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(54) **Postage meter apparatus having microprocessor-controlled D.C. motor and process for use therewith.**

(57) A postage meter includes a rotary drum (38) having a periphery adapted for feeding a sheet in a path of travel. A first device (56,58) senses a time interval during which a sheet is linearly displaced a predetermined distance in the path of travel. A d.c. motor (120) is coupled to the drum for rotation of the drum (38), and a second device (126) senses angular displacement of the drum (38). A computer (500) coupled to the first and second sensing devices (56,58,126) and to the d.c. motor (120) responds to the first sensing device (56,58) for providing respective amounts representative of desired angular displacements of the drum (38) during successive sampling time periods, responds to the second sensing device (126) for providing respective amounts representative of actual angular displacements of the drum (38) during successive sampling time periods, compensates for the difference between desired and actual angular displacements and generates a d.c. motor control signal for controlling rotation of the motor (120) to cause the linear displacement of the periphery of the drum (38) to substantially match the linear displacement of the sheet during respective sampling time periods. The computer (500) may also generate a d.c. motor control signal for controlling rotation of the motor (120) to cause the linear displacement of indicia printing means of the drum to initially engage the sheet in the path of travel a predetermined marginal distance from the leading edge of the sheet.

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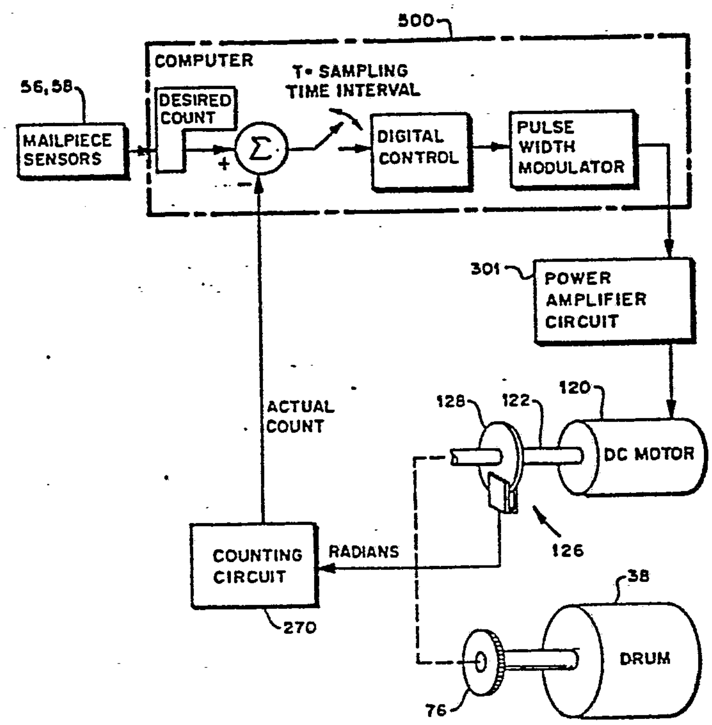
FIG. 10



500
COMPUTER
56, 58
DESIRED COUNT
T= SAMPLING TIME INTERVAL
MAILPIECE SENSORS
Σ
+
−
DIGITAL CONTROL
PULSE WIDTH MODULATOR
301
POWER AMPLIFIER CIRCUIT
ACTUAL COUNT
128
122
120
DC MOTOR
126
COUNTING CIRCUIT
RADIANS
270
38
DRUM
76

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POSTAGE METER APPARATUS HAVING MICROPROCESSOR - CONTROLLED D.C. MOTOR AND PROCESS FOR USE THEREWITH

The present invention is generally concerned with postage meters and mailing machines, and processes for operating such apparatus.

In U.S. Patent No. 2,934,009 issued April 26, 1960 to Bach, et al. and assigned to the assignee of the present invention there is described a postage meter which includes a drive mechanism connected by means of a drive train to a postage meter drum. The drive mechanism includes a single revolution clutch for rotating the drum from a home position and into engagement with a letter fed to the drum. The drum prints a postage value on the letter while feeding the same downstream beneath the drum as the drum returns to the home position. Each revolution of the single revolution clutch and thus the drum, is initiated by the letter engaging a trip lever to release the helical spring of the single revolution clutch. The velocity versus time profile of the peripherary of a drum driven by the clutch approximates a trapezoidal configuration, having acceleration, constant velocity and deceleration portions, fixed by the particular clutch and drive train used in the application. This being the case, the throughput rate of any mailing machine associated with the meter is dictated by the cycling speed of the postage meter rather than by the speed with which the individual mailpieces are fed to the postage meter. Further, although the single revolution clutch structure has served as the workhorse of the industry for many years it has long been recognized that it is a complex mechanism which is relatively expensive to construct and maintain, does not precisely follow the ideal trapezoidal velocity vs. time motion profile which is preferred for drum motion, tends to be unreliable in high volume applications, and is noisy and thus irritating to customers.

Accordingly, an object of the invention is to replace the postage meter drum drive mechanism of the prior art with the combination of a D.C. motor and a computer, and program the computer for causing the D.C. motor to drive the drum in accordance with an ideal trapezoidal-shaped velocity versus time profile which is a function of the input velocity of a mailpiece; and

Another object is to replace the trip lever as the drive initiating device and utilize in its place a pair of spaced apart sensing devices in the path of travel of a mailpiece fed to the postage meter, and program the computer to calculate the input velocity of a mailpiece, based upon the time taken for the mailpiece to traverse the distance between the sensing devices, and adjust the time delay and acceleration of the drum before arrival of the mailpiece at a position at which drum rotation is commenced to cause the drum to timely engage the leading edge of the mailpiece.

According to one aspect of the invention, in combination with a postage meter including a rotary drum having a periphery adapted for feeding a sheet in a path of travel, there is provided an improvement comprising: first means for sensing a time interval during which a sheet is linearly displaced a predetermined distance in the path of travel; a d.c. motor coupled to the drum for rotation thereof; second means for sensing angular displacement of the drum; and computer means coupled to the first and second sensing means and to the d.c. motor, the computer means comprising: means responsive to the first sensing means for providing respective amounts representative of desired angular displacements of the drum during successive sampling time periods, means responsive to the second sensing means for providing respective amounts representative of actual angular displacements of the drum during successive sampling time periods, and means for compensating for the difference between desired and actual angular displacements and generating a d.c. motor control signal for controlling rotation of the motor to cause the linear displacement of the periphery of the drum to substantially match the linear displacement of the sheet during respective sampling time periods.

Figure 8 is a truth table showing the status of the transistors in the power amplifying circuit for clockwise and counter-clockwise rotation of the D.C. motor;

Figure 9 shows the relationship between the encoder output signals for various D.C. motor duty cycles;

Figure 10 shows a closed-loop servo system including the D.C. motor and computer;

Figure 11 is a block diagram portraying the laplace transform equations of the closed-loop servo system shown in Fig. 10;

Figure 12 shows the equations for calculating the overall gain of the closed loop servo system of Fig. 10 before (Fig. 2a) and after (Fig. 2b) including a gain factor corresponding to the system friction at motor start up;

Figure 13 is a bode diagram including plots for the closed loop servo system before and after compensation to provide for system stability and maximization of the system's bandwidth;

Figure 14 shows the equation for calculating, in the frequency domain, the value of the system compensator;

Figure 15 shows the equation for calculating the damping factor, overshoot and settling time of the servo controlled system;

Figure 16 shows the equation for the laplace operator expressed in terms of the Z-transform operator;

Figure 17 shows the equation for calculating the value of the system compensator in the position domain;

Figure 18 shows the equations for converting the system compensator of Fig. 17 to the position domain;

Figure 19 shows the equation of the output of the system compensator in the time domain;

Figure 20 is a block diagram of a preferred microprocessor for use in controlling the D.C. Motor;

Figure 21 (including Figs. 21a, 21b and 21c) shows the time intervals during which the motor control signal and its separable components are calculated to permit early application of the signal to the motor;

Figure 22 (including Figs. 22a and 22b) is a block diagram of the computer according to the invention; and

Figure 23 (including Figs. 23a-1, 23a-2, 23b and 23c) shows the flow charts portraying the processing steps of the computer.

As shown in Fig. 1, the apparatus in which the invention may be incorporated generally includes an electronic postage meter 10 which is suitably removably mounted on a conventional mailing machine 12, so as to form therewith a slot 14 (Fig. 2) through which sheets, including mailpieces 16, such as envelopes, cards or other sheet-like materials, may be fed in a downstream path of travel 18.

The postage meter 10 (Fig. 1) includes a keyboard 30 and display 32. The keyboard 30 includes a plurality of numeric keys, labeled 0-9 inclusive, a clear key, labeled "c" and a decimal point key, labeled ".", for selecting postage values to be entered; a set postage key, labeled "s", for entering selected postage values; and an arithmetic function key, labeled "$\pm$", for adding subsequently selected charges (such as special delivery costs) to a previously selected postage value before entry of the total value. In addition, there is provided a plurality of display keys, designated 34, each of which are provided with labels well known in the art for identifying information stored in the meter 10, and shown on the display 32 in response to depression of the particular key 34, such as the "postage used", "postage unused", "control sum", "piece count", "batch value" and "batch count" values. A more detailed description of the keys of the keyboard 30 and the display 32, and their respective functions may be found in U.S. Patent No. 4,283,721 issued August 11, 1981 to Eckert, et al. and assigned to the assignee of the present invention.

In addition, the meter 10 (Fig. 1) includes a casing 36, on which the keyboard 30 and display 32 are conventionally mounted, and which is adapted by well known means for carrying a cyclically operable, rotary, postage printing drum 38. The drum 38 (Fig. 2) is conventionally constructed and arranged for feeding the respective mailpieces 16 in the path of travel 18, which extends beneath the drum 38, and for printing entered postage on the upwardly disposed surface of each mailpiece 16. For postage value selecting purposes, the meter 10 (Fig. 1) also includes a conventional postage value selection mechanism 40, for example, of the type shown in U.S. Patent No. 4,287,825 issued September 8, 1981 to Eckert, et al. and assigned to the assignee of the present invention. The mechanism 40 which is operably electrically coupled via the postage meter's computer 41 to the keyboard 30 and display 32, includes a first stepper motor 42 for selecting any one of a plurality of racks 43, associated on a one for one basis with each of the print wheels 44, and a second stepper motor 45 for actuating each selected rack 43 for positioning the appropriate printing element of the associated print wheel 44. The rack selection stepper motor 42, which is referred to by skilled artisans as a bank selector motor, is appropriately energized via power lines 46 from the computer 41 for selecting the appropriate rack; and the rack actuating stepper motor 45, which is referred to by skilled artisans as a digit selector motor, is appropriately energized via power lines 47 from the computer 41 to move the selected rack for selecting the appropriate digit element of the associated print wheel 44. A more detailed description of the value selection mechanism 40 may be found in the aforesaid U.S. Patent No. 4,287,825.

The computer 41 for the postage meter 10 generally comprises a conventional, microcomputer system having a plurality of microcomputer modules including a control or keyboard and display module, 41a, an accounting module 41b and a printing module 41c. The control module 41a is both operably electrically connected to the accounting module 41b and adapted to be operably electrically connected to an external device via respective two-way serial communications channels, and the accounting module 41b is operably electrically connected to the printing module 41c via a corresponding two-way serial communication channel. In general, each of the modules 41a, 41b and 41c includes a dedicated microprocessor 41d, 41e or 41f, respectively, having a separately controlled clock and programs. And two-way communications are conducted via the respective serial communication channels utilizing the echoplex communication discipline, wherein communications are in the form of serially transmitted single byte header-only messages, consisting of ten bits including a start bit followed by an 8 bit byte which is in turn followed by a stop bit, or in the form of a multi-byte message consisting of a header and one or more additional bytes of information. Further, all transmitted messages are followed by a no error pulse if the message was received error free. In operation, each of the modules 41a, 41b and 41c is capable of processing data independently and asynchronously of the other. In addition, to allow for compatibility between the postage meter 10 and any external apparatus, all operational data transmitted to, from and between each of the three modules 41a, 41b and 41c, and all stored operator information, is accessible to the external device via the two-way communication channel, as a result of which the external apparatus (if any) may be adapted to have complete control of the postage meter 10 as well as access to all current operational information in the postage meter 10. In addition, the flow of messages to, from and between the three internal modules 41a, 41b and 41c is in a predetermined, hierarchical direction. For example, any command message from the control module 41a is communicated to the accounting module 41b, where it is processed either for local action in the accounting module 41b and/or as a command message for the printing module 41c. On the other hand, any message from the printing module 41c is communicated to the accounting module 41b where it is either used as internal information or merged with additional data and communicated to the control module 41c. And, any message from the accounting module 41b is initially directed to the printing module 41c or to the control module 41a. A more detailed description of the various prior art modules 41a, 41b and 41c, and various modifications thereof, may be found in U.S. Patent Nos. 4,280,180; 4,280,179; 4,283,721 and 4,301,507; each of which patents is assigned to the assignee of the present invention.

The mailing machine 12 (Fig. 2), which has a casing 19, includes a A.C. power supply 20 which is adapted by means of a power line 22 to be connected to a local source of supply of A.C. power via a normally open main power switch 24 which may be closed by the operator. Upon such closure, the mailing machine's D.C. power supply 26 is energized via the power line 28. In addition, the mailing machine 12 includes a conventional belt-type conveyor 49, driven by an A.C. motor 50, which is connected for energization from the A.C. power supply 20 via a conventional, normally open solid state, A.C. motor, relay 52, which is timely energized by a computer 500 for closing the relay 52. Upon such closure the A.C.

motor 50 drives the conveyor 49 for feeding mailpieces 16 to the drum 38. To facilitate operator control of the switch 24, the mailing machine preferably includes a keyboard 53 having a "start" key 53a and a "stop" key 53b, which are conventionally coupled to the main power switch 24 to permit the operator to selectively close and open the switch 24. Assuming the computer 500 has timely energized the relay 52, the A.C. motor 50 is energized from the A.C. power supply 20. Whereupon the conveyor 49 transports the individual mailpieces 16, at a velocity corresponding to the angular velocity of the motor 50, in the path of travel 18 to the postage printing platen 54.

According to the invention, the machine 12 includes first and second sensing devices respectively designated 56 and 58, which are spaced apart from each other a predetermined distance d_1, i.e., the distance between points A and B in the path of travel 18. Preferably, each of the sensing devices 56 and 58, is an electro-optical device which is suitably electrically coupled to the computer 500; sensing device 56 being connected via communication line 60 and sensing device 58 being connected via communication line 62. The sensing devices 56, 58 respectively respond to the arrival of a mailpiece 16 at points A and B by providing a signal to the computer 500 on communication line 60 from sensing device 56 and on communication line 62 from sensing device 58. Thus, the rate of movement or velocity V1 of any mailpiece 16 may be calculated by counting the elapsed time t_v (Fig. 3) between arrivals of the mailpiece 16 at points A and B, and dividing the distance d_1, by the elapsed time t_v. To that end, the computer 500 is programmed for continuously polling the communications lines 60 and 62 each time instant T_n at the end of a predetermined sampling time period, T, preferably T=1 millisecond, and to commence counting the number of time instants T_n when the leading edge of a given mailpiece 16 is detected at point A, as evidenced by a transition signal on communication line 60, and to end counting the time instants T_n when the given mailpiece 16 is detected at point B, as evidenced by a transition signal on communication line 62. Since the distance d_1, is a mechanical constant of the mailing machine 12, the velocity of the mailpiece may be expressed in terms of the total number N_t of time instants T_n which elapse as the given mailpiece traverses the distance d_1. For example, assuming a maximum velocity of 61 inches per second, d_1=2.75 inches and T=1 millisecond; the total number N_t of elapsed time instants T_n may be found by dividing d_1=2.75 inches by V1=61 inches per second to obtain N_t=45, i.e., the total number of time instants T_n which elapse between arrivals of the mailpiece at points A and B. Thus, the number N_t=45 corresponds to and is representative of a mailpiece velocity of V1=61 inches per second.

Assuming normal operation of the transport system and calculation of the value of V1 having been made, the time delay t_d (Fig. 3) before arrival of the mailpiece 16 at point C may be calculated by dividing the distance d_2 between points B and C by the mailpiece's velocity V1, provided the distance d_2 is known. Since the integral of the initial, triangularly-shaped, portion of the velocity versus time profile is equal to one-half of the value of the product of T_a and V_1, and is equal to the arc d_3 described by point E on the drum 38, as the drum 38 is rotated counter-clockwise to point D, the distance between points C and D is equal to twice the arcuate distance d_3. Accordingly, d_2 may be conventionally calculated, as may be the time delay t_d for the maximum throughput velocity. Assuming rotation of the drum 38 is commenced at the end of the time delay t_d and the drum 38 is linearly accelerated to the velocity V1 to match that of the mailpiece 16 in the time interval T_a during which point E on the drum 38 arcuately traverses the distance d_3 to point D, Ta may be conventionally calculated. In addition, assuming commencement of rotation at the end of the time delay t_d and that the drum 38 is linearly accelerated to the velocity V1 during the time interval Ta, the mailpiece 16 will arrive at point D coincident with the rotation of point E of the outer periphery 73 the drum 38 to point D, with the result that the leading edge 73a of the drum's outer periphery 73, which edge 73a extends transverse to the path of travel 18 of the mailpiece 16, will engage substantially the leading edge of the mailpiece 16 for feeding purposes and the indicia printing portion 73b of the periphery 73 will be marginally spaced from the leading edge of the mailpiece 16 by a distance d_4 which is equal to the circumferential distance between points E and F on the drum 38. Since the circumferential distance d_5 on the drum 38 between points E and G is fixed, the time interval Tc during which the drum 38 is rotated at the constant velocity V1 may also be calculated. When point G on the drum 38 is rotated out of engagement with the mailpiece 16, the drum 38 commences deceleration and continues to decelerate to rest during the time interval Td. The distance d_6 which is traversed by point G, as the drum 38 is rotated to return point E to its original position of being spaced a distance d_3 from point D, is fixed, and, Td may be chosen to provide a suitable deceleration rate for the drum, preferably less than Ta. In addition, a reasonable settling time interval Ts is preferably added to obtain the overall cycling time TcT of the drum 38 to allow for damping any overshoot of the drum 38 before commencing the next drum cycle. For a typical maximum drum cycle time period TcT of 234 milliseconds and a maximum mailpiece transport rate of 61 inches per second, typical values for the acceleration, constant velocity, deceleration and settling time intervals are Ta=37 milliseconds, T_c=124 milliseconds, Td=24 milliseconds and Ts=234-185=49 milliseconds. Utilizing these values, the required acceleration and decceleration values for the drum 38 during the time intervals Ta and Td may be conventionally calculated. In addition, since the integral of the velocity versus time profile is equal to the distance traversed by the circumference of the drum 38 during a single revolution of the drum 38, the desired position of the drum 38 at the end of any sampling time period of T=1 millisecond may be calculated. For target velocities V1 which are less than the maximum throughput velocity, it is preferably assumed that integral of, and thus the area under, the velocity versus time profile remains constant, and equal to the area thereof at the maximum throughput velocity, to facilitate conventional calculation of the values of the time delay t_d, the time intervals Ta, Tc and Td, and the acceleration and decceleration values for each of such lesser velocities V1.

For computer implementation purposes, the computer 500 is programmed as hereinbefore discussed to continously poll the communication lines 60 and 62, from the sensing devices 56 and 58, respectively, each time interval T_n, and count the time intervals T_n between arrivals of the mailpiece 16 at points A and B as evidenced by a transition signals on lines 60 or 62. Further, the computer 500 is programmed to calculate the current velocity of the mailpiece 16 in terms of the total number N_t of the counted time intervals T_n, store the current velocity and, preferably, take an average of that velocity and at least the next previously calculated velocity (if any) to establish the target velocity V1. In addition, it is preferable that precalculated values for the time delay td, acceleration and decceleration corresponding to each of a plurality of target velocities be stored in the memory of the computer 500 for fetching as needed after calculation of the particular target velocity. In this connection it is noted that the velocity at any time "t" of the drum 38 may be expressed by adding to the original velocity V_o each successive increment of the product of the acceleration and time during each time period of T=1 millisecond, each successive increment of constant velocity and each successive increment of the product of the decceleration and time during each time period T. Preferably, the acceleration and decceleration values are each stored in the form of an amount corresponding to a predetermined number of counts per millisecond square which are a function of the actual acceleration or decceleration value, as the case may be, and of the scale factor hereinafter discussed in connection with measuring the actual angular displacement of the motor drive shaft 122; whereby the computer 500 may timely calculate the desired angular displacement of the motor drive shaft 122 during any sampling time interval T. In this connection it is noted that the summation of all such counts is representative of the desired linear displacement of the circumference of the drum 38, and thus of the desired velocity versus time profile of drum rotation for timely accelerating the drum 38 to the target velocity V1, maintaining the drum velocity at V1 for feeding the particular mailpiece 16 and timely deccelerating the drum 38 to rest.

The postage meter 10 (Fig. 1) additionally includes a conventional, rotatably mounted, shaft 74 on which the drum 38 is fixedly mounted, and a conventional drive gear 76, which is fixedly attached to the shaft for rotation of the shaft 74.

According to the invention, the mailing machine 12 (Fig. 1) includes an idler shaft 80 which is conventionally journaled to the casing 19 for rotation, and, operably coupled to the shaft 80, a conventional home position encoder 82. The encoder 82 includes a conventional circularly-shaped disc 84, which is fixedly attached to the shaft 80 for rotation therewith, and an optical sensing device 86, which is operably coupled to the disc 84 for detecting an opening

88 formed therein and, upon such detection, signalling the computer 500. The machine 12, also includes an idler gear 90 which is fixedly attached to the shaft 80 for rotation therewith. Further, the machine 12 includes a D.C. motor 120, which is suitably attached to the casing 19 and has a drive shaft 122. The machine 12 also includes a pinion gear 124, which is fixedly attached to the drive shaft 122 for rotation by the shaft 122. The gear 124 is disposed in driving engagement with the idler gear 90. Accordingly, rotation of the motor drive shaft 122 in a given direction, results in the same direction of rotation of the drum drive shaft 76 and thus the drum 38. Preferably, the pinion gear 124 has one-fifth the number of teeth as the drum drive gear 76, whereas the idler gear 90 and drum drive gear 76 each have the same number of teeth. With this arrangement, five complete revolutions of the motor drive shaft 122 effectuate one complete revolution of the drum 38, whereas each revolution of the gear 90 results in one revolution of the gear 76. Since there is a one-to-one relationship between revolutions, and thus incremental angular displacements, of the drum shaft 74 and idler shaft 90, the encoder disc 84 may be mounted on the idler shaft 90 such that the disc's opening 88 is aligned with the sensing device 86 when the drum 38 is disposed in its home position to provide for detection of the home position of the drum shaft 74, and thus a position of the drum shaft 74 from which incremental angular displacements may be counted.

For sensing actual incremental angular displacements of the motor drive shaft 122 (Fig. 1) from a home position, and thus incremental angular displacements of the drum 38 from its rest or home position as shown in Fig. 2, there is provided a quadrature encoder 126 (Fig. 1). The encoder 126 is preferably coupled to the motor drive shaft 122, rather than to the drum shaft 74, for providing higher mechanical stiffness between the armature of the d.c. motor 120 and the encoder 126 to avoid torsional resonance effects in the system. The encoder 126 includes a circularly-shaped disc 128, which is fixedly attached to the motor drive shaft 122 for operably connecting the encoder 126 to the motor 120. The disc 128 (Fig. 4) which is otherwise transparent to light, has a plurality of opague lines 130 which are formed on the disc 128 at predetermined, equidistantly angularly-spaced, intervals along at least one of the dics's opposed major surfaces. Preferably the disc 128 includes one hundred and ninety-two lines 130 separated by a like number of transparent spaces 132. In addition, the encoder 126 includes an optical sensing device 134, which is conventionally attached to the casing 19 and disposed in operating relationship with respect to the disc 128, for serially detecting the presence of the respective opaque lines 130 as they successively pass two reference positions, for example, positions 136ra and 136rb, and for responding to such detection by providing two output signals, one on each of communications lines 136a and 136b, such as signal A (Fig. 5) on line 136a and signal B on line 136b. Since the disc

128 (Fig. 4) includes 192 lines 130 and the gear ratio of the drum drive gear 76 (Fig. 1) to the motor pinion gear 124 is five-to-one, nine hundred and sixty signals A and B (Fig. 5) are provided on each of the communications lines 136a and 136b during five revolutions of the motor-drive shaft 122, and thus, during each cycle of rotation of the drum 38. Since the angular distance between successive lines 130 (Fig. 4) is a constant, the time interval between successive leading edges (Fig. 5) of each signal A and B is inversely proportional to the actual velocity of rotation of the motor drive shaft (Fig. 1) and thus of the drum 38. The encoder 126 is conventionally constructed and arranged such that the respective reference positions 136a and 136b (Fig. 4) are located with respect to the spacing between line 130 to provide signals A and B (Fig. 5) which are 90 electrical degrees out of phase. Accordingly, if signal A lags signal B by 90° (Fig. 5) the D.C. motor shaft 122 (Fig. 1), and thus the drum 38, is rotating clockwise, whereas if signal A leads signal B by 90° (Fig. 5) the shaft 122 and drum 38 are both rotating counter-clockwise. Accordingly, the angular displacement in either direction of rotation of the drum 38 (Fig. 1) from its home position may be incrementally counted by counting the number of pulses A or B, (Fig. 5) as the case may be, and accounting for the lagging or leading relationship of pulse A (Fig. 5) with respect to pulse B.

The quadrature encoder communication lines, 136a and 136b (Fig. 1), may be connected either directly to the computer 500 for pulse counting thereby or to the computer

500 via a conventional counting circuit 270 (Fig. 6), depending on whether or not the internal counting circuitry of the computer 500 is or is not available for such counting purposes in consideration of other design demands of the system in which the computer 500 is being used. Assuming connection to the computer 500 via a counting circuit 270, the aforesaid communications lines, 136a and 136b are preferably connected via terminals A and B, to the counting circuit 270.

In general, the counting circuit 270 (Fig. 6) utilizes the pulses A (Fig. 5) to generate a clock signal and apply the same to a conventional binary counter 274 (Fig. 6), and to generate an up or down count depending on the lagging or leading relationship of pulse A (Fig. 5) relative to pulse B and apply the up or down count to the binary counter 274 (Fig. 6) for counting thereby. More particularly, the pulses A and B (Fig. 5) which are applied to the counting circuit terminals A and B (Fig. 6) are respectively fed to Schmidt trigger inverters 276A and 276B. The output from the inverter 276A is fed directly to one input of an XOR gate 278 and additionally via an R-C delay circuit 280 and an inverter 282 to the other input of the XOR gate 278. The output pulses from the XOR gate 278, which acts as a pulse frequency doubler, is fed to a conventional one-shot multivibrator 284 which detects the trailing edge of each pulse from the XOR gate 278 and outputs a clock pulse to the clock input CK of the binary counter 274 for each detected trailing edge. The output from the Schmidt trigger inverters 276A and 276B are respectively fed to a second XOR gate 286 which outputs a low logic level signal (zero), or up-count, to the up-down pins U/D of the binary counter 274 for each output pulse A (Fig. 5) which lags an output pulses B by 90 electrical degrees. On the other hand the XOR gate 286 (Fig. 6) outputs a high logic level (one) or down-count, to the up-down input pins of the binary counter 274 for each encoder output pulse A (Fig. 5) which leads an output pulse B by 90° electrical degrees. Accordingly, the XOR gate 286 (Fig. 6) provides an output signal for each increment of angular displacement of the encoded shaft 122 (Fig. 1) and identifies the direction, i.e., clockwise or counter-clockwise, of rotation of the encoded shaft 122. The binary counter 274 (Fig. 6) counts the up and down count signals from the XOR gate 286 whenever any clock signal is received from the multivibrator 284, and updates the binary output signal 272 to reflect the count.

Accordingly, the counting circuit 270 converts the digital signals A and B, which are representative of incremental angular displacements of the drive shaft 122 in either direction of rotation thereof, to an eight bit wide digital logic output signal 272 which corresponds to a summation count at any given time, of such displacements, multiplied by a factor of two, for use by the computer 500. Since the angular displacement of the shaft 122 from its home position is proportional to the angular displacement of the drum 38 from its home position, the output signal 272 is a count which is proportional to the actual linear displacement of the outermost periphery of the drum 38 at the end of a given time period of rotation of the drum 38 from its home position. For a typical postage meter drum 38, having a circumference, i.e., the arc described by the outermost periphery of the drum 38 in the course of revolution thereof, of 9.42 inches, which is connected to the motor drive shaft 122 via a mechanical transmission system having a 5:1 gear ratio between the motor 120 and drum 38, wherein the encoder disc 128 has 192 lines; the counting circuit 270 will provide an output of 2 x 192 = 384 counts per revolution of the shaft 122, and 5 x 384 = 1920 counts per revolution of the drum 38 which corresponds to 203.82 counts per inch of linear displacement of the periphery of the drum. Accordingly, the maximum mailpiece transport velocity of V1 = $61(10^{-3})$ inches per millisecond may be multiplied by a scale factor of 203.82 counts per inch to express the maximum transport velocity in terms of counts per millisecond, or, counts per sampling time period T where T=1 millisecond; i.e., $61(10^{-3})$ inches per millisecond times 203.82 counts per inch = 12.43 counts per sampling time period T. Similarly, any other target velocity V1, or any acceleration or decceleration value, may be expressed in terms of counts per sampling time interval T, or counts per square millisecond, as the case may be, by utilization of the aforesaid scale factor.

For energizing the D.C. motor 120 (Fig. 1) there is provided a power amplifying circuit 300. The power amplifying circuit 300 (Fig. 7) is conventionally operably connected to the motor terminals 302 and 304 via power lines 306 and 308 respectively. The power amplifying circuit 300 preferably comprises a conventional, H-type, push-pull, control signal amplifier 301 having input leads A, B, C and D, a plurality of optical-electrical isolator circuits 303 which are connected on a one-for-one basis between the leads A-D and four output terminals of the computer 500 for coupling the control signals from the computer 500 to the input leads A, B, C, and D of the amplifier 301, and a plurality of conventional pull-up resistors 305 for coupling the respective leads A-D to the 5 volt source. The amplifier 301 includes four conventional darlington-type, pre-amplifier drive circuits including NPN transistors T1, T2, T3 and T4, and four, conventional, darlington-type power amplifier circuits including PNP transistors Q1, Q2, Q3 and Q4 which are respectively coupled on a one-for-one basis to the collectors of transistors T1, T2, T3 and T4 for driving thereby. The optical-electrical isolator circuits 303 each include a light emitting diode D1 and a photo-responsive transistor T5. The cathodes of D1 are each connected to the 5 volt source, the emitters of T5 are each connected to ground and the collectors of T5 are each coupled, on a one-for-one basis, to the base of one of the transistors T1, T2, T3 and T4. With respect to each of the opto-isolator circuits 303, when a low logic level signal is applied to the anode of D1, D1 conducts and illuminates the base of T5 thereby driving T5 into its conductive state; whereas when a high logic level signal is applied to the anode of D1, D1 is non-conductive, as a result of which T5 is in its non-conductive state. With respect to each of the combined amplifier circuits, T1 and Q1, T2 and Q2, T3 and Q3, and T4 and Q4, when the lead A, B, C or D, as the case may be, is not connected to ground via the collector-emitter circuit of the associated opto-isolator circuit's transistor T5, the base of T1, T2, T3 or T4, as the case may be, draws current from the 5 volt source via the associated pull-up resistor 305 to drive the transistor T1, T2, T3 or T4, as the case may be, into its conductive state. As a result, the base of transistor Q1, Q2, Q3 or Q4, as the case may be, is clamped to ground via the emitter-collector circuit of its associated driver transistor T1, T2, T3 or T4, thereby driving the transistor Q1, Q2, Q3 or Q4, as the case may be, into its conductive state. Contrariwise, the transistor pairs T1 and Q1, T2 and Q2, T3 and Q3, and T4 and Q4 are respectively biased to cut-off when lead A, B, C or D, as the case may be, is connected to ground via the collector-emitter circuit of the associated opto-isolator circuit's transistor T5. As shown in the truth table (Fig. 8) for clockwise motor rotation, Q1 and Q4 are turned on and Q2 and Q3 are turned off; whereas for counter-clockwise motor rotation, Q2 and Q3 are turned on and Q1 and Q4 are turned off. Accordingly, for clockwise motor rotation: terminal 302 (Fig. 7) of the motor 120 is connected to the 30 volt source via the emitter-collector circuit of Q1, which occurs when Q2 is turned off and the base of Q1 is grounded through the emitter-collector circuit of T1 due to the base of T1 drawing current from the 5 volt source in the presence of a high logic level control signal at input terminal A; and terminal 304 of the motor 120 is connected to ground via the emitter-collector circuit of Q4, which occurs when Q3 is turned off and the base of Q4 is grounded through the emitter-collector circuit of T4 due to the base of T4 drawing current from the 5 volt source in the presence of a high logic level signal at the input terminal D. On the other hand, for counter clockwise rotation of the motor 120: terminal 302 of the motor 120 is connected to ground via the emitter-collector circuit of Q2, which occurs when Q1 is turned off and the base of Q2 is grounded through the emitter-collector circuit of T2 due to the base of T2 drawing current from the 5 volt source in the presence of a high logic level control signal at the input terminal B; and terminal 304 of the motor 120 is connected to the 30 volt source via the emitter-collector circuit of Q3, which occurs when Q4 is turned off and the base of Q3 is grounded through the emitter-collector of T3 due to the base of T3 drawing current from the 5 volt source in the presence of a high logic level control signal at the input terminal C. For turning off the respective powers transistors Q1-Q4, on a two at a time basis, low level control signals are applied on a selective basis to the two terminals B and C, or A and D, as the case may be, to which high logic control level signals are not being applied; which occurs when the opto-isolator circuit's transistors T5 associated with the respective leads B and C or A and D are driven to their conductive states, When this occurs the bases of the transistors T2 and T3, or T1 and T4, as the case may be, are biased to open the emitter-collectors circuits of the transistors T2 and T3, or T1 and

T4, as the case may be, as a result of which the bases of the transistors Q2 and Q3, or Q1 and Q4, as the case may be, are biased to open the emitter-collector circuits of transistors Q2 and Q3, or Q1 and Q4, as the case may be.

The velocity of the motor 120 (Fig. 7) is controlled by modulating the pulse width and thus the duty cycle of the high logic level, constant frequency, control signals, i.e., pulse width modulated (PWM) signals, which are timely applied on a selective basis to two of the leads A-D, while applying the low level logic signals to those of leads A-D which are not selected. For example, assuming PWM signals (Fig. 9) having a 50% duty cycle are applied to leads A and D (Fig. 7), and low level logic signals are applied to leads B and C, for clockwise rotation of the motor 120, the velocity of the motor 120 will be greater than it would be if high logic level PWM signals (Fig. 9) having a 25% duty cycle were similarly applied and will be less than it would be if high logic level PWM signals having a 75% duty cycle were similarly applied. Accordingly, assuming rotation of the motor 120 (Fig. 7) is commenced by utilizing high logic level PWM signals having a given duty cycle percentage, the velocity of the motor 120 may be decreased or increased, as the case may be, by respectively decreasing or increasing the duty cycle percentage of the applied high logic level PWM signals. Further, assuming the motor 120 is rotating clockwise due to PWM signals having a selected positive average value being applied to leads A and D, in combination with low level logic signals being applied to leads B and C, the motor 120 may be dynamically braked by temporarily applying high level PWM signals having a selected duty cycle corresponding to a given positive average value to leads B and C, in combination with low logic signals being applied to leads A and D. To avoid damage to the power transistors Q1, Q2, Q3 and Q4 which might otherwise result, for example, due to current spikes accompanying back emf surges which occur in the course of switching the circuit 301 from one mode of operation to the other, the emitter-collector circuits of the power transistors Q1, Q2, Q3 and Q4 are respectively shunted to the 30 volt source by appropriately poled diodes, D1, D2, D3 and D4 connected across the emitter-collector circuits of Q1, Q2, Q3 and Q4.

To control the motion of the drum 38 (Fig. 1) during each cycle of drum rotation, the D.C. motor 120 and its shaft encoder 126 are respectively connected to the computer 500 via the power amplifier circuit 300 and the counting circuit 270. And the computer 500 is programmed to calculate the duration of and timely apply PWM control signals to the power amplifier circuit 300 after each sampling time instant Tn, utilizing an algorithm based upon a digital compensator D(s) derived from analysis of the motor 120, motor load 38, 74, 76, 90 and 124 amplifying circuit 300, encoder 126, counting circuit 270, and the digital compensator D(s) in the closed-loop, sampled-data, servo-control system shown in Fig. 10.

With reference to Fig. 10, in general, at the end of each predetermined sampling time period of T=1 millisecond, the eight bit wide count representing the angular displacement of the motor drive shaft 122, and thus the drum 38, from its home position is sampled by the computer 500 at the time instant Tn. Under the control of the program of the computer 500 (Fig. 10), a summation is taken of the aforesaid actual count and the previously calculated count representing the desired position of the motor drive shaft 122, and thus the drum 38, at the end of the time period T, and, under control of the computer program implementation of the algorithm, a PWM control signal which is a function of the summation of the respective counts, or error, is applied to the power amplifier circuit 301 for rotating the motor drive shaft 122 such that the error tends to become zero at the end of the next sampling time period T.

To derive the algorithm, the servo-controlled system of Fig. 10 is preferably analyzed in consideration of its equivalent Laplace transformation equations shown in Fig. 11, which are expressed in terms of the following Table of Parameters and Table of Assumptions.

Table I - Parameters

Parameter	Symbol	Value and/or Dimension
Zero-Order-Hold	ZOH	None
Laplace Operator	S	jw
Sampling Interval	T	Milliseconds
PWM D.C. Gain	K_v	Volts
PWM Pulse Amplitude	V_p	5 Volts

PWM Pulse Width	t_1	10^{-6} Micro-seconds
Power Switching Circuit Gain	K_a	None
Motor back e.m.f. Constant	K_e	0.63 Volts/radian/second
Motor Armature Resistance	R_a	1.65 Ohms
Motor Armature Moment of Inertia	Ja	2.12 (10^{-5}) Kilograms
Motor Torque Constant	K_t	0.063 Newton-Meters/amp
Drum Moment of Inertia	J_1	70.63 (10^{-5}) Kilograms/meter^2
Gear Ratio, Motor to Load	G	5:1, None
Motor Armature Inductance	L_a	2.76 Millihenrys
Motor Shaft Encoder Gain	K_p	Counts/radian
Motor Shaft Encoder Constant	K_b	192 Lines/revolution
Counting Circuit Multiplier	K_x	2, None
Motor Gain	K_m	16, None
Poles in frequency domain	$f_1;f_2$	48;733 Radians/second
Starting Torque Gain	K_e	None
System Overall Gain	K_o	None

Table II - Assumptions

ZOH: Since the output and input are held constant during each sampling period a zero-order-hold is assumed to approximate the analog time function being sampled.

Veq.: Since the integral of the voltage in time is assumed equal to the area under the PWM pulse, the output from the PWM is linear.

With reference to Fig. 10, D(S) is the unknown transfer function of an open loop compensator in the frequency domain. Due to a key factor for providing acceptably fast motor response being the system's resonance between the motor and load, the derivation of the transfer function D(S) for stabilization of the system is preferably considered with a view to maximizing the range of frequencies within which the system will be responsive, i.e., maximizing the system's bandwidth, BW. For calculation purposes a sampling period of T=1 millisecond was chosen, due to having chosen a Model 8051 microprocessor, available from Intel Corporation, Palo Alto California, for control purposes, and inasmuch as the Model 8051 microprocessor equipt with a 12 MHz crystal for providing a clock rate of 12 MHz, is able to conveniently implement a 1 KHz sampling rate and also implement application software routines, after control algorithm interations, during the sampling period of T=1 millisecond. However, other sampling periods and other conventional microprocessors may be utilized without departing from the spirit and scope of the invention.

The open loop system gain $H_1(S)$ without compensation, of the servo-loop system of Fig. 10 is shown in Fig. 12(a). To tolerate inaccuracies in the transmission system between the motor and drum load, such as backlash, it was considered acceptable to maintain a steady-state count accuracy of plus or minus one count. To reflect this standard, the gain equation of Fig. 12(a) was adjusted to provide a corrective torque C_t with a motor shaft movement, in radians per count, equivalent to the inverse expressed in radians per count, of the gain K_p of the encoder counting circuit transform. Since the corrective torque C_t is primarily the friction of the transmission system which has to be overcome by the motor at start-up, the value of C_t may be assumed to be substantially equal to a maximum estimated numerical value based on actual measurements of the starting friction of the system, i.e., 35 ounce-inches, as a result of which a numerical value of the starting voltage V_s may be calculated from the expression $V_s = (C_t)R_a/K_t$, i.e., $V_s = 6.5$ volts, which, in turn, permits calculation of a numerical value for the minimum overall system gain K_o, at start-up, from the equation $K_o = V_s/K_p$, i.e., $K_o = 397$ volts per radian, or for simplication purposes, 400 volts/radian. Accordingly, the open-loop uncompensated gain $H_1(S)$ may be rewritten as $H_2(S)$ as shown in Fig. 12(b), in which a gain factor of K_c has been included, to account for the torque C_t and the value of K_o is substituted for the overall D.C. gain, i.e., $(K_v)(K_m)(K_p)(K_a)(K_c) = K_o$. Although the numerical value of K_c may also be calculated, it is premature to do so, since it has not as yet been established that K_o, which has been adjusted by the value of K_c to provide a minimum value of K_o, is acceptable for system stability and performance purposes. Otherwise stated, K_o may not be the overall system gain which is needed for system compensation for maximizing the system bandwidth BW, as a result of which it is premature to conclude that K_c will be equivalent to the D.C. gain of the system compensator D(S).

At this juncture, the bode diagram shown in Fig. 13, may be constructed due to having calculated a minimum value for K_o. As shown in Fig. 13, the absolute value of $H_2(S)$, in decibels, has been plotted against the frequency W in radians per second, based on the calculated minimum value of K_o, the selected value of T and calculated values of the poles f_1 and f_2. From the Bode diagram, a numerical value of the cross-over frequency W_{c1} of the Bode plot of $H_2(S)$ may be determined, i.e., W_{c1} was found to be substantially 135 radians per second. And, since the value of W_{c1} is substantially equal to the bandwidth BW_u of the uncompensated open-loop system $H_2(S)$, a calculation may be made of the phase margin Θ_m of the uncompensated system from the expression $\emptyset_m = 180° - \Theta\,[H(S)]$ at W_{c1}, or, otherwise stated: $\emptyset_m = 180° - \tan^{-1}(\text{pie}/2) - \tan^{-1}(W_{c1}/f_1) - \tan^{-1}(W_{c1}/f_2) - \tan^{-1}(W_{c1}T/2)$. From this calculation, there was obtained a phase margin value which was much, much, less (i.e., 5°) than 45°, which, for the purposes of the calculations was taken to be a minimum desirable value for the phase margin $\emptyset_m$ in a position-type servo system. Accordingly, it was found that the uncompensated system $H_2(S)$ was unstable if not compensated. Since an increase in phase lead results in an increase in bandwidth BW, and the design criteria calls for maximizing the bandwidth BW and increasing the phase margin to at least 45°; phase lead compensation was utilized.

By definition, a phase lead compensator D(S) has the Laplace transform shown in Fig. 14, wherein K_c is the phase lead D.C. gain, and f_z and f_p are respectively a zero pole frequency and a phase lead pole frequency. Adding the transfer function of the phase lead compensator D(S) to the Bode plot of the uncompensated system's transfer function $H_2(S)$, results in the Bode plot of the compensated system transfer function $H_3(S)$, if the zero pole f_z of the phase lead compensator D(S) is chosen to be equivalent to f_1 in order to cancel the lag due to the mechanical time constant of the uncompensated transfer function H_2S. As shown in Fig. 13, the cross-over frequency W_{c2} for the compensated system $H_3(S)$ may be read from the Bode diagram, i.e., W_{c2} was found to be substantially equal to 400 radians per second. And, since by definition the pole frequency f_p lies at the geometric means of f_p and W_{c2}, the value of the f_p may be established by doubling the linear distance between W_{c2} and W=O, as measured along the W-axis, and reading the value of f_p from the Bode diagram, i.e., f_p was found to be substantially equal to 3,400 radians per second. Since numerical values may thus be assigned to both W_{c2} and f_p from the Bode diagram, the compensated phase margin $\emptyset_{mc}$, i.e., the phase margin for the phase lead compensated system $H_3(S)$ in which f_z has been equated to f_1, may be found from the expression $\emptyset_{mc}=180°-90°-\tan^{-1}(W_{c2}/f_2)-\tan^{-1}(W_{c2}T/2)$. Upon calculating the compensated phase margin $\emptyset_{mc}$ it was found to be 50° and, therefore, greater than the minimum phase margin criteria of 45°. In addition, the value of W_{c2} for the compensated system $H_3(S)$ was found to be substantially three times that of the uncompensated system $H_2(S)$, as a result of which the bandwidth BW of the system H(S) was increased by a factor of substantially three to BW_c.

At this juncture, the compensated system $H_3(S)$ is preferably analyzed with reference to the system's overshoot O_s and settling time t_s based on a calculation of the system damping factor d_f and the assumption that the system will settle in five times constants, i.e., $t_s=5t_x$. The relevant values may be calculated or estimated, as the case may be, from the expressions, for d_f, o_s, t_x and t_s shown in Fig. 15. In connection with this analysis, reference is also made to the typical mailing machines hereinbefore described, wherein a maximum drum cycle time period T_{ct} (Fig. 3) of 234 milliseconds and a maximum mailpiece transport speed (Fig. 2) of 61 inches per second are typical values. Assuming the velocity profile of Fig. 3, and, as previously discussed an acceleration time period of T_a=37 milliseconds, a constant velocity time period of T_c=124 milliseconds and decceleration time period of T_d=24 milliseconds, the longest permissible settling time for the system was calculated, i.e., $T_{ct}-(T_a+T_c+T_d)$ = 234-185 = 49 milliseconds. For analysis purposes a series of calculations of the aforesaid system characteristics and phase margin were performed, assuming incremental increases in the overall system gain K_o, while holding $f_z=f_1$. The results of such calculations are shown in the following Table III.

Table III - $H_3(S)$ with $f_z=f_1$

K_O=system gain (db)	W_C=BW (rad./sec.)	Θ_m=phase Margin (deg.)	O_S=overshoot (percent)	t_S=settling time (MS.)
400	400	50	28	28.67
447	450	46	31	27.78
501	500	42	34	27.50
562	550	38	38	27.41

As shown in Table III, the system bandwidth BW may be maximized at 450 radians per second while maintaining a phase margin $\emptyset_m$ of at least 45° the two design criteria discussed above. Although this results in an increase in system overshoot O_s accompanied by a negligible decrease in the settling time t_s, the settling time t_s is well within the maximum allowable settling time, T_s=49 milliseconds. On the other hand, if a bandwidth of 400 radians per second is acceptable, it is desirable to reduce the percentage of overshoot O_s, and increase the phase margin to Θ_{mc}=50 to provide for greater system stability than would be available with a phase margin value (i.e., 46°) which is substantially equal to the design criteria minimum of 45°; in which instance it is preferable to choose the bandwidth of BW=400 radians per second, overshoot of O_s=28% and compensated phase margin of Θ_{mc}=50°. For the example given, a compensated Bandwidth of BW_c=400 radians per second is acceptable inasmuch as worst case load conditions were assumed. In this connection it is noted that the foregoing analysis is based on controlling a postage meter drum, which has a high moment of inertia, contributes high system friction, and calls for a cyclical start-stop mode of operation during which the load follows a predetermined displacement versus time trajectory to accommodate the maximum mailpiece transport speed in a typical mailing machine. Accordingly, the compensated system bandwidth BW_c=400 radians per second may be chosen, as a result of which the overall system gain K_o may be fixed at K_o=400, and the value of K_c may be calculated from the expression $K_c=K_o/(K_v)(K_a)(K_p)$. Since $f_z=f_1$, and f_1 and f_p are also known, the Bode plot of the compensator D(S), Fig. 14, may be added to the Bode diagram (Fig. 13) wherein the system compensator D(S) is shown as a dashed line.

Since the analog compensator D(S) was derived in the frequency domain, D(S) was converted to its Z-transform equivalent D(Z) in the sampled data domain for realization in the form of a numerical algorithm for implementation by a computer. Of the numerous well-known techniques for transforming a function in the frequency domain to a function in the sampled-data domain, the bi-linear transformation may be chosen. For bi-linear transformation purposes the Laplace operator S is defined by the expression shown in Fig. 16. Using the values K_c=13.64, $f_z=f_1$=48, and f_p=3,400 in the expression for D(S) shown in Fig. 14, and substituting the bi-linear transformation expression for S shown in Fig. 16 and the sampling interval T=1 millisecond, in the expression shown in Fig. 14 results in the expression for D(Z) shown in Fig. 17. As shown in Fig. 11, D(T)=output/input=g(T)/e(T), which, in the sampled data domain is expressed by the equation $D(Z)=G(Z)/E(Z)$. Accordingly, the expression for $D(Z)$ shown in Fig. 17 may be rewritten as shown in Fig. 18a. Cross-multiplying the equivalency of Fig. 18a results in the expression shown in Fig. 18b, which defines the output $G(Z)$ in the sampled data domain of the system compensator $D(S)$. Taking the inverse Z-transform of the expression shown in Fig. 18b, results in the expression shown in Fig. 19 which defines the output $G(T_n)$ in the time domain of the system compensator $D(S)$, and is a numerical expression of the algorithm to be implemented by the computer for system compensation purposes. As shown by the expression in Fig. 19 and in the following Table IV the output of the digital compensator for any current sampling instant T_n is a function of the position error at the then current sampling time instant T_n, is a function of the position error at the end of the next previous sampling time instant T_{n-1} and is a function of the algorithm output at the end of the next previous sampling time instant T_{n-1}.

TABLE IV

Function	Definition
$G(T_n)$	Algorithm output for current sampling time instant T_n
$E(T_n)$	Position error for current sampling time instant T_n
$G(T_{n-1})$	Algorithm output for next previous sampling time instant T_{n-1}
$E(T_{n-t})$	Position error for next previous sampling time instant T_{n-1}

K_1, K_2 & K_3	Constants of the compensated system which are a function of the parameters of the motor load and system friction for a sampling time period of T=1 millisecond.

Accordingly, the algorithm which is to be implemented by the computer 500 for system compensation purposes is a function of a plurality of historical increments of sampled data for computing an input value for controlling a load to follow a predetermined position trajectory in a closed loop sampled-data servo-control system.

As shown in Fig. 20 the computer 500 preferably includes a conventional, inexpensively commercially available, high speed microprocessor 502, such as the Model 8051 single chip microprocessor commercially available from Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. The microprocessor 502, generally comprises a plurality of discrete circuits, including those of a control processor unit or CPU 504, an oscillator and clock 506, a program memory 508, a data memory 510, timer and event counters 512, programmable serial ports 514, programmable I/O ports 516 and control circuits 518, which are respectively constructed and arranged by well known means for executing instructions from the program memory 508 that pertain to internal data, data from the clock 506, data memory 510, timer and event counter 512, serial ports 514, I/O ports 514 interrupts 520 and/or bus 522 and providing appropriate outputs from the clock 506, serial ports 514, I/O ports 516 and timer 512. A more detailed discussion of the internal structural and functional characteristics and features of the Model 8051 microprocessor, including optional methods of programming port 3 for use as a conventional bi-directional port, may be found in the Intel Corporation publication entitled MCS-51 Family of Single Chip Microcomputers Users Manual, dated January 1981.

For implementing the sampling time period of T=1 millisecond, one of the microprocessor's timer and event counters 512 (Fig. 20) is conventionally programmed as a sampling time period clock source. To that end, a timer 512 is programmed for providing an interrupt signal each 250 microseconds, and each successive fourth interrupt signal is utilized as a clock signal for timing the commencement of successive sampling time periods of T=1 millisecond.

In general, as shown in Fig. 21, at the commencement of each sampling time period of T=1 millisecond, during the sampling instant T_n, a sample is taken of the count representative of the actual angular displacement of the motor drive shaft and, substantially immediately thereafter, the actual count is summed with the count representative of the desired angular displacement of the motor drive shaft which was calculated during the next preceeding time period T in order to obtain the then current error value $E(T_n)$ for calculating the then current compensation algorithm output value $G(T_n)$. Due to the recursive mathematical expression for $G(T_n)$ [Fig. 19] being a function of the then current error value $E(T_n)$, the next previous error value $E(T_{n-1})$ and the next previous compensation algorithm output value $G(T_{n-1})$, the expression for $G(T_n)$ is preferably separated into two components for calculation purposes, i.e., $G(T_n) = g_1 + g_2$; wherein $g_1 = K_1 \times E(T_n)$, and wherein $g_2 = -[K_2 \times E(T_{n-1}) + K_3 \times G(T_{n-1})]$, to permit calculation of the value of g_2 in advance of the time period T when it is to be added to the value of g_1 for calculating the value of $G(T_n)$, thereby reducing to a negligible value (in view of the time period T) the time delay T_{dy} before completion of sampling the actual displacement of the motor drive shaft at the instant T_n and applying the PWM motor control signal to the output ports of the microprocessor. For example, when calculating the value of $G(T_n)$ based upon the first error value resulting from the summation of the counts representing the desired and actual angular displacements of the motor drive shaft, the value of g_2 is by definition equal to zero since the error signal $E(T_{n-1})$ is equal to zero, due to the desired and actual angular displacement values during the next previous sampling time period T having been equal to each other. Accordingly, upon obtaining the value of the first error signal $E_1(T_n)$, the value of $G_1(T_n)$ may be calculated as being equivalent to g_1, i.e., $G_1(T_n) = g_1 = K_1 \times E_1(T_n)$. And, upon calculating $G_1(T_n)$ the value of g_2 for use in calculating the next successive compensation algorithm output value $G(T_{n+1})$ may be calculated for subsequent use, since $g_2(T_{n+1}) = -[K_2 \times E_1(T_n) + K_3 \times G_1(T_n)]$, and K_2, K_3, $E_1(T_n)$ and $G_1(T_n)$ are all known values. In addition, during any given time period T, a calculation may be made of the desired angular displacement of the motor drive shaft for the next subsequent time period T. Preferably, the microprocessor is programmed for implementation of the aforesaid calculation process to facilitate early utilization of the compensation algorithm output value $G(T_n)$ for driving the D.C. motor. Accordingly, the microprocessor is preferably programmed for: during the first-sampling time period T_1, sampling the count representative of the actual angular displacement of the motor drive shaft at the time instant T_n, then taking the summation of that count and the previously calculated value of the desired angular displacement of the motor drive shaft to obtain the first error value $E_1(T_n)$, then calculating the first compensation algorithm output value $G_1(T_n) = K_1 \times E_1(T_n) + g_2$, wherein $g_2=0$, and generating a PWM motor control signal representative of $G_1(T_n)$, then calculating the value of g_2 for the next sampling time period, i.e., $g_2 = -[K_2 \times E_1(T_n) + K_3 \times G_1(T_n)]$, and then calculating the count representing the desired angular displacement of the motor drive shaft for use during the next sampling time period T_2; during the second sampling time period T_2, sampling the count representative of the actual angular displacement of the motor drive shaft and taking the summation of that count and the previously calculated desired count to obtain the error value $E_2(T_{n+1})$, calculating the compensation algorithm output value $G_2(T_{n+1}) = K_1 \times E_2(T_{n+1}) + g_2 = K_1 \times E_2(T_{n+1}) - K_2 \times E_1(T_n) - K_3 \times G_1(T_n)$, and generating a PWM motor control signal representative thereof, then calculating the value of g_2 for the next sampling time period T_3, i.e., $g_2 -[K_2 \times E_2(T_{n+1}) + K_3 \times G_2(T_{n+1})]$, and then calculating the count representative of the desired angular displacement of the motor drive shaft for use during the time period T_3; and so on, during each successive sampling time period.

Accordingly, as shown in Fig. 21, the microprocessor is programmed for immediately after calculating the then current compensation algorithm output value $G(T_n)$, and thus while the calculation of the value of g_2 for the next sampling time period is in progress, generating a motor control signal for energizing the power amplifier. For this purpose, the relative voltage levels of motor control signal are determined by the sign, i.e., plus or minus, of the compensation algorithm output value $G(T_n)$, and the duty cycle of the control signal is determined by the absolute value of the compensation algorithm output value $G(T_n)$. Preferably, for timing the duration of the motor control signal, the other timer and event counter 512, i.e., the timer 512 which was not used as a sampling time period clock source, is utilized for timing the duration of the duty cycle of the motor control signal. For example, by loading the absolute value of the $G(T_n)$ into the other timer 512, commencing the count, and timely invoking an interrupt for terminating the duty cycle of the control signal. As shown in Fig. 21(c), the time delay T_{dy} from commencement of the time period T to updating the PWM motor control signal at the output ports of the microprocessor is substantially 55 microseconds, and the time interval allocated for calculating the value of g_2 and the count representative of the desired angular displacement of the motor drive shaft for use during the next time period is substantially 352 microseconds. As a result, substantially 593 microseconds of microprocessor calculation time is available during any given sampling time period T=1 millisecond for implementing non-motor control applications.

As shown in Fig. 22 the computer 500 is preferably modularly constructed for segregating the components of the logic circuit 501a and analog circuit 501b of the computer 500 from each other. To that end, the respective circuits 501a and 501b may be mounted on separate printed circuit boards which are electrically isolated from each other and adapted to be interconnected by means of connectors located along the respective dot-dash lines 516, 527 and 528. In any event, the components of the logic circuit 521a and analog circuit 521b are preferably electrically isolated from each other. To that end, the logic circuit 501a preferably includes 5V and ground leads from the mailing machine's power supply for providing the logic circuit 501a with a local 5 volt source 530 having 5V and GND leads shunted by filter capacitors C1 and C2. And the analog circuit 501b includes 30 volt and ground return leads from the mailing machine's power supply for providing the analog circuit 501b with a local 30 volt source 536 including 30V and GND leads shunted by filter capacitors C3 and C4. In addition, the analog circuit 501b includes a conventional 30 volt detection circuit 542 having its input conventionally connected to the analog circuit's 30 volt source 536, and its output coupled to a power up/down lead from the analog circuit via a conventional optical-electrical isolator circuit 544.

Further, to provide the analog circuit 501b with a local 5 volt source 546, the analog circuit 501b is equipt with a conventional regulated power supply having its input appropriately connected to the analog circuit's 30 volt source 536 via a series connected resistor R1 and a 5 volt, voltage regulator 548. A zener diode D1, having its cathode shunted to ground and having its anode connected to the input of the 5V regulator 548 and also connected via the resistor R1 to the 30 volt terminal line, is provided for maintaining the input to the 5V regulator 548 at substantially a 5 volt level. In addition, a pair of capacitors C5 and C6 are provided across the output of the regulator 548 for filtration purposes.

To accommodate interfacing the postage meter's computer 41 (Fig. 1) with the computer 500, any two available ports of the computer 41 may be programmed for two-way serial communications purposes and coupled to the computer 500. For example, the postage meter's printing module 41a may be conventionally modified to include an additional two-way serial communications channel for communication with the computer 500.

Assuming the latter arrangement, serial input communications to the computer 500 (Fig. 22) are received from the postage meter computer's printing module 41c via the serial input lead to the logic circuit 501a (Fig. 22), which is operably coupled to port $P3_0$ of the microprocessor 502 by means of a conventional inverting buffer circuit 550. Accordingly, port $P3_0$ is preferably programmed for serial input communications, and the input to the buffer circuit 550 is resistively coupled to the logic circuit's 5 volt source 530 via a conventional pull-up resistor R2. Serial output communications from the microprocessor 502 are transmitted from port $P3_1$. Accordingly, port $P3_1$ is preferably programmed for serial output communications, and is operably coupled to the input of a conventional inverting buffer 552, the output of which is resistively coupled to the logic circuit's 5V source 530 via a suitable pull-up resistor R2 and is additionally electrically connected to the serial output lead from the logic circuit 501a.

Since it is preferable that the microprocessor 502 be reset in response to energization of the logic circuit 501a, the logic circuit's 5V source 530 is connected in series with an R-C delay circuit and a conventional inverting buffer circuit 554 to the reset pin, RST, of the microprocessor 502. The R-C circuit includes a suitable resistor R3 which is connected in series with the logic circuit's local 5V source 530 and a suitable capacitor C7 which has one end connected between the resistor R3 and the input to the buffer circuit 554, and the other end connected to the logic circuit's ground return.

In addition to the VCC and VSS terminals of the microprocessor 502 being respectively conventionally connected to the logic circuit's 5 volt source and ground, since the microprocessor 502 does not utilize an external program memory, the $\overline{EA}$ terminal is connected to the logic circuit's 5V source. And, since no other external memory is position lead of the logic circuit, which, in turn, is connected to one input of a differential amplifier 562, the output of which is connected to the other input of the differential amplifier 562 via a feedback resistor R4. The aforesaid other input to the amplifier 562 is also resistively coupled, by means of a resistor R5, to the mid-point of a voltage divider circuit including resistors R6 and R7. Resistors R6 and R7 are connected in series with each other and across the logic circuit's 5V source and ground return leads. The LED sensors 56 and 58, which are utilized for successively sensing the leading edges of each envelope being fed by the letter transport, are separately coupled to the computer 500 via the envelope sensor-1 and envelope sensor-2 input leads of the logic circuit 501a. In the logic circuit 501a, the envelope sensor-1 and sensor-2 leads are connected on a one-for-one basis to one of the inputs of a pair of conventional amplifiers 564, the other inputs of which are connected together and to the mid-point of a voltage divider including resistors R8 and R9. Resistors R8 and R9 are connected in series with each other and across the logic circuit's 5V source and ground return leads. Further, the three output signals from the differential amplifier 562 and the two amplifiers 564 are connected on a one-for-one basis to the three input ports PO_{0-2} of the microprocessor 502, each via a conventional tri-state buffer circuit 566, one of which is shown. The input signals A and B from the D.C. motor shaft encoder 126 are coupled to the logic circuit 501a position lead of the logic circuit, which, in turn, is connected to one input of a differential amplifier 562, the output of which is connected to the other input of the differential amplifier 562 via a feedback resistor R4. The aforesaid other input to the amplifier 562 is also resistively coupled, by means of a resistor R5, to the mid-point of a voltage divider circuit including resistors R6 and R7. Resistors R6 and R7 are connected in series with each other and across the logic circuit's 5V source and ground return leads. The LED sensors 56 and 58, which are utilized for successively sensing the leading edges of each envelope being fed by the letter transport, are separately coupled to the computer 500 via the envelope sensor-1 and envelope sensor-2 input leads of the logic circuit 501a. In the logic circuit 501a, the envelope sensor-1 and sensor-2 leads are connected on a one-for-one basis to one of the inputs of a pair of conventional amplifiers 564, the other inputs of which are connected together and to the mid-point of a voltage divider including resistors R8 and R9. Resistors R8 and R9 are connected in series with each other and across the logic circuit's 5V source and ground return leads. Further, the three output signals from the differential amplifier 562 and the two amplifiers 564 are connected on a one-for-one basis to the three input ports PO_{0-2} of the microprocessor 502, each via a conventional tri-state buffer circuit 566, one of which is shown. The input signals A and B from the D.C. motor shaft encoder 126 are coupled to the logic circuit 501a by means of leads A and B, which are conventially electrically connected to the counting circuit 270 to provide the microprocessor 502 the the count representative of the actual angular displacement of the motor shaft 122 from its home position. The counting circuit's leads Q0-Q7 are electrically connected on a one-for-one basis to Ports PO_0-PO_7 of the microcomputer 502 via one of eight conventional tri-state buffer circuits 568, one of which is shown, having their respective control input leads connected to each other and to the output of a conventional inverting buffer circuit 570, which has its input conventionally connected port $P3_4$ of the microprocessor 502. Thus, either the three input signals, i.e., from the drum home position and the two envelope position sensors are operably electrically coupled to Ports $P0_0$-$P0_2$ of the microprocessor 502, or the eight input signals Q0-Q7 from the counter circuit 270 are operably electrically coupled to ports $P0_0$-PO_7 of the microprocessor 502, for scanning purposes, in response to an appropriate control signal being applied to the respective buffer circuits 566 and 568 from port $P3_4$ of the microprocessor 502. In operation, assuming a low logic level signal is required for activating either of the sets of buffers 566 or 568; when the microprocessor 502 applies such a signal to port $P3_4$, the buffer circuits 566 operate, whereas since the buffer circuit 570 inverts this signal to a high logic level signal before applying the same to the buffer circuit 568, the latter is inoperative. Conversely, a high logic level signal from port $P3_4$ will operate buffer circuits 568 and not operate the buffer circuits 566. Accordingly, depending upon the level, high or low, of the signal from port $P3_4$ of the microprocessor 502, the eight bit input to one or the other buffer circuits 566 or 568 will be made available to port P0 for scanning purposes. Aside from the foregoing, to permit the microprocessor 502 to clear the counter 270 for any reason in the course of execution of the program, port $P3_5$ is connected to the clear pin CLR of the counter 270 via a conventional inverting buffer 572, and the microprocessor 502 is programmed for timely applying the appropriate signal to port $P3_5$ which, when inverted, causes the counting circuit 270 to be cleared.

In general, ports $P1_0$-$P1_3$ are utilized by the microprocessor 502 for providing pulse width modulated (PWM) motor control signals for controlling energization of the D.C. motor 120 and port $P1_4$ is utilized by the microprocessor 502 for controlling energization of the solid state, A.C. motor, relay 52 and thus operation of the mailpiece conveyor 49. To that end, ports $P1_0$-$P1_4$ of the microprocessor 502 are each conventionally electrically connected on a one-for-one basis to the input of a conventional inverting buffer circuit 580, one of which is shown. The outputs of each of the buffer circuits 580 are connected on a one-for-one basis, via a conventional resistor R10, to output leads from the logic circuit 501b, one of which is designated solid state, A.C. motor, relay, and four of which are respectively designated T1, T3, T2 and T4, since, as shown in Fig. 7, the four preamplifier stages of the power amplifier utilized for opto-isolator's photo-transistor when the light emitting diode D1 is lit in response to the D.C. supply voltage level matching the internal reference voltage level, e.g., 30 volts, of the 30 volt detection circuit.

In the analog circuit 501b each of the outputs from the photo-transistors of each of the opto-isolators 303 are resistively coupled to the analog circuits 5V source by means of a conventional pull-up resistor 305, and the emitters of the photo-transistors T5 are connected to the analog circuit's ground system. In addition, the collectors of the photodiodes of the opto-isolators 303, which are utilized for transmitting the motor control signals from ports Pl_0-Pl_3 of the microprocessor 502 are connected on a one-for-one basis to the appropriate input leads A, B, C and D of the power amplifiers shown in Fig. 7, the outputs of which are connected to the D.C. motor 120. Further, the collector of the photodiode of the opto-isolator 303 which is utilized for transmitting the A.C. relay control signals from port Pl_4 of the microprocessor 502 is connected to the input lead of a conventional darlington-type power amplifier 550, the output of which is conventionally connected to the mailing machine's 30 volt D.C. source via a solid state, A.C. motor, relay 52, which is turn conventionally connected for energizing the A.C. motor 50 from the local A.C. source.

In general, the computer 500 includes three software programs, including a main line program Fig. 23, a transmit and receive program and a command execution program, respectively identified by the 600, 700 and 800 series of opto-isolator's photo-transistor when the light emitting diode Dl is lit in response to the D.C. supply voltage level matching the internal reference voltage level, e.g., 30 volts, of the 30 volt detection circuit.

In the analog circuit 501b each of the outputs from the photo-transistors of each of the opto-isolators 303 are resistively coupled to the analog circuits 5V source by means of a conventional pull-up resistor 305, and the emitters of the photo-transistors T5 are connected to the analog circuit's ground system. In addition, the collectors of the photodiodes of the opto-isolators 303, which are utilized for transmitting the motor control signals from ports Pl_0-Pl_3 of the microprocessor 502 are connected on a one-for-one basis to the appropriate input leads A, B, C and D of the power amplifiers shown in Fig. 7, the outputs of which are connected to the D.C. motor 120. Further, the collector of the photodiode of the opto-isolator 303 which is utilized for transmitting the A.C. relay control signals from port Pl_4 of the microprocessor 502 is connected to the input lead of a conventional darlington-type power amplifier 550, the output of which is conventionally connected to the mailing machine's 30 volt D.C. source via a solid state, A.C. motor, relay 52, which is turn conventionally connected for energizing the A.C. motor 50 from the local A.C. source.

In general, the computer 500 includes three software programs, including a main line program Fig. 23, a transmit and receive program and a command execution program, respectively identified by the 600, 700 and 800 series of

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numbers. When the mailing machine 10 is energized by actuation of the main power switch 24, the resulting low level logic signal from D.C. supply is applied to the reset terminal RST of the computer's microprocessor 502, thereby enabling the microprocessor 502. Whereupon, as shown in Fig. 23, the microprocessor 502 commences execution of the main line program 600.

The main line program 600 (Fig. 23) commences with the step of conventionally initializing the microprocessor 602, which generally includes establishing the initial voltage levels at the microprocessor's ports, and interrupts, and setting the timers and counters. Thereafter, the D.C. motor drive unit is initialized 604. Step 604 entails scanning the motor home position sensor input port PO_0, to determine whether or not the D.C. motor 120 is located in its home position and, if it is not, driving the motor 120 to its home position. Assuming the D.C. motor 120 is in its home position, either before or after the initialization step 604, the program then enters an idle loop routine 606.

In the idle loop routine 606, a determination is initially made as to whether or not the sampling time period of T=1 millisecond has elapsed, step 608, it being noted that each successive sample is taken at the time instant T_n immediately after and in response to the fourth 250 millisecond interrupt generated by the timer utilized for implementing the sampling time period T. Assuming the time period T has not elapsed, the program loops to idle 606. On the other hand, assuming the time period T has elapsed, the microprocessor 502 updates the servo-control system, step 610. For the purpose of explaining step 610 it will be assumed until otherwise stated that the desired location of the postage meter drum 38, and thus the motor drive shaft 122, is the home position. Step 610 includes the successive steps 610a and 610b, respectively, of sampling the count of the actual position Pa of the motor drive shaft 122 at the sampling time instant T_n, and fetching the previously computed count representing the desired position Pd of the shaft 122 at the same sampling time instant T_n. If for any reason the motor drive shaft 122 is not located in its home position when the value of the desired position count $Pd(T_n)$ is representative of the home position location, then the values of $Pa(T_n)$ and $Pd(T_n)$ will be different. On the other hand, if the motor drive shaft 122 is located in its home position when the desired position count $Pd(T_n)$ is representative of the home position location, then the values of $Pa(T_n)$ and $Pd(T_n)$ will be the same. Accordingly, computation of the error count, 610c, may or may not result in an error count value $E(T_n)$ of zero. Further, independently of the computed value of $E(T_n)$, the computed value $G(T_n)$ of the motor control signal, step 601d, may or may not result in a value of $G(T_n)$ of zero; it being noted that although step 610c results in a computed value of $E(T_n)=0$, the value of g_2 may not be equal to zero due to the computed value of the error for the next previous sampling time instant $E(T_{n-1})$ having resulted in a non-zero value, step 610g. Assuming steps 610c and 610d both result in zero shaft 122 out of the home position, until a mailpiece 16 is fed to the drum 38.

At this juncture it will be assumed that the enable flag is set, as a result of which the inquiry of step 612 is answered affirmatively, or, as above stated, a mailpiece 16 is being fed to the drum 38. Accordingly, the microprocessor 502 commences polling the ports connected to the envelope sensors 56 and 58, step 614. Since polling occurs at one millisecond time intervals, the polling sequence is continuous. As shown by the following step 616, between successive time instants T_n, the program continuously loops to idle 606 and through steps 608-616 inclusive until the envelope sensing sequence for a given envelope is complete. Whereupon the microprocessor commences executing step 618, which includes the steps of calculating the envelope's velocity, 618a; then fetching from memory the corresponding acceleration, deceleration and constant velocity constants, 618b, for computation of the desired position counts Pd at each successive time instant T_n in advance of sampling the actual position counts Pa as hereinbefore discussed in connection with step 610; then fetching and implementing the time delay t_d for timely commencing acceleration of the drum 38 to the target velocity V1; and then commencing drum rotation by generating the desired position P_d for the initial one millisecond sampling time instant of acceleration of the motor drive shaft 122 and storing the value for subsequent use in step 601b. Accordingly, the value of Pd shaft 122 out of the home position, until a mailpiece 16 is fed to the drum 38.

At this juncture it will be assumed that the enable flag is set, as a result of which the inquiry of step 612 is answered affirmatively, or, as above stated, a mailpiece 16 is being fed to the drum 38. Accordingly, the microprocessor 502 commences polling the ports connected to the envelope sensors 56 and 58, step 614. Since polling occurs at one millisecond time intervals, the polling sequence is continuous. As shown by the following step 616, between successive time instants T_n, the program continuously loops to idle 606 and through steps 608-616 inclusive until the envelope sensing sequence for a given envelope is complete. Whereupon the microprocessor commences executing step 618, which includes the steps of calculating the envelope's velocity, 618a; then fetching from memory the corresponding acceleration, deceleration and constant velocity constants, 618b, for computation of the desired position counts Pd at each successive time instant T_n in advance of sampling the actual position counts Pa as hereinbefore discussed in connection with step 610; then fetching and implementing the time delay t_d for timely commencing acceleration of the drum 38 to the target velocity V1; and then commencing drum rotation by generating the desired position P_d for the initial one millisecond sampling time instant of acceleration of the motor drive shaft 122 and storing the value for subsequent use in step 601b. Accordingly, the value of Pd will no longer be assumed to be the value representative of the home position.

Thereafter, the inquiry is made as to whether or not the drum cycle is complete, step 620. Assuming as stated above that only the initial desired value of Pd has been computed and stored, the inquiry of step 620 will be answered in the negative. Whereupon the microprocessor 502 transmits a status message, step 622, to the postage meter's computer 41 and the program loops to idle 606. Thereafter the microprocessor 502 continuously executes steps 608-620 until the entire Pd count sequence 618d for the trapazoidal-shaped velocity versus time profile for the target velocity V1 has been exhausted. In this connection it is noted that the drum cycle T_{ct} is not complete until the settling time interval T_s which is allowed for damping any overshoot of the motor drive shaft 122 is complete. During the settling time interval T_s the value of Pd is a constant and representative of the home position of the shaft 122 and thus the drum 38. Assuming that the drum cycle is complete, the inquiry of step 620 will be answered affirmatively. Whereupon the microprocessor 502 transmits a status message, step 624, to the postage meter's computer 41 and the program loops to idle 606. Thereafter, the foregoing steps 606-622 of the main line, servo-control, idle loop are continuously executed by the microprocessor 502 in accordance with the above discussion until the main power switch 24 is opened by the operator.

The serial communications program 700 includes the transmit status routine 704. The latter routine 704 includes the steps of receiving and decoding any message, step 706, and invoking the execute command routine, step 708, both of which steps are self explanatory.

Assuming the execute command routine 800 has been invoked, step 708, the microprocessor 502 executes the routine 800 commencing with the step 802 of inquiring whether or not the decoded message is an enable command. Assuming the answer is yes, an enable status flag is set, step 804, to indicate that an envelope is to be fed to the drum 38. Whereupon the A.C. motor relay 52 is energized, step 806, for feeding the envelope to the drum 38, and the transmit status routine is invoked, step 808. On the other hand, assuming the decoded message is not an enable command, step 802, a enable status flag is cleared, step 810. Whereupon the A.C. relay is deenergized, step 812, and the status transmit routine is invoked 808.

Assuming the status transmit routine 702 has been invoked, step 806, the microprocessor 502 executes the routine 702 commencing with the step 710 of inquiring whether or not the drum cycle is complete. Assuming completion of the drum cycle, a drum cycle complete message is transmitted to the postage meter's computer 41, step 712. On the other hand, assuming the drum cycle is not complete, an inquiry is made as to whether or not the A.C. relay is energized, step 716, and, if it is, an A.C. relay energized message is transmitted to the postage meter's computer 41, step 718. If however the drum cycle is not complete, step 710, and the A.C. relay is not energized, step 716, then, an A.C. relay deenergized message is transmitted to the postage meter's computer 41, step 720. Upon transmitting any of the messages, drum cycle complete, step 710, A.C. relay energized, step 716, or A.C. relay deenergized, step 720, the microprocessor 502 returns to the idle 606 of the main line program 600.

The term postage meter as used herein includes any device for affixing a value or other indicia on a sheet or sheet like material for governmental or private carrier parcel, envelope or package delivery, or other purposes. For example, private parcel or freight services purchase and employ postage meters for providing unit value pricing on tape for application on individual parcels.

For a more detailed description of the programs herein-before discussed, reference is directed to the attached APPENDIX forming part of this specification which discloses a program listing which describes in greater detail the various routines incorporated in, and used in the operation of, the postage meter.

Although the invention disclosed herein has been described with reference to a simple embodiment thereof, variations and modifications may be made therein by persons skilled in the art without departing from the spirit and scope of the invention. Accordingly, it is intended that the following claims cover the disclosed invention and such variations and modifications thereof as fall within the true spirit and scope of the invention.

APPENDIX

(our ref: 42 699)
(B-931)


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8051 ASSEMBLER V1.0    14-JUN-1984 10:42:37.77               PAGE   1

    <<< ASSEMBLY COMMAND STRING >>>

MOTORCI.

    <<< end of assembly command string >>>
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ER  LINE  ADDR  OBJECT        TYPE

                                    $ABS
                                    $NOGEN
                                    $ERRORPRINT
                                    $INCLUDE(DECLARE.DMS)
                                    ;***********************************************
                                    ;         INTERNAL 8051 RAM'S DECLARATION
                                    ;***********************************************
                                    ;*must have directly addressable bits.
                                    ;-------------------------------------
                                                    DSEG
                                                    ORG     20H
      0020                          FLAGS:          DS      5       ;*Mapped for flags.
      0025                          SAV_SENSR:      DS      1       ;*Sensors status register.
      0026                          STAT_HEADER:    DS      1       ;*System status communication header.
      0027                          MSG1_STAT:      DS      1       ;*System status first byte.
      0028                          MSG2_STAT:      DS      1       ;*System status second byte.
      0029                          MISTRIP_CTR:    DS      1       ;*Missed-trip counter (third status byte).
      002A                          ERR_CNT:        DS      1       ;*Error count register.
      002B                          K2H:            DS      1       ;*ABS(error) x COEFF2 (High) register.
      002C                          K2L:            DS      1       ; Low byte.
      002D                          CMMD_HEADER:    DS      1       ;Command-complete header.
      002E                          POSN_ACC:       DS      2       ;Desired position count accum (2-byte).
      0030                          BASE_INDEX:     DS      2       ;One cycle index accum (2-byte).
      0032                          RUN_SPEED:      DS      1       ;Computed velocity, counts/sample.
      0033                          VEL_OFFS:       DS      1       ;Velocity offset during deccel.
      0034                          GP_LATCH:       DS      1       ;Register for 'on-the-fly' latching.
      0035                          MARGIN:         DS      1       ;Print margin delay register.
      0036                          AUX_REG:        DS      1       ;Indirectly addressed register.
      0037                          ACCEL_CNT:      DS      2       ;Acceleration distance, counts (2-byte)
      0039                          DECCEL_INT:     DS      1       ;Decceleration time interval
      003A                          CYC_CTR:        DS      1       ;Cycle repeater counter
      003B                          TOTAL_CNT:      DS      2       ;Desired total distance (2-byte)
      003D                          ACCELK:         DS      1       ;Accel constant
      003E                          SLEWK:          DS      1       ;Maximum speed constant.
      003F                          ROFFS:          DS      2       ;REIER_INDEX save area.
      0041                          DECCELK:        DS      1       ;Deccel constant
      0042                          PLIM_ERR:       DS      1       ;Positive error count limit.
      0043                          NLIM_ERR:       DS      1       ;Negative error count limit.
      0044                          PORTX_LATCH:    DS      1       ;Port X software latch.
      0045                          TRIP_CTR:       DS      2       ;Trip counter.
      0047                          SAV2_AREA:      DS      2       ;Last set bank no. and Ilr conv.
      0049                          DRUM_DECCEL:    DS      2       ;Drum deccel time constant reg.
      004B                          GP_PTR:         DS      2       ;General purpose pointer.
      004D                          START_OF_STACK: DS      1
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```
ER   LINE  ADDR  OBJECT        TYPE

       46                                 ;*********************************
       47                                 ;       REGISTER BANK 0
       48                                 ;*********************************
       49                                 ;USED BY MAIN LINE ROUTINE.
       50                                 ;       R0 = general purpose; for indirect addressing modes.
       51                                 ;       R1 = general purpose; for indirect addressing modes.
       52                                 ;            local in Stepper Drive Loop.
       53                                 ;       R2 = 1ms-interval counter.
       54                                 ;       R3 = 256-ms interval counter
       55                                 ;       R4 = general purpose register.
       56  0004                           R4_RB0        EQU     04
       57                                 ;       R5 = accel/deccel timer high byte.
       58                                 ;       R6 = 1ms-increment time delay counter.
       59                                 ;       R7 = accel/deccel timer low byte.

       61                                 ;*****************************
       62                                 ;       REGISTER BANK 1
       63                                 ;*****************************
       64                                 ;R4 is exclusively used by Communication rtn.
       65                                 ;----------------------------------------
       66                                               DSEG
       67                                               ORG     08
       68  0008                           R0_RB1:       DS      1
       69  0009                           R1_RB1:       DS      1
       70  000A                           R2_RB1:       DS      1
       71  000B                           R3_RB1:       DS      1
       72  000C                           R4_RB1:       DS      1
       73  000D                           R5_RB1:       DS      1
       74                                               CSEG
       75  0004                           COMERR_CTR    EQU     R4
       76  0008                           GP1_SAVE      EQU     R0_RB1
       77  0009                           GP2_SAVE      EQU     R1_RB1
```

```
ER   LINE  ADDR  OBJECT          TYPE

      79                              ;**********************************
      80                              ;        REGISTER BANK 2
      81                              ;**********************************
      82                              ;        R0 = trajectory computed count.
      83                              ;        R1 = accum save location during int rtn.
      84                              ;        R2 = control algorithm partial result storage (lbyte).
      85                              ;        R3 = control algorithm partial result storage (hbyte).
      86                              ;        R4 = scratchpad
      87                              ;        R5 = scratchpad
      88                              ;        R6 = 'on-the-fly' count latch
      89                              ;        R7 = T1 timeout counter.
      90                                               DSEG
      91                                               ORG      10H
      92   0010                       COMP_CNT:        DS       1        ;Computed encoder count.
      93   0011                       TEMP:            DS       1        ;Accum temp storage.
      94   0012                       K1L:             DS       1        ;Partial control result lbyte.
      95   0013                       K1H:             DS       1        ;                       hbyte.
      96   0014                       R4_RB2:          DS       1
      97   0015                       R5_RB2:          DS       1
      98   0016                       SAVE_LATCH:      DS       1
      99   0017                       T1_CTR:          DS       1

     101                              ;**********************************
     102                              ;        REGISTER BANK 3
     103                              ;**********************************
     104                              ;RECEIVED MESSAGE ARRAY

     106   0018                       CMMD:            DS       5
     107   001D                       OLD_CMMD:        DS       1        ;Previous command.
```

```
ER   LINE  ADDR  OBJECT        TYPE

     109                              ;*************************************
     110                              ;        FLAGS DECLARATION
     111                              ;*************************************
     112                              ;5 (20H-24H) BYTES WITH DIRECTLY-ADDRESSABLE BITS RESERVED
     113                              ;Bit address 0 to 27H.
     114                              ;-----------------------------------------------------------
     115                                            BSEG
     116                                            ORG     00
     117   0000                       COM_RSRV:     DBIT    5
     118   0005                       BITMODE_FLG:  DBIT    1       ;Bit mode communication.
     119   0006                       COMERR_FLG:   DBIT    1       ;Communication error flag.
     120   0007                       DCMDIR_FLG:   DBIT    1       ;0 =DCmotor dir =CCW; 1=CW.
     121   0008                       RUN_FLG:      DBIT    1       ;Slew mode flag.
     122   0009                       ACCEL_FLG:    DBIT    1       ;Accel/deccel flag
     123   000A                       PROF_FLG:     DBIT    1       ;0 =point-to-point; 1=velocity-position
     124   000B                       INITZ_FLG:    DBIT    1       ;Initialization mode.
     125   000C                       TR1_FLG:      DBIT    1       ;First mail detect.
     126   000D                       TR2_FLG:      DBIT    1       ;Second mail detect.
     127   000E                       QMSG_FLG:     DBIT    1       ;Message qued flag.
     128   000F                       HOME_FLG:     DBIT    1       ;Load home indicator.
     129   0010                       SMALL_FLG:    DBIT    1       ;5 counts or less flg.
     130   0011                       CONT_FLG:     DBIT    1       ;Continuous mode flag.
     131   0012                       SKIP_FLG:     DBIT    1       ;Flow skip flag.
     132   0013                       CMMDSRC_FLG:  DBIT    1       ;Command source flag.
     133   0014                       TEST_FLG:     DBIT    1       ;Test mode flag.
     134   0015                       SAVE1_BIT:    DBIT    1       ;Bit temp storage.
     135   0016                       RETWER_FLG:   DBIT    1       ;Transmission receiver.
     136   0017                       DCMOVE_FLG:   DBIT    1       ;DC motor in active motion.
```

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ER   LINE  ADDR  OBJECT        TYPE

      139                             ;*************************************
      140                             ;       STATUS BITS EQUATES
      141                             ;       (REGISTERS MSG_STAT)
      142                             ;*************************************
      143                                          CSEG
      144  0038                       WTCHDOG_FLG  EQU   MSG1_STAT.0   ;Program flow watchdog.
      145  003A                       SYS_ENABLE   EQU   MSG1_STAT.2   ;Drive system enabled
      146  003B                       STAT_FLG     EQU   MSG1_STAT.3   ;Status-change flag.
      147  003C                       BADSENS_FLG  EQU   MSG1_STAT.4   ;Sensor stucked on.
      148  003D                       TRIPEN_FLG   EQU   MSG1_STAT.5   ;Trip logic enable flag.
      149  003E                       DCMBND_FLG   EQU   MSG1_STAT.6   ;DC motor bind

      151  0040                       LO30VDC_FLG  EQU   MSG2_STAT.0   ;Low 30 VDC supply.
      152  0041                       BADFEED_FLG  EQU   MSG2_STAT.1   ;Bad feed (paper jammed/shingle)
      153  0042                       STRMF_FLG    EQU   MSG2_STAT.2   ;Streamfeed flag.
      154  0045                       XPORT_FLG    EQU   MSG2_STAT.5   ;Transport path not clear
      155  0046                       BADCOM_FLG   EQU   MSG2_STAT.6   ;Bad communication line.
      156  0047                       INITZERR_FLG EQU   MSG2_STAT.7   ;Initialization error.
```

```
ER   ADDR  OBJECT        TYPE

                              ;*****************************************
                              ;         CONSTANTS DECLARATION
                              ;*****************************************
     0000                     CHECK_SUM        EQU      0000   ;Checksum code.
     03E8                     TC_SAMP          EQU      1000   ;Sampling interval= 1000us.
     00FA                     TC_T1INT         EQU       250   ;T1 interrupt inerval = 750us.
     000A                     TRIP_LIM         EQU        10   ;Trip limit pause.
     1F40                     COMMTCHDOG       EQU      8000   ;Communication rtn watchdog interval.
     0014                     LONG_TC          EQU        20   ;Long settling time interval.
     0005                     SHORT_TC         EQU         5   ;Short.
     0014                     TC3_SETTLE       EQU        20
     000A                     TC1_STEP         EQU        10   ;Per step time interval.
     0004                     TC2_STEP         EQU         4
     0024                     HARD             EQU        36   ;Hard error count limit.
     0030                     HARDER           EQU        48   ;Harder error.
     003F                     HARDEST          EQU        63   ;Hardest error count limit.
     0004                     SOFTERR          EQU         4   ;Soft (endstop) error limit.
     0001                     INITZ_SPEED      EQU         1   ;Digit move speed during initz'n.
     0059                     INITZ_ACCEL      EQU       59H   ;Accel constant with speed = INITZ_SPEED
     0006                     SRCH_CNT         EQU         6   ;Search mode count constant.
     0004                     ADJC             EQU         4   ;Backlash adjustment constant.
     0168                     COEFF0           EQU       360   ;Algorithm coefficient 0
     00FF                     COEFF1           EQU       255   ;Algorithm coefficient 1
     0050                     COEFF2           EQU        60   ;Algorithm coefficient 2 (COEFF2/256)
     0A00                     BASE_1REV        EQU     512*5   ;Base drv shaft 1 rotation distance.
     0011                     RUND             EQU        17          ;Drum velocity, cnt/sample.
     001A                     BMAX_RUN         EQU        26          ;Base maximum velocity.
     0079                     ACCD             EQU       79H          ;Drum accel rate, cnt/sample^2.
     00AE                     DECCD            EQU      0AEH          ;Drum deccel rate.
     0088                     BACCT            EQU       88H          ;Base maximum accel rate.
     009A                     INTEN            EQU       9AH          ;Interrupt enable mask.
     1000                     END_OF_PGM       EQU     1000H          ;End of program memory.
     FA00                     MAX_CNT          EQU   BASE_1REV*25     ;Base maximum displacement.
```

```
ER   LINE  ADDR  OBJECT        TYPE

      192                             $NOCOND
      193                             ;*******************************************
      194                             ;       8155's MEMORY & I/O ADDRESS MAP
      195                             ;-------------------------------------------
      196  B800                       P8155          EQU     0B800H  ;SDK emulation = 0B800H
      197                                                            ;2732A eprom = 07800H.

      199                                            IF      HIGH(P8155) EQ 0B8H
      200  B801                       PORTA          EQU     0B801H  ;Port A address
      201  B802                       PORTB          EQU     0B802H  ;Port B address
      202  B803                       PORTC          EQU     0B803H  ;Port C address
      203  9000                       PORTX          EQU      9000H  ;Port X address
      204  1000                       EXRAM1         EQU      1000H  ;8155 start of RAM.

      206                             ;-----------------------------------------
      207                             ;       SDK-51 AUXILLARY RTNS ENTRY
      208                             ;-----------------------------------------
      209  E00F                       CLRDSP         EQU     0E00FH  ;Clear SDK display.
      210  E006                       DSPCHR         EQU     0E006H  ;Display an ASCII character.
      211  E018                       DSP2BY         EQU     0E018H  ;Display 2-byte hex.
      212  E015                       DSP1BY         EQU     0E015H  ;Display 1-byte hex.
      213  E01E                       DSPMSG         EQU     0E01EH  ;Display ASCII string.
      214  E64C                       UPI_IN         EQU     0E64CH
      215  E625                       UPI_CMD        EQU     0E625H
      216  E1CB                       CSMERR         EQU     0E1CBH  ;Display checksum err msg.
      217  C000                       KEYBD          EQU     0C000H
      218                                            ELSE
      219                                            ENDIF
      220                             $INCLUDE(INTVECTOR,DMS)
```

```
ER   LINE  ADDR  OBJECT        TYPE

     222                                ;*************************************************************
     223                                ;                    PROGRAM STARTS HERE
     224                                ;*************************************************************
     225                                                ORG     00
     226   0000                         BEGIN           EQU     $
     227   0000  01 99          .C..                    AJMP    POWER_ON        ;Power-on initialization routine.

     229                                ;*****************************************
     230                                ;                    LOOPS FOREVER
     231                                ;*****************************************
     232                                                ORG     03
     233   0003  02 00 03       ..C.                    LJMP    $               ;Loops forever if checksum error.
     234   0006  00 00                  CHKSUM_CODE:    DW      CHECK_SUM
     235   0008  C0 83          .D..    TOCONT:         PUSH    DPH
     236   000A  32                                     RETI

     238                                ;*************************************************************
     239                                ;                    TO INTERRUPT SERVICE ROUTINE
     240                                ;*************************************************************
     241                                ;Used to keep track of the PWM turn-on time interval.
     242                                ;Timer is reloaded and started in the T1_INT interrupt routine
     243                                ;       every sampling interval with computed servo output
     244                                ;       value ( =PWM turn-on time for the next sampling interval.)
     245                                ;Used by communication routine as watchdog.
     246                                ;Not used by servo control (output Xtors always OFF) when
     247                                ;       used by communication routine.
     248                                ;-------------------------------------------------------------
     249                                                ORG     0BH
     250   000B  43 90 03       .D..    TO_INT:         ORL     P1,#00000011B   ;Turn-off both source Xtors.
     251   000E  10 06 01       .DR.                    JBC     COMERR_FLG,$+4  ;COMERR_FLG =1 when in comm rtn.
     252   0011  32                                     RETI
     253   0012  90 0A 9F       ..C.                    MOV     DPTR,#RADCOM    ;Force return to RADCOM but restore
     254   0015  8E 81          .D..                    MOV     SP,R6           ;SP for proper program continuation.
     255                                ;------------------------------------
     256                                ;       SPECIFY RETURN ADDRESS
     257                                ;         FOR FORCED RETURN
     258                                ;------------------------------------
     259   0017  C0 82          .D..    FORCRET:        PUSH    DPL             ;Push to stack PC return address.
     260   0019  80 ED          .R..                    SJMP    TOCONT
```

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ER   LINE  ADDR  OBJECT        TYPE

     262                                  ;*********************************************************************
     263                                  ;NAME:  TIMER1_INT
     264                                  ;
     265                                  ;ABSTRACT: Invokes by the sampling interval timeout; computes
     266                                  ;        the desired duty cycle for the next sampling interval
     267                                  ;        based on the sampled error count, last error count, and
     268                                  ;        last output (pwm turn-on time).
     269                                  ;
     270                                  ;INPUTS:  SYS_WTCHDOG, K1L, K1H, ERR_CNT, DCMOVE_FLG, OPTR
     271                                  ;
     272                                  ;OUTPUTS:  SGN(PWM turn-on time) in K2H, K2L.
     273                                  ;          ABS(PWM turn-on time) in Timer 0 and start Timer.
     274                                  ;
     275                                  ;VARIABLES MODIFIED: RB1 Registers, ERR_CNT, T0 Latches, TR0, P1
     276                                  ;                K2H, K2L, Carry C, SYS_WTCHDOG
     277                                  ;
     278                                  ;RESTRICTIONS:
     279                                  ;          For logic correctness and servo loop stability, this
     280                                  ;          interrupt service rtn is position and time sensitive.
     281                                  ;          Timer 1 interrupt must have WAIT_T1 loop of UPDTE_SERVO
     282                                  ;          module as its only background routine to synchronize
     283                                  ;          the system to the servo sampling interval. The time to
     284                                  ;          compute the servo output must be insignificant relative
     285                                  ;          to the sampling period, ie., time delay between sampling
     286                                  ;          and outputting of PWM motor control must approach zero.
     287                                  ;          Hence, OPTR, B register, and PSW are preset to PORT1,
     288                                  ;          LOW(COEFF0), and Register Bank 2 respectively.
     289                                  ;
     290                                  ;SUBRTNS ACCESSED: None
     291                                  ;*********************************************************************

     293                                                ORG     1BH
     294  001B  D5 17 7A      .DR.        TIMER1_INT:   DJNZ    T1_CTR,T1_EXIT
     295  001E  C2 8C         .B..                      CLR     TR0          ;Stop PWM timer.
     296  0020  F9                                      MOV     R1,A         ;Save accum of background rtn.
```

```
ER  LINE  ADDR  OBJECT      TYPE

    298                              ;----------------------------------
    299                              ;        COMPUTE ERROR COUNT
    300                              ;----------------------------------
    301   0021  E0                                  MOVX   A,@DPTR            ;Sample actual position.
    302   0022  FD                                  MOV    R5,A
    303   0023  E0                                  MOVX   A,@DPTR
    304   0024  B5 15 02     .DR.                   CJNE   A,R5_RB2,REREAD
    305   0027  80 02        .R..                   SJMP   COMP_ERR
    306   0029  E0                   REREAD:        MOVX   A,@DPTR
    307   002A  FD                                  MOV    R5,A
    308   002B  E8                   COMP_ERR:      MOV    A,R0                      ;Get desired position count.
    309   002C  C3                                  CLR    C                         ;Acc =desired ;COMP_CNT =sampled.
    310   002D  9D                                  SUBB   A,R5                      ;Error Count =desired count-sampled .
    311   002E  F5 2A        .D..                   MOV    ERR_CNT,A                 ;Save error count.
    312   0030  20 E7 02     .BR.                   JB     ACC.7,$+5                 ;Determine sign of error.
    313   0033  80 02        .R..                   SJMP   CHK_IDLE_TOL              ;Bit =0 +; =1 -.
    314   0035  F4                                  CPL    A                         ;Get absolute value of error if negat
    315   0036  04                                  INC    A
    316   0037  20 17 06     .BR.    CHK_IDLE_TOL:  JB     NCMOVE_FLG,COMP_PWM       ;Is mode still in active or motor c
    317   003A  B4 01 03     ..R.                   CJNE   A,#01,COMP_PWM            ;+/- 1 count tolerance if in idling .
    318   003D  E4                                  CLR    A                         ;le, error count is made =0.
    319   003E  F5 2A        .D..                   MOV    ERR_CNT,A

    321                              ;----------------------------------------------
    322                              ;                COMPUTE SERVO OUTPUT
    323                              ;----------------------------------------------
    324   0040  FC                   COMP_PWM:      MOV    R4,A               ;Acc =Abs(err cnt) =R4.
    325   0041  A4                                  MUL    AB                 ;B =constant LOW(COEFF0).
    326   0042  CC                                  XCH    A,R4
    327   0043  25 F0        .D..                   ADD    A,B
    328   0045  CA                                  XCH    A,R2               ;LOW( COEFF0 x err cnt )= R4; HIGH =R2.
    329   0046  20 57 05     .BR.                   JB     ERR_CNT.7,MINUS
    330   0049  2C                                  ADD    A,R4               ;R2(low),R3(high) registers hold the term
    331   004A  CB                                  XCH    A,R3               ;[-COEFF1 x E(k-1)T - COEFF2 x G(k-1)T]
    332   004B  3A                                  ADDC   A,R2               ;Output G(k)T is in R3=Lbyte, Acc=Hbyte.
    333   004C  80 04        .R..                   SJMP   UPD_PWM
    334   004E  C3                   MINUS:         CLR    C
    335   004F  9C                                  SUBB   A,R4
    336   0050  CB                                  XCH    A,R3
    337   0051  9A                                  SUBB   A,R2

    339                              ;-----------------------------------------------
    340                              ;                UPDATE PWM DRIVE
    341                              ;-----------------------------------------------
    342   0052  8B 2C        .D..    UPD_PWM:       MOV    X2L,R3
    343   0054  20 5F 05     .BR.                   JB     X2H.7,$+8                 ;Determine previous output sign bit.
    344   0057  20 E7 07     .BR.                   JB     ACC.7,SIGNC_NEG           ;Output sign change from + to -.
    345   005A  80 1F        .R..                   SJMP   SAME_POS                  ;No change + to +.
```

```
ER   LINE  ADDR  OBJECT      TYPE

     346   005C  30 E7 15    .BR.                 JNB    ACC.7,SIGNC_POS        ;Changed from - to +.
     347   005F  80 07       .R..                 SJMP   SAME_NEG               ;No change - to -.
     348   0061  43 90 0F    .D..   SIGNC_NEG:    ORL    P1,#00001111B     ;Turn off output xtors if sign
     349   0064  7C 08                            MOV    R4,#08            ;changed to avoid pwr supply short.
     350   0066  DC FE       .R..                 DJNZ   R4,$              ;Turn-off delay time.
     351   0068  F5 2B       .D..   SAME_NEG:     MOV    K2H,A             ;Save output.
     352   006A  F5 8C       .D..                 MOV    TH0,A             ;Load timer registers.
     353   006C  8B 8A       .D..                 MOV    TL0,R3
     354   006E  00                               NOP
     355   006F  53 90 F6    .D..   DIR_CW:       ANL    P1,#11110110B     ;Turn on Xtor CW pair.
     356   0072  80 13       .R..                 SJMP   ON_TIMER          ;+err cnt =CCW; -err cnt =CW.
     357   0074  43 90 0F    .D..   SIGNC_POS:    ORL    P1,#00001111B
     358   0077  7C 08                            MOV    R4,#08
     359   0079  DC FE       .R..                 DJNZ   R4,$
     360   007B  F5 2B       .D..   SAME_POS:     MOV    K2H,A
     361   007D  F4                               CPL    A                 ;Get cpl of output if positive
     362   007E  CB                               XCH    A,R3              ;because timer is upcount overflow.
     363   007F  F4                               CPL    A
     364   0080  F5 8A       .D..                 MOV    TL0,A
     365   0082  53 90 F9    .D..   DIR_CCW:      ANL    P1,#11111001B     ;Turn on Xtor CCW pair.
     366   0085  8B 8C       .D..                 MOV    TH0,R3
     367   0087  D2 8C       .B..   ON_TIMER:     SETB   TR0               ;Start timer.

     369   0089  E9                               MOV    A,R1              ;Restore accumulator.
     370   008A  10 38 0B    .BR.                 JBC    WTCHDOG_FLG,T1_EXIT     ;Program in sync?
     371   008D  D2 38       .B..                 SETB   WTCHDOG_FLG       ;Program went out of sync with servo
     372   008F  D0 4B       .D..   TFATAL:       POP    GP_PTR            ;control sampling clock.
     373   0091  D0 4C       .D..                 POP    GP_PTR+1          ;Save actual return address for later
     374   0093  90 02 03    ..C.                 MOV    DPTR,#JFATAL      ;diagnostics before forcing a RETI to
     375   0096  01 17       .C..                 AJMP   FORCRET           ;fatal error trap.
     376   0098  32                 T1_EXIT:      RETI
     377                            $INCLUDE(POWERON,UPS)
```

```
ER  LINE  ADDR  OBJECT      TYPE

    379                              ;*****************************************************
    380                              ;******      POWER-UP PROGRAM INITIALIZATION     ******
    381                              ;*****************************************************

    383                              ;-----------------------------------------------------
    384                              ;              COMPUTE PROGRAM CHECKSUM
    385                              ;-----------------------------------------------------
    386   0099  30 B3 FD    .BR.     POWER_ON:       JNB     P3.3,$          ;Wait for 10 volts supply.
    387   009C  90 00 00    ..C.                     MOV     DPTR,#BEGIN     ;Program memory 0 to 1K.
    388   009F  7F 00                                MOV     R7,#00
    389   00A1  E4                   CHKSUM_LOOP:    CLR     A
    390   00A2  93                                   MOVC    A,@A+DPTR
    391   00A3  2F                                   ADD     A,R7
    392   00A4  FF                                   MOV     R7,A
    393   00A5  A3                                   INC     DPTR
    394   00A6  E5 83       .D..                     MOV     A,DPH
    395   00A8  B4 10 F6    ..R.                     CJNE    A,#10H,CHKSUM_LOOP
    396   00AB  EF                                   MOV     A,R7
    397   00AC  60 03       .R..                     JZ      INITZ_RTN
    398   00AE  02 E3 CB             CHKSUM_ERR:     LJMP    CSMERR

    400                              ;-----------------------------------------------
    401                              ;              INITIALIZE I/O PORTS
    402                              ;-----------------------------------------------
    403   00B1  C2 B1       .B..     INITZ_RTN:      CLR     P3.1            ;Hold Transmit Line low.
    404   00B3  12 E0 0F                             LCALL   CLRDSP          ;Clear SDK display.
    405   00B6  74 0C                                MOV     A,#0CH          ;Set up 8155 command register.
    406   00B8  90 88 00                             MOV     DPTR,#P8155     ;Configures Port C as output
    407   00BB  F0                                   MOVX    @DPTR,A         ;Ports A and B as inputs.
    408   00BC  74 FF                                MOV     A,#0FFH         ;Write 1's to output ports:
    409   00BE  F5 90       .D..                     MOV     P1,A            ;P1
    410   00C0  75 82 03    .D..                     MOV     DPL,#03
    411   00C3  F0                                   MOVX    @DPTR,A         ;Port C
    412   00C4  90 90 00                             MOV     DPTR,#9000H
    413   00C7  F0                                   MOVX    @DPTR,A         ;Port X
```

```
ER   LINE  ADDR  OBJECT         TYPE

      415                                  ;-----------------------------------------------
      416                                  ;              CLEAR INTERNAL RAMS
      417                                  ;       SET UP TIMERS, INTERRUPTS, STACK
      418                                  ;-----------------------------------------------
      419  00C8  E4                                    CLR     A
      420  00C9  78 7F                                 MOV     R0,#7FH                ;Clear 8051 internal ram's.
      421  00CB  F6                         CLR_8031:  MOV     @R0,A
      422  00CC  D8 FD          .R..                   DJNZ    R0,CLR_8031
      423  00CE  F5 88          .D..                   MOV     TCON,A                 ;Clear all interrupt flags.
      424  00D0  F5 A8          .D..                   MOV     IE,A                   ;and interrupt enables.
      425  00D2  F4                                    CPL     A
      426  00D3  F5 44          .D..                   MOV     PORTX_LATCH,A          ;Put FFH to Port X latch.
      427  00D5  75 B8 02       .D..                   MOV     IP,#02                 ;T0 highest priority
      428  00D8  75 89 21       .D..                   MOV     TMOD,#21H              ;T1 =mode 2; T0 =mode 1.
      429  00DB  75 8D 06       .D..                   MOV     TH1,#(-TC_T1INT)       ;Timer 1 interval constant.
      430  00DE  75 81 4C       .DD.                   MOV     SP,#START_OF_STACK-1   ;First stack location.
      431  00E1  43 A8 9A       .D..                   ORL     IE,#INTEN              ;Enable interrupts except EX1.

      433                                  ;-----------------------------------------------
      434                                  ;           COMPUTE CONSTANT PARAMETERS
      435                                  ;-----------------------------------------------
      436  00E4  75 3D AE       .D..                   MOV     ACCELK,#DECCD    ;Given deccel rate and running speed.
      437  00E7  0F                         ITER00:    INC     R7               ;compute deccel distance and
      438  00E8  12 09 42       ..C.                   LCALL   COMP_ACCEL       ;deccel time interval.
      439  00EB  25 4A          .D..                   ADD     A,DRUM_DECCEL+1
      440  00ED  F5 4A          .D..                   MOV     DRUM_DECCEL+1,A
      441  00EF  BC 11 F5       ..R.                   CJNE    R4,#RJMD,ITER00
      442  00F2  8F 49          .D..                   MOV     DRUM_DECCEL,R7
      443  00F4  75 35 46       .D..                   MOV     MARGIN,#70       ;Initialize MARGIN to 1/4 inch.
      444                                  $INCLUDE(INITZLOAD.DMS)
```

```
ER   LINE  ADDR  OBJECT      TYPE

     446                                ;*********************************************
     447                                ;*****     INITIALIZE MECHANICAL BASE     *****
     448                                ;*********************************************
     449   00F7  D2 3A        .B..      INITZ_LOAD:     SETB    SYS_ENABLE             ;Enable system.
     450   00F9  91 34        .C..                      ACALL   START_SERVO            ;Start servo control.

     452                                ;-----------------------------------
     453                                ;       CHECK OPTICAL SENSORS
     454                                ;-----------------------------------
     455   00FB  90 88 01                               MOV     DPTR,#PORTA            ;Check for stucked sensrs.
     456   00FE  E0                                     MOVX    A,@DPTR
     457   00FF  44 38                                  ORL     A,#00111000B
     458   0101  B4 FF 02     ..R.                      CJNE    A,#0FFH,STUCKED
     459   0104  80 04        .P..                      SJMP    ENBLE_OPTO             ;Enable optics if all off.
     460   0106  D2 3C        .B..      STUCKED:        SETB    BADSENS_FLG            ;Set status bit for 'sensr fail'.
     461   0108  21 1F        .C..                      AJMP    FAIL_INITZ
     462   010A  7C EF                  ENBLE_OPTO:     MOV     R4,#11101111B          ;Enable system optical sensors.
     463   010C  91 94        .C..                      ACALL   ON_BIT

     465                                ;-----------------------------------------
     466                                ;       FIND MAIN DRIVE SHAFT HOME
     467                                ;-----------------------------------------
     468   010E  12 05 05     ..C.                      LCALL   HOME_CHK               ;Read base home sensr.
     469   0111  60 06        .R..                      JZ      ALIGNED                ;Not home if not 0.
     470   0113  12 04 ED     ..C.                      LCALL   HOME_SRCH              ;Initialize main drv shaft home.
     471   0116  10 3B 06     .BR.                      JBC     STAT_FLG,FAIL_INITZ
     472   0119  F5 30        .D..      ALIGNED:        MOV     BASE_INDEX,A           ;Reset base index regs.
     473   011B  F5 31        .D..                      MOV     BASE_INDEX+1,A
     474   011D  21 23        .C..                      AJMP    EX_INITZLOAD

     476                                ;-------------------------------------
     477                                ;       INITIALIZATION FAILURE
     478                                ;-------------------------------------
     479   011F  D2 47        .B..      FAIL_INITZ:     SETB    INITZERR_FLG           ;Tell of initial'n failure.
     480   0121  41 03        .C..                      AJMP    JFATAL                 ;Proceed to Fatal Loop.
     481   0123                         EX_INITZLOAD    EQU     $
     482                                $INCLUDE(MAINLINE.SRS)
```

```
ER  ADDR  OBJECT      TYPE
                              ;****************************************
                              ;*****     IDLE CONTROL LOOP     *****
                              ;****************************************
                              ;The program loops here when not executing
                              ;any command; polls the control flags, the
                              ;communication line, the SDK keyboard, the
                              ;machine's optical sensors and switches.
                              ;True state triggers a task/ or a command.
                              ;One loop pass is equal to the servo sampling
                              ;interval, hence, steady-state dcmotor shaft
                              ;posn is always maintained.
                              ;R3 (RMO) is used as loop monitor for coarse,
                              ;long time durations, seconds, +/-.255sec, ie.,
                              ;timeout in waiting for an event to occur.
                              ;-----------------------------------------
    0121  7B 00               IDLE_LOOP:     MOV    R3,#00          ;Clr 256ms-interval counter.
    0125  C2 B4       .R..    MON_LOOP:      CLR    P3.4            ;Entry point for loop monitor.
    0127  75 3A 01    .D..                   MOV    CYC_CTR,#01     ;Clr busy line and reset cmnd
                                                                    ;repeater counter.
                              ;-----------------------------------------
                              ;       POLL CONTROL FLAGS AND INPUTS
                              ;-----------------------------------------
    012A  10 3B 02    .RR.    CHK_STAT:      JBC    STAT_FLG,$+5     ;STAT_FLG =1 change of status occured;
    012D  80 02       .R..                   SJMP   CHK_OMSG          ;transmit status registers to
    012F  21 B6       .C..                   AJMP   JXMIT             ;main control module.
    0131  10 0E 02    .RR.    CHK_OMSG:      JBC    OMSG_FLG,$+5     ;OMSG_FLG =1 message received while
    0134  80 02       .R..                   SJMP   CHK_TMSG          ;executing the previous task;
    0136  21 D5       .C..                   AJMP   GET_CMMD          ;get message and execute command.
    0138  91 60       .C..    CHK_IMSG:      ACALL  CHKIMSG           ;Check for incoming msg from channels.
    013A  50 02       .R..                   JNC    CHK_TRIP          ;C =1 get msg and execute cmnd.
    013C  21 A3       .C..                   AJMP   JRECVMSG
    013E  20 0D 59    .RR.    CHK_TRIP:      JB     TR2_FLG,TRIP_RDY  ;TR2_FLG =1 valid trip sequence
                                                                      ;detected while in last trip cycle.
                              ;-----------------------------------------------
                              ;       MAINTAIN SERVO STEADY-STATE POSITION
                              ;-----------------------------------------------
    0141  12 08 02    ..C.    STEADY_STATE:  LCALL  UPDTE_SERVO        ;Update srvo cntrl; track realtime eve
    0144  20 3D 26    .RR.                   JB     TRIPEN_FLG,TRIP_ON   ;=1 trip logic is enabled.
                                                                         ;=0 trip logic is disabled.
                              ;--------------------------------------
                              ;       TRIP LOGIC IS DISABLED
                              ;--------------------------------------
    0147  74 FF                              MOV    A,#0FFH          ;Keep stepper motor off.
    0149  B1 14       .C..                   ACALL  OUT_STEP
    014B  E5 18       .D..                   MOV    A,CMMD           ;Check if cmnd = Seal-Only.
    014D  B4 47 02    ..R.                   CJNE   A,#47H,NOTSEAL   ;If true, same logic as Trip-On
    0150  80 18       .R..                   SJMP   TRIP_ON              ;but drum trip is ignored.
```

```
ER   LINE  ADDR  OBJECT        TYPE

     532   0152  70 05         .R..    NOTSEAL:      JNZ    IDLE_MODE          ;If cnt = 00, wait 20sec for the cntrl
     533   0154  B8 4E CF      ..R.                  CJNE   R3,#78,MON_LOOP    ;module to indicate its presence.
     534   0157  41 03         .C..                  AJMP   JFATAL                ;Disable system if it timed out.
     535   0159  74 02                 IDLE_MODE:    MOV    A,#00000010B       ;Drive unit is idling; no task to do.
     536   015B  91 8B         .C..                  ACALL  OFF_SOL            ;Insure inker solenoid is off.
     537   015D  91 C4         .C..                  ACALL  PEEK_STAT          ;Monitor sensrs/swtchs for any change.
     538   015F  BA 1B 04      ..R.                  CJNE   R3,#27,CHK_DRV     ;Check if there is power on motor.
     539   0162  D2 3E         .R..                  SETB   DCMBND_FLG         ;There should be no restraining force
     540   0164  41 03         .C..                  AJMP   JFATAL               ;on motor shaft, hence, servo output
     541   0166  12 05 0F      ..C.    CHK_DRV:      CALL   CHKZDC               ;must be zero. Do not allow this condi-
     542   0169  60 B8         .R..                  JZ     IDLE_LOOP            ;for a long period of time, else, con-
     543   016B  21 25         .C..    JMONLOOP:     AJMP   MON_LOOP             ;sider condition a dc motor bind error.

     545                               ;-------------------------------------
     546                               ;        TRIP LOGIC IS ENABLED
     547                               ;-------------------------------------
     548   016D  10 0D 2A      .RR.    TRIP_ON:      JBC    TR2_FLG,TRIP_RDY    ;=1 trip detect sequence OK; =0 false
     549   0170  30 0C 05      .RR.                  JNB    TR1_FLG,CHK_PATH    ;=1 start trip detect; =0 false
     550   0173  20 41 0F      .RR.                  JB     BADFEED_FLG,BAD_FEED  ;=1 bad feed detected; =0 false
     551   0176  21 23         .C..                  AJMP   IDLE_LOOP
     552                                                                        ;R4 holds sensrs reading from UPDTE.

     570   019A  30 30 D7      .RR.    TRIP_RDY:     JNB    TRIPEN_FLG,IGNORE_TRIP  ;TRIPEN_FLG =1 rotate true.
     571   019D  41 40         .C..                  AJMP   PRNT_WAIT
```

```
ER  ADDR  OBJECT      TYPE

                              ;------------------------------------------------
                              ;      EXTERNAL MESSAGE IS TO BE RECEIVED
                              ;------------------------------------------------
    01A3  D2 B4       .R..    JRECVMSG: ;       SETB    P3.4                          ;Set busy signal.
    01A5  12 0A 14    ..C.                      LCALL   RECV_MSG                      ;Receive message from source.
    01A8  10 3B 02    .BR.                      JBC     STAT_FLG,IGNORE_MSG           ;Ignore msg if error, else
    01AB  21 D5       .C..                      AJMP    GET_CMND                      ;Get command.
    01AD  30 3D 91    .BR.    IGNORE_MSG:       JNB     TRIPEN_FLG,STEADY_STATE       ;Loop idle if trip not enabled!
    01B0  C2 0D       .B..    DISABLE_TRIP:     CLR     TR2_FLG                       ;Disable trip if enabled.
    01B2  91 40       .C..                      ACALL   STOP_XPORT
    01B4  21 23       .C..    EX_IGNORE:        AJMP    IDLE_LOOP

                              ;------------------------------------------------------------
                              ;      A CHANGE OF STATUS IS TO BE TRANSMITTED
                              ;------------------------------------------------------------
    01B6  91 48       .C..    JXMIT:            ACALL   CHK_RECV                ;Check for incoming msg before xmit.
    01B8  12 09 7C    ..C.                      LCALL   XMIT_STAT               ;Transmit status to Control Module.
    01BB  30 3A 45    .BR.                      JNB     SYS_ENABLE,JFATAL       ;Check if status is fatal (syst. disabled)
    01BE  21 23       .C..                      AJMP    IDLE_LOOP               ;(If there is comm err, status will be
                                                                               ;retransmitted, ie., STAT_FLG still 1.
                              ;----------------------------------------------
                              ;      COMMAND EXECUTION IS COMPLETED
                              ;----------------------------------------------
    01C0  20 3B 0D    .BR.    CMND_COMPLETE:    JB      STAT_FLG,EXRET              ;Error?
    01C3  91 48       .C..                      ACALL   CHK_RECV
    01C5  20 0E 03    .BR.                      JB      QMSG_FLG,RETURN_IDLE        ;Repeat cmnd if no msg queued.
    01C8  D5 3A 0F    .DR.                      DJNZ    CYC_CTR,REPEAT              ;Command to be repeated?
    01CB  12 09 97    ..C.    RETURN_IDLE:      LCALL   XMIT_CMNDC                  ;Status will be xmitted if comm err
    01CE  C2 3B       .B..                      CLR     STAT_FLG
    01D0  20 41 DD    .BR.    EXRET:            JB      BAUFEED_FLG,DISABLE_TRIP    ;Insure transport is stopped if true
    01D3  21 23       .C..                      AJMP    IDLE_LOOP                   ;Else, terminate cmnd execution.
```

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ER  LINE  ADDR  OBJECT       TYPE

    607                              ;------------------------------------------
    608                              ;        COMMAND VECTORS FROM MESSAGE
    609                              ;------------------------------------------
    610   01D5  A2 13        .B..    GET_CMMD:     MOV    C,CMNDSRC_FLG             ;Indicate source of command.
    611   01D7  92 16        .B..                  MOV    RECVER_FLG,C
    612   01D9  D2 B4        .B..    REPEAT:       SETB   P3.4                      ;Set busy signal.
    613   01DB  E5 18        .D..                  MOV    A,CMMD                    ;Get command.
    614   01DD  90 01 E5     ..C.    EXEC_CMMD:    MOV    DPTR,#CMMD_TAB            ;Load start of table.
    615   01E0  54 0F                              ANL    A,#0FH                    ;Mask upper nibble.
    616   01E2  C3                                 CLR    C
    617   01E3  33                                 RLC    A                         ;Multiply by 2.
    618   01E4  73                                 JMP    @A+DPTR     ;SDK-51 key   ;Look-up jump table.
    619   01E5  21 B6        .C..    CMMD_TAB:     AJMP   REQ_STAT          ;P      ;Status request.
    620   01B6                       REQ_STAT      EQU    JXMIT
    621   01E7  21 23        .C..                  AJMP   IDLE_LOOP         ;A
    622   01E9  21 B0        .C..                  AJMP   DISABLE_TRIP      ;B      ;Disable trip logic.
    623   01EB  41 3D        .C..                  AJMP   ENABLE_TRIP       ;C      ;Enable trip logic.
    624   01ED  21 23        .C..                  AJMP   IDLE_LOOP         ;D
    625   01EF  21 23        .C..                  AJMP   IDLE_LOOP         ;E
    626   01F1  21 23        .C..                  AJMP   IDLE_LOOP         ;F
    627   01F3  41 48        .C..                  AJMP   SEAL              ;G      ;Turn on the AC motor only.
    628   01F5  21 23        .C..                  AJMP   IDLE_LOOP         ;H
    629   01F7  21 23        .C..                  AJMP   IDLE_LOOP         ;I
    630   01F9  21 23        .C..                  AJMP   IDLE_LOOP         ;J
    631   01FB  41 4D        .C..                  AJMP   PRNT_MAIL         ;K      ;Print on mail.
    632   01FD  21 23        .C..                  AJMP   IDLE_LOOP         ;L
    633   01FF  21 23        .C..                  AJMP   IDLE_LOOP         ;M
    634   0201  21 23        .C..                  AJMP   IDLE_LOOP         ;N
    635   0203                       ;FATAL        EQU    $                 ;O      ;Disable system.
    636                              ;----------------------------------------------
    637                              ;             FATAL ERROR TRAP
    638                              ;----------------------------------------------
    639   0203  C2 AB        .B..                  CLR    IE.3              ;Disable T1 interrupt.
    640   0205  C2 3A        .B..                  CLR    SYS_ENABLE        ;Disable system.
    641   0207  D2 A8        .B..                  SETB   IE.0              ;Insure EX0 is enabled.
    642   0209  74 0F                              MOV    A,#0FH
    643   020B  F5 90        .D..                  MOV    P1,A              ;Turn off demotors drive.
    644   020D  91 BB        .C..                  ACALL  OFF_SOL           ;     : solenoids drive.
    645   020F  12 E0 0F                           LCALL  CLRDSP                    ;System disable.
    646   0212  7A 02        .C..                  MOV    R2,#HIGH(STRING)             ;Display ERROR &status bytes.
    647   0214  7B 39        .C..                  MOV    R3,#LOW(STRING)
    648   0216  12 E0 1F                           LCALL  DSPMSG
    649   0219  AA 28        .D..                  MOV    R2,MSG2_STAT
    650   021B  AB 27        .D..                  MOV    R3,MSG1_STAT
    651   021D  12 E0 1B                           LCALL  DSP2BY
    652   0220  B2 B4        .B..    FATAL_LOOP:   CPL    P3.4                      ;Toggle system status LED.
    653   0222  20 46 0C     .BR.    LOOPINS:      JB     BADCRM_FLG,JLOOP
    654   0225  91 60        .C..                  ACALL  CHKINSG
```

```
ER  LINE  ADDR  OBJECT        TYPE

    655   0227  50 08         .R..                JNC    JLOOP
    656   0229  12 0A 14      ..C.                CALL   RECV_MSG
    657   022C  DC FE         .R..                DJNZ   R4,$
    658   022E  12 09 7C      ..C.                CALL   XMIT_STAT
    659   0231  DC FE         .R..    JLOOP:      DJNZ   R4,$
    660   0233  DC FE         .R..                DJNZ   R4,$
    661   0235  DA EB         .R..                DJNZ   R2,LOOPINS
    662   0237  80 E7         .R..                SJMP   FATAL_LOOP          ;Loop forever.

    664   0239  03 45 3D 20           STRING:     DB     3,'E= '
```

```
ER   LINE  ADDR  OBJECT       TYPE

      666                                 ;*********************************************************
      667                                 ;*******                                          ; *******
      668                                 ;*********************************************************
      669                                 ;Status Registers is used to pass status information from
      670                                 ;module-to-module (or sub-routines).
      671                                 ;        STAT_FLG =0 if no change in status
      672                                 ;                 =1 if there is a change in status
      673                                 ;        and corresponding change information bit(s).
      674                                 ;Tasks which are required to transmit a Cmd-Complete
      675                                 ;to the meter module pass thru CMND_COMPLETE before
      676                                 ;terminating, else, task terminates directly to IDLE_LOOP.
      677                                 ;----------------------------------------------------------

      679                                 ;**********************************************
      680                                 ;              ENABLE TRIP LOGIC
      681                                 ;**********************************************
      682  023D  43 27 28     .D..         ENABLE_TRIP:   ORL    MSG1_STAT,#00101000B   ;Tell trip logic is enabled.
      683  0240  53 28 F9     .D..         RUN_XPORT:     ANL    MSG2_STAT,#11111001B
      684  0243  74 FB                                   MOV    A,#11111011B           ;Turn on AC motor.
      685  0245  91 87        .C..                       ACALL  ON_SOL
      686  0247  91 34        .C..                       ACALL  START_SERVO    ;Reset real-timekeeping registers.
      687  0249  21 23        .C..         EX_ONXPORT:    AJMP   IDLE_LOOP


      694                                 ;**********************************************************
      695                                 ;              PRINT_ON_MAIL CYCLE
      696                                 ;**********************************************************
      697                                 ;Compute time delay before start of drum print motion.
      698                                 ;----------------------------------------------------------
```

```
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ER   LINE  ADDR  OBJECT      TYPE

      714  0265  CC                                  XCH     A,R4
      715  0266  C1                                  CLR     C
      716  0267  9C                                  SUBB    A,R4           ;Remainder =time delay before start
      717  0268  60 12       .R..                    JZ      DRV_DRUM       ;of drum print cycle.
      718  026A  50 0D       .R..                    JNC     LOAD_DELAY     ;C =0 positive valid letters gap.
      719  026C  C2 0C       .B..                    CLR     TRI_FLG        ;Streamfeed error!
      720  026E  D2 42       .B..                    SETB    STRMF_FLG      ;C =1 negative gap too close.
      721  0270  05 29       .D..                    INC     MISTRIP_CTR    ;Not enough time for complete cycle
      722  0272  24 D2                               ADD     A,#210         ;2's cpl add'n.
      723  0274  FE                                  MOV     R6,A           ;Pad in delay to complete cycle.
      724  0275  91 81       .C..                    ACALL   DELAY_LOOP
      725  0277  21 23       .C..   NO_PRINT:        AJMP    IDLE_LOOP      ;Skip print on passing mail.

      727  0279  FE                 LOAD_DELAY:      MOV     R6,A
      728  027A  91 81       .C..                    ACALL   DELAY_LOOP
      729  027C  51 80       .C..   DRV_DRUM:        ACALL   MOVE_DRUM      ;Print on mail.
      730  027E  21 C0       .C..   EX_MAIL:         AJMP    CMMD_COMPLETE
      731                          $INCLUDE(MOTION.OMS)
```

```
ER   LINE  ADDR  OBJECT       TYPE

      733                                  ;              ************************************************************
      734                                  ;              *******     MOTION CONTROL CALL ROUTINES        *********
      735                                  ;              ************************************************************

      737                                  ;*************************************
      738                                  ;      ROTATE PRINT DRUM
      739                                  ;*************************************
      740  0280  C2 07        .B..         MOVE_DRUM:     CLR    DCMOTR_FLG
      741  0282  51 B6        .C..                        ACALL  DRUM_MOVE
      742  0284  20 38 08     .BR.                        JB     STAT_FLG,EX_DRUM
      743  0287  05 45        .D..                        INC    TRIP_CTR              ;Count no. of drum trips.
      744  0289  E5 45        .D..                        MOV    A,TRIP_CTR
      745  028B  70 02        .R..                        JNZ    EX_DRUM
      746  028D  05 46        .D..                        INC    TRIP_CTR+1
      747  028F  22                    EX_DRUM:       RET

      749                                  ;****************************************
      750                                  ;      MOVE TO DRIVE HOME POSITION
      751                                  ;****************************************
      752  0290  90 05 00              RHOME_MOVE:    MOV    DPTR,#BASE_1REV/2
      753  0293  78 30        .D..                        MOV    R0,#BASE_INDEX
      754  0295  C3                                   CLR    C                   ;Move load to absolute home posn.
      755  0296  E5 82        .D..                        MOV    A,DPL               ;Compute distance from current posn
      756  0298  96                                   SUBB   A,@R0                  ;to home posn.
      757  0299  FC                                   MOV    R4,A                ;Result is displacement
      758  029A  E5 83        .D..                        MOV    A,DPH                  ;to be travelled
      759  029C  08                                   INC    R0                     ;and direction of motion.
      760  029D  96                                   SUBB   A,@R0
      761  029E  86 3C        .D..                        MOV    TOTAL_CNT+1,@R0
      762  02A0  18                                   DEC    R0
      763  02A1  86 3B        .D..                        MOV    TOTAL_CNT,@R0
      764  02A3  D2 07        .B..                        SETB   DCMOTR_FLG
      765  02A5  30 E7 0C     .BR.                        JNB    ACC.7,EX_HOMOVE
      766  02A8  CC                                   XCH    A,R4
      767  02A9  25 82        .D..                        ADD    A,DPL
      768  02AB  F5 3B        .D..                        MOV    TOTAL_CNT,A
      769  02AD  EC                                   MOV    A,R4
      770  02AE  35 83        .D..                        ADDC   A,DPH
      771  02B0  F5 3C        .D..                        MOV    TOTAL_CNT+1,A
      772  02B2  C2 07        .B..                        CLR    DCMOTR_FLG
      773  02B4  61 06        .C..         EX_HOMOVE:     AJMP   BPOSN_MOVE
```

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```
ER   LINE  ADDR  OBJECT.        TYPE

     775                                    ;*********************************************************
     776                                    ;                 MOTION PROFILE REQUIREMENTS
     777                                    ;*********************************************************
     778                                    ;The caller has to supply the following variables.
     779                                    ;-----------------------------------------------
     780                                    ;1. ACCELK = acceleration constant (counts/ms^2)
     781                                    ;2. DECCELK =  decceleration constant (counts/ms^2)
     782                                    ;3. SLEWK  = running velocity constant (counts/ms)
     783                                    ;4. TOTAL_CNT = total distance to be traversed (counts)
     784                                    ;5. CONT_FLG = incremental or continuous motion
     785                                    ;6. PROF_FLG = profile or position-only (point-to-point) control.
     786                                    ;7. LIM_ERR = max error count before calling a fault condition.
     787                                    ;---------------------------------------------------------------

     789  02B6  75 3D 00      .D..     DRUM_MOVE:      MOV     TOTAL_CNT,#LOW(BASE_IREV)  ;Specifies drum rotation
     790  02B9  75 3C 0A      .D..                     MOV     TOTAL_CNT+1,#HIGH(BASE_IREV) ;velocity profile and
     791  02BC  75 3D 79      .D..                     MOV     ACCELK,#ACCD                        ;type of control.
     792  02BF  75 41 AE      .D..                     MOV     DECCELK,#DECCD
     793  02C2  75 3E 11      .D..                     MOV     SLEWK,#RUND
     794  02C5  85 49 39      .DD.                     MOV     DECCEL_INT,DRUM_DECCEL
     795  02C8  85 4A 37      .DD.                     MOV     ACCEL_CNT,DRUM_DECCEL+1
     796  02CB  75 38 00      .D..                     MOV     ACCEL_CNT+1,#0D
     797  02CE  D2 0A         .B..                     SETB    PROF_FLG
     798  02D0  75 42 3F      .D..                     MOV     PLIM_ERR,#HARDEST
     799  02D3  75 43 C1      .D..                     MOV     NLIM_ERR,#(-HARDEST)
     800  02D6  61 14         .C..                     AJMP    START_MOTION

     802  02D8  E4                     HUNT_MOVE:      CLR     A                 ;Search for a home position signal.
     803  02D9  F5 3C         .D..                     MOV     TOTAL_CNT+1,A
     804  02DB  F5 3A         .D..                     MOV     CYC_CTR,A          ;Will stop in SRCH_CNT once home
     805  02DD  75 3B 06      .D..                     MOV     TOTAL_CNT,#SRCH_CNT  ;the home posn signal is seen.
     806  02E0  D2 11         .B..                     SETB    CONT_FLG                  ;Run continuously
     807  02E2  D2 0F         .B..                     SETB    HOME_FLG                  ;Tell sampling handler to
     808  02E4  75 42 06      .D..                     MOV     PLIM_ERR,#(SRCH_CNT)        ;look for the signal.
     809  02E7  75 43 FA      .D..                     MOV     NLIM_ERR,#(-SRCH_CNT)
     810  02EA  80 0C         .R..                     SJMP    HUNT2

     812  02EC  75 3B FF      .D..     ENDSTOP_MOVE:   MOV     TOTAL_CNT,#OFFH   ;Move towards an endstop.
     813  02EF  75 3C FF      .D..                     MOV     TOTAL_CNT+1,#OFFH   ;Load max 16 bit count.

     815  02F2  75 42 04      .D..     INITZ_MOVE:     MOV     PLIM_ERR,#SOFTERR        ;Lowest error limit for
     816  02F5  75 43 FC      .D..                     MOV     NLIM_ERR,#(-SOFTERR)     ;soft collision at endstop.
     817  02F8  75 3E 01      .D..     HUNT2:          MOV     SLEWK,#INITZ_SPEED       ;Slow speed= 1 cnt/sample.
     818  02FB  75 3D 59      .D..                     MOV     ACCELK,#INITZ_ACCEL
     819  02FE  80 12         .R..                     SJMP    TRAPZPROF
     820  0300  75 3B 00      .D..     ONEREV_MOVE:    MOV     TOTAL_CNT,#LOW(BASE_IREV)   ;One rotation move
     821  0303  75 3C 0A      .D..                     MOV     TOTAL_CNT+1,#HIGH(BASE_IREV) ;at base drv shaft.
     822  0306  75 3D 88      .D..     BPOSN_MOVE:     MOV     ACCELK,#BACCT     ;Base point-to-point drive.
```

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```
ER   LINE  ADDR  OBJECT        TYPE

      823  0309  75 3E 1A      .D..                      MOV    SLFWK,#UMAX_PUN
      824  030C  75 42 30      .D..     RPOSN2:          MOV    PLIM_ERR,#HARDER     ;Load max. error count limit
      825  030F  75 43 D0      .D..                      MOV    NLIM_ERR,#(-HARDER) ;(harder stop).

      827                               ;-------------------------------------------
      828                               ;        INITIALIZE MOTION CONTROL LOOP
      829                               ;                HOUSEKEEPING
      830                               ;-------------------------------------------
      831  0312  91 A2         .C..     TRAPZPROF:       ACALL  COMP_PROF          ;Compute a trapezoidal motion profile.
      832  0314  E4                     START_MOTION:    CLR    A
      833  0315  FD                                      MOV    R5,A
      834  0316  F5 2E         .D..                      MOV    POSN_ACC,A         ;Clear position accumulator.
      835  0318  F5 2F         .D..                      MOV    POSN_ACC+1,A
      836  031A  04                                      INC    A
      837  031B  FF                                      MOV    R7,A               ;Initialize accel/deccel/settl timer.
      838  031C  74 05                                   MOV    A,#05                        ;Check for size of displacement.
      839  031E  B5 3B 01      .DR.                      CJNE   A,TOTAL_CNT,$+4                ;5 counts or less= single step
      840  0321  C3                                      CLR    C                              ; by 1 count/sample.
      841  0322  40 11         .R..                      JC     PROCEED                        ;Else, proceed with trapz profile
      842  0324  E4                                      CLR    A
      843  0325  B5 3C 0D      .DR.                      CJNE   A,TOTAL_CNT+1,PROCEED
      844  0328  B5 3B 01      .DR.                      CJNE   A,TOTAL_CNT,LESS5            ;Check for non-zero displacement.
      845  032B  22                                      RET                                 ;No motion required if zero.
      846  032C  D2 10         .B..     LESS5:           SETB   SMALL_FLG
      847  032E  C2 08         .B..                      CLR    RUN_FLG
      848  0330  75 12 01      .D..                      MOV    RUN_SPEED,#01
      849  0333  80 06         .R..                      SJMP   DCMLOOP
      850  0335  D2 08         .B..     PROCEED:         SETB   RUN_FLG
      851  0337  C2 10         .B..                      CLR    SMALL_FLG
      852  0339  D2 17         .B..                      SETB   DCMOVE_FLG                   ;Start of dcmotor motion.
```

```
ER   LINE  ADDR  OBJECT        TYPE

      854                                ;*********************************************
      855                                ;********   DC MOTOR MOTION CONTROL LOOP   *******
      856                                ;*********************************************
      857                                ;Loops here during dc motor servo control of a
      858                                ;desired motion profile.
      859                                ;RUN_FLG and ACCEL_FLG are modified to reflect
      860                                ;a trapezoidal motion profile.
      861                                ;Output decision is used at the next sampling
      862                                ;instant generation of the target trajectory.
      863                                ;---------------------------------------------
      864  033B  12 08 02     ..C.       DCMLOOP:        LCALL  UPDTE_SERVO            ;Update servo control.
      865  033E  E5 2A        .D..                       MOV    A,ERR_CNT
      866  0340  20 E7 08     .BR.                       JB     ACC.7,CNT_NEG          ;ACC.7 =1 neg cnting: 0=pos.
      867  0343  B5 42 01     .DR.       CNT_POS:        CJNE   A,PLIM_ERR,$+4         ;Check if error count is within
      868  0346  D3                                      SETB   C                        ;allowable limit = abs(HARDERR)
      869  0347  50 08        .R..                       JNC    FAULT
      870  0349  61 79        .C..                       AJMP   COMP_TIMING
      871  034B  B5 43 01     .DR.       CNT_NEG:        CJNE   A,NLIM_ERR,$+4
      872  034E  C3                                      CLR    C
      873  034F  50 28        .R..                       JNC    COMP_TIMING

      875                                ;-----------------------------------------------------------
      876                                ;                DC MOTOR CONTROL LOOP EXIT
      877                                ;-----------------------------------------------------------
      878  0351  30 0A 04     .BR.       FAULT:          JNB    PROF_FLG,SHUTOFF       ;Do not shut off if drum drv.
      879  0354  D2 3B        .B..                       SETB   STAT_FLG               ;Just indicate fault to caller.
      880  0356  80 71        .R..                       SJMP   COMP_TIMING            ;Proceed as usual.
      881  0358  C2 3A        .B..       SHUTOFF:        CLR    SYS_ENABLE             ;DC motor move error.
      882  035A  43 27 48     .D..                       ORL    MSG1_STAT,#01001000B   ;Set error flags and-
      883  035D  43 90 03     .D..                       ORL    P1,#00000011B          ;and turn off motor drive.
      884  0360  75 32 00     .D..       END_OF_MOTION:  MOV    RUN_SPEED,#00          ;Insure that before exit,
      885  0363  C2 08        .B..                       CLR    RUN_FLG                ;motion is in constant vel
      886  0365  C2 09        .B..                       CLR    ACCEL_FLG              ;mode with speed = 0 (stop).
      887  0367  20 3B 0C     .BR.                       JB     STAT_FLG,EX_DCMLOOP
      888  036A  20 97 07     .BR.                       JB     P1.7,LONG_SETTLE       ;Select settling time delay.
      889  036D  20 0B 04     .BR.                       JB     INITZ_FLG,LONG_SETTLE   ;Longer is when in base
      890  0370  91 6F        .C..                       ACALL  DEL05MS                  ;drive and/or initz'n mode.
      891  0372  80 02        .R..                       SJMP   EX_DCMLOOP
      892  0374  91 73        .C..       LONG_SETTLE:    ACALL  DEL20MS
      893  0376  C2 17        .B..       EX_DCMLOOP:     CLR    DCMOVE_FLG             ;End of dcmotor motion.
      894  0378  22                                      RET
```

```
ER  ADDR OBJECT      TYPE

                                 ;********************************************
                                 ;       TRAPEZOIDAL MOTION PROFILE
                                 ;             HOUSEKEEPING
                                 ;********************************************
                                 ;Decides whether the motion is in accel phase,
                                 ;constant velocity phase, deccel phase, or in
                                 ;settling phase based on the motion specs and
                                 ;control mode inputs.
                                 ;Insure the motion stops at final position count.
                                 ;Uses the following registers and control flags:
                                 ;TOTAL_CNT  =desired total displacement count
                                 ;POSN_ACC   =accumulated displacement count wrt time
                                 ;ACCEL_CNT  =POSN_ACC value when in accel phase.
                                 ;RUN_SPEED  =computed target speed last sampling instant
                                 ;VEL_OFFS   =offset count to insure total displ. = desired.
                                 ;ACCELK     =desired accel rate
                                 ;SLEWK      =desired slew rate (running speed)
                                 ;DECCELK    =desired deccel rate
                                 ;CYC_CTR    =desired displacement multiplier.
                                 ;RUN_FLG    =0 constant velocity phase; 1 accel/deccel
                                 ;ACCEL_FLG  =0 accel phase; 1 deccel phase
                                 ;PROF_FLG   =0 accel rate = deccel rate; 1 not equal
                                 ;CONT_FLG   =0 start-stop mode; 1 continuous run mode
                                 ;SMALL_FLG  =0 TOTAL_CNT > 5; 1 not > 5.
                                 ;R7 and R5 (RB0) as a 16-bit register for
                                 ;keeping track of accel/deccel time interval.
                                 ;Modifies RUN_FLG, ACCEL_FLG ,R7, R5 for next sampling
                                 ;instant generation of the target position count.
                                 ;------------------------------------------------

    0379 20 08 07   .BR.   COMP_TIMING:   JB    RUN_FLG,NOTCV          ;Examine last sampling
    037C 61 B0      .C..                  AJMP  CONST_VEL              ;instant's motion phase,
    037E 30 09 02   .BR.   NOTCV:         JNB   ACCEL_FLG,ACCEL_VEL    ;ie.,const velocity? accel?
    0381 81 18      .C..                  AJMP  DECCEL_VEL             ;deccel phase?
                                 ;------------------------------------------------
                                 ;                ACCELERATION PHASE
                                 ;------------------------------------------------
    0383 20 0A 0B   .BR.   ACCEL_VEL:     JB    PROF_FLG,CHK_SPEEDLIM  ;Motion in accel mode IF
    0386 C3                               CLR   C                      ;POSN_ACC < TOTAL_CNT/4
    0387 E5 2E      .D..                  MOV   A,POSN_ACC             ;OR RUN_SPEED < SLEWK
    0389 95 37      .D..                  SUBB  A,ACCEL_CNT            ;ELSE motion in constant vel mode.
    038B E5 2F      .D..                  MOV   A,POSN_ACC+1
    038D 95 38      .D..                  SUBB  A,ACCEL_CNT+1
    038F 50 0E      .R..                  JNC   END_ACCEL              ;Check SGN( POSN-ACCEL ).
    0391 E5 32      .D..   CHK_SPEEDLIM:  MOV   A,RUN_SPEED            ;If not end of accel, is com-
    0393 B5 3E 02   .DR.                  CJNE  A,SLEWK,$+5            ;puted speed = target running
    0396 80 07      .R..                  SJMP  END_ACCEL              ;speed? End of accel if it is.
    0398 0F                               INC   R7                     ;Else, increment accel/deccel
```

```
ER  LINE  ADDR  OBJECT      TYPE

    944   0399  BF 00 01    ..R.                   CJNE  R7,#00,$+4           ;Timekeeping regs R7, R5.
    945   039C  0D                                 INC   R5
    946   039D  81 29       .C..                   AJMP  EXIT_TIMING
    947   039F  30 0A 04    .BR.    END_ACCEL:     JNB   PROF_FLG,$+7         ;If end of accel, if accel not
    948   03A2  AF 39       .D..                   MOV   R7,DECCEL_INT        ;= deccel (PROF_FLG set), preset
    949   03A4  80 06       .R..                   SJMP  $+8                  ;R7 with deccel interval; else,
    950   03A6  85 2E 37    .DD.                   MOV   ACCEL_CNT,POSN_ACC   ;save current posn cnt, ie.,
    951   03A9  85 2F 38    .DD.                   MOV   ACCEL_CNT+1,POSN_ACC+1 ;accel displacement.
    952   03AC  C2 08       .B..                   CLR   RUN_FLG              ;indicate motion is in
    953   03AE  81 29       .C..                   AJMP  EXIT_TIMING          ;'constant velocity phase'.
    954                             ;------------------------------------------------------------
    955                             ;              CONSTANT VELOCITY PHASE
    956                             ;------------------------------------------------------------
    957   03B0  C3                  CONST_VEL:     CLR   C                 ;Motion in constant vel mode if
    958   03B1  E5 3B       .D..                   MOV   A,TOTAL_CNT       ;TOTAL_CNT - POSN_ACC - ACCEL_CNT - RUN_SP
    959   03B3  95 2E       .D..                   SUBB  A,POSN_ACC        ;result is > 0 OR CONT_FLG is set.
    960   03B5  30 10 04    .BR.                   JNB   SMALL_FLG,GT5     ;ELSE motion in deccel mode.
    961   03B8  60 30       .R..                   JZ    END_CONST         ;(When SMALL_FLG is set, ie., target
    962   03BA  81 29       .C..                   AJMP  EXIT_TIMING       ;displacement <= 5 cnts, profile is
    963   03BC  F5 F0       .D..    GT5:           MOV   B,A               ;always constant velocity.)
    964   03BE  E5 3C       .D..                   MOV   A,TOTAL_CNT+1
    965   03C0  95 2F       .D..                   SUBB  A,POSN_ACC+1
    966   03C2  C5 F0       .D..                   XCH   A,B               ;Result (TOTAL-POSN) lo =A ; hi =B.
    967   03C4  50 0A       .R..                   JNC   CNTINUE           ;If SGN(TOTAL-POSN) negative;
    968   03C6  12 09 71    ..C.                   CALL  TWOS_CPL          ;displacement, must be in continuous
    969   03C9  F5 2E       .D..                   MOV   POSN_ACC,A        ;mode. Set absolute count to correct
    970   03CB  85 F0 2F    .DD.                   MOV   POSN_ACC+1,B      ;position registers.
    971   03CF  81 29       .C..                   AJMP  EXIT_TIMING
    972   03D0  95 37       .D..    CNTINUE:       SUBB  A,ACCEL_CNT       ;If SGN positive, result - ACCEL_CNT
    973   03D2  F5 33       .D..                   MOV   VEL_OFFS,A        ;Save difference (= offset velocity if
    974   03D4  E5 F0       .D..                   MOV   A,B               ;difference =< RUN_SPEED)
    975   03D6  95 38       .D..                   SUBB  A,ACCEL_CNT+1
    976   03D8  FC                                 MOV   R4,A              ;Difference lo =VEL_OFFSET; hi =R4.
    977   03D9  C3                                 CLR   C
    978   03DA  E5 33       .D..                   MOV   A,VEL_OFFS        ;Result = Difference - RUN_SPEED
    979   03DC  95 32       .D..                   SUBB  A,RUN_SPEED       ;lo =R4 ; hi =Acc.
    980   03DE  CC                                 XCH   A,R4
    981   03DF  94 00                              SUBB  A,#00
    982   03E1  40 07       .R..                   JC    END_CONST         ;End of const vel phase if negative
    983   03E3  C2 12       .B..                   CLR   SKIP_FLG          ;or zero result.
    984   03E5  70 42       .R..                   JNZ   EXIT_TIMING
    985   03E7  BC 00 3F    ..R.                   CJNE  R4,#00,EXIT_TIMING
    986                             ;------------------------------------------------
    987                             ;      CONTINUOUS RUN MODE OR START-STOP
    988                             ;------------------------------------------------
    989   03EA  30 11 1B    .BR.    END_CONST:     JNB   CONT_FLG,STOP_MOTION   ;CONT_FLG =0 start-stop mode,
    990   03ED  20 12 0E    .BR.                   JB    SKIP_FLG,CHKSMALL      ;         =1 continuous run.
    991   03F0  D2 12       .B..                   SETB  SKIP_FLG               ;0 to 1 transition of SKIP_FLG
```

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ER   LINE  ADDR  OBJECT       TYPE

      992  03F7  91 BD        .C..                  ACALL   CHKKBD                   ;Indicates start of deccel phase.
      993  03F4  40 03        .R..                  JC      RST_CYCTR                ;motion to be stopped if in
      994  03F6  D5 3A 05     .DR.                  DJNZ    CYC_CTR,CHKSMALL         ;continuous run mode?
      995  03F9  75 3A 01     .D..   RST_CYCTR:     MOV     CYC_CTR,#01              ;Reset cycle counter.
      996  03FC  80 0A        .R..                  SJMP    STOP_MOTION
      997  03FE  30 10 28     .BR.   CHKSMALL:      JNB     SMALL_FLG,EXIT_TIMING
      998  0401  E4                                 CLR     A                        ;Reset POSN if in continuous
      999  0402  F5 2E        .D..                  MOV     POSN_ACC,A               ;run mode and SMALL_FLG set,
     1000  0404  F5 2F        .D..                  MOV     POSN_ACC+1,A             ;ie., TOTAL <=5.
     1001  0406  81 29        .C..                  AJMP    EXIT_TIMING
     1002  0408  C2 11        .B..   STOP_MOTION:   CLR     CONT_FLG                 ;Yes, motion is to be stopped.
     1003  040A  20 10 17     .BR.                  JB      SMALL_FLG,DECR           ;No deccel phase if SMALL_FLG
     1004  040D  D2 12        .B..                  SETB    SKIP_FLG                 ;is set.
     1005  040F  D2 08        .B..                  SETB    RUN_FLG                  ;Indicate deccel phase.
     1006  0411  D2 09        .B..                  SETB    ACCEL_FLG
     1007  0413  85 41 3D     .DD.                  MOV     ACCELK,DECCELK           ;Load deccel rate.
     1008  0416  81 29        .C..                  AJMP    EXIT_TIMING
     1009                            ;-----------------------------------------------------
     1010                            ;              DECCELERATION PHASE
     1011                            ;-----------------------------------------------------
     1012  0418  30 12 09     .BR.   DECCEL_VEL:    JNB     SKIP_FLG,DECR   ;Motion in deccel mode IF
     1013  041B  E5 33        .D..                  MOV     A,VEL_OFFS      ;R7 is > 0 ELSE motion is stopped.
     1014  041D  B5 32 04     .DR.                  CJNE    A,RUN_SPEED,DECR   ;Adjust with offset velocity to
     1015  0420  C2 12        .B..                  CLR     SKIP_FLG           ;arrive at exact target count
     1016  0422  80 05        .R..                  SJMP    EXIT_TIMING        ;displacement.
     1017  0424  1F                  DECR:          DEC     R7              ;Decrement accel/deccel timekeeping
     1018  0425  BF FF 01     ..R.                  CJNE    R7,#0FFH,EXIT_TIMING     ;registers.
     1019  0428  1D                                 DEC     R5
     1020                            ;-------------------------------------------
     1021                            ;              END OF MOTION?
     1022                            ;-------------------------------------------
     1023  0429  BF 00 05     ..R.   EXIT_TIMING:   CJNE    R7,#00,CHKFLG   ;R7 =R5 =0 end of cycle.
     1024  042C  BD 00 02     ..R.                  CJNE    R5,#00,CHKFLG
     1025  042F  61 60        .C..                  AJMP    END_OF_MOTION
     1026  0431  00                  CHKFLG:        NOP
     1027  0432  61 3B        .C..                  AJMP    DCMLOOP
     1028                            $INCLUDE(MAINSUB.UMS)
```

```
ER   LINE  ADDR  OBJECT       TYPE

                                    ;            ************************************************
                                    ;            **********    MAIN CALL ROUTINES    ***********
                                    ;            ************************************************

                                    ;*********************************************
                                    ;       START DCMOTOR SERVO CONTROL
                                    ;*********************************************
           0434  75 8B 06     .D..  START_SERVO:   MOV    TL1,#(-TC_TIINT)              ;Initialize TL1 and
           0437  75 17 04     .D..                 MOV    T1_CTR,#TC_SAMP/TC_TIINT         ;T1 int ctr.
           043A  E4                                CLR    A                             ;Clear both 1ms- and
           043B  FA                                MOV    R2,A                          ; 256ms-timeout ctrs.
           043C  FB                                MOV    R3,A
           043D  D2 8E        .B...                SETB   TR1                           ;Start Timer 1.
           043F  22                                RET

                                    ;************************************************
                                    ;               STOP MAIL TRANSPORT
                                    ;************************************************
                                    ;Turn off the AC motor.
                                    ;Lock the shutter bar if Trip Logic is enabled.
                                    ;-------------------------------------------------
           0440  74 04              STOP_XPORT:    MOV    A,#00000100B                  ;Turn off AC motor.
           0442  91 8B        .C..                 ACALL  OFF_SOL
           0444  75 18 62     .D..                 MOV    CMND,#62H
           0447  22                                RET

                                    ;*******************************************
                                    ;       CHECK RECEIVE BEFORE TRANSMIT
                                    ;*******************************************
           0448  10 05 14     .BR.  CHK_RECV:      JBC    BITMODE_FLG,EX_CHKRECV
           044B  91 60        .C..                 ACALL  CHKIMSG        ;Check for incoming msg.
           044D  40 08        .R..                 JC     TURN_RECV      ;Receive msg if C =1.
           044F  7E 0F                             MOV    R6,#0FH        ;Wait ~30us to avoid contention;
           0451  DE FE        .R..                 DJNZ   R6,$

                                    ;*********************************
                                    ;       RECEIVE QUEU MESSAGE
                                    ;*********************************
           0453  91 60        .C..  MSG_QUED:      ACALL  CHKIMSG        ;Look again.
           0455  50 08        .R..                 JNC    EX_CHKRECV
           0457  12 0A 14     ..C.  TURN_RECV:     LCALL  RECV_MSG
           045A  10 30 02     .BR.                 JBC    STAT_FLG,EX_CHKRECV ;Ignore msg if comm err.
           045D  D2 0E        .B..                 SETB   QMSG_FLG       ;Inform mainline of queued msg.
           045F  22                 EX_CHKRECV:    RET

                                    ;*****************************************
                                    ;       CHECK FOR INCOMING MESSAGE
                                    ;*****************************************
```

```
ER  LINE  ADDR  OBJECT       TYPE

    1078  0460  C3                  CHKIMSG:      CLR    C                  ;C =1 Incoming msg; C =0 none.
    1079  0461  30 B0 04     .RR.                 JNB    P3.0,CHK_KEY
    1080  0464  D3                                SETB   C
    1081  0465  C2 13        .R..                 CLR    CMDSRC_FLG           ;Command source is serial line.
    1082  0467  22                                RET
    1083  0468  91 BD        .C..   CHK_KEY:      ACALL  CHKKBD
    1084  046A  50 02        .R..                 JNC    EX_CHKIMSG
    1085  046C  D2 13        .R..                 SETB   CMDSRC_FLG           ;Command source is keyboard.
    1086  046E  22                  EX_CHKIMSG:   RET

    1088                            ;****************************************************************
    1089                            ;             DELAY LOOPS IN MILLISEC INCREMENT
    1090                            ;****************************************************************
    1091  046F  7E 05               DEL05MS:      MOV    R6,#SHORT_TC           ;Short settling time.
    1092  0471  80 0E        .R..                 SJMP   DELAY_LOOP
    1093  0473  7E 14               DEL20MS:      MOV    R6,#LONG_TC            ;Long settling time.
    1094  0475  80 0A        .R..                 SJMP   DELAY_LOOP
    1095  0477  7E 3C               DEL60MS:      MOV    R6,#60                 ;60ms delay.
    1096  0479  80 06        .R..                 SJMP   DELAY_LOOP
    1097  047B  7E 78               DEL120MS:     MOV    R6,#120                ;120ms delay.
    1098  047D  80 02        .R..                 SJMP   DELAY_LOOP
    1099  047F  7E F0               DEL240MS:     MOV    R6,#240                ;240ms delay.

    1101  0481  12 08 02     ..C.   DELAY_LOOP:   LCALL  UPDTE_SERVO
    1102  0484  DE FB        .R..                 DJNZ   R6,DELAY_LOOP
    1103  0486  22                                RET
```

```
ER   LINE  ADDR  OBJECT        TYPE

     1105                                  ;*****************************************************
     1106                                  ;                   UPDATE AUXILIARY PORT X
     1107                                  ;*****************************************************
     1108                                  ;Output solenoid drives on Port X.
     1109                                  ;---------------------------------------------
     1110  0487  55 44          .D..       ON_SOL:          ANL     A,PORTX_LATCH
     1111  0489  80 02          .R..                        SJMP    SAVE_PORTX
     1112  048B  45 44          .D..       OFF_SOL:         ORL     A,PORTX_LATCH
     1113  048D  F5 44          .D..       SAVE_PORTX:      MOV     PORTX_LATCH,A
     1114  048F  90 90 00                                   MOV     DPTR,#PORTX
     1115  0492  F0                                         MOVX    @DPTR,A
     1116  0493  22                                         RET

     1118                                  ;*****************************************************
     1119                                  ;                   UPDATE PORT C BITS
     1120                                  ;*****************************************************
     1121  0494  90 88 03                  ON_BIT:          MOV     DPTR,#PORTC     ;PC4, PC5 = 0.
     1122  0497  E0                                         MOVX    A,@DPTR
     1123  0498  5C                                         ANL     A,R4
     1124  0499  F0                                         MOVX    @DPTR,A
     1125  049A  22                                         RET
     1126  049B  90 88 03                  OFF_BIT:         MOV     DPTR,#PORTC     ;PC4, PC5 = 1.
     1127  049E  E0                                         MOVX    A,@DPTR
     1128  049F  4C                                         ORL     A,R4
     1129  04A0  F0                                         MOVX    @DPTR,A
     1130  04A1  22                                         RET
```

```
ER   LINE  ADDR  OBJECT       TYPE

     1132                                ;*******************************************************
     1133                                ;                     POINT_TO_POINT PROFILE
     1134                                ;*******************************************************
     1135                                ;Determines accel/deccel distances for a point-to-point
     1136                                ;trapezoidal velocity profile.
     1137                                ;-------------------------------------------------------
     1138  04A2  85 3D 41     .DD.       COMP_PROF:     MOV     DECCELK,ACCELK
     1139  04A5  C2 0A        ..B..                     CLR     PROF_FLG                ;Point-to-point motion.
     1140  04A7  7C 02                                  MOV     R4,#02                  ;Estimated accel distance equals
     1141  04A9  85 3C 38     .DD.                      MOV     ACCEL_CNT+1,TOTAL_CNT+1    ;total count / 4.
     1142  04AC  85 3B 37     .DD.                      MOV     ACCEL_CNT,TOTAL_CNT
     1143  04AF  E5 38        .D..       DIV_FOUR:      MOV     A,ACCEL_CNT+1           ;16 bits divided by 4.
     1144  04B1  C3                                     CLR     C
     1145  04B2  13                                     RRC     A
     1146  04B3  F5 38        .D..                      MOV     ACCEL_CNT+1,A
     1147  04B5  E5 37        .D..                      MOV     A,ACCEL_CNT
     1148  04B7  13                                     RRC     A
     1149  04B8  F5 37        .D..                      MOV     ACCEL_CNT,A
     1150  04BA  DC F3        .R..                      DJNZ    R4,DIV_FOUR
     1151  04BC  22                      EX_PACCEL:     RET

     1153                                ;****************************************
     1154                                ;            CHECK FOR KEY DEPRESSION
     1155                                ;****************************************
     1156  04BD  90 C0 00                CHKKBD:        MOV     DPTR,#KEYBD     ;Check for UPI Output Buffer
     1157  04C0  E0                                     MOVX    A,@DPTR           ;Full signal.
     1158  04C1  A2 E1        .B..                      MOV     C,ACC.1
     1159  04C3  22                                     RET
```

```
ER   LINE  ADDR  OBJECT      TYPE

                                    ;*************************************************************
                                    ;       CHECK FOR ANY CHANGE IN STATUS WHEN TRIP LOGIC IS OFF
                                    ;*************************************************************
                                    ;Returns to the main routine with:
                                    ;       1. the corresponding status bit (in MSG_STAT) updated.
                                    ;       2. STAT_FLG set if a status change occurs.
                                    ;       3. STAT_FLG cleared if no change of status.
                                    ;-------------------------------------------------------------
           04C4  90 88 01           PEEK_STAT:      MOV     DPTR,#PORTA             ;Read sensors.
           04C7  E0                                 MOVX    A,@DPTR
           04C8  F5 75         .D..                 MOV     SAV_SENSR,A             ;Save reading.
           04CA  20 20 04      .BR.                 JB      SAV_SENSR.5,NOSET
           04CD  D2 14         .B..                 SETB    TEST_FLG
           04CF  80 02         .R..                 SJMP    CHK_MODSEL
           04D1  C2 14         .B..     NOSET:      CLR     TEST_FLG
           04D3  00                     CHK_MODSEL: NOP
                                    ;*************************************      -----
                                    ;       HOME SIGNAL SEARCH RTN
                                    ;*************************************
           04ED  75 3A 05      .D..     HOME_SRCH:  MOV     CYC_CTR,#5
           04F0  D2 3A         .B..     SRCHRTRY:   SETB    SYS_FIABLE              ;Restore error flags.
           04F2  53 27 U5      .D..                 ANL     MSG1_STAT,#10110101B
           04F5  51 D8         .C..                 CALL    HOME_MOVE
           04F7  20 3B 05      .BR.                 JB      STAT_FLG,HOME_RTRY
           04FA  20 0F U2      .BR.                 JB      HOME_FLG,HOME_RTRY
           04FD  E4                                 CLR     A
           04FF  22                                 RET
           04FF  D5 3A EE      .DR.     HOME_RTRY:  DJNZ    CYC_CTR,SRCHRTRY        ;No. of of retries.
           0502  D2 3B         .B..                 SETB    STAT_FLG                ;Give up if exceeded.
           0504  22                                 RET
```

```
ER  LINE  ADDR  OBJECT      TYPE

    1210                                 ;********************************
    1211                                 ;       READ HOME SIGNAL
    1212                                 ;********************************
    1213  0505  91 73       .C..        HOME_CHK:     CALL    DEL20MS
    1214  0507  90 8B 01                              MOV     DPTR,#PORTA        ;Read in home signal input.
    1215  050A  E0                                    MOVX    A,@DPTR
    1216  050B  54 04                                 ANL     A,#4
    1217  050D  22                                    RET

    1219                                 ;***************************************
    1220                                 ;       CHECK FOR ZERO DUTY CYCLE
    1221                                 ;***************************************
    1222  050E  E5 2C       .D..        CHKZDC:       MOV     A,K2L
    1223  0510  70 02       .P..                      JNZ     EX_CHKZDC
    1224  0512  65 2B       .D..                      XRL     A,K2H              ;Returns 0 in acc if dc =0.
    1225  0514  22                      EX_CHKZDC:    RET
    1226  0514                          OUT_STEP      EQU     EX_CHKZDC
    1227                                 $INCLUDE(UPDSERVO.DMS)
```

```
ER   LINE  ADDR  OBJECT        TYPE

     1229                                        ;*********************************************
     1230                                        ;*****   UPDATE SERVO CONTROL ELEMENTS   *****
     1231                                        ;*********************************************
     1232                                                       ORG     800H
     1233  0800  C3                              DUMMY_CALL:    CLR     C                   ;For dummy call when SDK-51
     1234  0801  22                                             RET                         ;is not in used.

     1236                                        ;****************************************
     1237                                        ;       COMPUTE MOTION TRAJECTORY
     1238                                        ;****************************************
     1239  0802  53 D0 E7     .D..               UPDTE_SERVO:   ANL     PSW,#11100111B           ;Insure Reg Bank is 0!!
     1240  0805  30 08 04     .BR.                              JNB     RUN_FLG,CONST_SPEED      ;0= constant speed mode.
     1241  0808  31 42        .C..                              ACALL   COMP_ACCEL               ;1= accel/deccel (time varying) mode
     1242  080A  F5 32        .D..                              MOV     RUN_SPEED,A              ;Save speed result.
     1243  080C  85 32 36     .DD.               CONST_SPEED:   MOV     AUX_REG,RUN_SPEED        ;Convert result to double precisio
     1244  080F  75 F0 00     .D..                              MOV     B,#00                    ;Integrate speed to get distance:
     1245  0812  78 2E        .D..                              MOV     R0,#POSN_ACC                ;Target trajectory (in abs posn)
     1246  0814  31 10        .C..                              ACALL   INTEGRATE                   ;in POSN_ACC register.

     1248                                        ;****************************************
     1249                                        ;       UPDATE ABSOLUTE POSITIONS
     1250                                        ;****************************************
     1251  0816  30 07 08     .BR.                              JNB     DCHDIR_FLG,INCR_INDEX    ;Sign convention of speed
     1252  0819  E5 36        .D..                              MOV     A,AUX_REG                ;for CCW or CW rotation
     1253  081B  60 07        .R..                              JZ      INCR_INDEX               ;needed for absolute posn
     1254  081D  F4                                             CPL     A                        ;bookkeeping and desired
     1255  081E  04                                             INC     A                        ;signed encoder count reading
     1256  081F  F5 36        .D..                              MOV     AUX_REG,A                ;CCW=0=pos cnting; CW=1=neg.
     1257  0821  75 F0 FF     .D..                              MOV     B,#0FFH
     1258  0824  00                              INCR_INDEX:    NOP
     1259  0825  11 E2        .C..                              ACALL   TRACK_BASE               ;Compute absolute position.
     1260  0827  78 10        .D..                              MOV     R0,#COMP_CNT
     1261  0829  31 10        .C..                              ACALL   INTEGRATE

     1263                                        ;*********************************************
     1264                                        ;       COMPUTE ALGORITHM VARIABLES
     1265                                        ;         FOR NEXT SAMPLING INSTANT
     1266                                        ;*********************************************
     1267  082B  D2 D4        .D..               COMP_K1K2:     SETB    PSW.4               ;Select register bank 2.
     1268  082D  90 00 FF                                       MOV     DPTR,#COEFF1        ;K1 =-(COEFF1 x signed last error cnt)
     1269  0830  E5 2A        .D..                              MOV     A,ERR_CNT             ;Get last sampling instant's err cnt.
     1270  0832  30 E7 06     .BR.                              JNB     ACC.7,POS_ERR         ;Get absolute value if negative.
     1271  0835  F4                              NEG_ERR:       CPL     A
     1272  0836  04                                             INC     A
     1273  0837  31 57        .C..                              ACALL   XRTN
     1274  0839  80 04        .R..                              SJMP    SAV_K1              ;Result is +, ie., -(-K1).
     1275  083B  31 57        .C..               POS_ERR:       ACALL   XRTN
     1276  083D  31 71        .C..                              ACALL   TWOS_CPL            ;Result is -, ie., -(+K1).
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ER   LINE  ADDR  OBJECT        TYPE

     1277  083F  FA                        SAV_K1:     MOV     R2,A          ;Save result.
     1278  0840  AB F0          .D..                   MOV     R3,B
     1279                                                                    ;K2 =-[COEFF2/256 x signed last output]
     1280  0842  20 5F 0C       .BR.       CMPTK2:     JB      K2H.7,NEG_DC   ;Get abs value of last sampling
     1281  0845  85 2B 83       .DD.       POS_DC:     MOV     DPH,K2H        ;instant's algorithm output if (-).
     1282  0848  85 2C 82       .DD.                   MOV     DPL,K2L
     1283  084B  31 2D          .C..                   ACALL   COMP_K2        ;Multiply with COEFF2 constant.
     1284  084D  31 71          .C..                   ACALL   TWOS_CPL        ;Result is (-), ie., -K2.
     1285  084F  80 0E          .R..                   SJMP    PARTIAL
     1286  0851  E5 2C          .D..       NEG_DC:     MOV     A,K2L
     1287  0853  85 2B F0       .DD.                   MOV     B,K2H
     1288  0856  31 71          .C..                   ACALL   TWOS_CPL
     1289  0858  F5 82          .D..                   MOV     DPL,A
     1290  085A  85 F0 83       .DD.                   MOV     DPH,B
     1291  085D  31 2D          .C..                   ACALL   COMP_K2         ;Result is (+), ie., -(-K2).
     1292  085F  2A                        PARTIAL:    ADD     A,R2          ;Compute algorithm partial result,
     1293  0860  FA                                    MOV     R2,A            ;K1 regs =K1 + K2.
     1294  0861  E5 F0          .D..                   MOV     A,B
     1295  0863  3B                                    ADDC    A,R3
     1296  0864  FB                                    MOV     R3,A
```

```
ER   LINE  ADDR  OBJECT       TYPE

     1298                                 ;**************************************************
     1299                                 ;       WAIT FOR SAMPLING PERIOD TIMEOUT
     1300                                 ;**************************************************
     1301  0865  90 B8 03                 WAIT_1MS:     MOV    DPTR,#PORTC      ;Enable encoder buffer.
     1302  0868  E0                                     MOVX   A,@DPTR
     1303  0869  B2 E5        .B..                      CPL    ACC.5
     1304  086B  F0                                     MOVX   @DPTR,A
     1305  086C  B2 B5        .B..                      CPL    P3.5             ;Trigger 5V hardware watchdog.
     1306  086E  15 82        .D..                      DEC    DPL              ;Preset DPTR and B.
     1307  0870  75 F0 68     .D..                      MOV    B,#LOW(COEFF0)
     1308  0873  D2 38        .B..                      SETB   WTCHDOG_FLG      ;Must be set when T1 interrupts to
     1309  0875  30 38 19     .BR.     WAIT_T1:         JNB    WTCHDOG_FLG,T1_DONE ;indicate pgrm is in sync with
     1310  0878  30 0F FA     .BR.                      JNB    HOME_FLG,WAIT_T1         ;servo sampling clock.
     1311  087B  C2 AF        .B..                      CLR    EA               ;Prevent interrupt because DPTR
     1312  087D  15 82        .D..                      DEC    DPL              ;is changed to PORTA; wait until
     1313  087F  E0                                     MOVX   A,@DPTR          ;portA is read and DPTR is restored.
     1314  0880  A3                                     INC    DPTR             ;Bump DPTR to PORTB.
     1315  0881  D2 AF        .B..                      SETB   EA
     1316  0883  54 04                                  ANL    A,#04
     1317  0885  70 EE        .R..                      JNZ    WAIT_T1          ;Home was seen if not zero.
     1318  0887  31 1D        .C..                      ACALL  READ_YCTR
     1319  0889  FE                                     MOV    R6,A             ;Store reading to SAVE_LATCH.
     1320  088A  C2 0F        .B..                      CLR    HOME_FLG         ;Tell caller home count is latched.
     1321  088C  75 3A 01     .D..                      MOV    CYC_CTR,#01      ;Tell motion timing housekeeper to stop
     1322  088F  80 E4        .R..                      SJMP   WAIT_T1          ;motion.

     1324  0891  A3                       T1_DONE:      INC    DPTR             ;Disable encoders buffer.
     1325  0892  E0                                     MOVX   A,@DPTR
     1326  0893  B2 E5        .B..                      CPL    ACC.5
     1327  0895  F0                                     MOVX   @DPTR,A
     1328  0896  B2 B5        .B..                      CPL    P3.5             ;Re-arm watchdog.
     1329  0898  7F 04                                  MOV    R7,#TC_SAMP/TC_T1INT    ;Reload T1 timeout counter.
     1330  089A  C2 D4        .B..                      CLR    PSW.4            ;Restore to RB0.
     1331  089C  31 27        .C..                      ACALL  TRACKTIME        ;Update realtime-keeping.
     1332  089E  20 B3 05     .BR.     CHK30VOLT:       JB     P3.3,EX_UPDTE    ;=0 30VDC dips down beyond tolerance.
     1333  08A1  D2 40        .B..                      SETB   LO30VDC_FLG
     1334  08A3  02 00 8F     ..C.                      JMP    TFATAL           ;Force return to fatal error trap.
     1335  08A6  20 3D 01     .BR.     EX_UPDTE:        JB     TRIPEN_FLG,CHK_FFED
     1336  08A9  22                                     RET
```

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ER   LINE  ADDR  OBJECT        TYPE

     1338                                ;****************************************************************
     1339                                ;               CHECK MAIL FEED WHEN IN PRINT CYCLE
     1340                                ;****************************************************************
     1341                                ;Detects trips at the transport path to give the EE, info:
     1342                                ;       1. time when next mail is detected at TRIP1 for its speed
     1343                                ;          calculation in next cycle.
     1344                                ;
     1345                                ;
     1346                                ;
     1347                                ;
     1348                                ;Returns to main routine with:
     1349                                ;       1. TRIP sensors status updated.
     1350                                ;       2. TR1_FLG set if TRIP1 sensor is tripped (0 to 1 transition).
     1351                                ;       3. TR2_FLG set if TRIP2 sensor is tripped.
     1352                                ;       4. No change in flags' state if no trip is detected.
     1353                                ;----------------------------------------------------------------
     1354  08AA  90 A8 01               CHK_FEED:    MOV    DPTR,#PORTA             ;Read sensors.
     1355  08AD  E0                                  MOVX   A,@DPTR
     1356  08AE  FC                                  MOV    R4,A                    ;Save reading.
     1357  08AF  20 0C 11      .BR.                 JB     TR1_FLG,CHK_TR2         ;TR1_FLG =1 TRIP1 tripped; =0 not
     1358  08B2  20 E6 02      .BR.      CHK_TR1:   JB     ACC.6,$+5               ;Check for 0 to 1 Xition at TRIP1
     1359  08B5  80 1E         .R..                 SJMP   UPD_TRIP                ;No trip.
     1360  08B7  30 2E 02      .BR.                 JNB    SAV_SENSR.6,TR1_TRIPPED ;Tripped if previous status is 0.
     1361  08BA  80 19         .R..                 SJMP   UPD_TRIP
     1374  08D5  8C 25         .D..      UPD_TRIP:  MOV    SAV_SENSR,R4            ;Update TRIP status.
     1375  08D7  30 0C 07      .BR.                 JNB    TR1_FLG,EX_CHKFEED
     1376  08DA  BA 3C 04      ..R.                 CJNE   R2,#60,EX_CHKFEED       ;Check TRIP2 watchdog.


     1381                                ;**********************************************.*****
     1382                                ;       CONVERT RELATIVE TO ABSOLUTE
     1383                                ;           LOAD POSITION COUNT
     1384                                ;****************************************************
     1385  08E2  78 30         .D..      TRACK_BASE:  MOV   R0,#BASE_INDEX          ;Pointer to base index reg.
```

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ER   LINE  ADDR  OBJECT        TYPE

     1386  08E4  31 10         .C..                       ACALL   INTEGRATE            ;Integrate computed velocity.
     1387  08E6  90 0A 00                                 MOV     DPTR,#BASE_1REV      ;DPTR = base drv 1 rev count.
     1388  08E9  E6                         COMP_ABS:     MOV     A,@R0
     1389  08EA  30 E7 09      .BR.                       JNB     ACC.7,ABS1       ;Convert index to a positive value
     1390  08ED  18                                       DEC     R0               ;relative to the nose position count.
     1391  08EE  C6                                       XCH     A,@R0              ;IF SGN(index) is negative
     1392  08EF  25 82         .D..                       ADD     A,DPL                ;THEN index =index + 1 rev count
     1393  08F1  C6                                       XCH     A,@R0                ;ELSE
     1394  08F2  35 83         .D..                       ADDC    A,DPH
     1395  08F4  08                                       INC     R0
     1396  08F5  F6                                       MOV     @R0,A              ;Endif.
     1397  08F6  18                         ABS1:         DEC     R0               ;Convert positive index value to an
     1398  08F7  C3                                       CLR     C                ;absolute position count starting from
     1399  08F8  E5 82         .D..                       MOV     A,DPL            ;nose (zero) count.
     1400  08FA  96                                       SUBB    A,@R0              ;temp =1 rev count - index
     1401  08FB  FC                                       MOV     R4,A
     1402  08FC  E5 83         .D..                       MOV     A,DPH
     1403  08FE  08                                       INC     R0
     1404  08FF  96                                       SUBB    A,@R0
     1405  0900  30 E7 0C      .BR.                       JNB     ACC.7,EX_ABS       ;IF SGN(temp) is negative
     1406  0903  CC                                       XCH     A,R4                 ;THEN index = (-temp)
     1407  0904  F4                                       CPL     A                    ;ELSE
     1408  0905  24 01                                    ADD     A,#01
     1409  0907  18                                       DEC     R0
     1410  0908  F6                                       MOV     @R0,A
     1411  0909  CC                                       XCH     A,R4
     1412  090A  F4                                       CPL     A
     1413  090B  34 00                                    ADDC    A,#00
     1414  090D  08                                       INC     R0
     1415  090E  F6                                       MOV     @R0,A
     1416  090F  22                         EX_ABS:       RET                          ;Endif.
```

```
ER   LINE  ADDR  OBJECT        TYPE

     1418                                   ;****************************************
     1419                                   ;        INTEGRATE VELOCITY COUNT
     1420                                   ;****************************************
     1421  0910  E6                         INTEGRATE:     MOV     A,@R0            ;R0 holds index address lobyte.
     1422  0911  25 36          .D..                       ADD     A,AUX_REG        ;AUX_REG =signed velocity count
     1423  0913  F6                                        MOV     @R0,A              ;in counts/sample.
     1424  0914  08                                        INC     R0
     1425  0915  E5 F0          .D..                       MOV     A,B
     1426  0917  36                                        ADDC    A,@R0
     1427  0918  F6                                        MOV     @R0,A
     1428  0919  22                                        RET

     1430                                   ;**********************************************
     1431                                   ;        READ EXTERNAL COUNTER BUFFER
     1432                                   ;**********************************************
     1433  091A  90 B8 02                   READ_XCTR:     MOV     DPTR,#PORTB
     1434  091D  E0                         READ1_XCTR:    MOVX    A,@DPTR          ;Read buffer.
     1435  091E  F5 36          .D..                       MOV     AUX_REG,A
     1436  0920  E0                                        MOVX    A,@DPTR
     1437  0921  B5 36 01       .DR.                       CJNE    A,AUX_REG,RE_READ
     1438  0924  22                                        RET
     1439  0925  E0                         RE_READ:       MOVX    A,@DPTR          ;Best of 3 readings.
     1440  0926  22                         EX_READXCTR:   RET

     1442                                   ;**********************************************
     1443                                   ;        UPDATE SYSTEM REAL-TIMEKEEPING
     1444                                   ;**********************************************
     1445  0927  0A                         TRACKTIME:     INC     R2                       ;R2 counts 1ms-interval.
     1446  0928  BA 00 01       ..R.                       CJNE    R2,#00,EX_TRACKT         ;R3 counts 256ms-interval.
     1447  092B  0B                                        INC     R3                       ;Must be in RB0.
     1448  092C  22                         EX_TRACKT:     RET
```

```
ER  LINE  ADDR  OBJECT        TYPE

                                         ;**********************************************
                                         ;       COMPUTE SERVO ALGORITHM VARIABLE
                                         ;         (K2 =LAST OUTPUT x COEFF2)
                                         ;**********************************************
                                         ;DPTR =ABS(output) at last sampling instant.
                                         ;-----------------------------------------
            0920  C3                     COMP_K2:     CLR     C                       ;Limit to maximum absolute
            092E  74 E8                               MOV     A,#LOW(TC_SAMP)         ;output value, ie., equals
            0930  95 82        .D..                   SUBB    A,DPL                   ;sampling period interval.
            0932  74 03                               MOV     A,#HIGH(TC_SAMP)
            0934  95 83        .D..                   SUBB    A,DPH
            0936  50 06        .R..                   JNC     XK2
            0938  75 83 03     .D..                   MOV     DPH,#HIGH(TC_SAMP)
            093B  75 82 E8     .D..                   MOV     DPL,#LOW(TC_SAMP)
            093E  74 50                  XK2:         MOV     A,#COEFF2               ;Multiply output by COEFF2
            0940  80 06        .R..                   SJMP    BINFRAC                 ;algorithm constant.

                                         ;******************************************
                                         ;       COMPUTE POSITION COUNT IN
                                         ;         ACCELERATION PHASE
                                         ;******************************************
                                         ;Accel posn =accel rate x time displacement
                                         ;-----------------------------------------
            0942  8F 82        .D..      COMP_ACCEL:  MOV     DPL,R7         ;DPTR =motion-real-timekeeping regs.
            0944  8D 83        .D..                   MOV     DPH,R5         ;ie., time displacement in millisec.
            0946  E5 3D        .D..                   MOV     A,ACCELK       ;Get accel rate, counts/ms^2.

                                         ;******************************************
                                         ;       FIXED-POINT BINARY-INTEGER
                                         ;          MULTIPLICATION
                                         ;******************************************
                                         ;DPTR =integer ;ACC =binary fraction (N/256)
                                         ;-----------------------------------------
            0948  31 57        .C..      BINFRAC:     ACALL   XRTN        ;Do an integer multiply, integer x N,
            094A  A2 E7        .B..      DIV256:      MOV     C,ACC.7     ;Divide result by 256.
            094C  E5 F0        .D..                   MOV     A,B              ;Shift 1 byte to left R4, B, ACC.
            094E  34 00                               ADDC    A,#00            ;Round off to nearest integer.
            0950  CC                                  XCH     A,R4             ;Result low byte = ACC.
            0951  34 00                               ADDC    A,#00            ;Result high byte = B.
            0953  F5 F0        .D..                   MOV     B,A
            0955  EC                                  MOV     A,R4
            0956  22                                  RET
```

```
ER  LINE  ADDR  OBJECT      TYPE

    1493                                ;*****************************************
    1494                                ;        DOUBLE-PRECISION INTEGER
    1495                                ;            MULTIPLICATION
    1496                                ;*****************************************
    1497                                ;Multiplier (positive 8 bits) =ACC
    1498                                ;Multiplicand (positive 16 bits) =DPTR
    1499                                ;Product result in R4 (msd), B, ACC (lsd).
    1500                                ;-----------------------------------------
    1501  0957  FC                      XRTN:         MOV    R4,A      ;Compute product low byte.
    1502  0958  85 82 F0    .DD.                      MOV    B,DPL          ;Load multiplicand low byte
    1503  095B  A4                                    MUL    AB             ;Multiplier saved to R4.
    1504  095C  C0 E0       .D..                      PUSH   ACC            ;Save product low byte.
    1505  095E  C0 F0       .D..                      PUSH   B              ;Save partial product high byte.
    1506  0960  EC                                    MOV    A,R4      ;Compute product high byte.
    1507  0961  85 83 F0    .DD.                      MOV    B,DPH          ;Load multiplicand high byte.
    1508  0964  A4                                    MUL    AB
    1509  0965  D0 83       .D..                      POP    DPH            ;Set intermediate prod high byte.
    1510  0967  25 83       .D..                      ADD    A,DPH          ;Sum is final prod high byte.
    1511  0969  C5 F0       .D..                      XCH    A,B            ;Prod 2nd byte = B.
    1512  096B  34 00                                 ADDC   A,#00
    1513  096D  FC                                    MOV    R4,A           ;Prod 3rd byte(MSB) = R4.
    1514  096E  D0 E0       .D..                      POP    ACC            ;Prod 1st byte(LSB) = ACC
    1515  0970  22                                    RET                   ;Return to caller.

    1517                                ;********************************
    1518                                ;        DOUBLE-PRECISION
    1519                                ;        TWOS COMPLEMENT
    1520                                ;********************************
    1521  0971  F4                      TWOS_CPL:     CPL    A              ;ACC =lo byte.
    1522  0972  24 01                                 ADD    A,#01          ;B =hi byte.
    1523  0974  C5 F0       .D..                      XCH    A,B
    1524  0976  F4                                    CPL    A
    1525  0977  34 00                                 ADDC   A,#00
    1526  0979  C5 F0       .D..                      XCH    A,B
    1527  097B  22                                    RET
    1528                                $INCLUDE(NEWCOMRTN.OPS)
```

```
ER   LINE  ADDR  OBJECT        TYPE

                          ;****************************************
                          ;        COMMUNICATION ROUTINES
                          ;        TIME DELAY DECLARATIONS
                          ;****************************************
                          ;Transmitter echoplex protocol time
                          ;constants in microsecond.
                          ;--------------------------------
           006B           BITTX        EQU    104              ;Bit-to-bit xmit/echo-sample time.
           00AA           SBTX         EQU    170              ;CTS detect to Start Bit time.
           0154           NEPTX        EQU    340              ;No-Error-Pulse width.
           046F           BYTETX       EQU    1135             ;Byte-to-byte xmit time.
           005C           DELAY1       EQU    (BITTX-12)       ;Delay before xmitting 1st data bit.
           0055           DELAY2       EQU    (BITTX-19)       ;Delay before xmitting next data bit.
           005C           DELAY3       EQU    (BITTX-12)       ;Delay before sampling EOM/EOB.
           005B           DELAY4       EQU    (BYTETX-(BITTX*10)-4)   ;Delay before next byte xmit.
                          ;----------------------------------------
                          ;Receiver echoplex protocol time constants.
                          ;----------------------------------------
           0064           CTSRX        EQU    100              ;RTS detect to CTS xmit time.
           002A           SBRX         EQU    42               ;SB detect to Sd echo time.
           0078           BIT1RX       EQU    120              ;SB detect to 1st bit sample time.
           008C           ECH1RX       EQU    140              ;SB detect to 1st data bit echo time.
           006A           BITRX        EQU    106              ;Bit-to-bit sample/xmit-echo time.
           04A4           NEPRX        EQU    1188             ;SB detect to NEP sample time.
           0610           BYTERX       EQU    1552             ;Time until next receiver activity.
           0050           DELAY5       EQU    (CTSRX-20)       ;Delay before xmitting CTS.
           004B           DELAY6       EQU    (BIT1RX-SBRX-3)  ;Delay before sampling 1st data bit.
           0012           DELAY7       EQU    (ECH1RX-BIT1RX-7) ;Delay before echoing recv'd bit.
           0050           DELAY8       EQU    (BITRX-DELAY7-8)  ;Delay before sampling next data bit.
           008E           DELAY9       EQU    (BYTERX-(BIT1RX+BITRX*8)-25) ;Delay before next byte recv.
           00C3           DELAY10      EQU    (NEPRX-BYTERX+DELAY9)   ;Delay before sampling NEP.
           016C           DELAY11      EQU    (BYTERX-NEPRX)          ;Delay before recv rtn exit.

                          ;******************************************
                          ;        MACRO TO GENERATE CODE FOR
                          ;              TIME DELAYS
                          ;******************************************
                          TIME         MACRO  DVND
                                       IF     (DVND MOD 2) EQ 0
                                       MOV    R2,#((DVND-2)/2)
                                       DJNZ   R2,$
                                       NOP
                                       ELSE
                                       MOV    R2,#(DVND/2)
                                       DJNZ   R2,$
                                       ENDIF
                                       ENDM
```

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ER   LINE  ADDR  OBJECT       TYPE

     1578                            ;*******************************************
     1579                            ;          TRANSMIT MESSAGE TO SOURCE
     1580                            ;*******************************************
     1581                            ;RECVER_FLG =0 xmit thru serial line/ =1 thru display.
     1582                            ;------------------------------------------------
     1583  097C  E4                  XMIT_STAT:      CLR     A
     1584  097D  51 D1        .C..                   ACALL   XCOMPREP           ;Transmit system status.
     1585  097F  30 16 0C     .BR.                   JNB     RECVER_FLG,STAT_SERIAL
     1586  0982  12 E0 0F                            LCALL   CLRDSP
     1587  0985  AA 28        .D..                   MOV     R2,MSG2_STAT
     1588  0987  AB 27        .D..                   MOV     R3,MSG1_STAT
     1589  0989  12 E0 18                            LCALL   DSP2BY
     1590  098C  41 12        .C..                   AJMP    END_OF_XMIT
     1591  098E  79 26        .D..   STAT_SERIAL:    MOV     R1,#STAT_HEADER
     1592  0990  7D 03                               MOV     R5,#03
     1593  0992  75 26 80     .D..                   MOV     STAT_HEADER,#80H
     1594  0995  21 AF        .C..                   AJMP    XMIT_RTN
     1595  0997  74 02               XMIT_CMMDC:     MOV     A,#02
     1596  0999  51 D1        .C..                   ACALL   XCOMPREP       ;Transmit command-execution-complete.
     1597  099B  30 16 0A     .BR.                   JNB     RECVER_FLG,CMMDC_SERIAL
     1598  099E  12 E0 0F                            LCALL   CLRDSP
     1599  09A1  AA 46        .D..                   MOV     R2,TRIP_CTR+1
     1600  09A3  12 E0 15                            LCALL   DSP1BY
     1601  09A6  41 12        .C..                   AJMP    END_OF_XMIT
     1602  09A8  79 2D        .D..   CMMDC_SERIAL:   MOV     R1,#CMMD_HEADER
     1603  09AA  7D 02                               MOV     R5,#02
     1604  09AC  75 2D 83     .D..                   MOV     CMMD_HEADER,#83H

     1606                            ;*******************************************
     1607                            ;       TRANSMISSION ECHOPLEX ROUTINE
     1608                            ;              ( 12 MHZ CLOCK )
     1609                            ;*******************************************
     1610                            ;CAUTION: Instruction code, sequence, and loops
     1611                            ;        are critical to time delay computations.
     1612                            ;R0 =pointer to time constant watchdog.
     1613                            ;R1 =start addrs of xmitting buffer.
     1614                            ;R2 =timer delay constants register.
     1615                            ;R3 =save area for byte to be xmitted.
     1616                            ;R4 =communication failure counter.
     1617                            ;R5 =no. of bytes to be xmitted.
     1618                            ;R6 =stack pointer save area for wtchdg timeout.
     1619                            ;R7 =save area for no. of data bits per byte.
     1620                            ;------------------------------------------------
     1621  09AF  D2 B1        .B..   XMIT_RTN:       SETB    P3.1           ;Xmit RTS.
     1622  09B1  30 B0 FD     .BR.                   JNB     P3.0,$         ;Wait CTS until wtchdog times out.
     1623  09B4                                      TIME    SBTX           ;Delay before xmitting Start Bit.
     1630  09B9  C2 B1        .B..   START_XMIT:     CLR     P3.1           ;Xmit Start Bit.
     1631  09BB  7F 08                               MOV     R7,#08         ;Load no. of data bits per byte.
```

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ER  LINE  ADDR  OBJECT    TYPE

    1632  09BD  C3                              CLR    C
    1633  09BE  92 15     .B..                  MOV    SAVE1_BIT,C        ;First N-1 bit is Start bit, ie., 0.
    1634  09C0  E7                              MOV    A,@R1              ;Get byte to be xmitted.
    1635  09C1  FB                              MOV    R3,A               ;Save to work area.
    1636  09C2  09                              INC    R1                 ;Points to next byte.
    1637  09C3                                  TIME   DELAY1             ;Delay before xmitting first data bit.
    1644  09C8  EB                  BITOUT:     MOV    A,R3
    1645  09C9  13                              RRC    A                  ;Place bit into C.
    1646  09CA  FB                              MOV    R3,A
    1647  09CB  92 B1     .B..                  MOV    P3.1,C             ;Transmit Nth bit (C).
    1648  09CD  51 FC     .C..                  ACALL  CHK_ECHO           ;Check echo of N-1 bit.
    1649  09CF  30 06 3B  .BR.                  JNB    COMERR_FLG,XMITERR     ;Echo error if set.
    1650  09D2  92 15     .B..                  MOV    SAVE1_BIT,C        ;Save N bit, ie., N-1 bit = N.
    1651  09D4                                  TIME   DELAY2             ;Delay before xmitting next data bit.
    1657  09D8  DF EE     .R..                  DJNZ   R7,BITOUT          ;All data bits xmitted?
    1658  09DA  00                              NOP                       ;NOP to balance bit-to-bit delay.
    1659  09DB  DD 18     .R..                  DJNZ   R5,XMIT_EOB        ;End-of-msg if zero, else, End-of-byte.
    1660  09DD  C2 B1     .B..      XMIT_EOM:   CLR    P3.1               ;Xmit EOM.
    1661  09DF  51 FC     .C..                  ACALL  CHK_ECHO           ;Check echo of last data bit.
    1662  09E1  30 06 26  .BR.                  JNB    COMERR_FLG,XMITERR
    1663  09E4                                  TIME   DELAY3             ;Delay before reading EOM/EOB echo.
    1670  09E9  20 B0 1F  .BR.                  JB     P3.0,XMITERR       ;Check EOM echo.
    1671  09EC  D2 B1     .B..                  SETB   P3.1               ;Everything is OK; xmit NEP.
    1672  09EE                                  TIME   NEPTX              ;Delay for NEP width.
    1679  09F3  80 1D     .R..                  SJMP   END_OF_XMIT        ;End of xmission.
    1680  09F5  D2 B1     .B..      XMIT_EOB:   SETB   P3.1               ;Xmit EOB.
    1681  09F7  51 FC     .C..                  ACALL  CHK_ECHO           ;Check echo of last data bit.
    1682  09F9  30 06 0E  .BR.                  JNB    COMERR_FLG,XMITERR
    1683  09FC                                  TIME   DELAY3
    1690  0A01  30 B0 06  .BR.                  JNB    P3.0,XMITERR       ;Check EOB echo.
    1691  0A04                                  TIME   DELAY4             ;Delay before start of next byte xmit.
    1697  0A08  21 B9     .C..                  AJMP   START_XMIT         ;Start xmitting next byte.
    1698  0A0A  C2 06     .B..      XMITERR:    CLR    COMERR_FLG         ;Indicate communication error.
    1699  0A0C  C2 B1     .B..                  CLR    P3.1               ;Drop Xmit line.
    1700  0A0E  DA FE     .R..                  DJNZ   R2,$               ;Force an EOM error.
    1701  0A10  DA FE     .R..                  DJNZ   R2,$
    1702  0A12  41 8C     .C..      END_OF_XMIT: AJMP  CHK_COMERR         ;Check for xmit error.
```

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ER   LINE  ADDR  OBJECT        TYPE

     1704                             ;*******************************************
     1705                             ;       RECEIVE MESSAGE FROM SOURCE
     1706                             ;*******************************************
     1707  0A14  85 18 1D      .DD.   RECV_MSG:      MOV    OLD_CMMD,CMMD    ;Save current command.
     1708  0A17  75 09 18      .DD.                  MOV    R1_RB1,#CMMD
     1709  0A1A  51 28         .C..                  ACALL  RECV_RTN
     1710  0A1C  30 38 03      .BR.                  JNB    STAT_FLG,EX_RECVRTN
     1711  0A1F  85 1D 18      .DD.                  MOV    CMMD,OLD_CMMD
     1712  0A22  22                   EX_RECVRTN:    RET

     1714  0A23  75 09 36      .DD.   RECV_KCODE:    MOV    R1_RB1,#AUX_REG
     1715  0A26  51 28         .C..                  ACALL  RECV_RTN
     1716  0A28  E5 36         .D..                  MOV    A,AUX_REG
     1717  0A2A  22                                   RET

     1719  0A2B  74 04                RECV_RTN:      MOV    A,#04
     1720  0A2D  51 D1         .C..                  ACALL  XCOMPREP
     1721  0A2F  30 13 0D      .BR.                  JNB    CMMDSRC_FLG,STRT_RECV
     1722  0A32  12 E6 4C             GETKCODE:      CALL   UPI_IN           ;Use SDK-51 tool.
     1723  0A35  C2 E7         .B..                  CLR    ACC.7
     1724  0A37  F7                                  MOV    @R1,A            ;Save keycode.
     1725  0A38  7A 00                               MOV    R2,#00
     1726  0A3A  12 E6 25                             CALL   UPI_CMD          ;Reset UPI.
     1727  0A3D  41 BC         .C..                  AJMP   END_OF_RECV

     1729                             ;****************************************
     1730                             ;       RECEIVE ECHOPLEX ROUTINE
     1731                             ;             ( 12 MHZ CLOCK )
     1732                             ;****************************************
     1733                             ;CAUTION: Instruction code, sequence, and
     1734                             ;loops are critical to time delay computations.
     1735                             ;R1 =start addrs of msg recv buffer.
     1736                             ;R3 =byte-building register.
     1737                             ;----------------------------------------
     1738  0A3F                       STRT_RECV:     TIME   DELAY5           ;Delay before xmitting CTS.
     1745  0A44  D2 B1         .B..                  SETB   P3.1             ;Transmit CTS.
     1746  0A46  20 B0 FD      .BR.   WAIT_STARTB:   JB     P3.0,$           ;Wait Start Bit until watchdog times out.
     1747  0A49                                      TIME   SUBX             ;Delay before echoing Start Bit.
     1754  0A4E  C2 B1         .B..                  CLR    P3.1             ;Echo Start Bit.
     1755  0A50  7F 08                               MOV    R7,#08           ;Reset no. of data bits /byte.
     1756  0A52                                      TIME   DELAY6           ;Delay before sampling first data bit.
     1762  0A56  A2 B0         .B..   RECV_BIT:      MOV    C,P3.0           ;Get bit from recv line.
     1763  0A58                                      TIME   DELAY7           ;Delay before echoing recv'd data bit.
     1770  0A5D  92 B1         .B..                  MOV    P3.1,C           ;Echo received bit.
     1771  0A5F  EB                                  MOV    A,R3             ;Get byte-building register.
     1772  0A60  13                                  RRC    A                ;Move recv'd bit to register.
     1773  0A61  FB                                  MOV    R3,A
     1774  0A62                                      TIME   DELAY8           ;Delay before sampling next data bit.
```

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ER   LINE  ADDR  OBJECT        TYPE

     1781  0A67  DF ED         .R..                      DJNZ   R7,RECV_BIT
     1782  0A69  A2 B0         .B..   BYTE_COMPLETE:     MOV    C,P3.0            ;Sample EOB/EOM.
     1783  0A6B                                          TIME   DELAY7
     1790  0A70  92 B1         .B..                      MOV    P3.1,C            ;Echo EOB/EOM.
     1791  0A72  A7 0B         .D..                      MOV    @R1,R3_RB1        ;Move byte to msg recv buffer.
     1792  0A74  09                                      INC    R1                ;Points to next byte buffer.
     1793  0A75  50 07         .R..                      JNC    EOM_RECVD         ;What was it, EOB or EOM?
     1794  0A77                       EOB_RECVD:         TIME   DELAY9            ;Delay before receiving next byte.
     1801  0A7C  41 46         .C..                      AJMP   WAIT_STARTB
     1802  0A7E                       EOM_RECVD:         TIME   DELAY10           ;Delay before sampling NFP.
     1808  0A82  20 B0 02      .BR.                      JB     P3.0,NO_ERROR     ;No error in received msg if set.
     1809  0A85  C2 06         .B..                      CLR    COMERR_FLG        ;Else, indicate communication error.
     1810  0A87                       NO_ERROR:          TIME   DELAY11           ;Delay before rtn becomes ready for next msg
     1817  0A8C                       END_OF_RECV        EQU    $

     1819                             ;****************************************
     1820                             ;         COMMUNICATION RTN EXIT
     1821                             ;****************************************
     1822  0A8C  10 06 0D      .BR.   CHK_COMERR:        JBC    COMERR_FLG,GOODCOM
     1823  0A8F  D2 3B         .B..   BADCOM:            SETB   STAT_FLG          ;Communication error is a soft error.
     1824  0A91  BC FF 05      ..R.                      CJNE   COMERR_CTR,#255,INCOMERR
     1825  0A94  D2 46         .B..                      SETB   BADCOM_FLG        ;Indicate bad comm line error.
     1826  0A96  02 02 03      ..C.                      JMP    JFATAL
     1827  0A99  0C                   INCOMERR:          INC    COMERR_CTR
     1828  0A9A  80 02         .R..                      SJMP   COMRETRY
     1829  0A9C  7C 00                GOODCOM:           MOV    COMERR_CTR,#00    ;Reset retry ctr
     1830  0A9E  C2 8C         .B..   COMRETRY:          CLR    TR0               ;Stop watchdog timer.
     1831  0AA0  C2 B1         .B..                      CLR    P3.1              ;Drop TX line low.
     1832  0AA2  C2 D3         .B..                      CLR    PSW.3             ;Return to RB0.
     1833  0AA4  C3                                      CLR    C                 ;Adjust mainline real-timekeeping,
     1834  0AA5  E5 8A         .D..                      MOV    A,TL0             ;ie., compensate for time spent in
     1835  0AA7  25 82         .D..                      ADD    A,DPL             ;echoplex communication
     1836  0AA9  FC                                      MOV    R4,A                      ;because servo clock was
     1837  0AAA  E5 8C         .D..                      MOV    A,TH0                     ;turned off.
     1838  0AAC  35 83         .D..                      ADDC   A,DPH
     1839  0AAE  CC                   TIERADJ:           XCH    A,R4                ;Determine no. of sampling period
     1840  0AAF  C3                                      CLR    C                      ;that had passed while in
     1841  0AB0  94 E8                                   SUBB   A,#LOW(TC_SAMP)          ;communication.
     1842  0AB2  CC                                      XCH    A,R4
     1843  0AB3  94 03                                   SUBB   A,#HIGH(TC_SAMP)
     1844  0AB5  40 04         .R..                      JC     ADJRMDR
     1845  0AB7  31 27         .C..                      ACALL  TRACKTIME           ;Adjust timekeeping registers.
     1846  0AB9  80 F3         .R..                      SJMP   TIERADJ
     1847  0ABB  CC                   ADJRMDR:           XCH    A,R4                ;Round off within one sampling
     1848  0ABC  BC F0         .D..                      MOV    B,R4                  ;period.
     1849  0ABE  31 71         .C..                      ACALL  TWOS_CPL
     1850  0AC0  C3                                      CLR    C
     1851  0AC1  94 F4                                   SUBB   A,#LOW(TC_SAMP/2)
```

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ER   LINE  ADDR  OBJECT       TYPE

     1852  0AC3  E5 F0        .D..                     MOV     A,B
     1853  0AC5  94 01                                 SUBB    A,#HIGH(TC_SAMP/2)
     1854  0AC7  40 02        .R..                     JC      ADJDONE
     1855  0AC9  31 27        .C..                     ACALL   TRACKTIME
     1856  0ACB  75 8B 06     .D..      ADJDONE:       MOV     TL1,#(-TC_TIINT)
     1857  0ACE  D2 8E        .B..                     SETB    TR1              ;Re-start servo control.
     1858  0AD0  22                                    RET                      ;Return to caller.

     1860                               ;*******************************************
     1861                               ;       SET UP COMMUNICATION WATCHDOG
     1862                               ;*******************************************
     1863  0AD1  C2 8E        .B..      XCOMPREP:      CLR     TR1              ;Stop servo.
     1864  0AD3  C2 8C        .B..                     CLR     TR0              ;Stop PWM timer.
     1865  0AD5  43 90 03     .D..                     ORL     P1,#00000011B    ;Insure no drive to motors.
     1866  0AD8  D2 D3        .B..                     SETB    PSW.3            ;Select Register Bank 3.
     1867  0ADA  90 0A F6     ..C.                     MOV     DPTR,#WTCHDG_TAB
     1868  0ADD  93                                    MOVC    A,@A+DPTR
     1869  0ADE  FE                                    MOV     R6,A
     1870  0ADF  A3                                    INC     DPTR
     1871  0AE0  93                                    MOVC    A,@A+DPTR
     1872  0AE1  F5 82        .D..                     MOV     DPL,A            ;Save watchdog time interval.
     1873  0AE3  F4                                    CPL     A
     1874  0AE4  F5 8A        .D..                     MOV     TL0,A            ;Load watchdog timer.
     1875  0AE6  EE                                    MOV     A,R6
     1876  0AE7  F5 83        .D..                     MOV     DPH,A
     1877  0AE9  F4                                    CPL     A
     1878  0AEA  F5 8C        .D..                     MOV     TH0,A
     1879  0AEC  D2 06        .B..                     SETB    COMERR_FLG       ;Enable communication error flag.
     1880  0AEE  D2 8C        .B..                     SETB    TR0              ;Start watchdog timer.
     1881  0AF0  E5 81        .D..                     MOV     A,SP             ;Set-up stack pointer for
     1882  0AF2  14                                    DEC     A                ;forced-return if watchdog
     1883  0AF3  14                                    DEC     A                ;times out.
     1884  0AF4  FE                                    MOV     R6,A             ;Save to R5 (RB1).
     1885  0AF5  22                                    RET
     1886  0AF6  0F A0                  WTCHDG_TAB:    DW      4000             ;4ms interval.
     1887  0AF8  13 88                                 DW      5000             ;5ms interval.
     1888  0AFA  1F 40                                 DW      8000             ;8ms interval.

     1890                               ;*******************************************
     1891                               ;       CHECK XMITTED DATA BIT ECHO
     1892                               ;*******************************************
     1893  0AFC  20 B0 04     .BR.      CHK_ECHO:      JB      P3.0,ECH_IS_ONE
     1894  0AFF  20 15 04     .BR.      ECH_IS_ZERO:   JB      SAVEI_BIT,ECHOERR     ;Echo error if not the same.
     1895  0B02  22                                    RET
     1896  0B03  20 15 02     .BR.      ECH_IS_ONE:    JB      SAVEI_BIT,$+5
     1897  0B06  C2 06        .B..      ECHOERR:       CLR     COMERR_FLG            ;Indicate communication error.
     1898  0B08  22                                    RET
     1899  0B09                                        END
M51 assembly errors =     0
```

END

Claims:

1. A postage meter (10) including a rotary drum (38) having a periphery adapted for feeding a sheet (16) in a path of travel (18), characterised by:

a) first means (56,58) for sensing a time interval during which a sheet (16) is linearly displaced a predetermined distance in the path of travel (18);

b) a d.c. motor (120) coupled to the drum (38) for rotation thereof;

c) second means (86,126) for sensing angular displacement of the drum (38); and

d) computer means (500) coupled to the first (56,58) and second (86,126) sensing means and to the d.c. motor (120), the computer means (500) comprising:

i) means responsive to the first sensing means (56,58) for providing respective amounts representative of desired angular displacements of the drum (38) during successive sampling time periods,

ii) means responsive to the second sensing means (86,126) for providing respective amounts representative of actual angular displacements of the drum (38) during successive sampling time periods, and

iii) means for compensating for the difference between desired and actual angular displacements and generating a d.c. motor control signal for controlling rotation of the motor (120) to cause the linear displacement of the periphery of the drum (38) to substantially match the linear displacement of the sheet (16) during respective sampling time periods.

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2. A meter according to claim 1, wherein the first sensing means comprises first (56) and second (58) sensing devices spaced apart from each other a predetermined distance (d_1) for sensing successive arrivals of a sheet (16) at two spaced apart locations in the path of travel (18).

3. A meter according to claim 1 or 2 wherein the motor (120) has an output shaft (122), and the second sensing means comprises quadrature encoder means (126) coupled to the output shaft (122).

4. A meter according to any one of claims 1 to 3 wherein the computer means (500) includes means (504) for comparing amounts representative of the desired and actual angular displacements and generating an error signal representative of the difference therebetween, the compensation means responsive to said error signal for generating the motor control signal, and the motor control signal compensating for the difference between said desired and actual angular displacements.

5. A meter according to any one of claims 1 to 4 including power amplifier means (301) for coupling the computer means (500) to the d.c. motor (120).

6. A meter according to any one of claims 1 to 5 wherein the drum (38) has a cycle of rotation, and the motor control signal accelerating the periphery of the drum (38) to the linear velocity of the sheet (16) substantially coincident with the periphery of the drum (38) engaging the leading edge of the sheet.

7. A meter according to claim 2, wherein the first sensing means comprises a mailing machine (12) including said first and second sensing devices.

8. A meter according to claim 3 including counting means (270) for coupling the quadrature encoder means to the computer means.

9. A meter according to Claim 4, wherein the motor control signal comprises a pulse width modulated control signal.

10. A meter according to Claim 4, wherein the motor control signal comprises a function of a regressive mathematical expression.

11. A meter according to Claim 4, wherein the motor control signal comprises a function of the error signal and a prior error signal.

12. A meter according to Claim 4, wherein the motor control signal comprises a function of the error signal and a prior motor control signal.

13. A meter according to claim 6 wherein the motor control signal is such as to decelerate the drum (38) from said velocity thereof to rest subsequent to disengagement of the drum (38) and sheet (16).

14. A meter according to claim 8 wherein the counting means (270) comprises means for providing an output signal for the computer means (500) which is representative of the angular displacement and direction of rotation of the motor drive shaft (122).

15. A meter according to Claim 12, wherein the prior motor control signal comprises a function of a prior error signal.

16. For use in a postage meter including a rotary drum (38), wherein the drum (38) includes a periphery adapted for feeding a sheet (16) in a path of travel (18), a process for controlling rotation of the drum (38) as a function of the velocity of the sheet (16), the process characterised by:

a) sensing a time interval during which a sheet (16) is linearly displaced a predetermined distance in the path of travel (18) and in response thereto providing amounts representative of respective desired angular displacements of the drum (38) during successive sampling time periods;

b) providing a d.c. motor (120) for rotating the drum (38);

c) sensing angular displacement of the drum (38) and in response thereto providing amounts representative of respective actual angular displacements of the drum (38) during successive sampling time periods; and

d) digitally compensating for the difference between desired and actual angular displacements and generating a motor control signal for controlling rotation of the drum (38) to cause the linear displacement of the periphery of the drum to substantially match the linear displacement of the sheet (16) during respective sampling time periods.

17. A process according to Claim 16, wherein step (a) includes the step of sensing successive arrivals of a sheet (16) at two spaced apart locations in the path of travel (18).

18. A process according to Claim 16, wherein step (c) includes the step of sensing the direction of angular displacement of the d.c. motor (120).

19. A process according to Claim 16, wherein step (d) includes the steps of:

1. comparing amounts representative of respective desired and actual angular displacements,

2. generating an error signal representative of the difference between respective desired and actual angular displacements and in response thereto generating a motor control signal which compensates for the difference between said desired and actual angular displacements.

20. A process according to Claim 16, wherein step (c) includes the step of accelerating the periphery of the drum (38) to the velocity of the sheet (16) substantially coincident with engagement of the drum and sheet.

21. A process according to Claim 16, wherein step (d) includes the step of calculating the motor control signal from a function of a regressive mathematical expression.

22. A process according to Claim 16, wherein step (a) includes the step of generating respective counts representative of desired angular displacements of the drum (38).

23. A process according to Claim 16, wherein step (c) includes the step of generating respective counts representative of actual angular displacements of the drum (38).

24. A process according to Claim 16, wherein step (d) includes the steps of:

1. generating a pulse width modulated motor control signal,

2. amplifying said pulse width modulated control signal, and

3. applying the amplified pulse width modulated control signal to said d.c. motor (120).

25. A process according to Claim 20, wherein step (c) includes the step of decelerating the periphery of the drum (38) to rest subsequent to disengagement of the drum (38) and sheet (16).

26. Apparatus including rotary means (38) having a periphery, the periphery including indicia printing means (44), and the periphery being adapted for feeding a sheet (16) in a path of travel (18), characterised by:

a) first means (56,58) for sensing a time interval during which a sheet (16) having a leading edge is linearly displaced a predetermined distance in the path of travel (18);

b) a d.c. motor (120) coupled to the rotary means (38) for rotation thereof;

c) second means (86,126) for sensing angular displacement of the rotary means (38); and

d) computer means (500) coupled to the first (56,58) and second (86,126) sensing means and to the d.c. motor (120), the computer means (500) comprising:

i) means responsive to the first sensing means (56,58) for providing respective amounts representative of desired angular displacements of the rotary means (38) during successive sampling time periods,

ii) means responsive to the second sensing means (86,126) for providing respective amounts representative of actual angular displacements of the rotary means (38) during successive sampling time periods, and

iii) means for compensating for the difference between desired and actual angular displacements and generating a d.c. motor control signal for controlling rotation of the motor (120) to cause the indicia printing means (44) to initially engage the sheet (16) in the path of travel (18) a predetermined marginal distance from the leading edge of the sheet (16).

27. Apparatus according to claim 26 wherein the first sensing means comprises first (56) and second (58) sensing devices spaced apart from each other a predetermined distance (d_1) for sensing successive arrivals of a sheet (16) at two spaced apart locations in the path of travel (18).

28. Apparatus according to claim 26 or 27 wherein the motor (120) has an output shaft (122), and the second sensing means comprises quadrature encoder means (126) coupled to the output shaft (122).

29. Apparatus according to any one of claims 26 to 28 wherein the computer means (500) includes means for comparing amounts representative of the desired and actual angular displacements and generating an error signal representative of the difference therebetween, the compensation means responsive to said error signal for generating the motor control signal, and the motor control signal compensating for the difference between said desired and actual angular displacements.

30. Apparatus according to any one of claims 26 to 29 including power amplifier means (301) for coupling the computer means (500) to the d.c. motor (120).

31. Apparatus according to any one of claims 26 to 30 wherein the apparatus comprises a postage meter (10), the rotary means includes a postage meter drum (38), the drum has a cycle of rotation, and the motor control signal is arranged to accelerate the periphery of the drum (38) to the linear velocity of the sheet (16) substantially coincident with the periphery of the drum (38) engaging the leading edge of the sheet (16).

32. Apparatus according to claim 27 wherein the apparatus comprises a postage meter (10), the rotary means includes a postage meter drum (38), and the first sensing means comprises a mailing machine (12) including said first and second sensing devices (56,58).

33. Apparatus according to claim 28 including counting means (270) for coupling the quadrature encoder means (126) to the computer means (500).

34. Apparatus according to claim 29 wherein the motor control signal comprises a pulse width modulated control signal.

35. Apparatus according to claim 29 wherein the motor control signal comprises a function of a regressive mathematical expression.

36. Apparatus according to claim 29 wherein the motor control signal comprises a function of the error signal and a prior error signal.

37. Apparatus according to claim 29 wherein the motor control signal comprises a function of the error signal and a prior motor control signal.

38. Apparatus according to claim 31 including the motor control signal decelerating the drum (38) from said velocity thereof to rest subsequent to disengagement of the drum (38) and sheet (16).

39. Apparatus according to claim 33 wherein the counting means (270) comprises means for providing an output signal for the computer means (500) which is representative of the angular displacement and direction of rotation of the motor drive shaft (122).

40. Apparatus according to claim 37 wherein the prior motor control signal comprises a function of a prior error signal.

41. For use with apparatus including rotary means (38), wherein the rotary means includes a periphery having indicia printing means (44) and is adapted for feeding a sheet (16) having a leading edge in a path of travel (18), a process for controlling rotation of the rotary means (38) for controlling engagement of the indicia printing means (44) with the sheet, the process characterised by:

a) sensing a time interval during which a sheet (16) is linearly displaced a predetermined distance in the path of travel (18) and in response thereto providing amounts representative of respective desired angular displacements of the rotary means (38) during successive sampling time periods;

b) providing a d.c. motor (120) for rotating the rotary means (38);

c) sensing angular displacement of the rotary means (38) and in response thereto providing amounts representative of respective actual angular displacements of the rotary means (38) during successive sampling time periods; and

d) digitally compensating for the difference between desired and actual angular displacements and generating a motor control signal for controlling rotation of the rotary means (38) to cause the indicia printing means (44) to initially engage the sheet (16) in the path of travel (18) a predetermined distance from the leading edge of the sheet (16).

42. A process according to claim 41 wherein step (a) includes the step of sensing successive arrivals of a sheet (16) at two spaced apart locations in the path of travel (18).

43. A process according to claim 41 or 42 wherein step (c) includes the step of sensing the direction of angular displacement of the d.c. motor (120).

44. A process according to any one of claims 41 to 43 wherein step (d) includes the steps of:

1. comparing amounts representative of respective desired and actual angular displacements, and

2. generating an error signal representative of the difference between respective desired and actual angular displacements and in response thereto generating

a motor control signal which compensates for the difference between said desired and actual angular displacements.

45. A process according to any one of claims 41 to 44 wherein step (c) includes the step of accelerating the periphery of the rotary means (38) to the velocity of the sheet (16) substantially coincident with engagement of the periphery and sheet (16).

46. A process according to any one of claims 41 to 45 wherein step (d) includes the step of calculating the motor control signal from a function of a regressive mathematical expression.

47. A process according to any one of claims 41 to 46 wherein step (a) includes the step of generating respective counts representative of desired angular displacements of the rotary means.

48. A process according to any one of claims 41 to 47 wherein step (c) includes the step of generating respective counts representative of actual angular displacements of the rotary means (38).

49. A process according to any one of claims 41 to 48 wherein step (d) includes the steps of:

1. generating a pulse width modulated motor control signal,

2. amplifying said pulse width modulated control signal, and

3. applying the amplified pulse width modulated control signal to said d.c. motor (120).

50. A process according to claim 45 wherein step (c) includes the step of decelerating the periphery of the rotary means (38) to rest subsequent to disengagement of the periphery and sheet (16).

FIG. 1

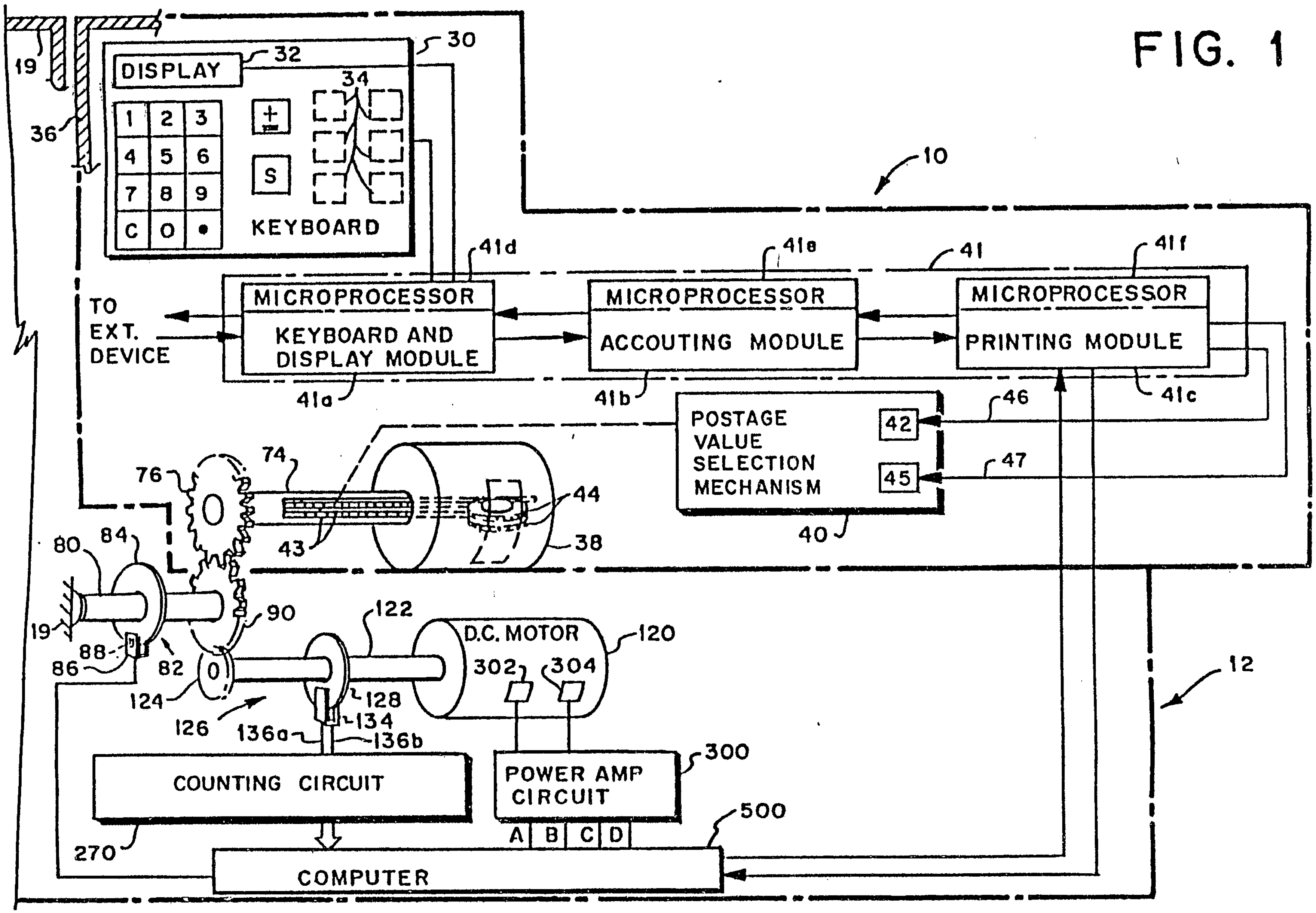
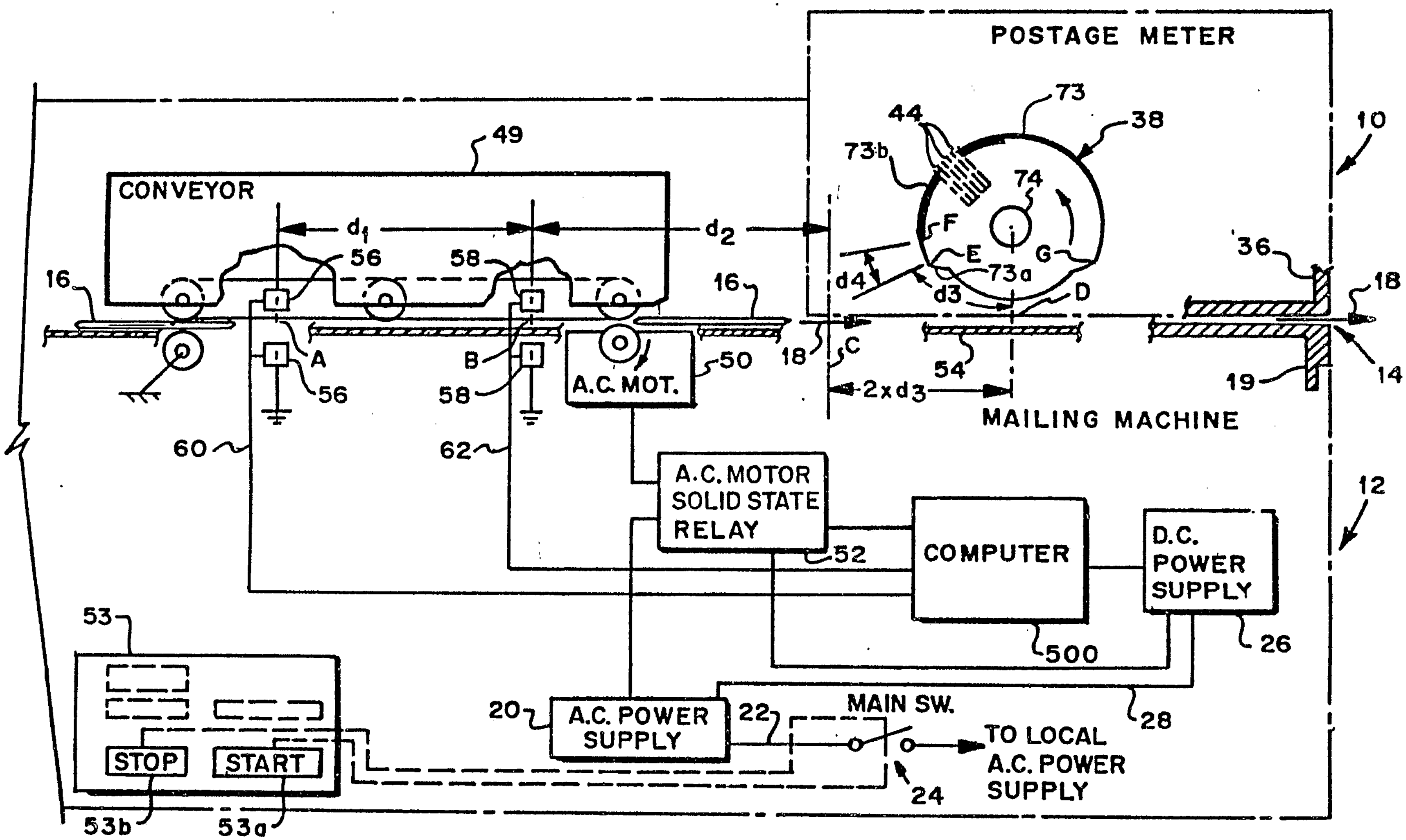

DISPLAY
1 2 3
4 5 6
7 8 9
C O •
±
S
KEYBOARD
MICROPROCESSOR
KEYBOARD AND DISPLAY MODULE
MICROPROCESSOR
ACCOUTING MODULE
MICROPROCESSOR
PRINTING MODULE
TO EXT. DEVICE
POSTAGE VALUE SELECTION MECHANISM
42
45
D.C. MOTOR
COUNTING CIRCUIT
POWER AMP CIRCUIT
A B C D
COMPUTER
10
12
19
30
32
34
36
38
40
41
41a
41b
41c
41d
41e
41f
43
44
46
47
74
76
80
82
84
86
88
90
120
122
124
126
128
134
136a
136b
270
300
302
304
500

FIG. 2


POSTAGE METER
MAILING MACHINE
CONVEYOR
A.C. MOT.
A.C. MOTOR SOLID STATE RELAY
COMPUTER
D.C. POWER SUPPLY
A.C. POWER SUPPLY
MAIN SW.
TO LOCAL A.C. POWER SUPPLY
STOP
START
10
12
14
16
18
19
20
22
24
26
28
36
38
44
49
50
52
53
53a
53b
54
56
58
60
62
73
73a
73b
74
500
A
B
C
D
E
F
G
d_1
d_2
d3
d4
2xd3

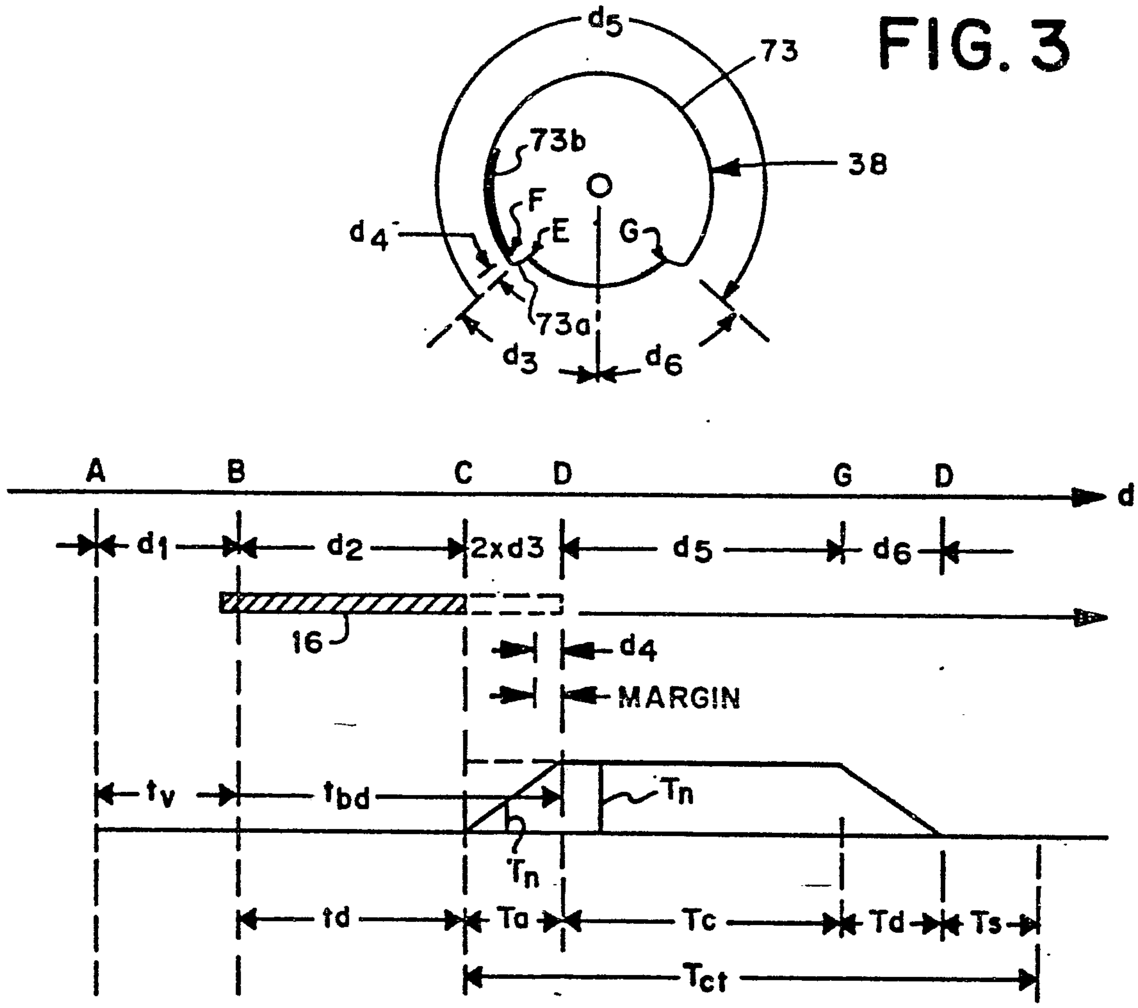
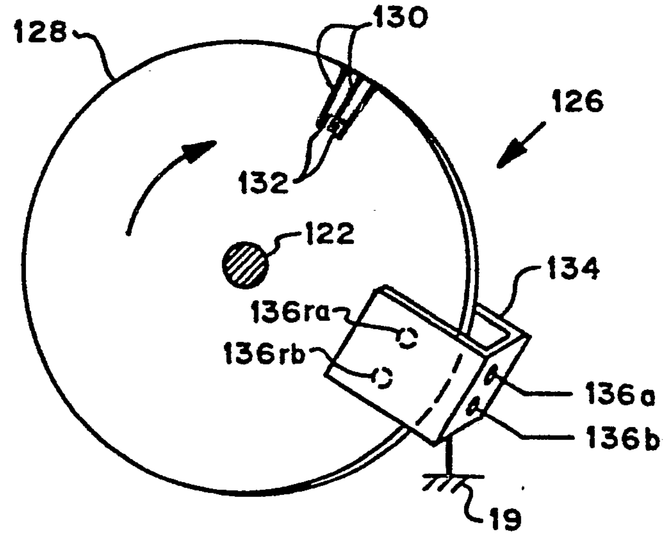

d5
73
38
73b
F
E
G
d4
73a
d3
d6
A
B
C
D
G
D
d
d1
d2
2xd3
d5
d6
16
d4
MARGIN
tv
tbd
Tn
Tn
td
Ta
Tc
Td
Ts
Tct

FIG. 3

FIG. 4


128
130
126
132
122
134
136ra
136rb
136a
136b
19

0177057

FIG. 5

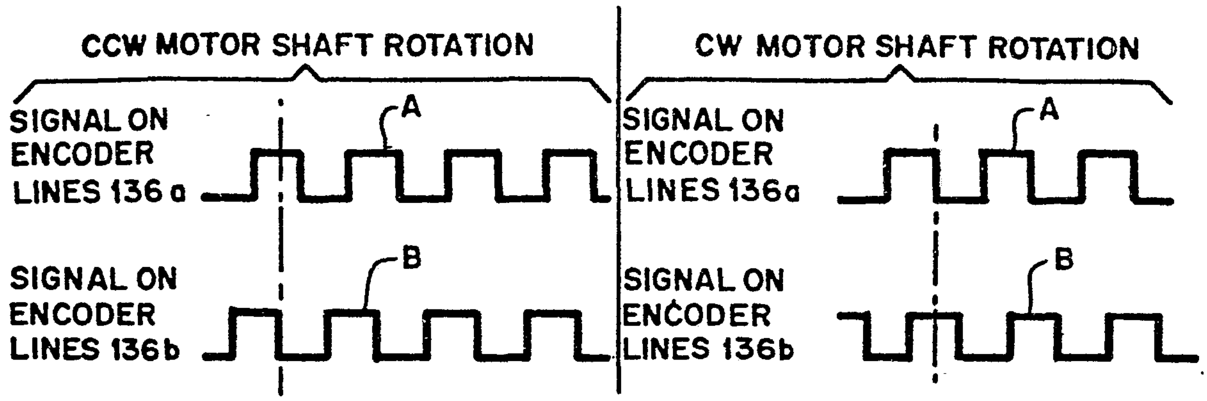
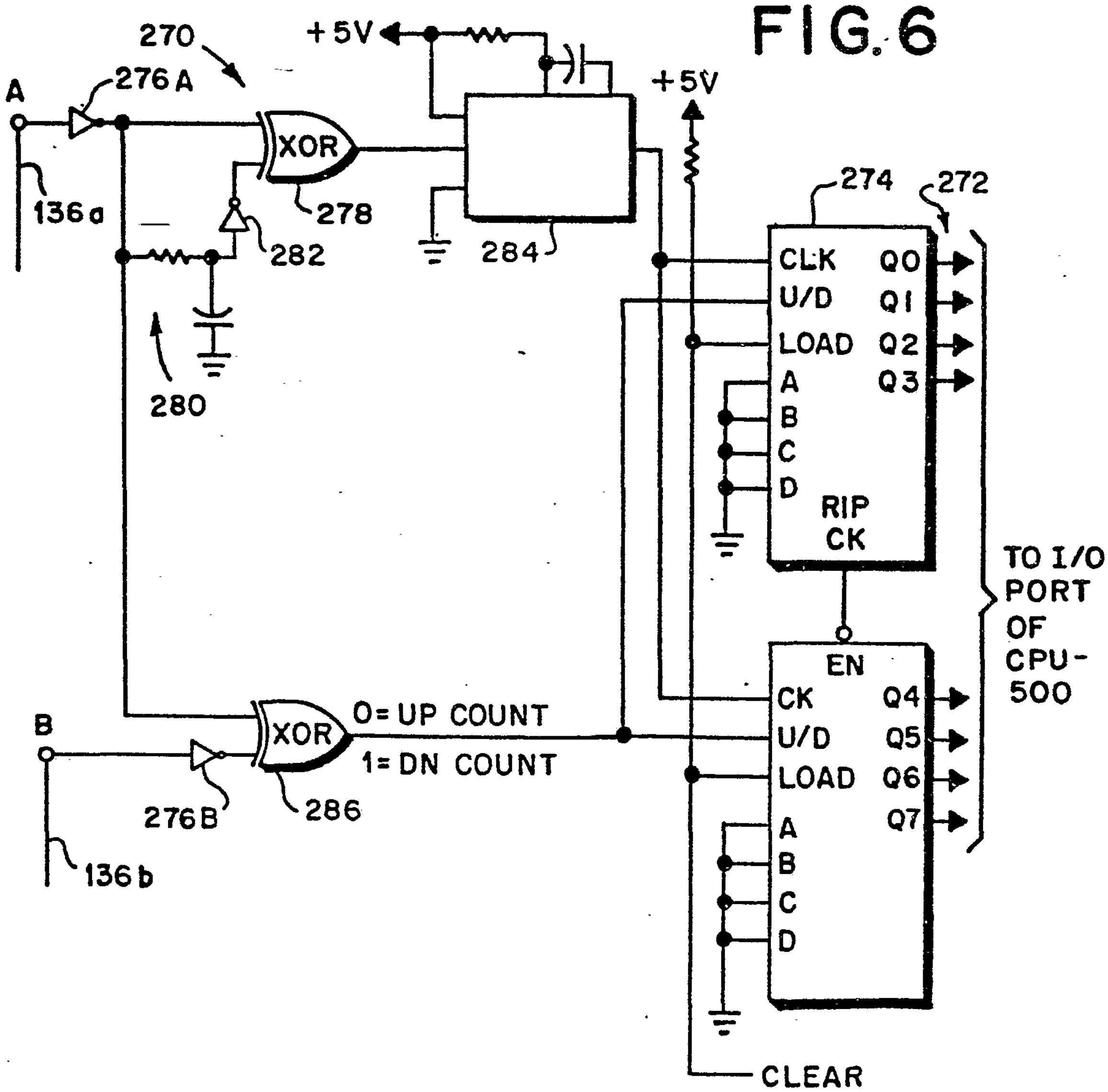


FIG. 6



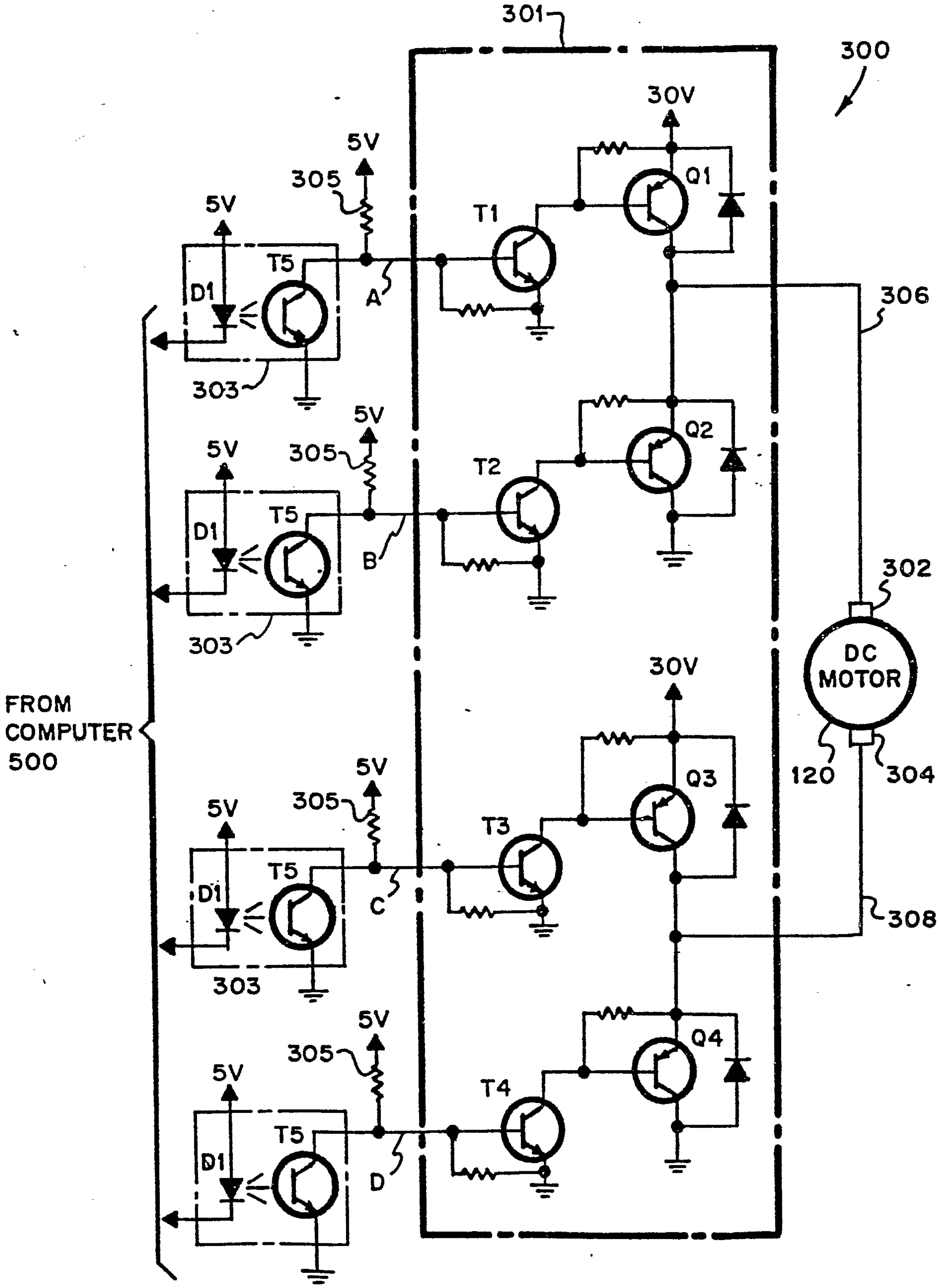

300
301
30V
5V
305
T1
Q1
T5
D1
A
306
303
Q2
T2
B
302
DC
MOTOR
FROM
COMPUTER
500
120
304
Q3
T3
C
308
T4
Q4
D

FIG. 7

FIG. 8

MOTOR ROTATION	Q1	Q2	Q3	Q4	T1	T2	T3	T4	A	B	C	D	302	304
CW	ON	OFF	OFF	ON	ON	OFF	OFF	ON	HIGH	LOW	LOW	HIGH	+	—
CCW	OFF	ON	ON	OFF	OFF	ON	ON	OFF	LOW	HIGH	HIGH	LOW	—	+

FIG. 9

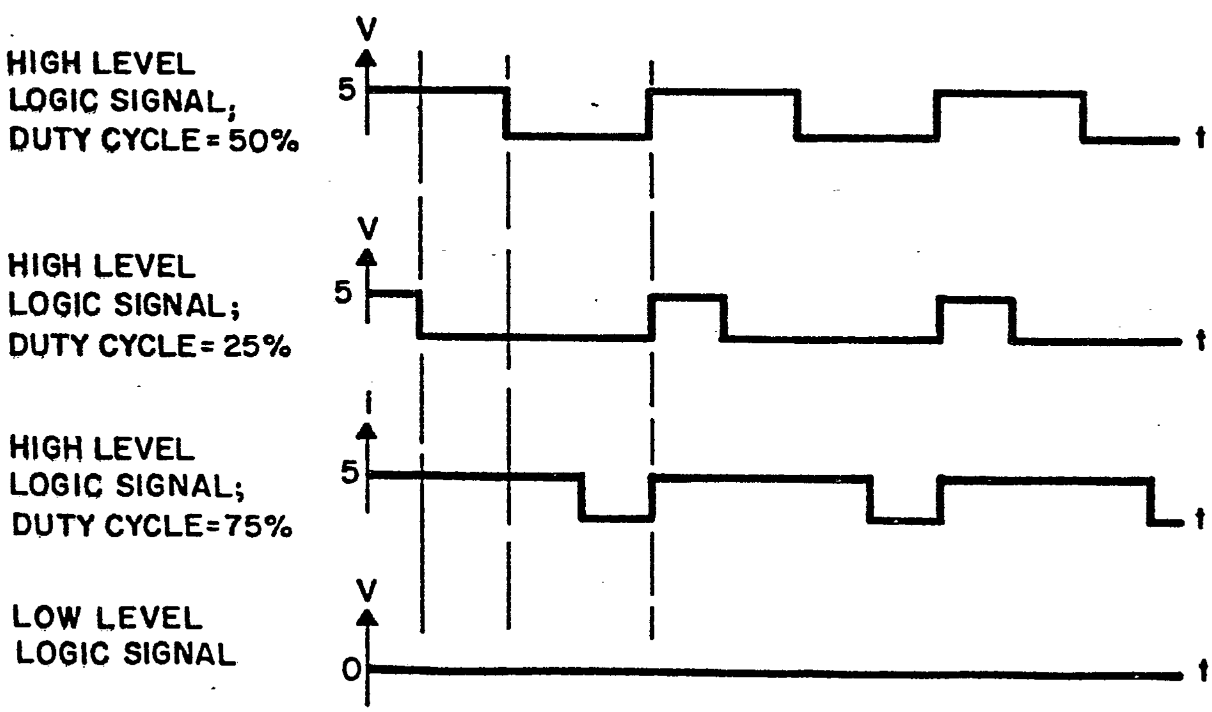


FIG. 10

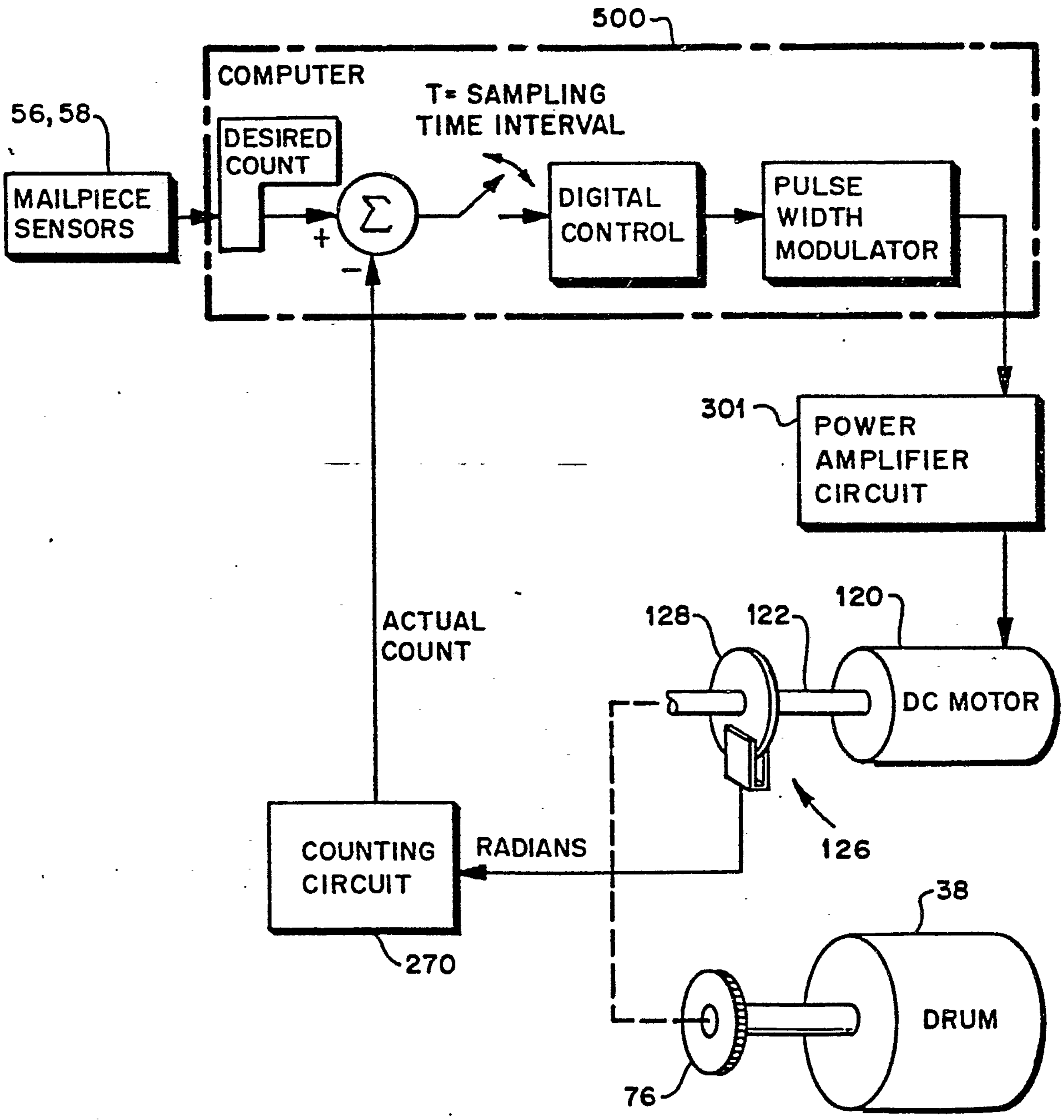

500
COMPUTER
56, 58
DESIRED COUNT
T= SAMPLING TIME INTERVAL
MAILPIECE SENSORS
+
Σ
−
DIGITAL CONTROL
PULSE WIDTH MODULATOR
301
POWER AMPLIFIER CIRCUIT
ACTUAL COUNT
128
122
120
DC MOTOR
126
COUNTING CIRCUIT
RADIANS
270
38
DRUM
76

FIG. 11

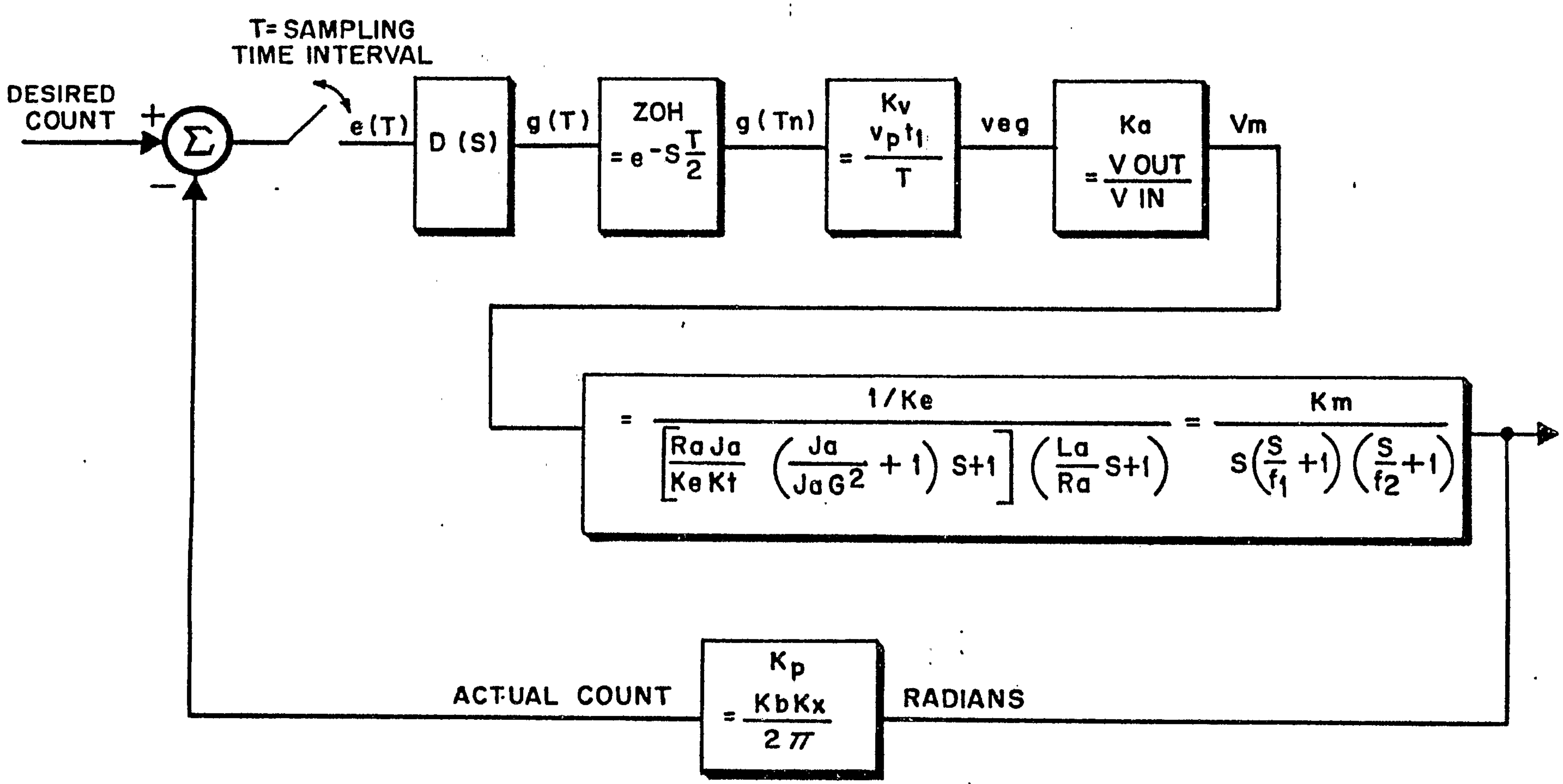

T= SAMPLING
TIME INTERVAL
DESIRED
COUNT
+
−
Σ
e (T)
D (S)
g (T)
ZOH
$= e^{-S\frac{T}{2}}$
g (Tn)
Kv
$= \frac{v_p t_1}{T}$
veg
Ka
$= \frac{V\ OUT}{V\ IN}$
Vm
$= \frac{1/Ke}{\left[\frac{RaJa}{KeKt}\left(\frac{Ja}{JaG^2}+1\right)S+1\right]\left(\frac{La}{Ra}S+1\right)} = \frac{Km}{S\left(\frac{S}{f_1}+1\right)\left(\frac{S}{f_2}+1\right)}$
ACTUAL COUNT
Kp
$= \frac{KbKx}{2\pi}$
RADIANS

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FIG. 12

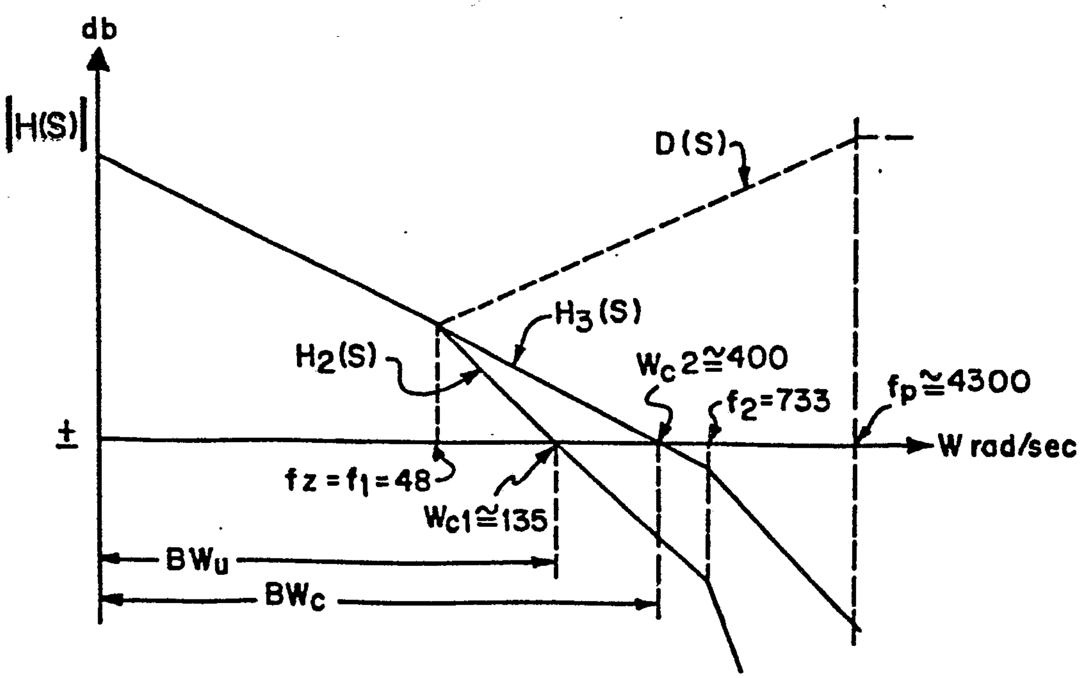
(a) $$H_1(S) = ZOH\,(K_v)\,(K_a)\,\frac{K_m}{S\left(\frac{S}{f_1}+1\right)\left(\frac{S}{f_2}+1\right)}\,K_p$$

(b) $$H_2(S) = ZOH\,(K_v)\,(K_a)\,\frac{K_m}{S\left(\frac{S}{f_1}+1\right)\left(\frac{S}{f_2}+1\right)}\,(K_p)\,(K_c)$$

$$= \frac{e^{S\frac{T}{2}}\,(K_v)\,(K_a)\,(K_m)\,(K_p)\,(K_c)}{S\left(\frac{S}{f_1}+1\right)\left(\frac{S}{f_2}+1\right)}$$

$$= \frac{K_o\,e^{S\frac{T}{2}}}{S\left(\frac{S}{f_1}+1\right)\left(\frac{S}{f_2}+1\right)} = \frac{400\,e^{-0.001\frac{S}{2}}}{S\left(\frac{S}{48}+1\right)\left(\frac{S}{733}+1\right)}$$

FIG. 13



$$D(S) = K_C \frac{\left(\frac{S}{f_z}+1\right)}{\left(\frac{S}{f_p}+1\right)}$$

$$= 13.64 \frac{\frac{S}{48}+1}{\frac{S}{3400}+1} = 966\frac{(S+48)}{(S+3400)}$$

FIG. 14

(a) $d_f = \theta m \frac{\pi}{360°}$

(b) $O_S = 100 \frac{e^{\frac{\pi}{d_f}}}{\sqrt{1-d_f^2}}$

(c) $t_X = \frac{1}{d_f}(W_n) \approx \frac{1}{d_f}(W_c)$

(d) $t_s \approx 5 t_X$

FIG. 15

$$S = \frac{2}{T} \times \frac{Z-1}{Z+1}$$

FIG. 16

FIG. 17

$$D(Z) \approx 366 \left(\frac{Z-0.953}{Z+0.259}\right)$$

$$= 366 \left(\frac{1-0.953Z^{-1}}{1+0.259Z^{-1}}\right)$$

FIG. 18

(a) $$D(Z) = \frac{G(Z)}{E(Z)} = 366 \left(\frac{1-0.953Z^{-1}}{1+0.259Z^{-1}}\right)$$

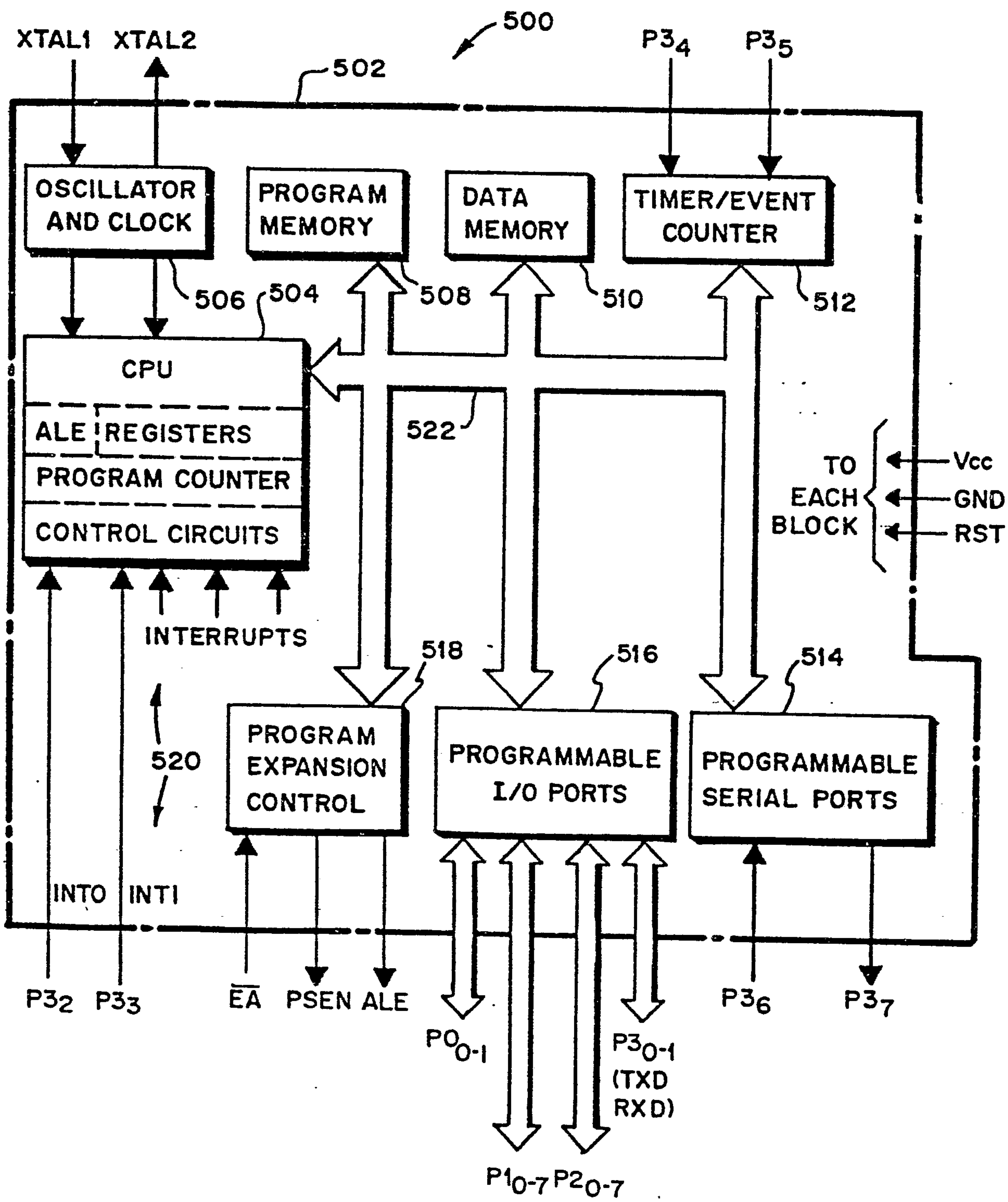
(b) $$G(Z) = 366E(Z) - 348E(Z)Z^{-1} - 0.259G(Z)Z^{-1}$$

FIG. 19

$$G(Tn) = 366E(Tn) - 348E(Tn-1) - 0.259G(Tn-1)$$

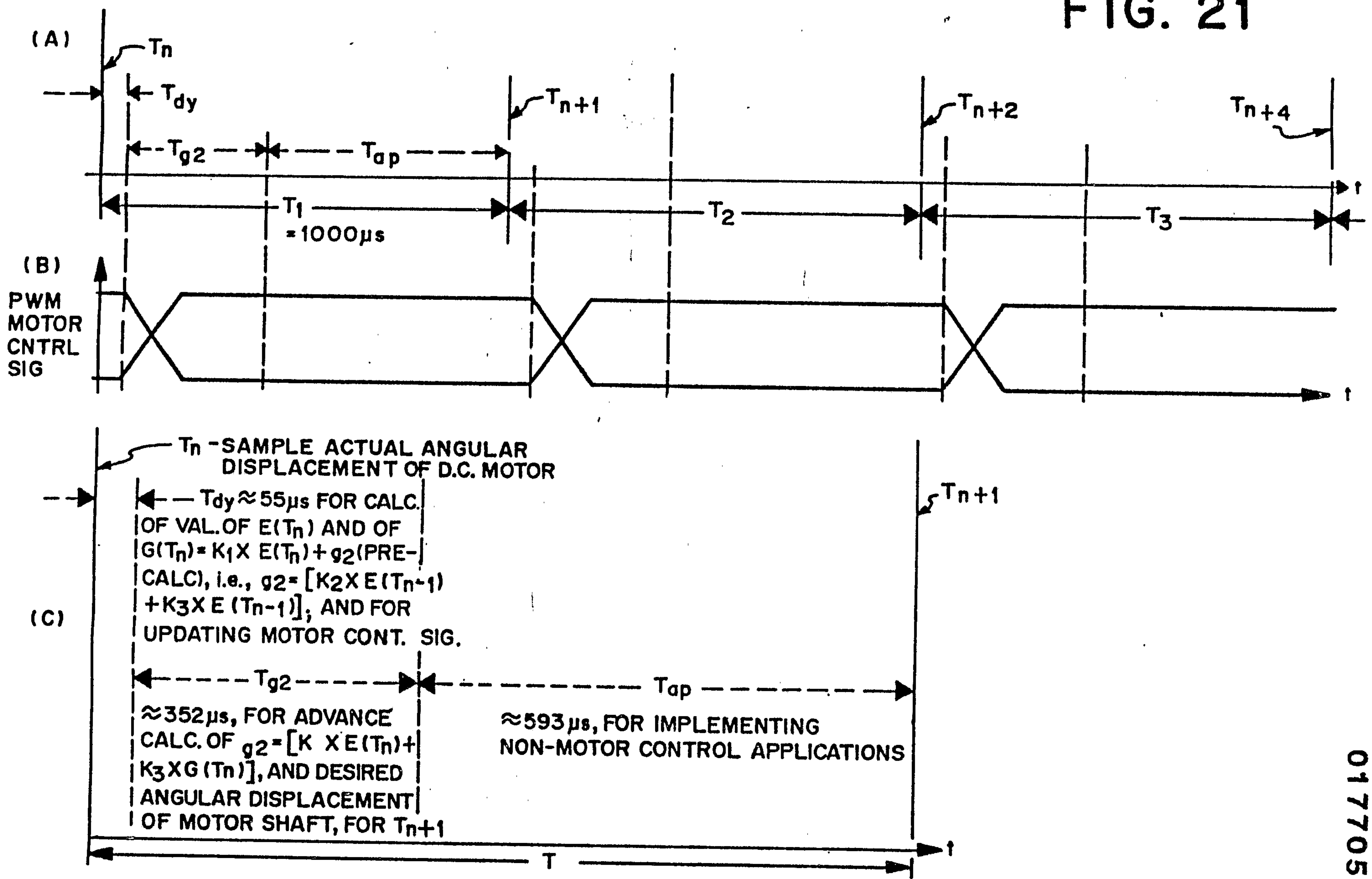
$$= K_1E(Tn) - K_2E(Tn-1) - K_3G(Tn-1)$$

FIG. 20



500
XTAL1
XTAL2
502
P3$_4$
P3$_5$
OSCILLATOR AND CLOCK
PROGRAM MEMORY
DATA MEMORY
TIMER/EVENT COUNTER
506
504
508
510
512
CPU
ALE
REGISTERS
PROGRAM COUNTER
CONTROL CIRCUITS
522
TO EACH BLOCK
Vcc
GND
RST
INTERRUPTS
518
516
514
520
PROGRAM EXPANSION CONTROL
PROGRAMMABLE I/O PORTS
PROGRAMMABLE SERIAL PORTS
INTO
INTI
P3$_2$
P3$_3$
$\overline{EA}$
PSEN
ALE
P0$_{0-1}$
P3$_{0-1}$
(TXD RXD)
P3$_6$
P3$_7$
P1$_{0-7}$
P2$_{0-7}$

FIG. 21


(A)
Tn
Tdy
Tn+1
Tg2
Tap
Tn+2
Tn+4
T1
=1000μs
T2
T3
(B)
PWM
MOTOR
CNTRL
SIG
(C)
Tn -SAMPLE ACTUAL ANGULAR DISPLACEMENT OF D.C. MOTOR
Tdy ≈ 55μs FOR CALC. OF VAL. OF E(Tn) AND OF G(Tn) = K1 X E(Tn) + g2 (PRE-CALC), i.e., g2 = [K2 X E(Tn-1) + K3 X E(Tn-1)], AND FOR UPDATING MOTOR CONT. SIG.
Tg2
≈352μs, FOR ADVANCE CALC. OF g2 = [K X E(Tn) + K3 X G(Tn)], AND DESIRED ANGULAR DISPLACEMENT OF MOTOR SHAFT, FOR Tn+1
Tap
≈593μs, FOR IMPLEMENTING NON-MOTOR CONTROL APPLICATIONS
Tn+1
T

0177057

FIG. 23a-1

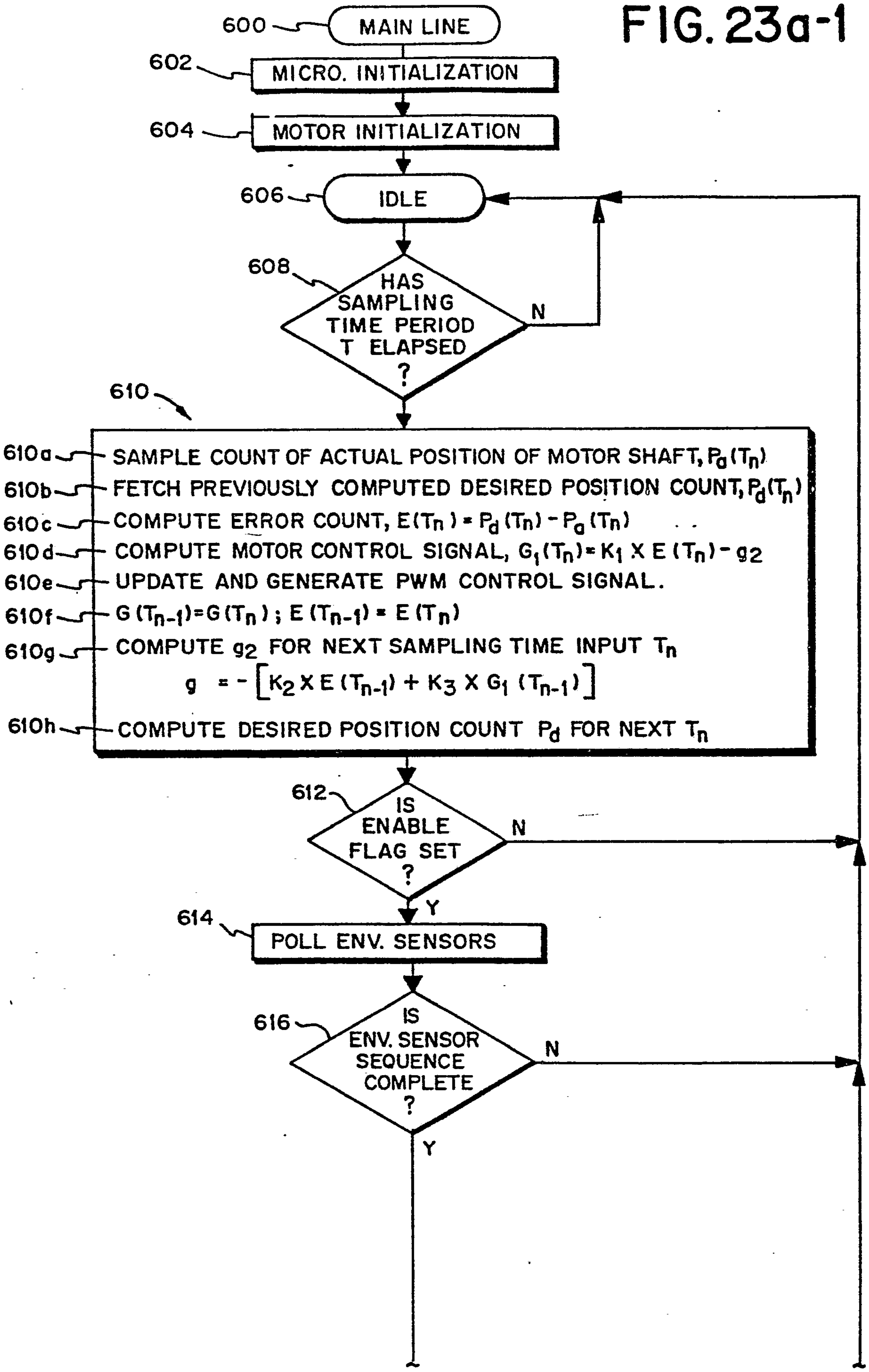
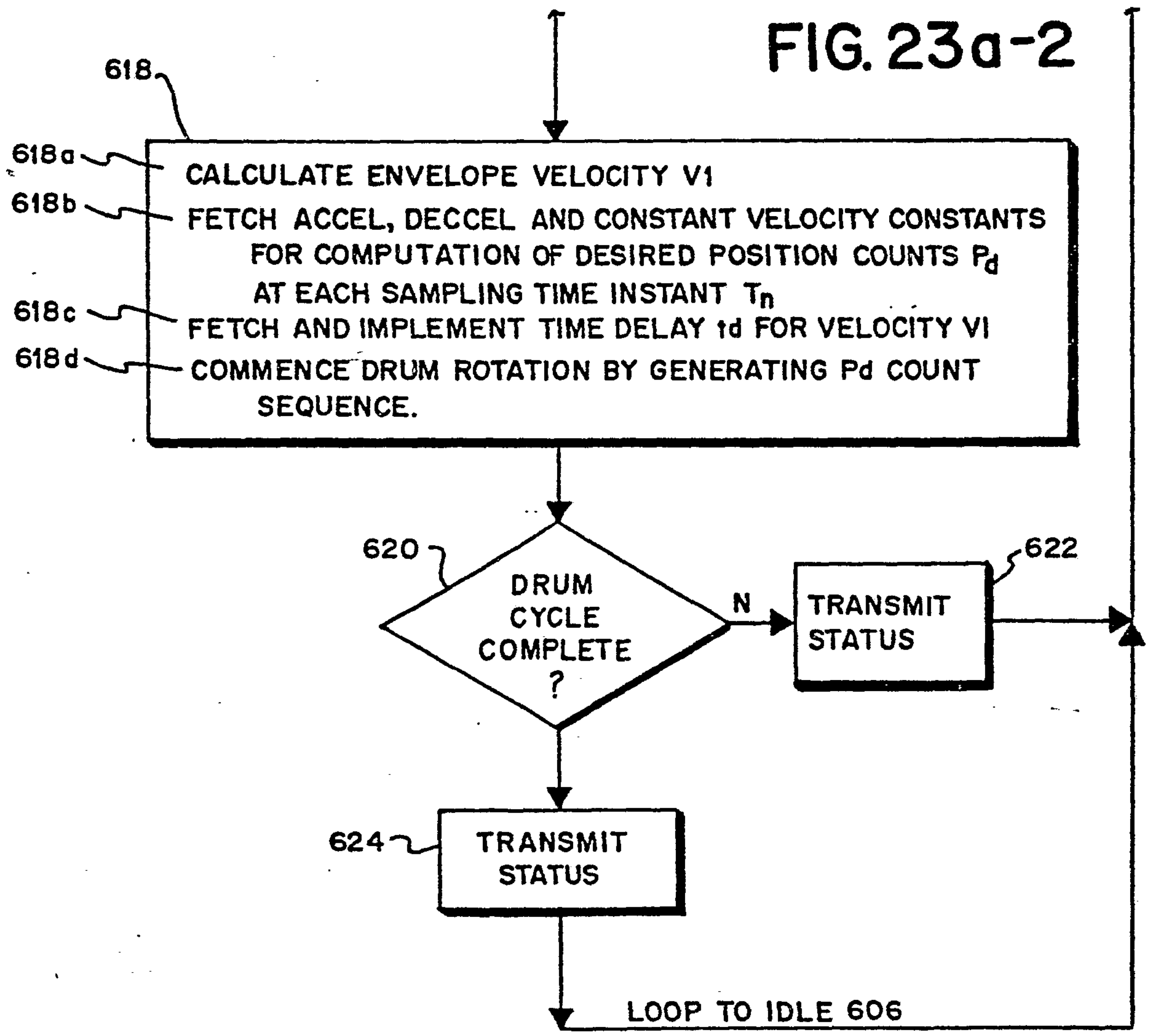


FIG. 23a-2



618
618a
CALCULATE ENVELOPE VELOCITY V1
618b
FETCH ACCEL, DECCEL AND CONSTANT VELOCITY CONSTANTS FOR COMPUTATION OF DESIRED POSITION COUNTS P_d AT EACH SAMPLING TIME INSTANT T_n
618c
FETCH AND IMPLEMENT TIME DELAY td FOR VELOCITY VI
618d
COMMENCE DRUM ROTATION BY GENERATING Pd COUNT SEQUENCE.
620
DRUM CYCLE COMPLETE ?
N
TRANSMIT STATUS
622
624
TRANSMIT STATUS
LOOP TO IDLE 606

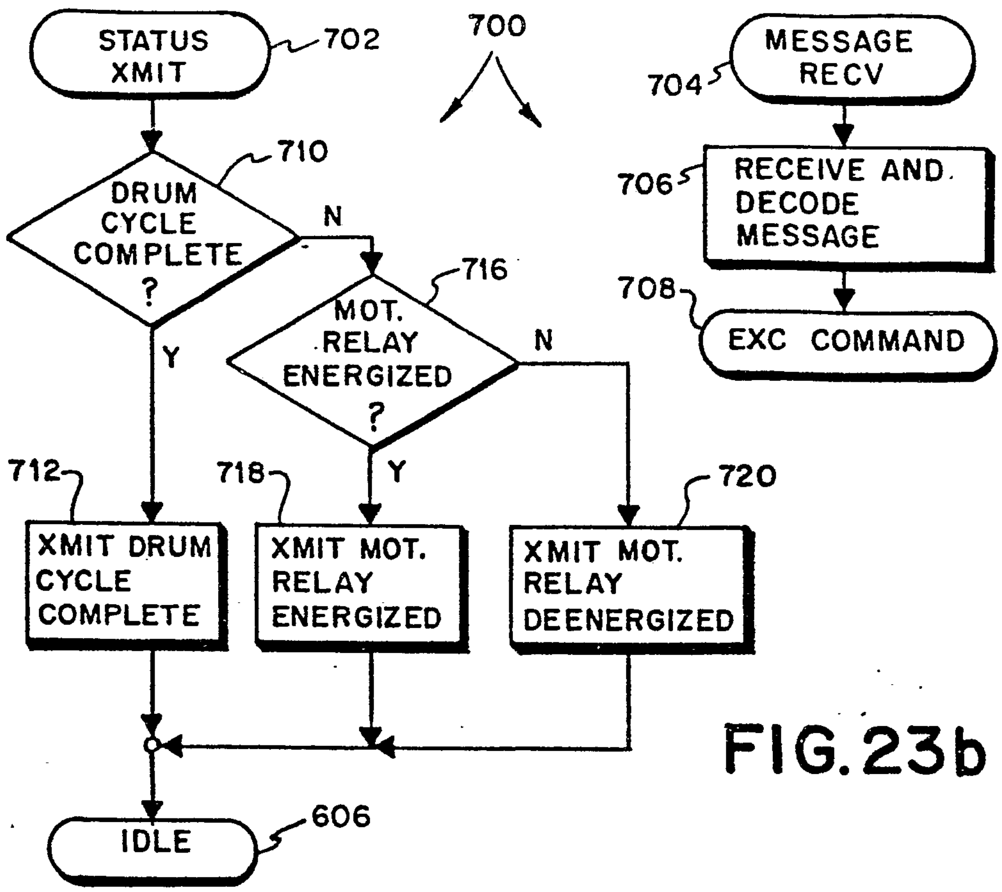


FIG. 23b

FIG. 23c