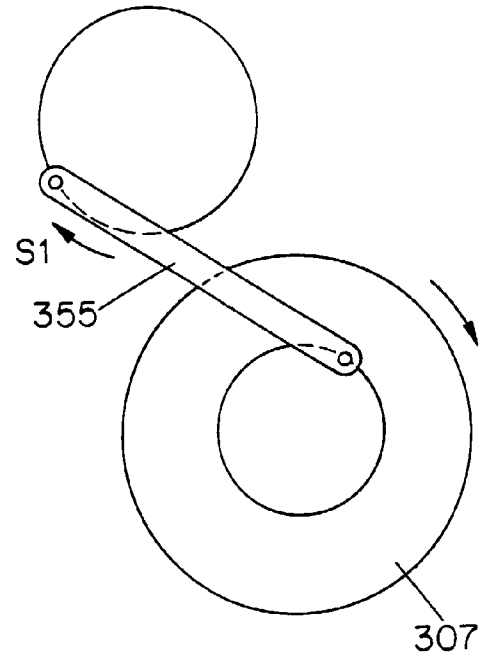


FIG. 5B

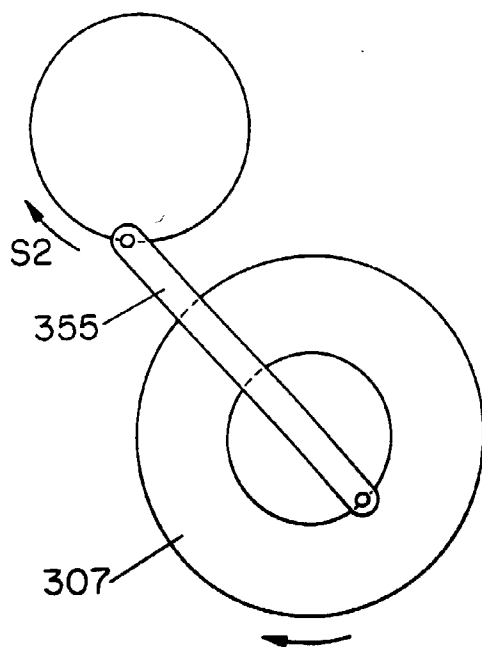


FIG. 5C

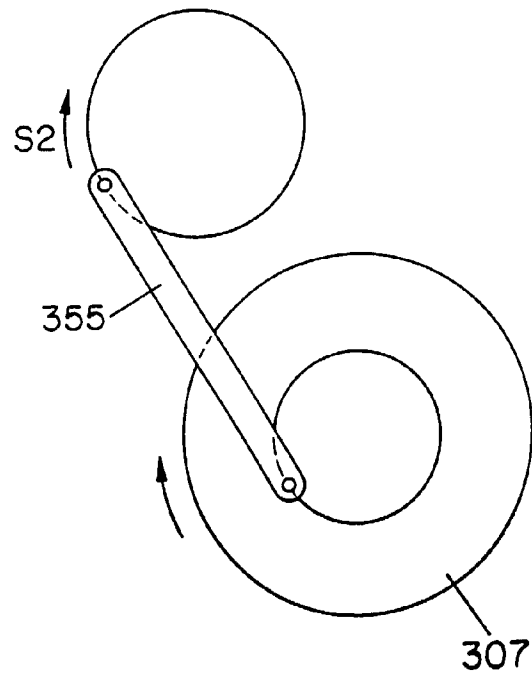


FIG. 5D

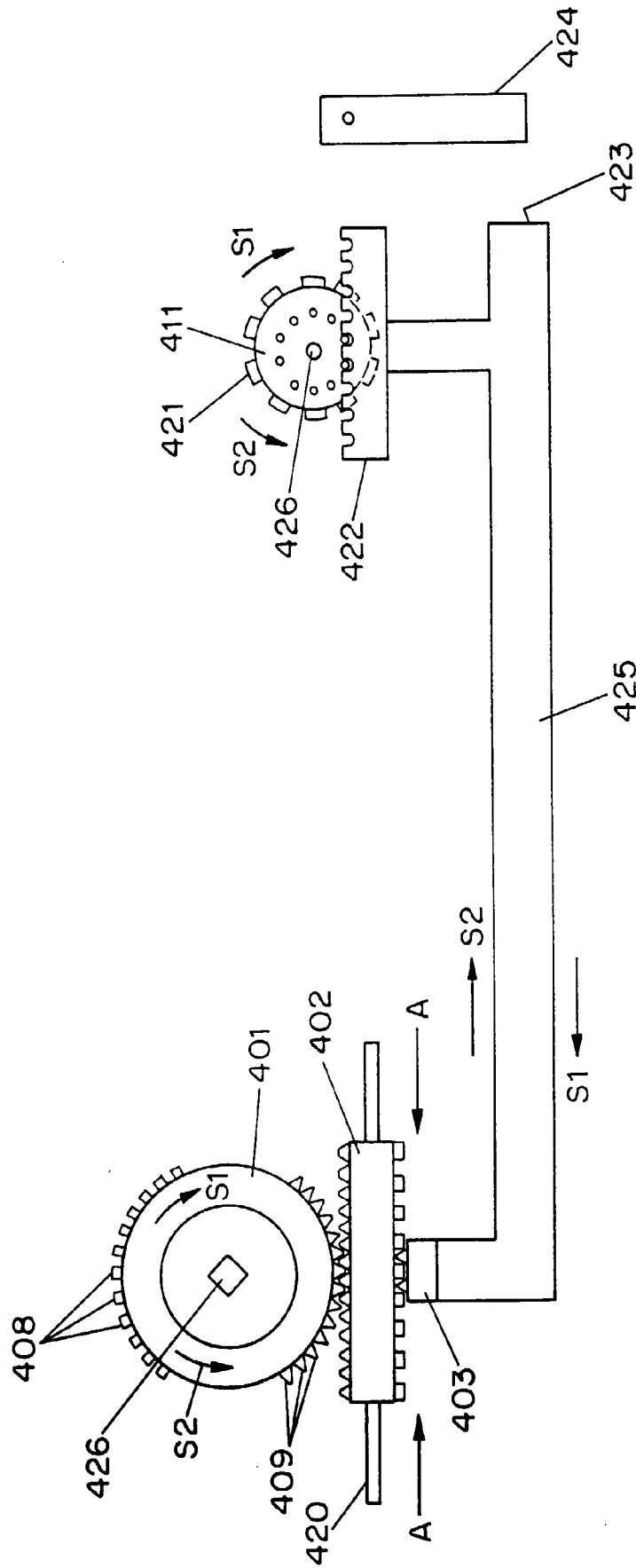


FIG. 6

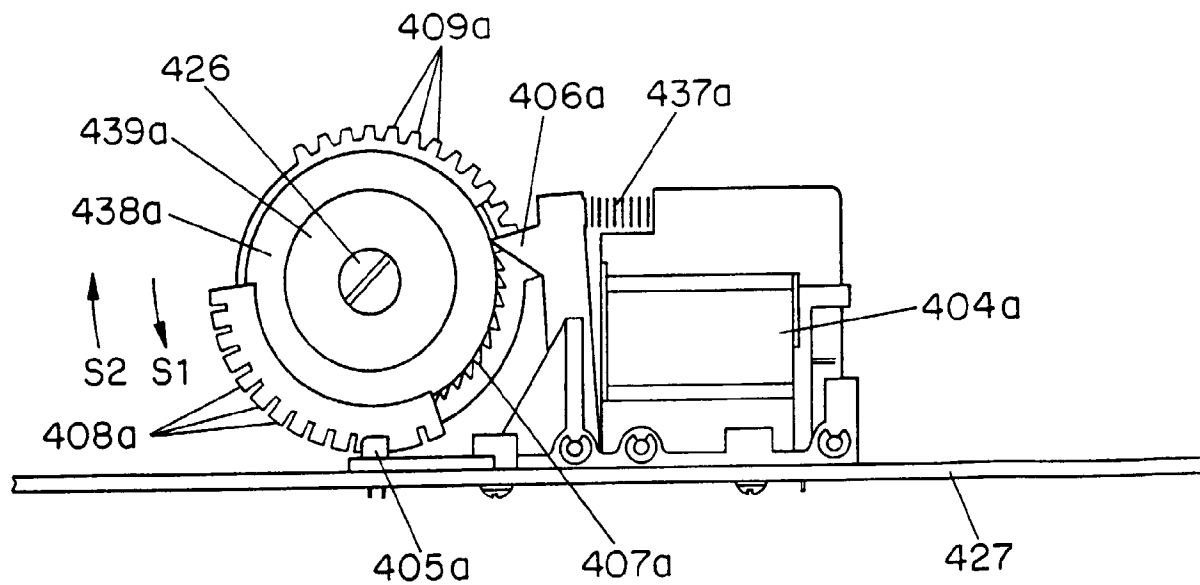


FIG. 7

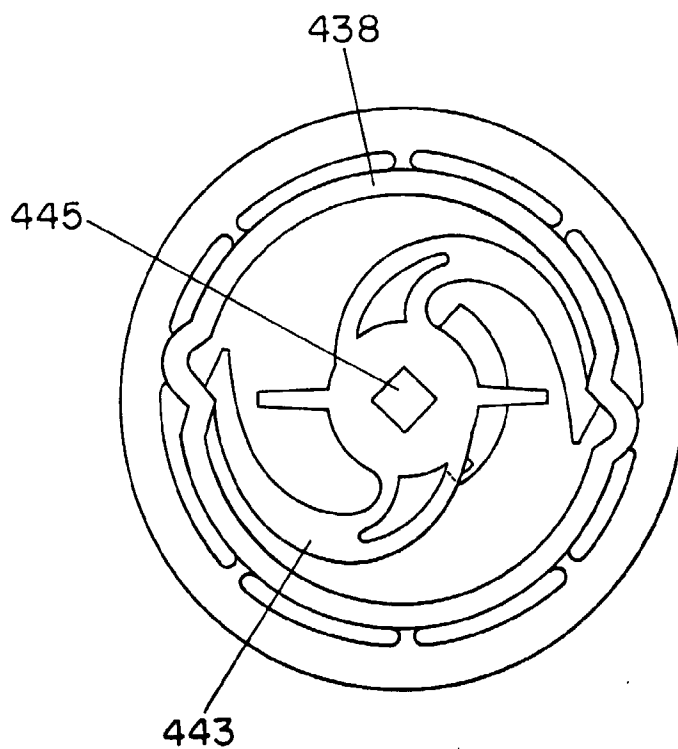


FIG. 8A

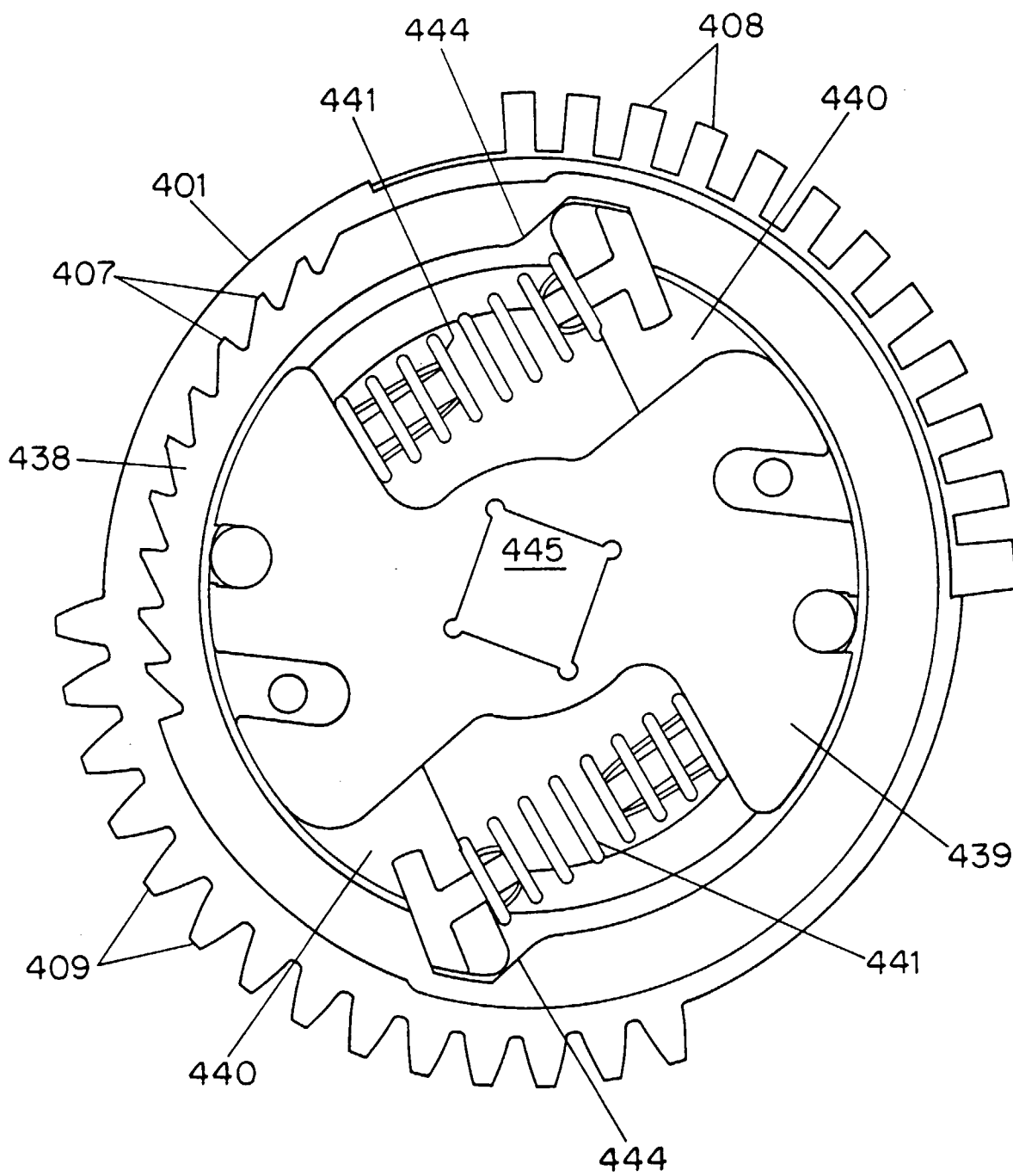


FIG. 8

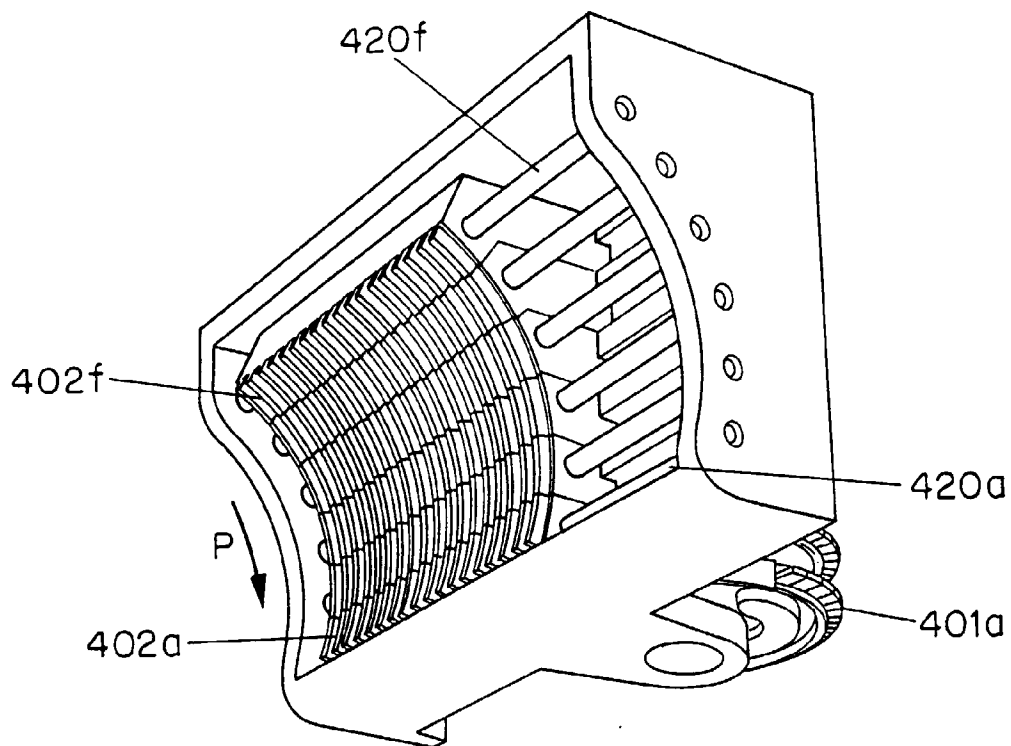


FIG. 9A

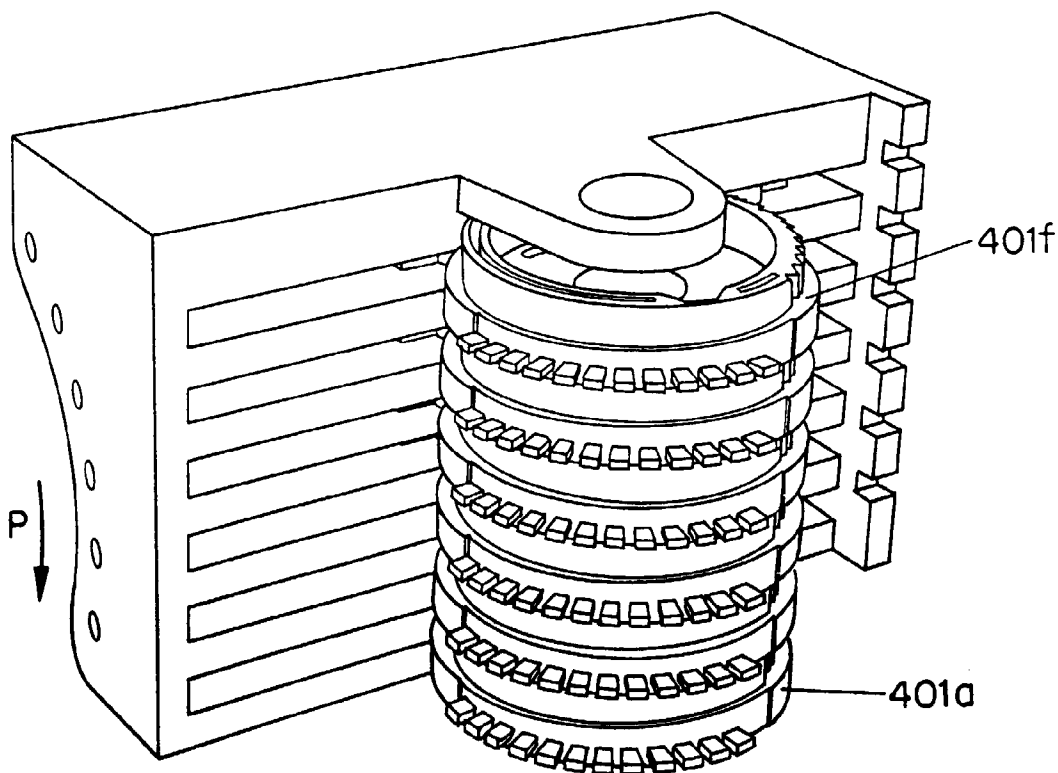


FIG. 9B

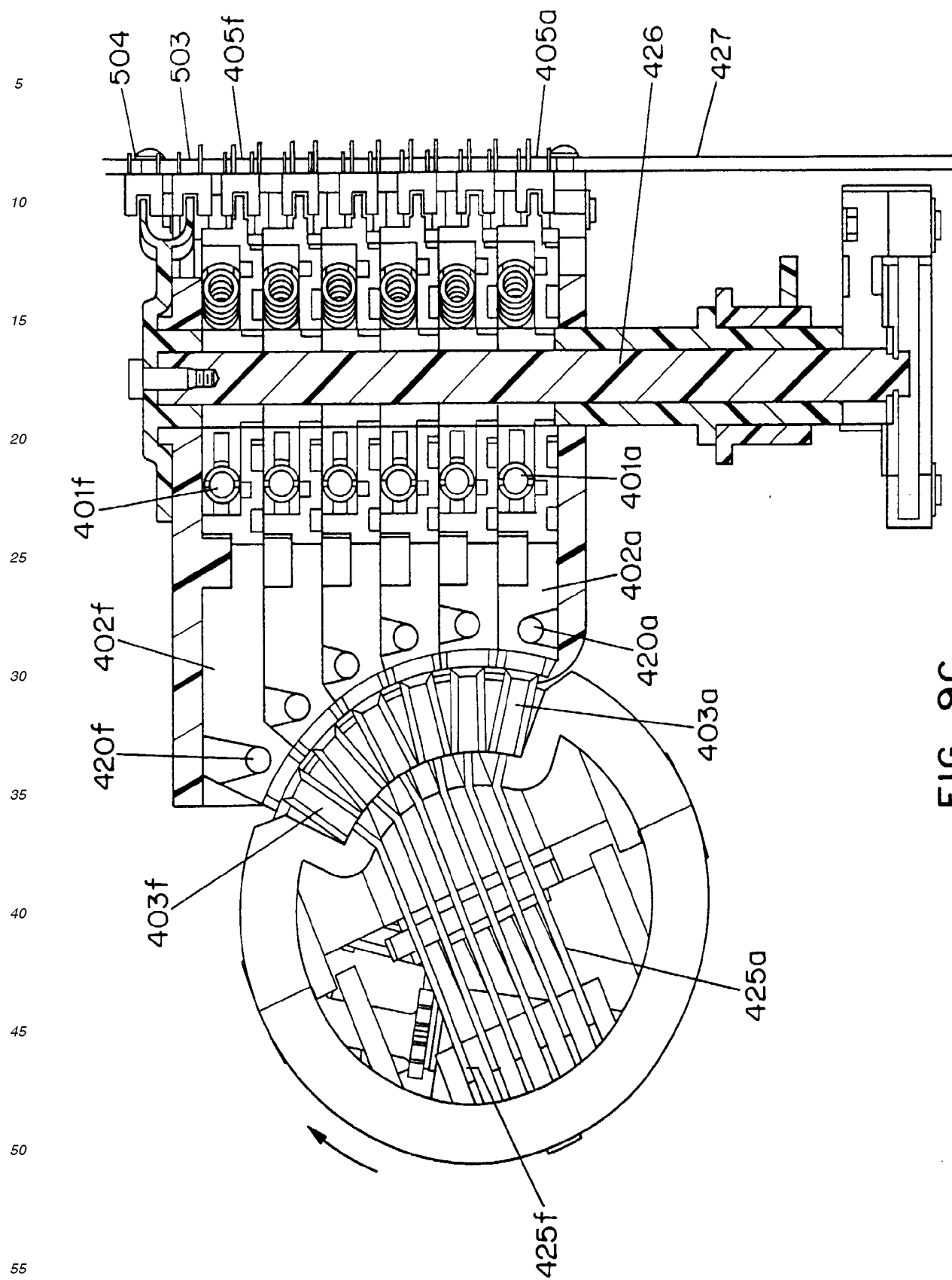


FIG. 9C

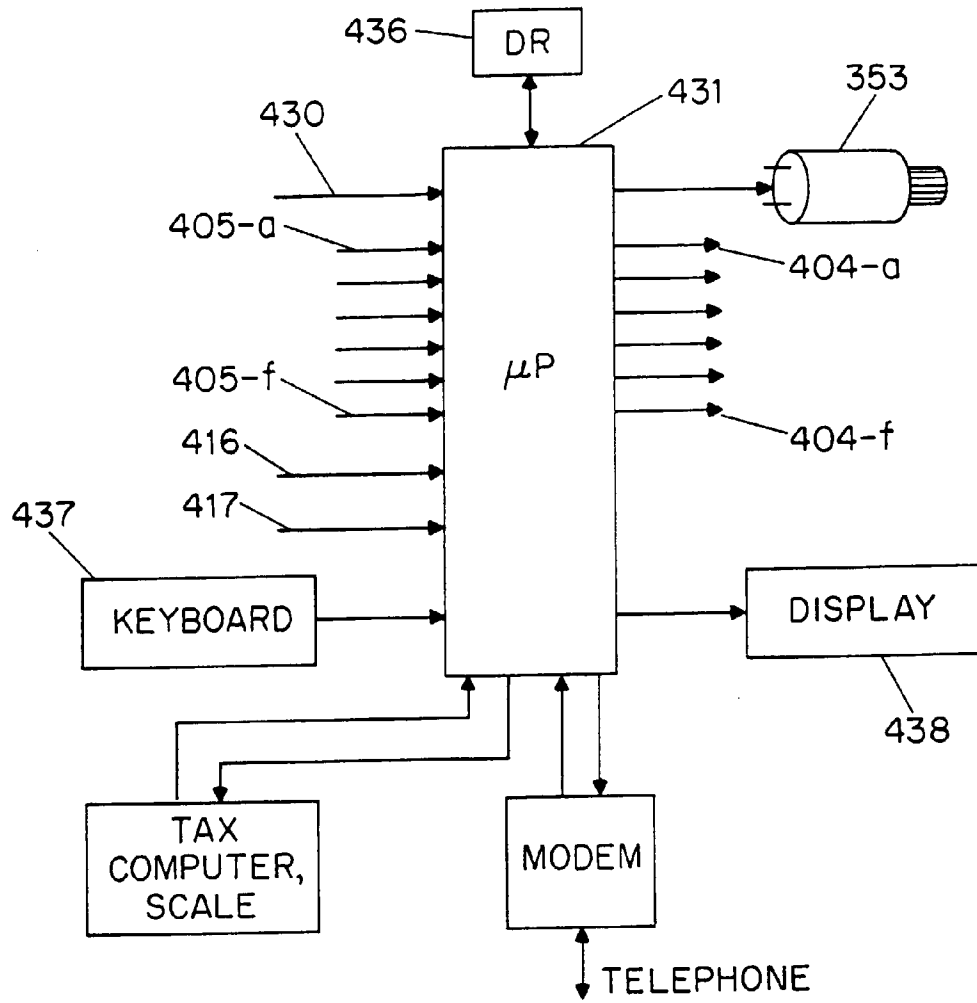


FIG. 10

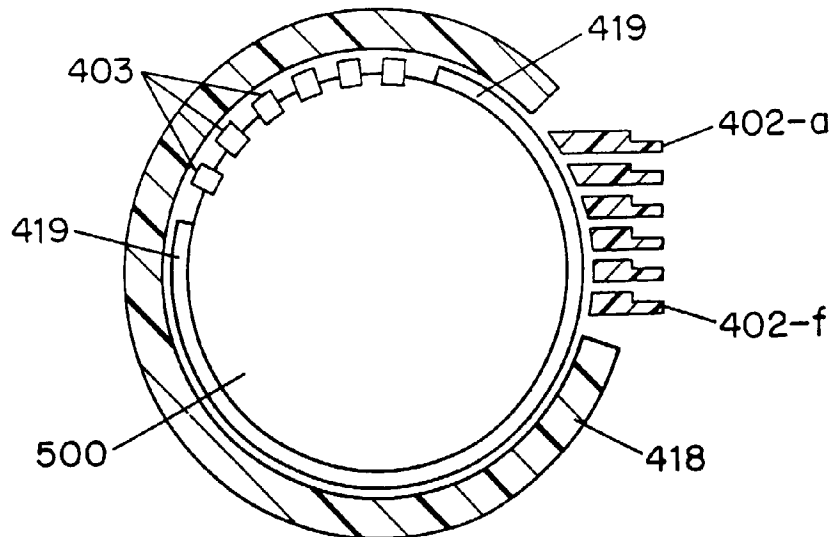


FIG. 12

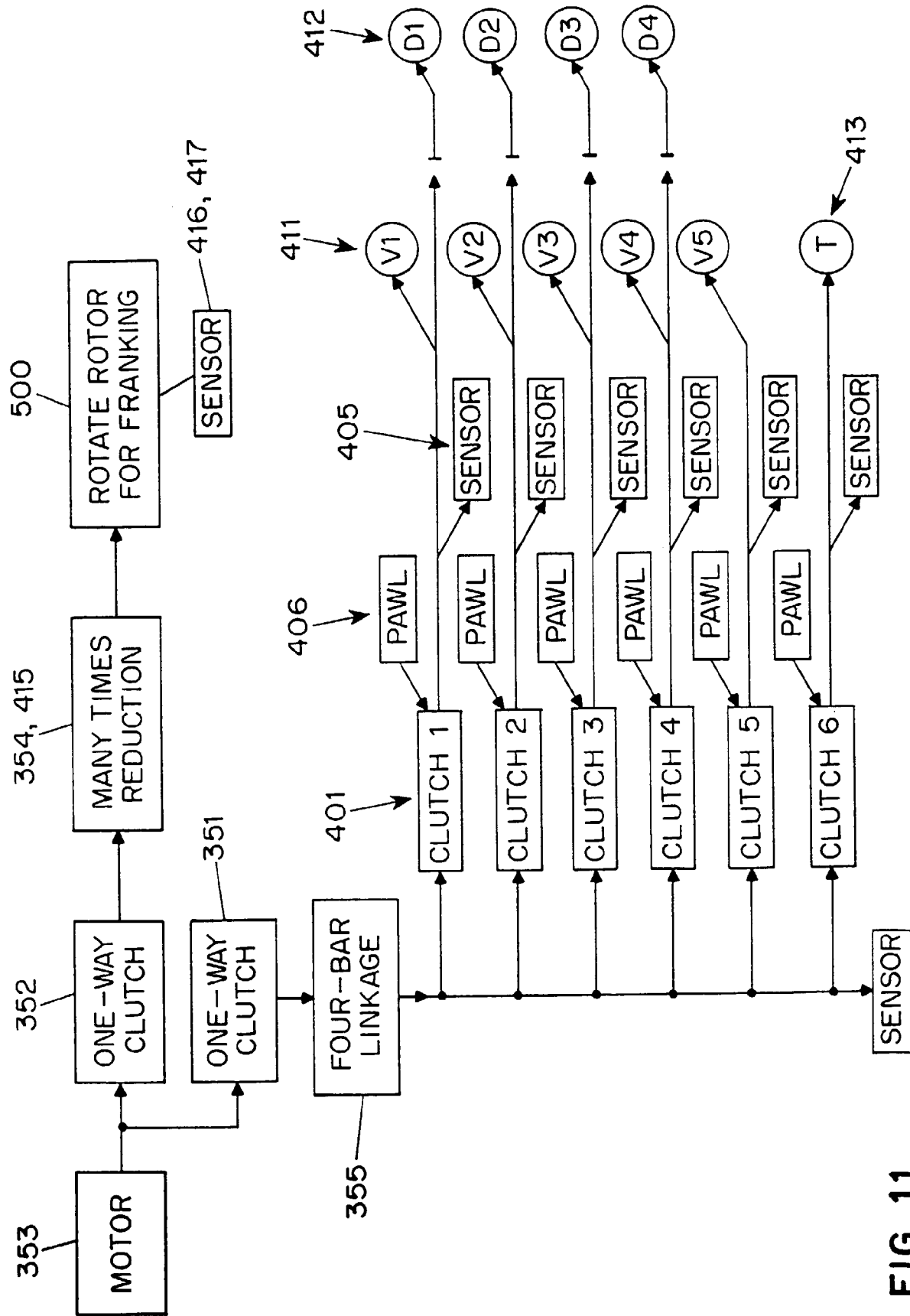


FIG. 11

FIG. 13

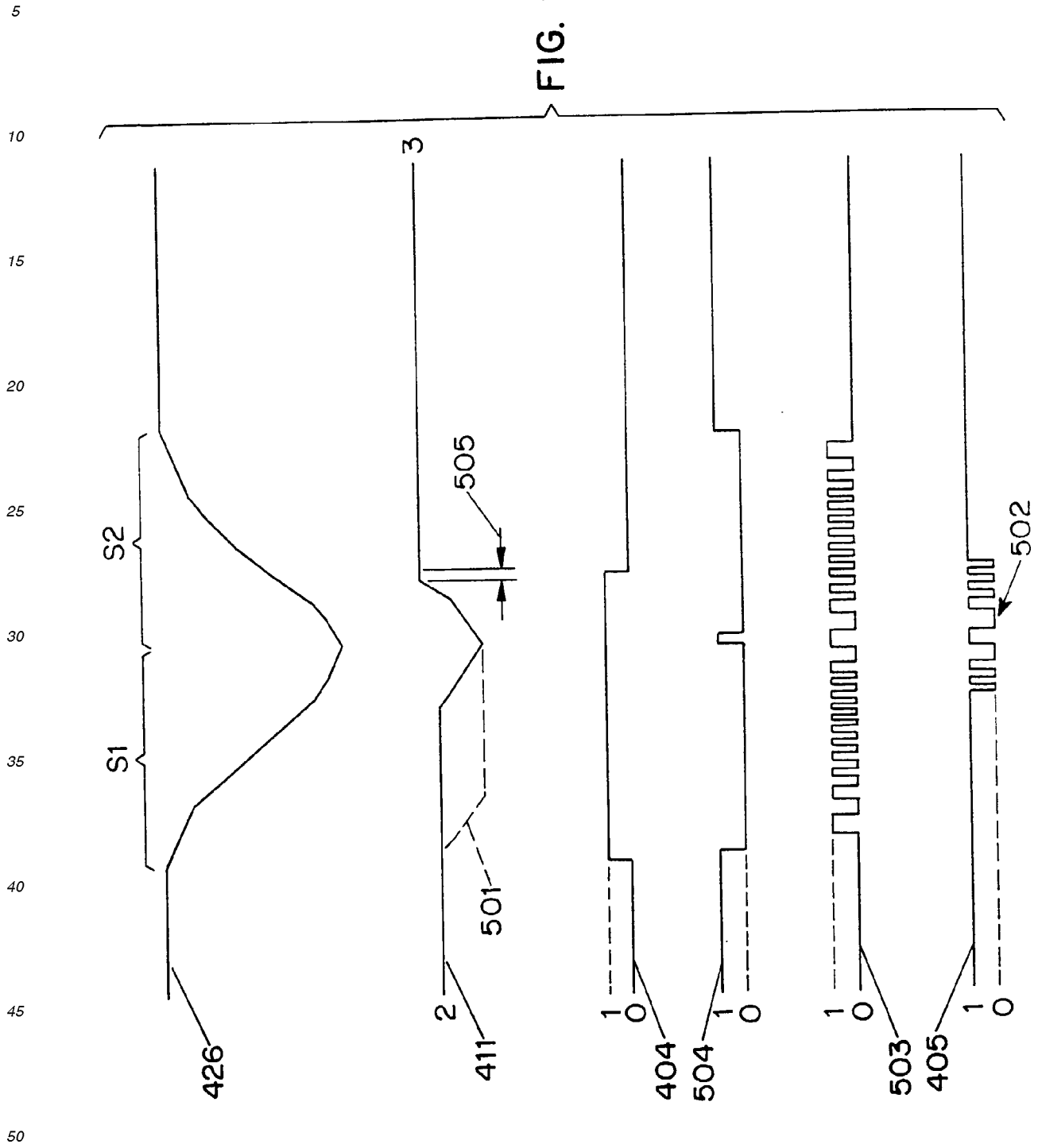
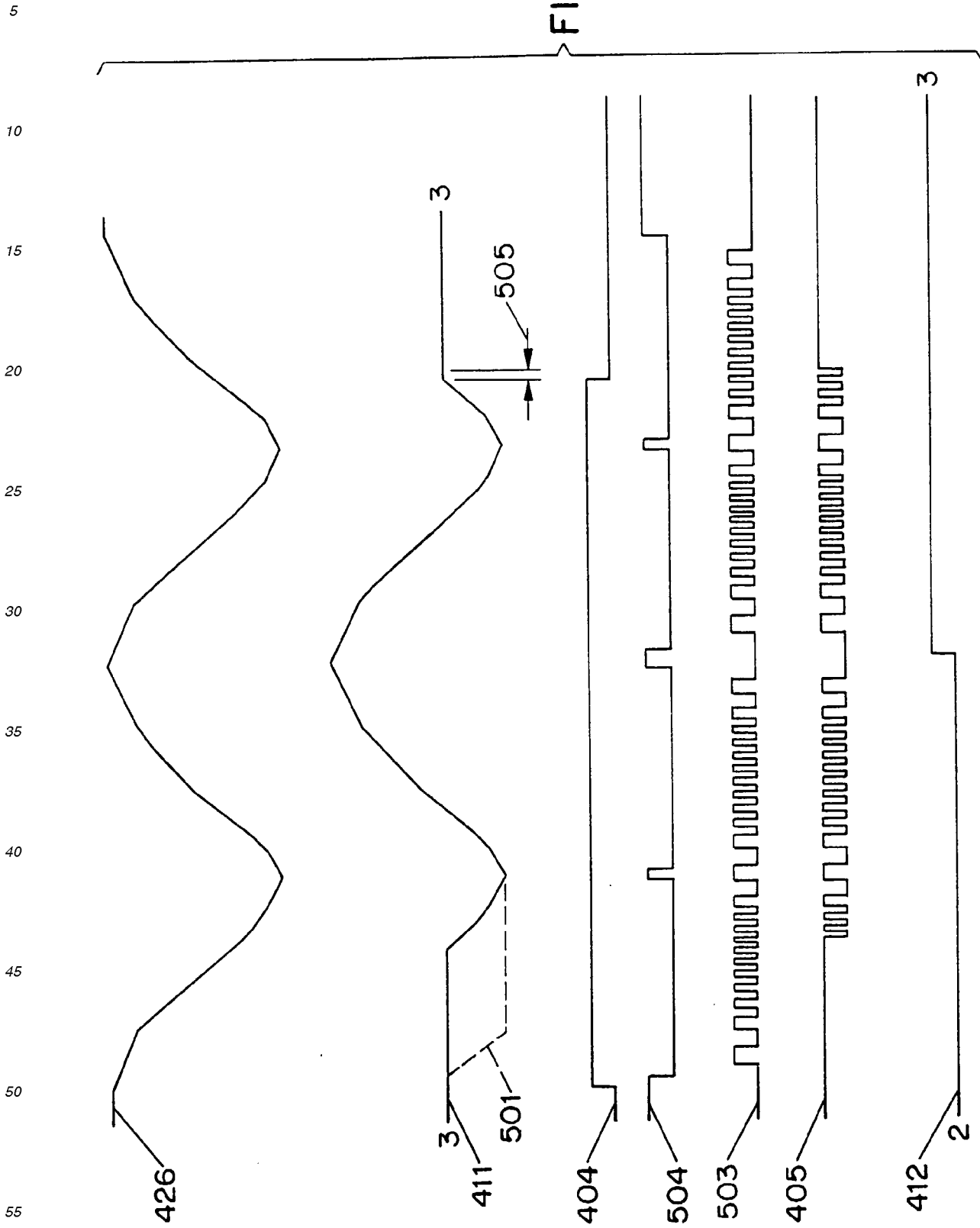


FIG. 14



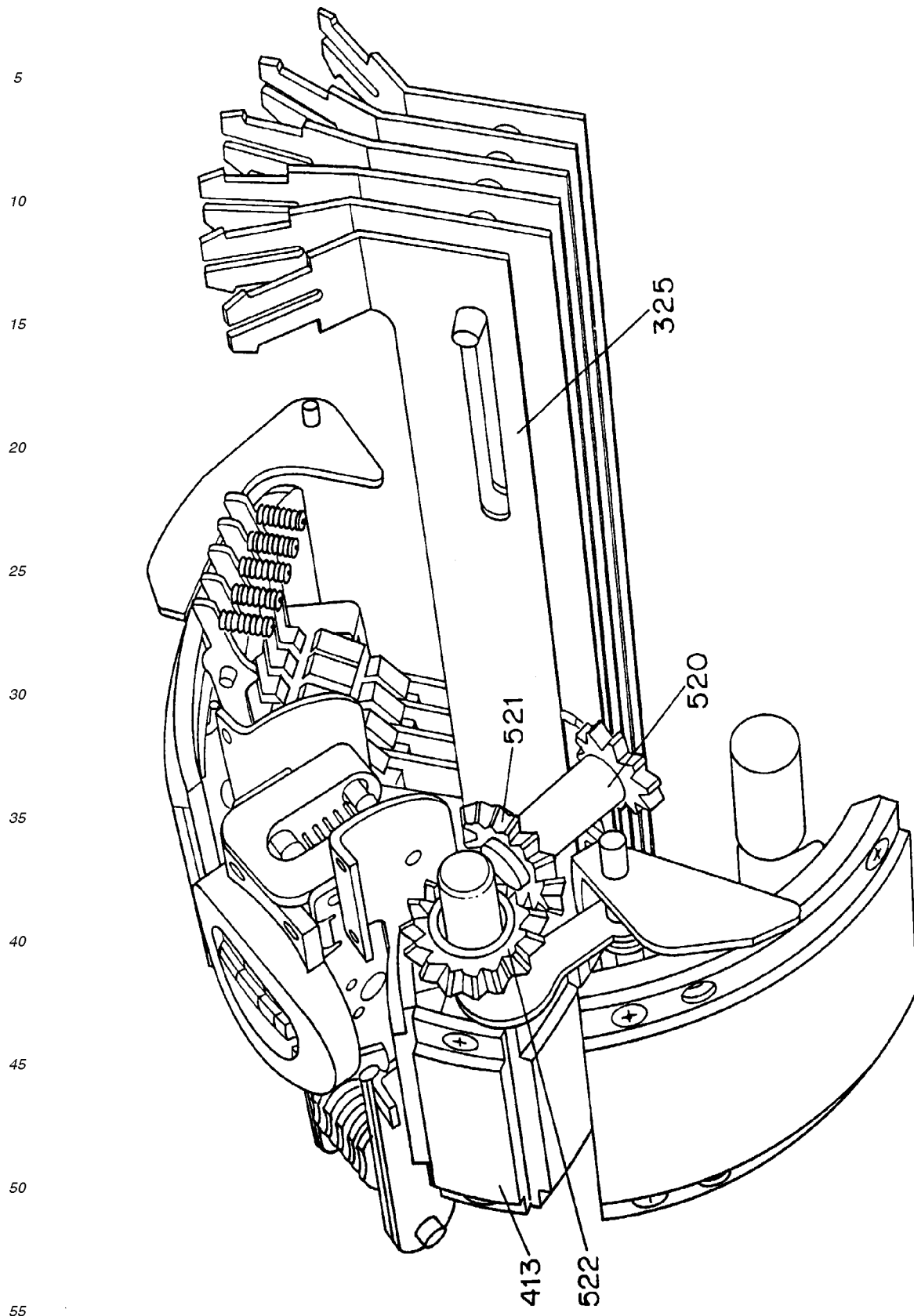


FIG. 15

Claims

1. A postage meter with settable date print wheels, said meter comprising:

5 a main body (20) and a print rotor (21);
 the main body (20) comprising a secure housing, the secure housing comprising a register relating to postage value printed, and further comprising control means operatively coupled with the rotor;
 the rotor (21) comprising:
 10 a plurality of value wheels (22), each value wheel having a plurality of indicia thereon indicative of a digit of postage value to be printed, each value wheel (22) further comprising a gear portion (30);
 a plurality of setting members (26) corresponding to respective ones of the value wheels (22), said setting members being operatively coupled with the control means, each setting member having teeth (29) engaging the gear portion (30) of the respective value wheel (22), each setting member being movable to a first respective number of positions, one for each indicium of the respective value wheel;
 15 a plurality of date wheel assemblies, each date wheel assembly comprising a date wheel (24) having indicia thereon indicative of a digit of a date to be printed, each date wheel assembly further comprising a ratchet wheel (40) operatively engaged with a corresponding date wheel (24);
 a plurality of date levers (32) corresponding to respective ones of the date wheel assemblies, each date lever (32) comprising a follower portion and a pawl (39) engaging the ratchet wheel (40) of the corresponding date wheel assembly;
 20 each of the date levers (32) engaging with a corresponding one of the setting members (26), each of the corresponding ones of the setting members (26) being movable to a second position in addition to its first respective number of positions, and having an actuating surface (31) positioned so that in the second position the actuating surface (31) engages the follower portion of the corresponding date lever (32).

25 2. A meter according to claim 1, wherein the register is a descending register indicative of postage value remaining to be printed.

30 3. A meter according to claim 1, wherein the register is an ascending register indicative of postage value that has been printed.

35 4. A meter according to any of claims 1 to 3, wherein each setting member is a rack (26) movable along a line axial to the rotor (21), the teeth (29) engaging the value wheel (22) comprising teeth along the length of the rack, and the first respective number of positions comprising positions along the line.

40 5. A meter according to claim 4, wherein the actuating surface of each setting member comprises a feature (31) on the end of the rack (26), and wherein the second position comprises a position along the line in addition to the positions comprising the first respective positions, whereby movement of a rack (26) to the second position causes its actuating surface to move the follower of a corresponding date lever (32), whereby the date lever (32) moves from a first position to a second position, whereby the pawl (39) of the date lever (32) actuates the ratchet wheel (40) of a corresponding date wheel assembly, whereby the ratchet wheel (40) causes the corresponding date wheel (24) to move to another print position.

45 6. A meter according to claim 5, wherein each date wheel is integral with its respective ratchet wheel.

50 7. A meter according to any of claims 1 to 6, wherein each ratchet wheel (40) further comprises a first gear (41), wherein each date wheel (24) further comprises a second gear in continuous engagement with the first gear (41), each date wheel assembly further comprising a detent means (42) urging the date wheel into particular ones of its angular positions corresponding to the date indicia thereof.

8. A meter according to any of claims 1 to 7, wherein each date lever (32) further comprises a return spring (34).

55 9. A meter according to any of claims 1 to 8, wherein the number of date wheels is at least three and the number of value wheels is at least four.

10. A meter according to claim 9, wherein the number of racks (26) is the same as the number of date levers (32).

11. A meter according to claim 9 wherein the number of racks (26) is greater than the number of date levers (32).

12. A meter according to any of claims 1 to 11, wherein the number of date wheels (24) is five.

13. A meter according to any of claims 1 to 12, wherein the number of value wheels (22) is five.

14. A meter according to any of claims 1 to 13, wherein the pawls (39) and ratchet wheels (40) are disposed so that adjacent ratchet wheels are advanced in opposite directions.

15. Apparatus for setting the position of a date wheel (24) in a rotor (21) of a postage meter, said meter comprising a main body (20) in addition to the print rotor; the main body comprising a secure housing, the secure housing comprising a register relating to postage value printed, and further comprising control means operatively coupled with the rotor; the meter further comprising a clock; the rotor comprising:

a value wheel (22) having a plurality of indicia thereon indicative of a digit of postage value to be printed, the value wheel further comprising a gear portion (30);

a setting member (26) operatively coupled with the control means, the setting member (26) having teeth (29) engaging the gear portion (30) of the value wheel, the setting member being movable to a first respective number of positions, one for each indicium of the value wheel;

a date wheel assembly comprising the date wheel (24) having indicia thereon indicative of a digit of a date to be printed, the date wheel assembly further comprising a ratchet wheel (40) operatively engaged with the date wheel (24);

a date lever (32) corresponding to the date wheel assembly, the date lever comprising a follower portion and a pawl (39) engaging the ratchet wheel (40) of the date wheel assembly; the date lever (32) engaging with the setting member, the setting member being movable to a second position in addition to its first respective number of positions, and having an actuating surface (31) positioned so that in the second position the actuating surface (31) engages the follower portion of the date lever (32).

16. A meter according to claim 15, wherein the register is a descending register indicative of postage value remaining to be printed.

17. A meter according to claim 15, wherein the register is an ascending register indicative of postage value that has been printed.

18. A date-setting method for use in a postage meter having date wheels, the method comprising the steps of:

setting the date wheels;

printing on a mail piece whereby a date is printed on the mail piece by the date wheels;

asking a user whether the date printed on the mail piece is correct;

receiving a response in the negative;

receiving information from the user indicative of the date printed on the mail piece;

resetting the date wheels;

logging a record indicative of the negative response and the resetting action;

printing on a mail piece whereby a date is printed on the mail piece by the date wheels;

asking a user whether the date printed on the mail piece is correct;

receiving a response in the negative;

receiving information from the user indicative of the date printed on the mail piece;

resetting the date wheels;

logging another record indicative of the negative response and the resetting action; and,

annunciating, to authorized service personnel, the records indicative of negative responses.

19. A method according to claim 18, wherein the annunciating step further comprises annunciating the event of records indicating back-dating of the meter.

20. A method according to claim 18, wherein the annunciating step further comprises communicating the ratio of the number of negative responses to the number of date wheel settings.

21. A date-setting method for use in a postage meter having date wheels capable of printing a date on a mail piece, the method comprising the steps of:

setting at least one date wheel (24);
 waiting until after the first time that postage has been printed on a mail piece subsequent to the setting of a
 date wheel; and thereafter,
 asking a user whether the date printed on the mail piece is correct.

22. A postage meter, the meter comprising:

a register within a secure housing relating to postage value printed;
 a value printing means operatively coupled with the register and disposed for printing of postage value;
 a plurality of date wheels located on a common axle, each date wheel having indicia thereon indicative of a
 component of a date;
 first and second advancing means, the advancing means being mechanically coupled with respective adjacent
 date wheels, the first advancing means being disposed to advance its respective date wheel in a direction
 opposite that of the respective date wheel of the second advancing means.

23. A meter according to claim 22, wherein the register is a descending register indicative of postage value remaining
 to be printed.

24. A meter according to claim 22, wherein the register is an ascending register indicative of postage value that has
 been printed.

25. A meter according to claim 22, wherein the date wheels respective to the first and second advancing means bear
 indicia increasing in opposite directions about the date wheels.

26. A date wheel assembly, the assembly comprising:

a plurality of wheels (24), each with raised indicia thereon, the indicia collectively defining a printable date
 comprising a year, a month, and a day having a units portion and a tens portion;
 an axle, the axle being disposed within the wheels such that the wheels each are rotatable thereabout; and,
 detent means urging each of the wheels into any of at least ten positions;
 wherein the improvement comprises arranging the raised indicia on the respective wheels such that on any
 two adjacent wheels, the indicia increase in opposite directions.

27. An assembly according to claim 26, wherein the number of indicia on each wheel is twelve, and wherein the unit
 wheel has twelve indicia each of which is a numerical digit.

28. A date wheel assembly, the assembly comprising:

a plurality of wheels (24), each with twelve raised indicia thereon, the indicia collectively defining a printable
 date comprising a year, a month, and a day having a units portion and a tens portion;
 an axle, the axle being disposed within the wheels such that the wheels each are rotatable thereabout; and,
 detent means urging each of the wheels into any of at least ten positions;

wherein the improvement comprises locating a numerical digit on each of the faces of the unit wheel.

29. An assembly according to claim 28, wherein the raised indicia on the respective wheels are arranged such that
 on any two adjacent wheels, the indicia increase in opposite directions.

30. A method for correcting a date for use with a postage meter having a plurality of date wheels each with twelve
 faces, the date wheels defining a year, a month, and a day, the day comprising a unit wheel and a tens wheel, the
 unit wheel having only numerical digits on its twelve faces, the meter further comprising a keyboard, the method
 comprising the steps of:

printing a first mail piece including a date;
 entering at the keyboard the date printed on the first mail piece;
 advancing at least one date wheel;
 printing a second mail piece including a date;
 entering at the keyboard the date printed on the second mail piece; and,

advancing at least one date wheel.

31. A method for correcting a date for use with a postage meter having a plurality of date wheels, the date wheels defining a year, a month, and a day, the meter further comprising a keyboard, the method comprising the steps of:

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printing a first mail piece including a date;
entering at the keyboard the date printed on the first mail piece; and,
advancing at least one date wheel.

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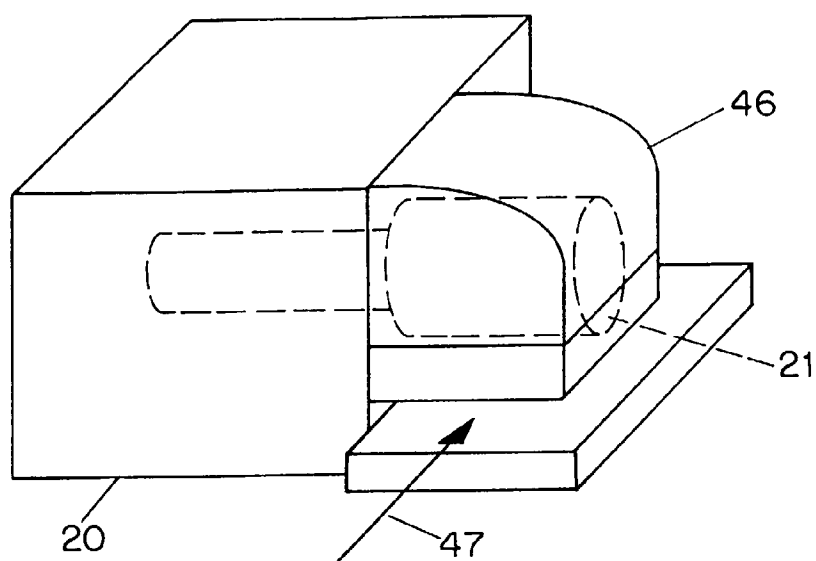


FIG. 1

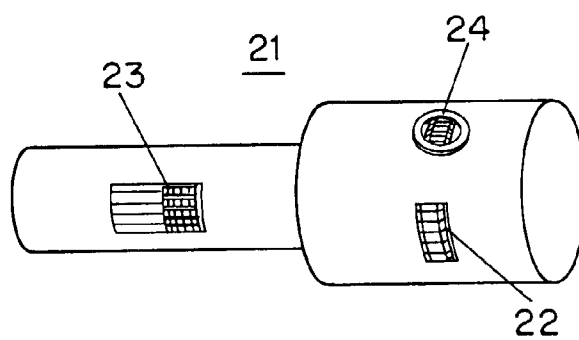


FIG. 2

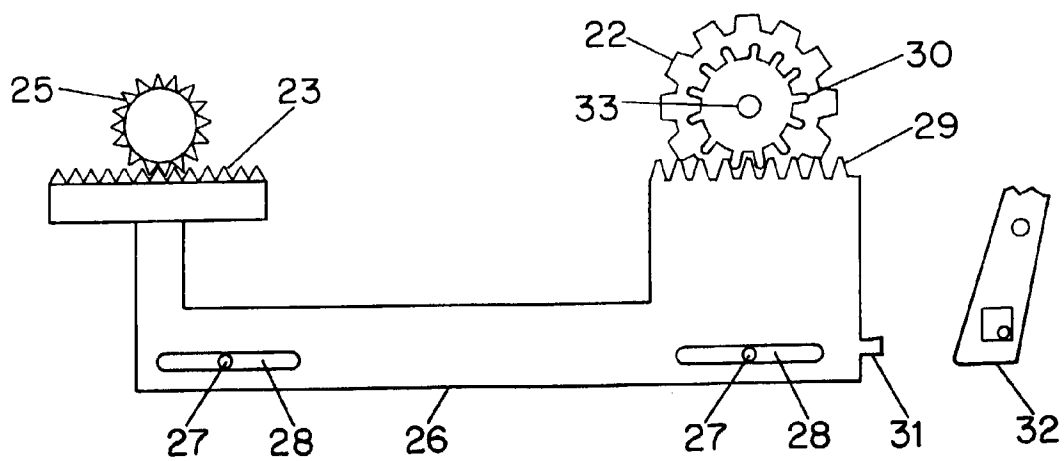


FIG. 3

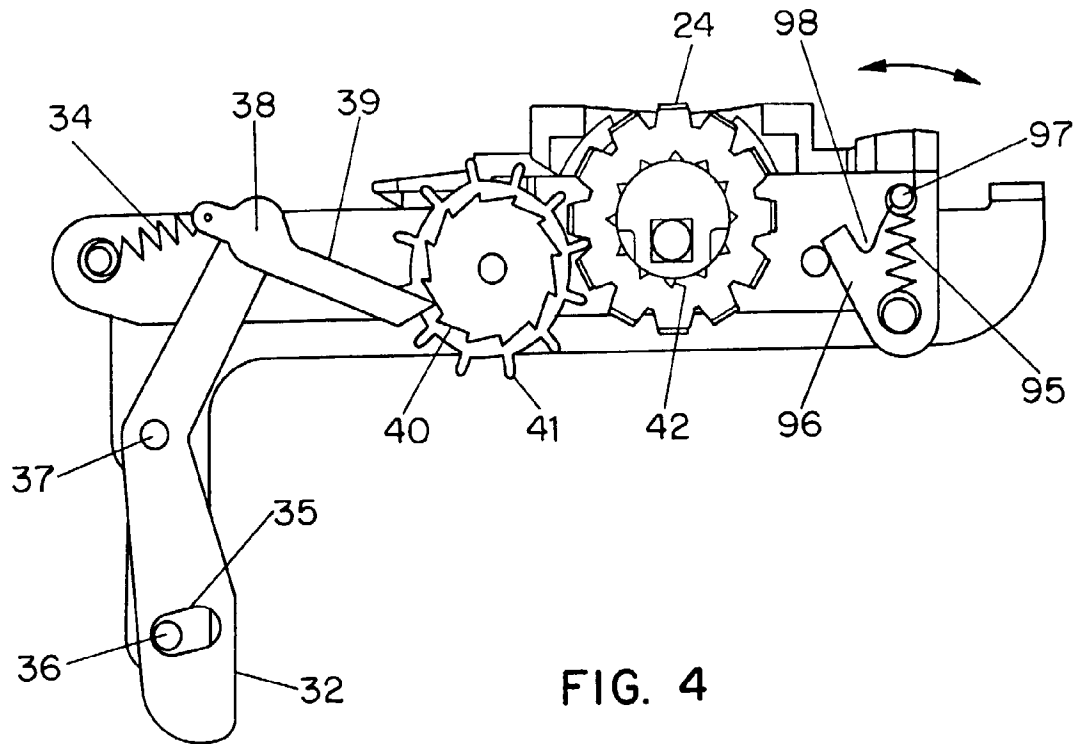


FIG. 4

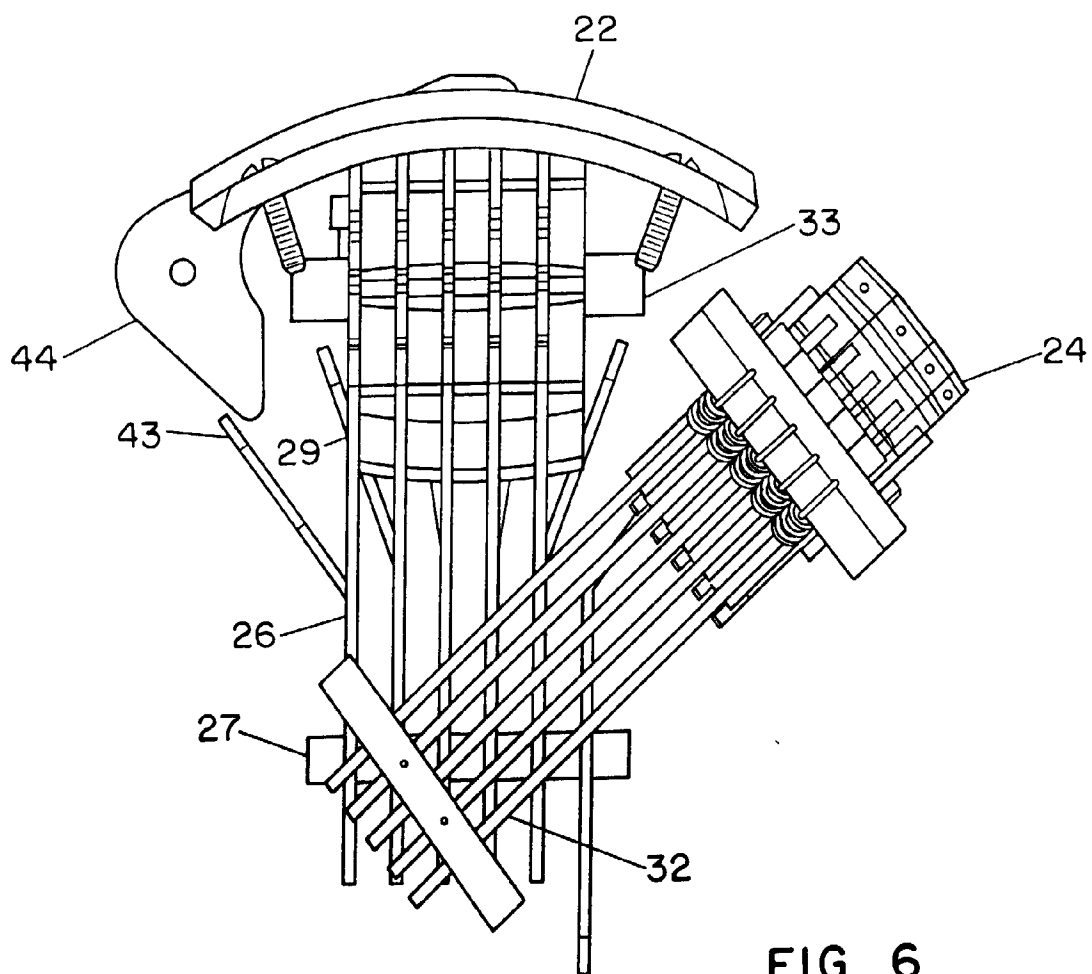


FIG. 6

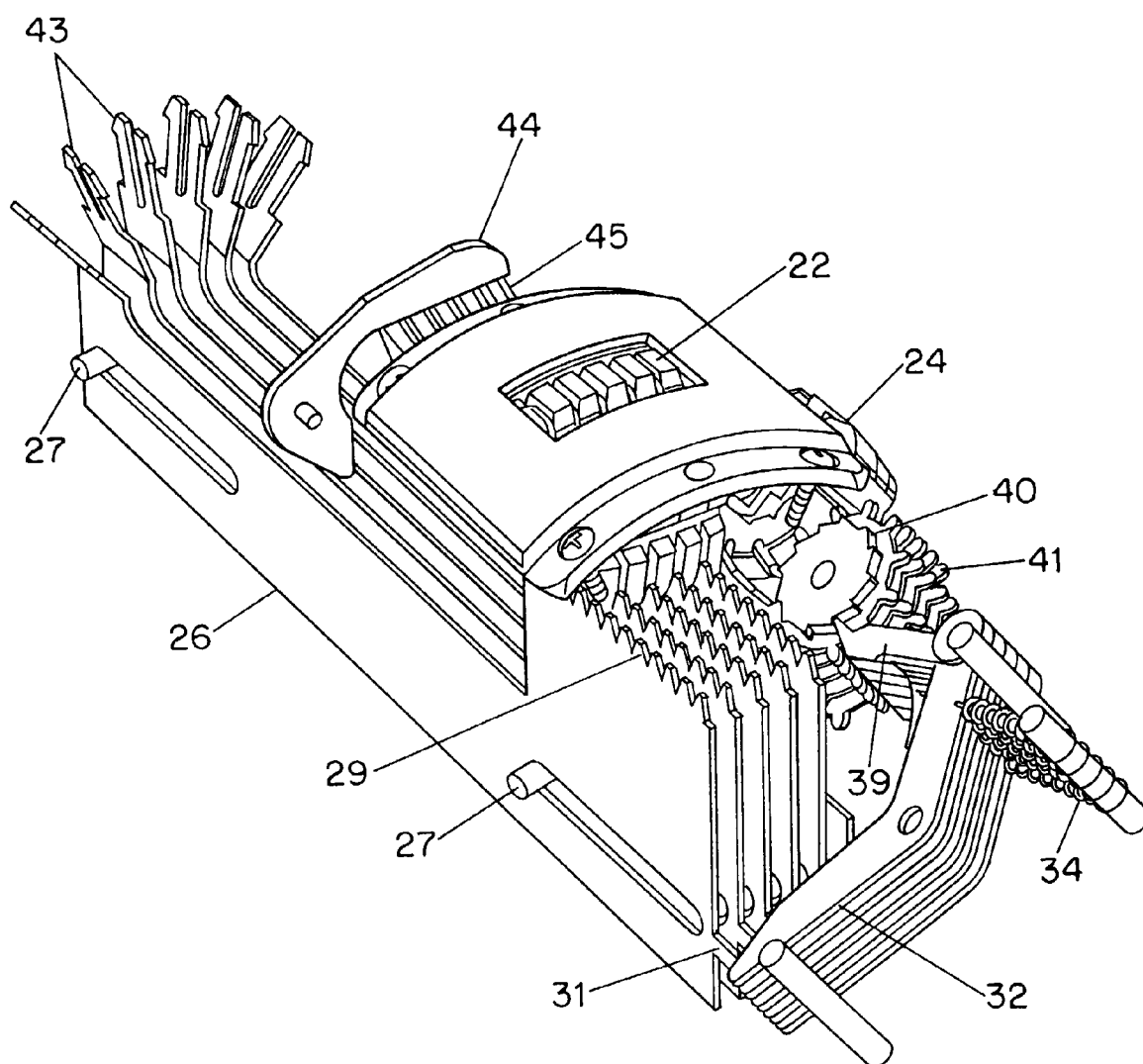


FIG. 5

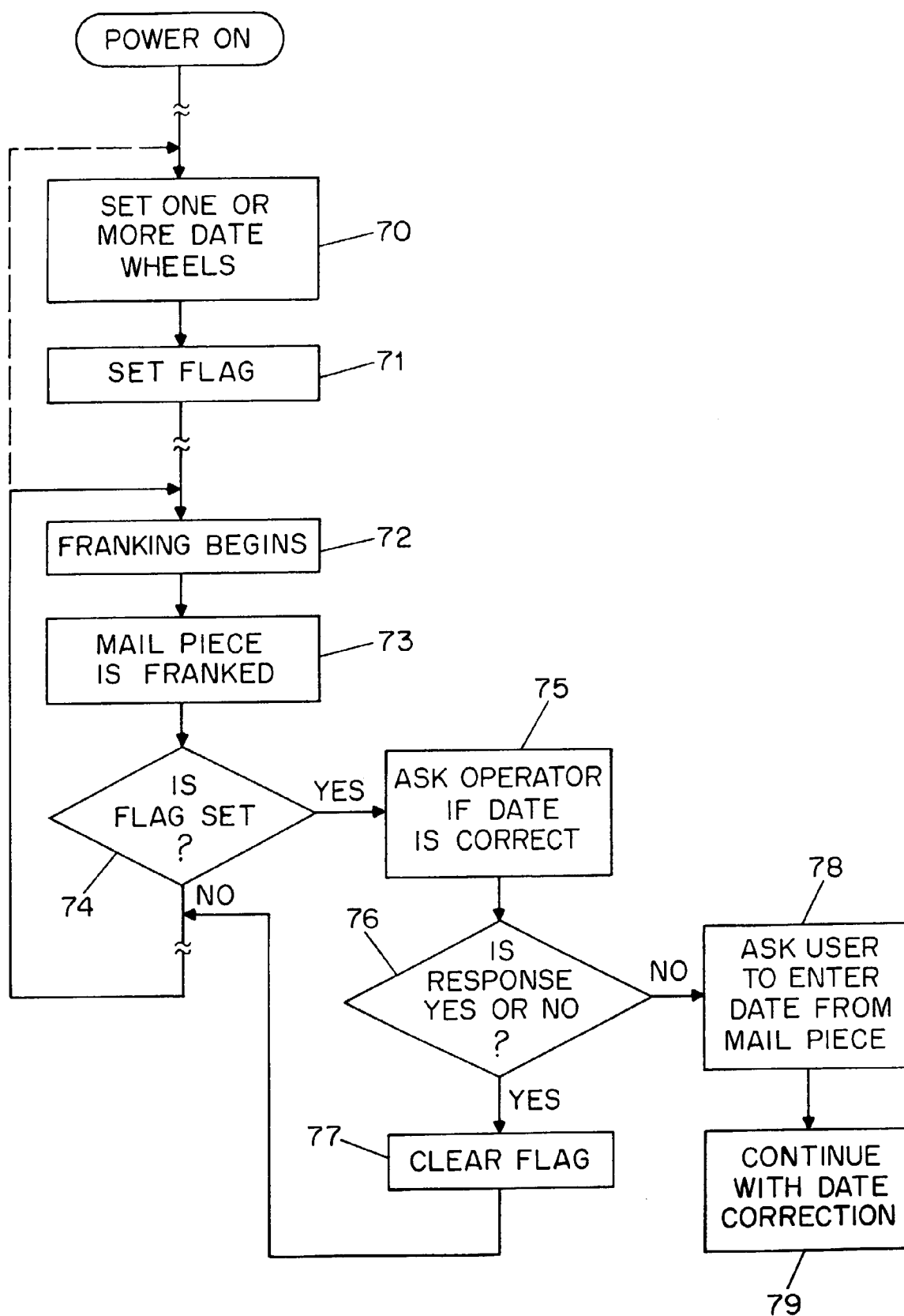


FIG. 7

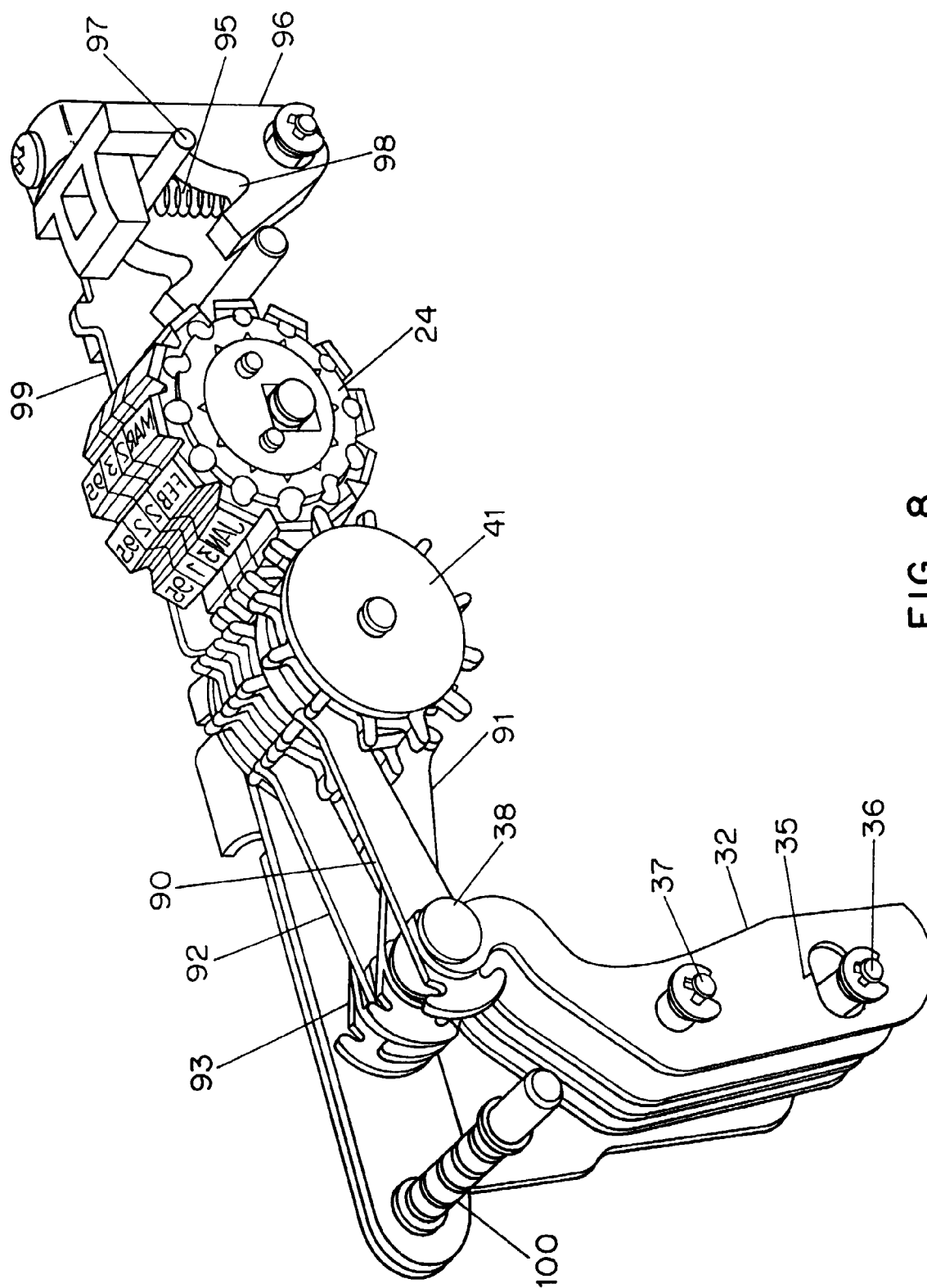
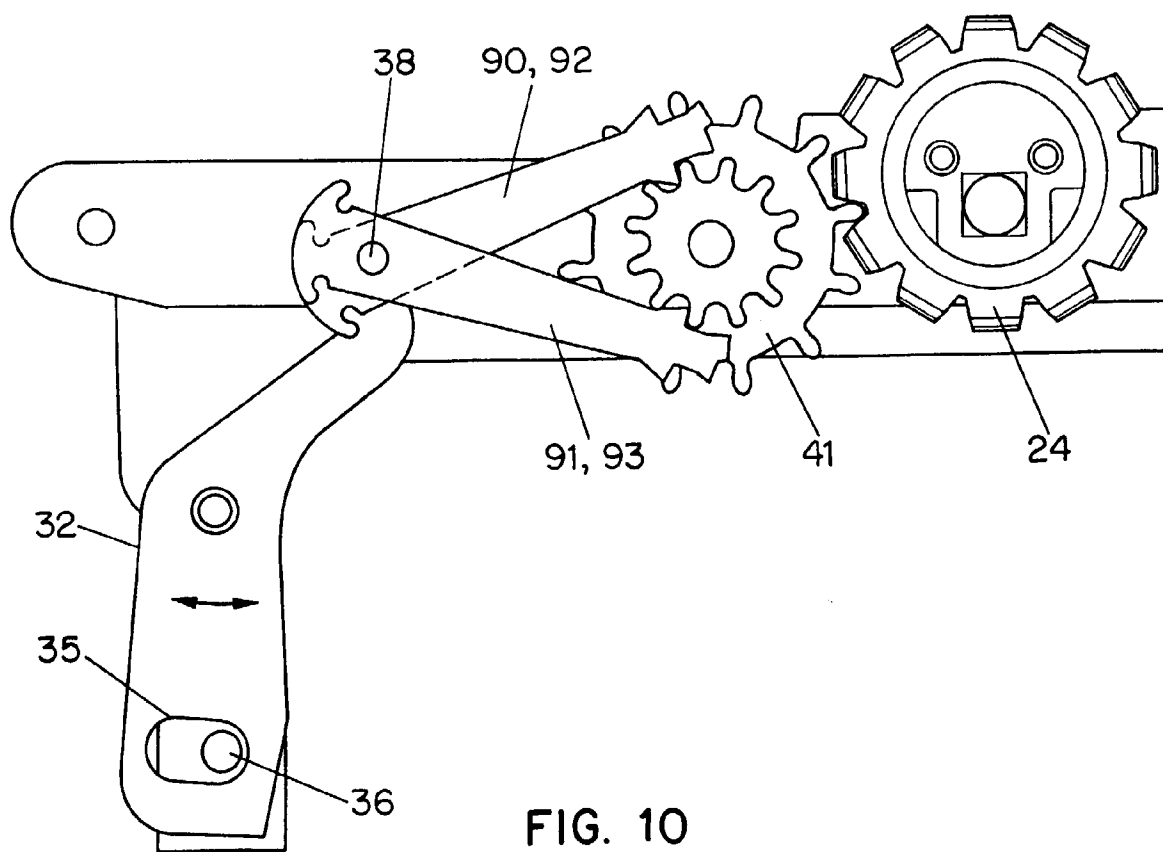
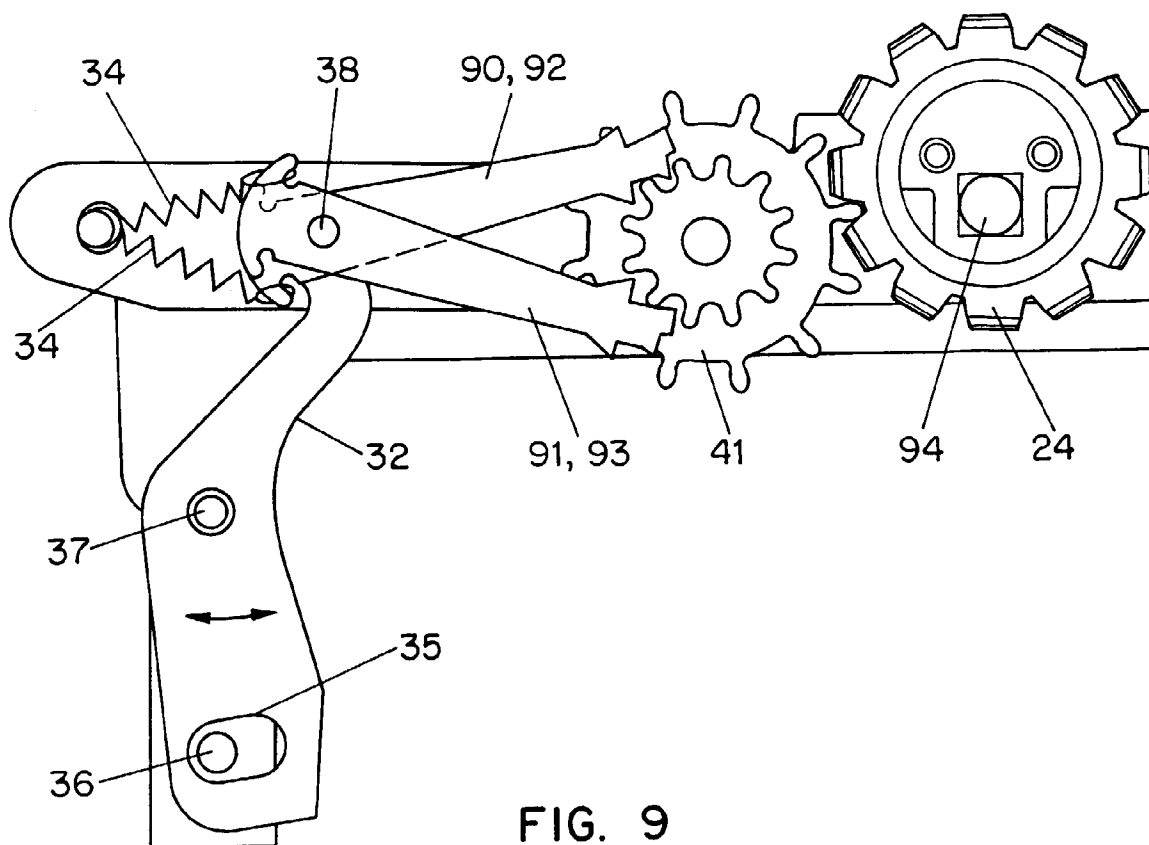


FIG. 8



1	0
2	1
3	2
∅	3
1	4
2	5
3	6
∅	7
1	8
2	9
3	—
∅	∅



FIG. 11a

PRIOR ART

1	0
2	1
3	2
0	3
1	4
2	5
3	6
0	7
1	8
2	9
3	9
0	0



FIG. 11b