United States Patent

[11] **3,588,450**

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[21] Appl. No. **761,589**
[22] Filed **Sept. 23, 1968**
[45] Patented **June 28, 1971**

[54] **TIME FEE COMPUTER**
15 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **235/61.8R**
[51] **Int. Cl.** **G06k 15/00**
[50] **Field of Search** ..... 235/61.8, 61.603; 340/149 (A)

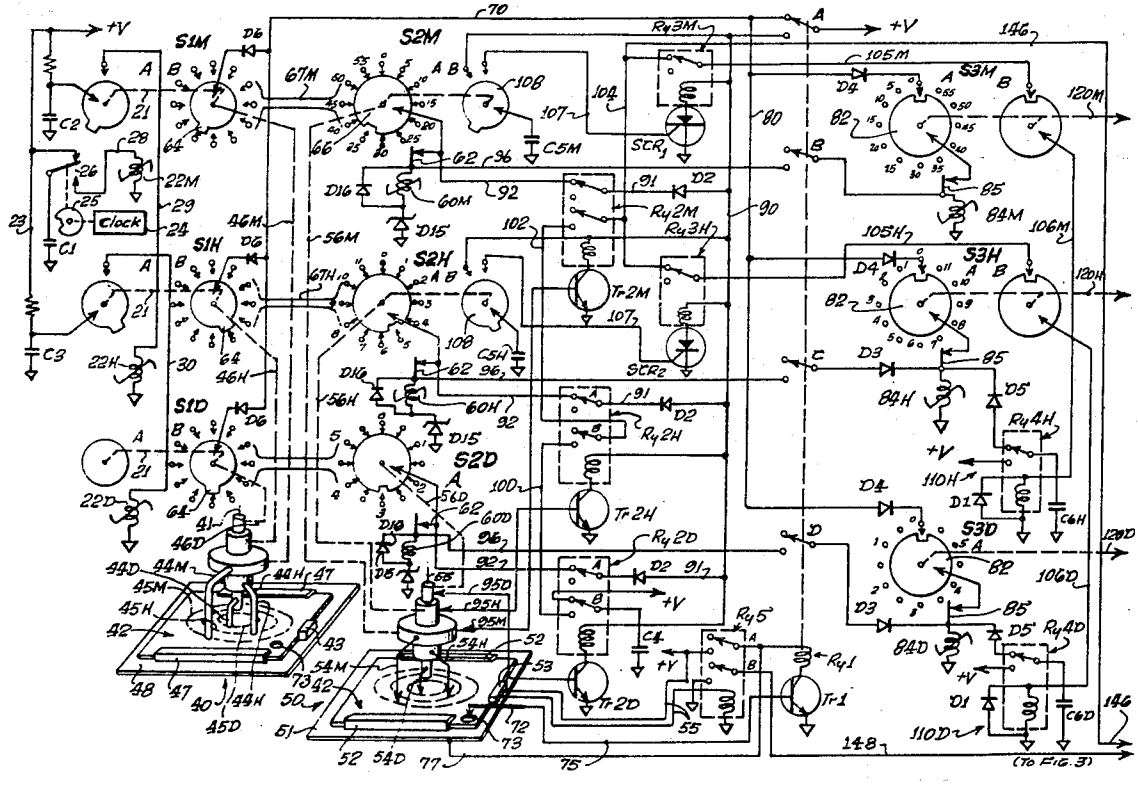
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2,913,172	11/1959	Stedelin et al.	235/61.8

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Assistant Examiner—Thomas J. Sloyan
Attorney—Charlton M. Lewis

ABSTRACT: A time fee computing system, suitable for use in parking lots and the like, utilizes as primary components conventional stepping switches having typically 12 or 24 positions. The start time is encoded digitally on a ticket in terms of the rotary position of a mark for each digit. After the elapsed time to be computed, the ticket is read by scanning the mark positions for each digit, starting at the positions that represent present time. Each scanning sensor is driven by a stepping switch, which steps forward both for maintaining the sensor normally at present time and for scanning the ticket. The elapsed time is then obtained from the complements of the numbers of steps required to find the respective marks. The cost or fee corresponding to the elapsed time is computed by stepping switches interconnected in a manner corresponding to the particular cost schedule in effect. The schedule is variable by changing the network, as by providing an interchangeable circuit unit for each desired fee schedule. For payment of the fee, a conventional coin receiver is controlled by stepping switches which compute and continuously indicate the fee remaining to be paid. The system includes circuitry for algebraic addition of values supplied as positions of stepping switches, and provides coding circuitry for translating such values into conventional decimal or other codes for display or output.



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SHEET 1 OF 6

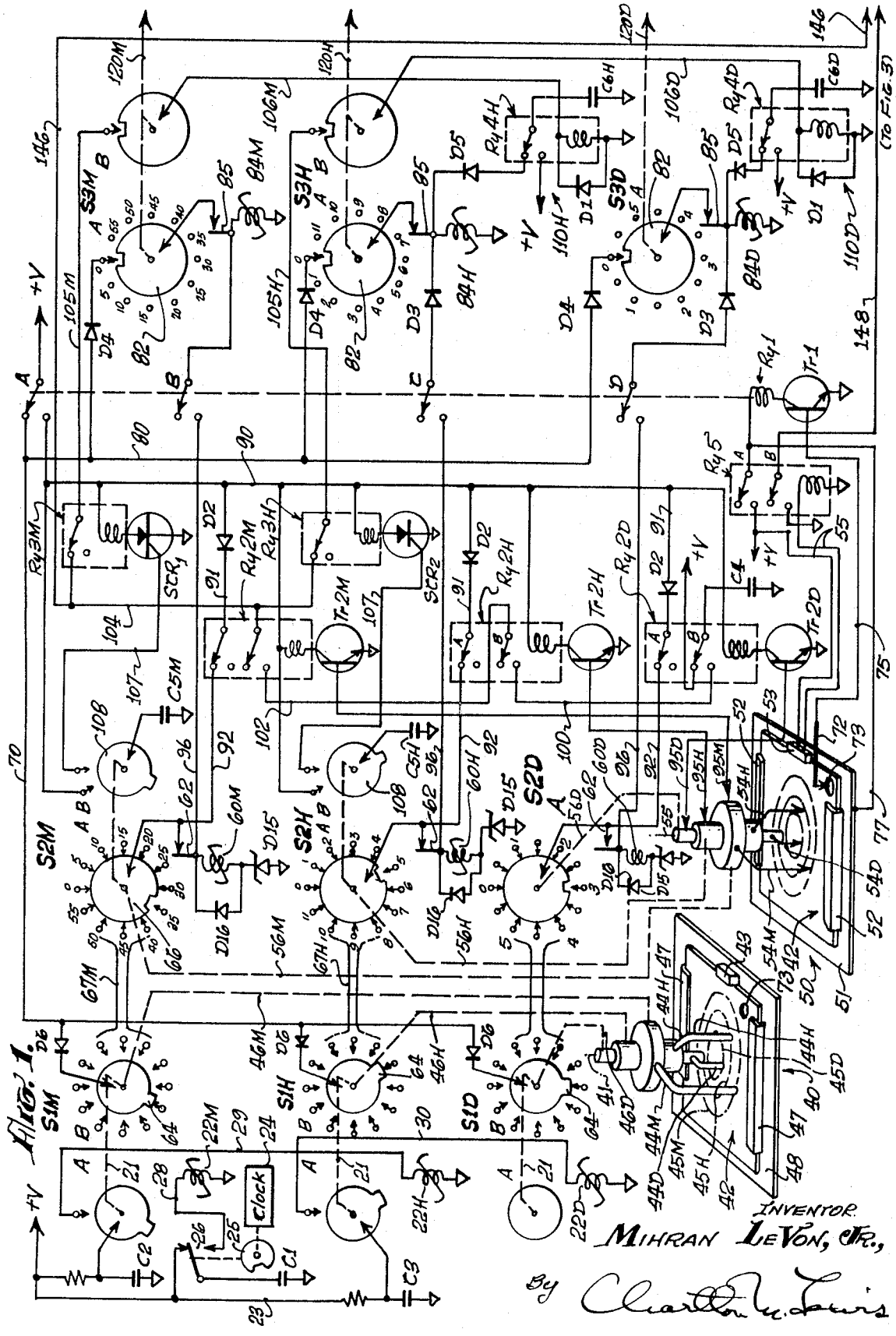
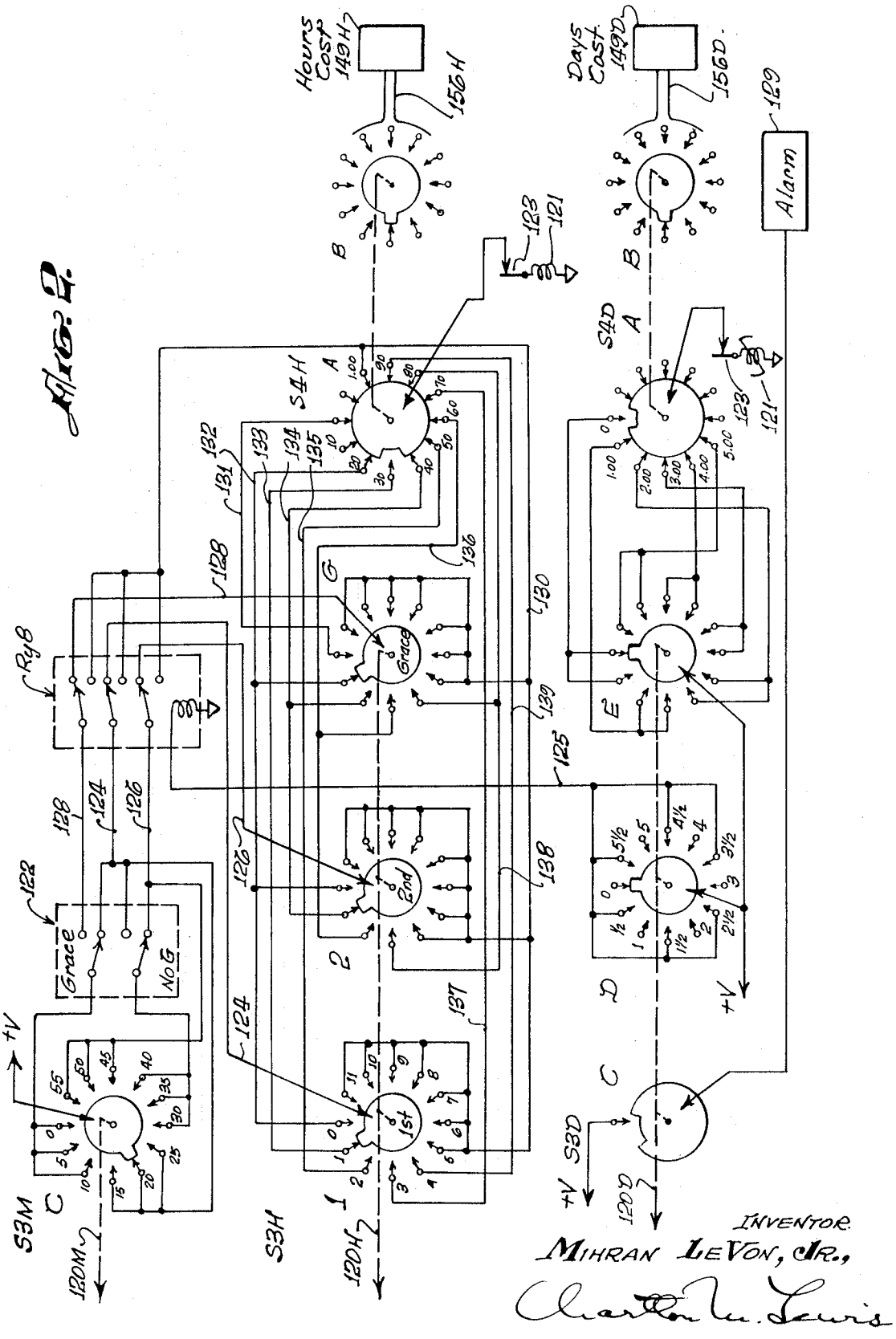


FIG. 1.

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FIG. 3.

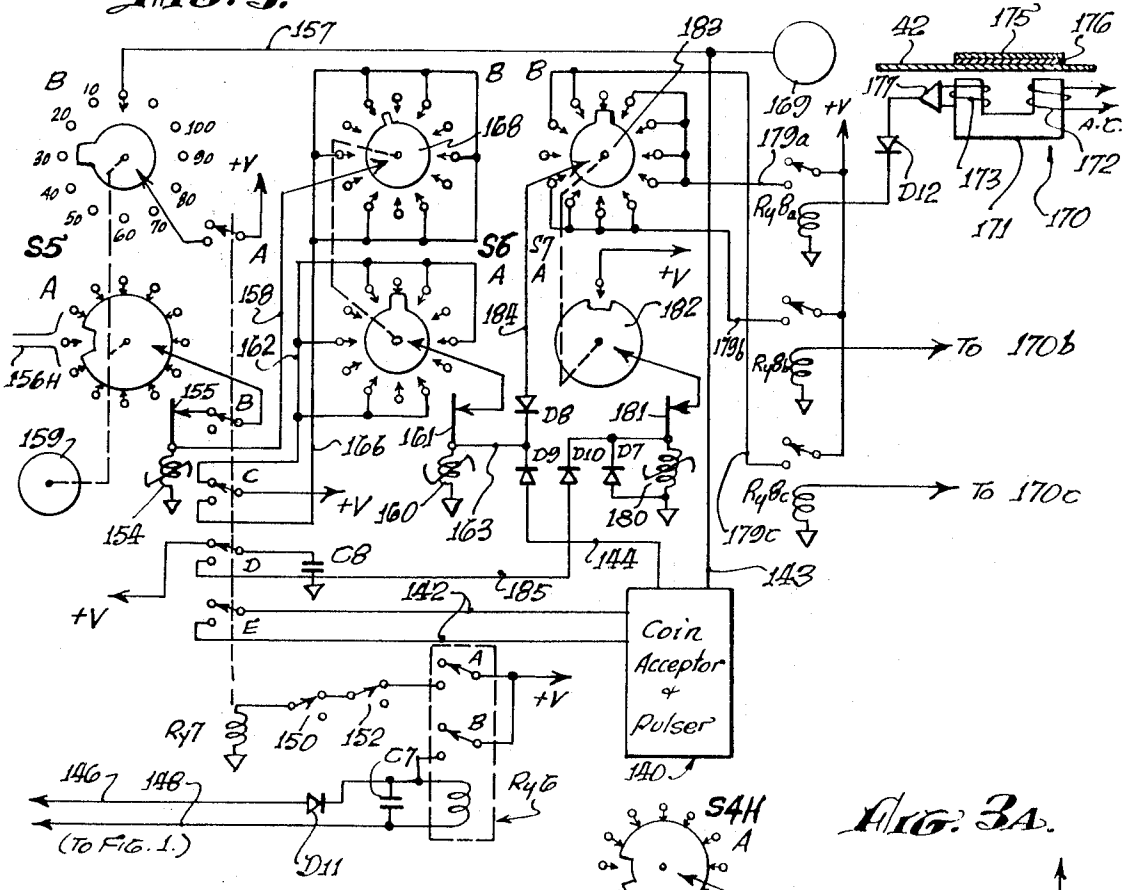


FIG. 3A.

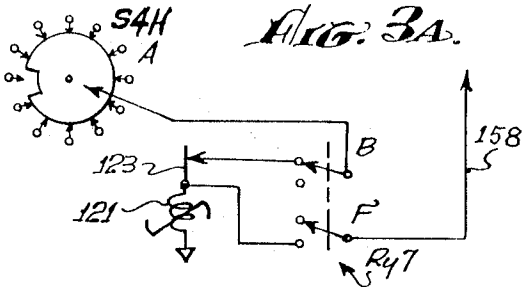
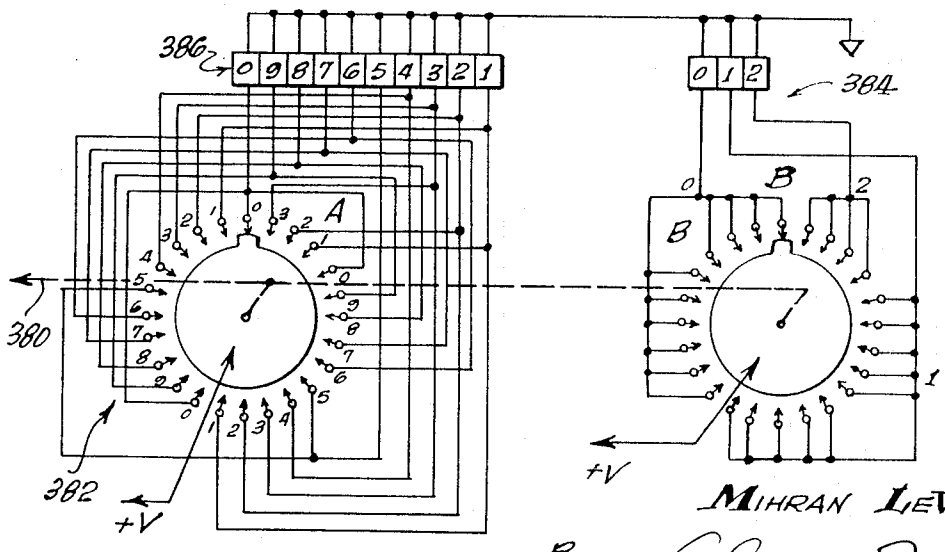


FIG. 7.



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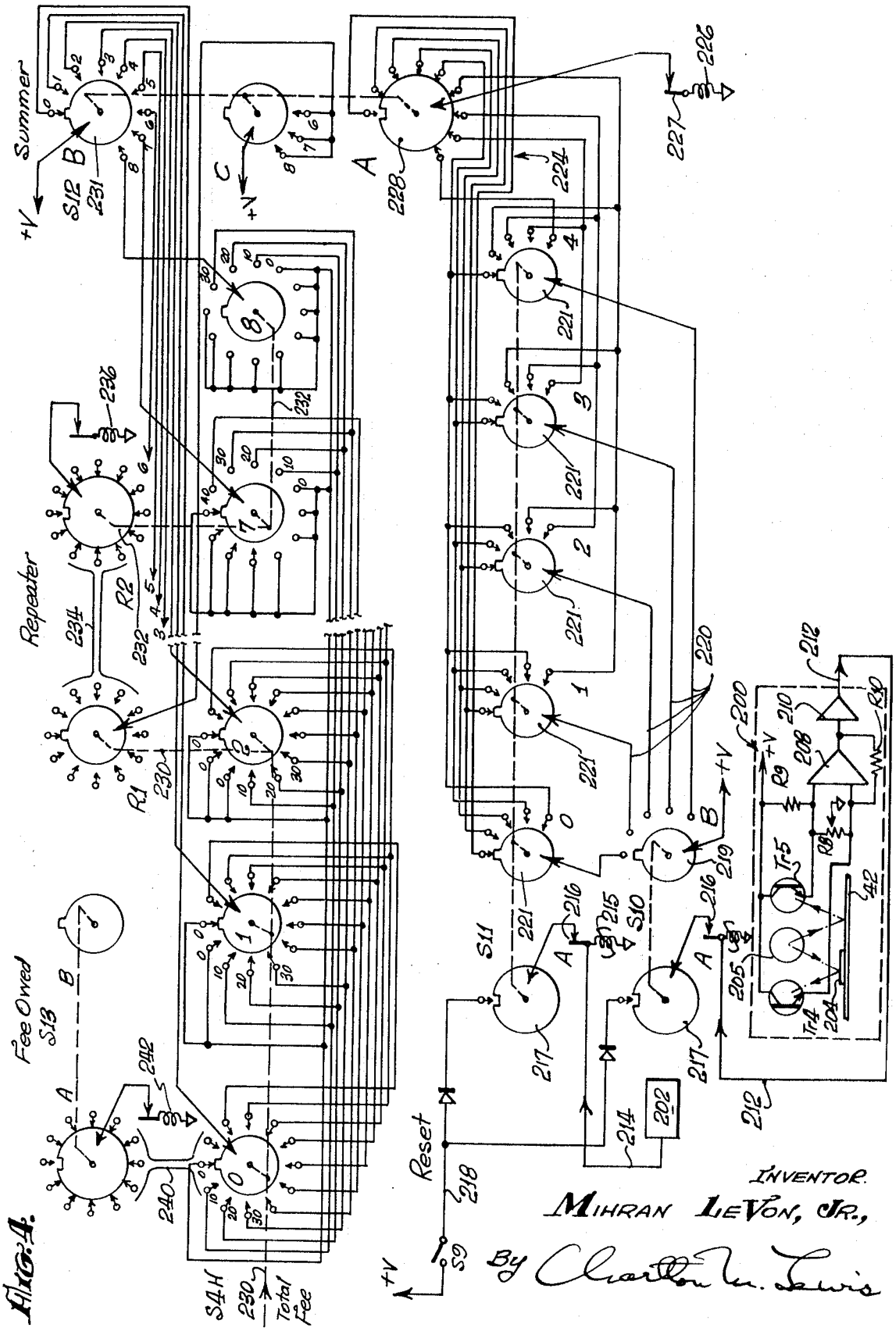
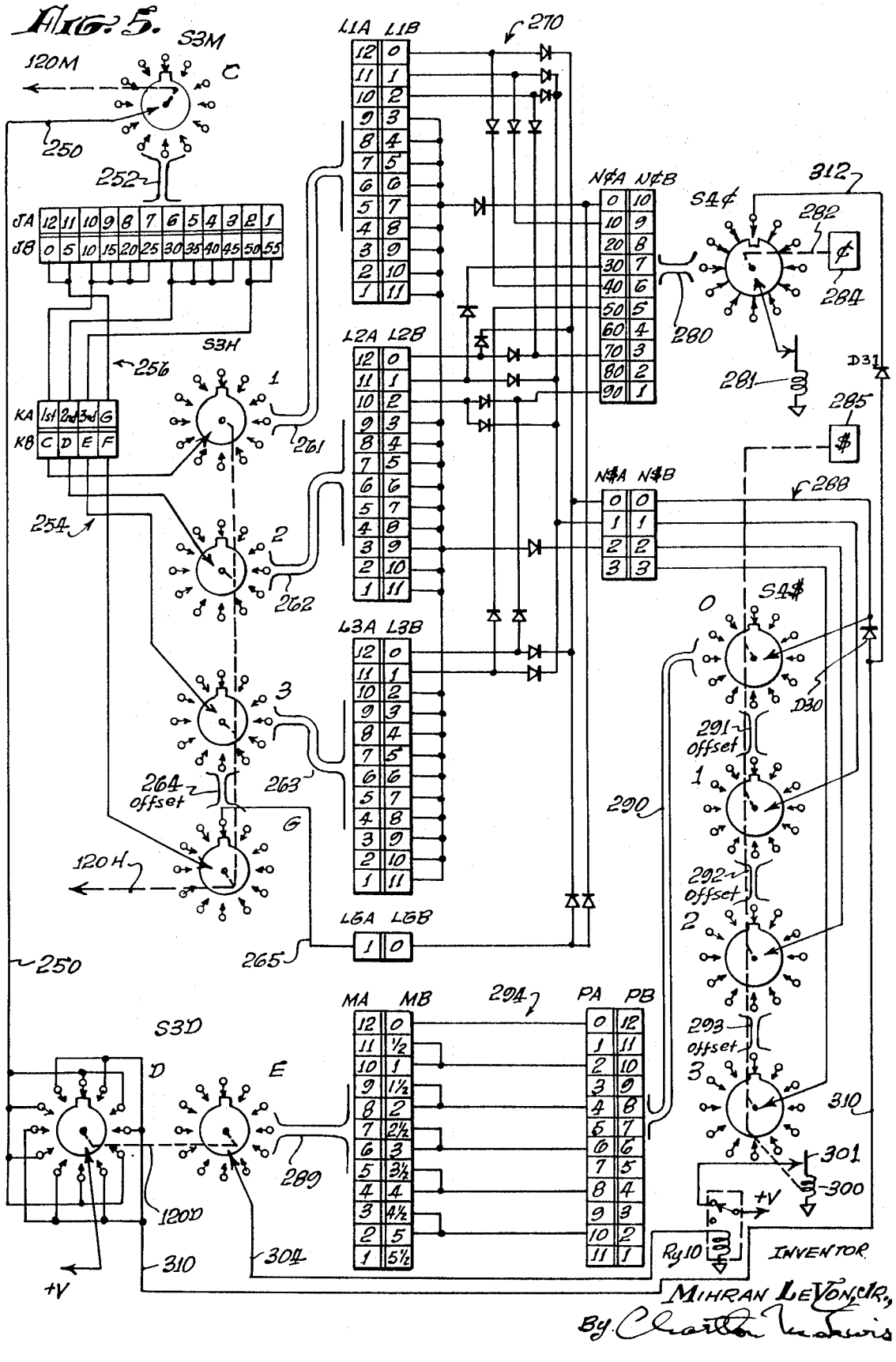


Fig. 4.

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FIG. 5.


S3M
120M
C
250
252
JA 12 11 10 9 8 7 6 5 4 3 2 1
JB 0 5 10 15 20 25 30 35 40 45 50 55
S3H
256
KA 1st 2nd 3rd G
KB C D E F
1
261
254
2
262
3
263
264 offset
G
120H
250
265
L1A L1B
L2A L2B
L3A L3B
L6A L6B
270
N¢A N¢B
280
S4¢
282
284
312
281
D31
285
N#A N#B
268
S4#
D30
290
291 offset
292 offset
293 offset
310
301
300
+V
Ry10
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MIHRAN LEVONIAN,
By Charles Lewis
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PA PB
S3D
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289
120D
310
304
+V

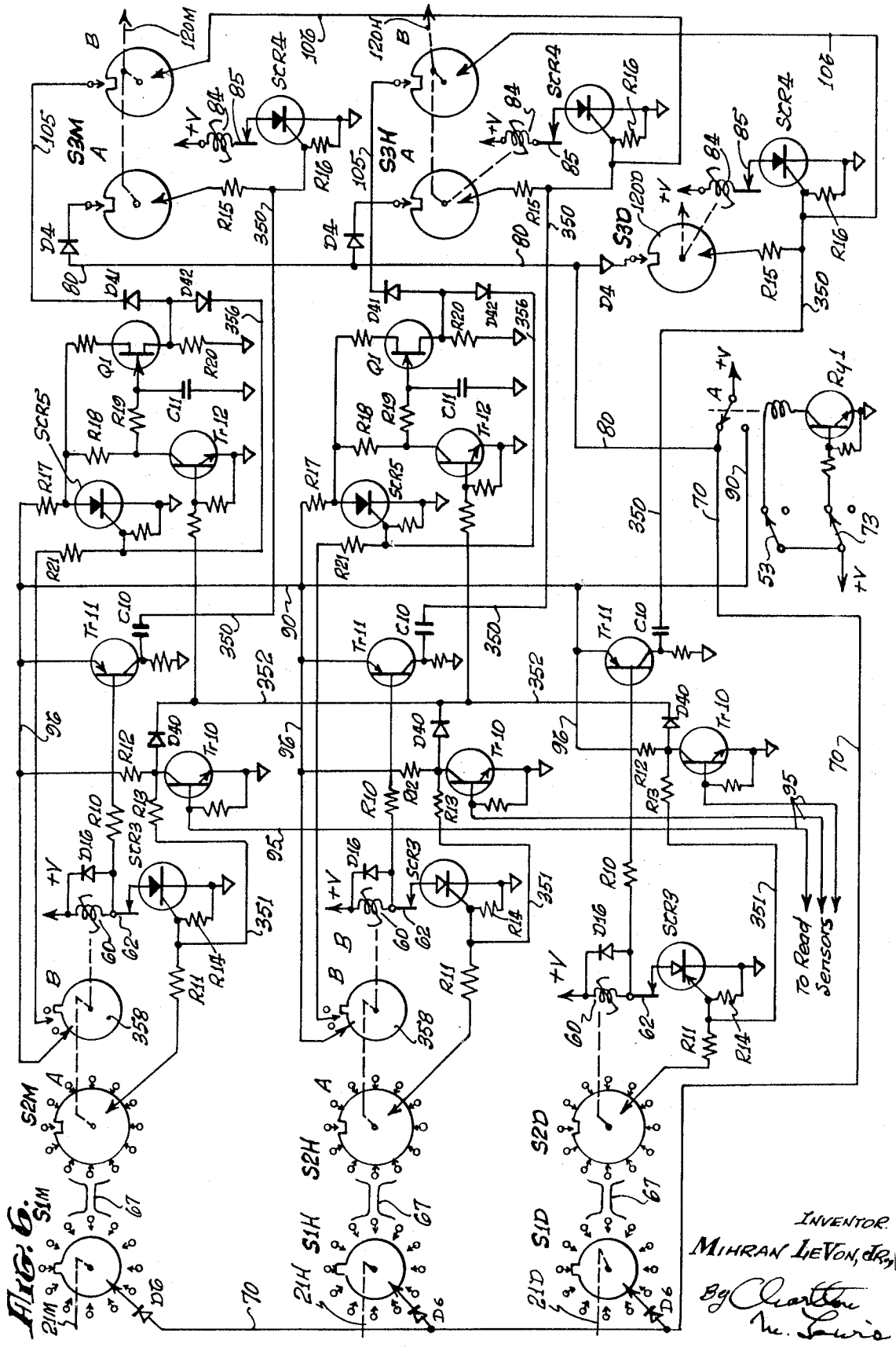


FIG. 6.

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TIME FEE COMPUTER

This invention has to do with automatic time fee computers in which a start time is recorded on a ticket in a machine-readable code, and the ticket is later processed to compare the recorded start time with present time, to compute the time difference or elapsed time, and ordinarily also to compute a fee which depends in some predetermined manner upon the elapsed time.

Such time fee computation systems are useful in a wide variety of situations in which a charge or payment is based upon an elapsed time. For clarity of description, the invention will be described especially with reference to automobile parking lot operations. In such operations the customer receives a ticket on which is recorded the start time for his parking period. On returning to his car, that ticket is read automatically, and the fee due is computed. In some installations provision is made for automatic collection of the fee due.

Many systems of the described type have been proposed, but are either inaccurate or unreliable in operation, or are so complex that they are unduly expensive to construct, operate and maintain.

The present invention utilizes a digital code for recording the start time and maintains digital techniques throughout the computation of elapsed time and other quantities such as the corresponding fee, so that, in absence of a complete malfunction, the computed time or fee is reliable accurate.

The invention provides a fee computation system which typically combines mechanical and electrical techniques in a manner permitting broad flexibility of function combined with simplicity of structure and reliability of operation.

The invention has the advantage that many of the active elements of the computation system may comprise conventional stepping switches or equivalent structures. Such stepping switches are available commercially in a wise variety of forms, and are satisfactorily reliable in operation. The invention will be described, for the sake of definiteness, largely in terms of embodiments utilizing such stepping switches. However, it is to be understood that equivalent functions can be performed by electrical circuits, especially those utilizing solid state components, and that the invention can be carried out, if desired, with such components and with essentially complete absence of moving mechanical parts.

In preferred form of the invention the start time is recorded on a ticket in terms of a plurality of digits, typically corresponding generally to minutes, hours, and days, respectively, the several values of each digit being represented by a series of positions on the ticket. A mark of any suitable type is placed on the ticket at the position that represents the value of each digit. Those positions are preferably arranged in concentric circles having different diameters for each digit. The ticket can then be read conveniently by a sensing probe that is movable in a circle to scan the successive digit values in sequence.

In accordance with one aspect of the invention, the scanning probes are normally maintained at positions that correspond to present time. Upon insertion of a ticket on which a previous start time has been recorded, the probes automatically scan from their positions corresponding to present time to the positions at which marks have been placed on the ticket to represent the start time. By carrying out that nulling movement stepwise, it is only necessary to count the steps to provide a digital measure of the elapsed time. If the marks for successive values of each digit are arranged in a row, rather than in a circle, return of the scanning probe from the end to the start of the row is counted as a step.

In accordance with a further important aspect of the invention, the described ticket scansion is carried out in the direction of ascending values of each digit, and the elapsed time is represented directly in terms of the complement of the number of steps required to null each digit. That procedure requires, however, that the counting mechanism provide a carry for each digit whenever the scanning probe for the digit of next lower significance moves without shifting between the positions representing the highest and lowest digit value.

The described representation of elapsed time by using complementary numbers has the great advantage that the stepping mechanism for driving the scanning probes is required to step only in one direction both for maintaining the described normal probe position and for carrying out the stepwise counting operation.

A further aspect of the invention provides particularly convenient circuitry for performing the described carry function.

A further aspect of the invention permits effective multiplication of the elapsed time by a cost factor to produce a representation of the required fee. Moreover that multiplying operation can be arranged to accommodate a wide variety of cost functions. For example, in computing the fee in connection with the parking of vehicles, it is often required that a grace period of several minutes be allowed without charge. It is also common practice to make a higher charge per unit time for the initial time periods than for subsequent time periods of the same length. Such irregularities in cost function can be accommodated in the present system merely by shifting the interconnections between switch terminals in the computer mechanism. A further aspect of the invention facilitates such changes by providing conveniently interchangeable plug-in units by which the rate structure can be modified.

A further advantage of the present invention is that all of the pertinent values can be visually indicated during the computation process without complex auxiliary equipment, such as is required by certain previously available systems.

A further advantage of the present system is that it can be conveniently adapted to automatic payment of the computed fee, as by insertion of coins in a conventional coin accepter which typically produces an output pulse for each 5 cents of coins inserted, for example.

The invention further includes mechanism for applying machine-readable validation markings to the ticket, automatically reading such markings and properly compensating the indicated fee due. A particular feature of the present invention is that such compensation is carried out with respect to the fee due, rather than to the elapsed time. The system thus computes an actual elapsed time, together with the fee due for that time, both of which may be recorded and utilized in desired manner.

A full understanding of the invention and of its further objects and advantages will be had from the following description of certain illustrative manners of carrying it out. The particulars of that description, and of the accompanying drawings which form a part of it, are intended only as illustration and not as a limitation upon the scope of the invention, which is defined in the appended claims.

In the drawings:

FIG. 1 is a schematic diagram representing a system for recording a start time on a ticket, later reading the ticket and computing the elapsed time;

FIG. 2 is a schematic diagram representing a system for computing a cost corresponding to an input elapsed time;

FIG. 3 is a schematic diagram representing a system for automatic collection of an input cost, with credit for validations recorded on a ticket; FIGS. 1, 2 and 3 together may represent a unitary time-cost computation and collection system;

FIG. 3A is a fragmentary schematic diagram representing a modification of portions of FIGS. 2 and 3;

FIG. 4 is a schematic diagram representing a modification of FIG. 3;

FIG. 5 is a schematic diagram representing a modification of FIG. 2;

FIG. 6 is a schematic diagram representing a modification of FIG. 1; and

FIG. 7 is a schematic diagram representing a decimal decoding system in accordance with the invention.

An illustrative time fee computation system in accordance with the invention is shown schematically in FIGS. 1, 2 and 3. FIG. 1 represents the portion of the system for recording the start time on a ticket and for later automatic reading of that time and computation of the time difference, while FIGS. 2 and 3 show the portion of the system that computes the fee

corresponding to the elapsed time and collects the fee. For some purposes either one of those system portions is useful without the other.

MECHANISM REPRESENTING PRESENT TIME

In the system, as shown, all times are represented by a code comprising three digits, one representing minutes in units of 5 minutes, the second representing hours and the third representing days in units of one-half days, as shown explicitly in connection with switches S2, to be described. With that code system each digit has 12 alternative values, permitting use of 12-position rotary switches throughout the system. If more accurate time computation is desired the digit representing minutes may be assigned 24 values corresponding to intervals of 2½ minutes each. In that case 24-position switches are used, at least for the minutes digit. To preserve uniformity under that condition, it is convenient to use 24-position switches also for the hours and days. The hours digit then preferably has 24 values, and the system can handle periods as long as 24 days. The invention is readily adaptable to a very wide variety of digital codes, that utilized by the present embodiment being purely illustrative.

In FIG. 1 present time is continuously represented in terms of the selected code by the three stepping switches S1, which pertain respectively to the digits that represent minutes, hours and days and are correspondingly designated S1M, S1H and S1D. Each of those time switches comprises an A deck and a B deck, typically mounted on a common shaft as indicated schematically by the dashed lines 21. The switches are driven clockwise, as seen in the drawing, by a conventional ratchet stepping device actuated by the solenoids 22M, 22H, and 22D, respectively. Those solenoids are typically energized by current pulses under control of a clock 24. As shown, the clock drives a cam 25 through one revolution during each 5 minute period, operation the cam switch 26. In normal position of that switch, the capacitor C1 is charged via the line 23 from an electrical power source of suitable voltage indicated as +V. That designation of other power sources throughout the present description does not imply uniformity as to voltage. Momentary operation of cam switch 26 applies charged condenser C1 via the line 28 to the grounded solenoid 22M, advancing switch S1M clockwise one step. Switch deck A of S1M acts once during each revolution to connect the charged capacitor C2 to the line 29, thereby energizing solenoid 22H and advancing the hours switch S1H. Similarly, deck A of that switch acts once each revolution to apply the charged capacitor C3 to the line 30, thereby energizing solenoid 22D and advancing the days switch S1D. The switches are shown illustratively in positions corresponding to 6 half-days, 5 hours and 35 minutes.

ENCODING MECHANISM

FIG. 1 shows schematically at 40 an illustrative device for recording present time on a ticket 42 under control of the three time switches just described. Device 40 comprises three ticket marking arms 44M, 44H, and 44D, which are rotatable coaxially about the axis 41. That rotation of the marking arms is driven in synchronism with the respective switch shafts as by coupling mechanism of any desired type, represented schematically by the dashed lines 46M, 46H, and 46D. Such coupling may include electrical follower mechanism driven by shafts 21 or directly by clock 24, or may employ a separate clock synchronized with clock 24. The marking arms 44 are arranged to move over a ticket 42 inserted between the guides 47 on the support 48 and against the stop 43. Each arm passes over a series of positions on the ticket which correspond to definite time intervals. As illustrated, the three series of mark positions for the three digits of the code lie on the circles indicated at 45M, 45H and 45D, respectively. Preprinted legends may explain the coded time marks.

Device 40 can be actuated by conventional mechanism, not explicitly shown, to cause the three arms to make suitable marks on the ticket. See, for example, U.S. Pat. No. 2,913,172 to Stedelin et al. Such actuation will normally be controlled in known manner so that it can occur only when a ticket is properly inserted, such insertion being typically sensed by a switch or other sensor, incorporated in stop 43. The recorded marks may be of many different types, including, for example, punches holes through the stock of the ticket, or spots of paint, fluorescent ink, or the like, which may be either visible or invisible, as desired. Electrically conducting ink or ink having magnetic properties that can be sensed by an electromagnetic transducer may also be used. An additional mark may identify the issuing parking lot. If tickets are issued from rolls or fan-folded stock through a "ticket spitter," device 40 is modified accordingly.

The term "mark" as used in the present specification and claims is intended to include all types of indicia which can be sensed by appropriate means. Similarly, the term "ticket," although represented schematically in FIG. 1 as a rectangular card, may comprise an element of any type whatever that can be encoded at one time and from which the recorded data can be read at a later time. The use of a flat card and the arrangement of code marks on concentric circles permits convenient and accurate scanning by a reading device, as will be described. Moreover, when visible marks are employed, such a code provides easy legibility of the recorded time by the customer without requiring additional printing mechanism.

READING MECHANISM

Mechanism for reading the start time recorded on ticket 42 at a later finish time, is represented schematically at 50. The ticket to be read is placed on the support 51 in a position accurately defined by the side guides 52 and the stop 53. When so positioned, ticket 42 closes a switch between the lines 55, completing a circuit from a source of positive voltage, indicated as +V, through the winding of relay Ry5 to ground. Operation of that relay signifies correct placement of the ticket, and performs specific control functions, to be described, through its switches A and B. Additional switches may be provided on Ry5 for further control functions as desired. Also, a ticket lock-in device of conventional type may be provided, if desired, with suitable electrical interlocks with the reading and computing system for preventing withdrawal of the ticket until completion of all required operations.

Ticket scanning elements 54M, 54H and 54D are mounted for rotation about the common axis 55 in a manner to pass sequentially over the mark positions for the respective digits. These scanning elements 54 are of any suitable type capable of detecting the marks. For example, photoelectric light sensors may be used. If the marks consist of holes punched in a card, the sensing may be pneumatic or use electrical contacts resiliently mounted and adapted to engage the flat conductive plate 51 on which the ticket is supported. That type of sensing structure will be assumed in the present description for purposes of illustration.

The scanning movement of sensing elements 54 is driven or otherwise controlled via coupling mechanisms 56M, 56H and 56D of any suitable type from the respective stepping switches S2M, S2H and S2D. Those switches are controlled by ratchet devices driven by the respective solenoids 60M, 60H and 60D which advance the associated switch one step in a clockwise direction in response to each current pulse. Each solenoid includes an interrupter switch, indicated at 62, which opens momentarily each time that a stepping impulse is transmitted to the switch S2. Hence, continuous current supply to the solenoid via interrupter switch 62 causes a continuous series of stepping operations until that current is externally interrupted. On the other hand, current applied to the solenoid without passing through switch 62 produces only a single step.

In accordance with the present invention, the reading switches S2 are subject to two distinct types of control. Under normal conditions, when no ticket is being read by the reading mechanism 50, the stepping switches are driven in follower

mode in accordance with present time. That is to say, they are continuously maintained at positions which correspond to the code representation of present time. On the other hand, when a ticket is inserted in reading mechanism **50**, the stepping switches S2 are automatically shifted to a control which causes them to scan stepwise through the total range of digit values, carrying sensing elements **54** of the reading device along with them, until those sensing elements detect the code marks carried by the ticket. That detection automatically interrupts the stepping action of the switches, and they remain stationary at the recorded time until the ticket is removed. The stepping switches are then restored to the normal control, already described, maintaining them at positions that represent present time, as illustrated. Under both types of control, the switch movement, and hence also the movement of scanning element **54**, is in the forward direction corresponding to advancing time.

In the present system, control of the reading switches is shifted between the two described conditions by energization of reading relay Ry1, which comprises the four switches A, B, C, and D. The winding of Ry1 is connected on one side via the switch A of ticket-in-place relay Ry5 to power source +V, and is connected on the other side via the transistor Tr1 to ground. To avoid crowding FIG. 1, the usual base current limiting resistor and the base return resist or are omitted for Tr1 and for the other transistors and silicon controlled rectifiers to be described. Tr1 is normally cut off, but can be rendered conductive by a positive control signal delivered to its base via the line **75** from the spring finger **72**, which detects a hole **73** in ticket 42, typically identifying the source of the ticket. Closure of switch A of Ry5 supplies power from +V to the winding of reading relay Ry1, and also via the line **77** to support **51**, enabling the sensing action of finger **72** and also of reading elements 54. Thus, in presence of a proper ticket to be read, Ry1 is operated, shifting switch A from its normal position shown, and closing the switches, B, C and D. Switch A normally applies power to the line **70** and also to the line **80**. With the relay operated, that power is removed from lines **70** and **80** ad applied instead to the line **90**.

With power applied to line **70** in absence of a ticket, the normal control of stepping switches S2 utilizes an electrical repeater system comprising switch banks B of time switches S1 and banks A of switches S2. Bank B of each switch S1 comprises a rotary selector contact **64** which engages only one of the 12 switch terminals. Switch bank A of each reading switch S2, on the other hand, comprises a rotary notch control contact **66** which engages all of the 12 switch terminals except one. The 12 terminals of bank A of each switch S2 are individually connected to the corresponding terminals of bank B of each time switch S1. That multiple connection is indicated schematically by the cable structures **67**, the detailed wire connections being omitted for clarity of illustration. With power on line **70**, that power is transmitted to the moving contact 64 of each deck B and thence via cable **67** to notch control contact 66 of the corresponding reading switch S2 whenever the switch positions do not coincide. Therefore, in absence of coincidence, power is supplied from notch control contact 66 via interrupter switch **62** to stepping solenoid **60**, stepping the reading switch S2 forward. That stepping action continues for each switch S2 until coincidence with the timing switch S1 opens the circuit. That action normally maintains each of the reading switches S2 continuously in coincidence with the corresponding timing switch S1. Any suitable mechanical or other drive from clock **24** or another clock may replace the follower action from switch S1, as illustrated. Sensing elements **54** of reading device **50** are similarly maintained at present time.

When a ticket to be read is inserted in reading device **50**, operation of Ry1 deletes power from line **70**, effectively isolating reading switches S2 from the above-described normal follower control action. Instead, they are subjected to control from the line **90**, to which power is applied by switch A of operated relay Ry1. That control is conditioned by the respective coincidence relays Ry2M, Ry2H and Ry2D, which have their windings connected between line **90** and the grounded transistors Tr2M, Tr2H and Tr2D, respectively. The respective transistor bases are connected via the lines **95** to the corresponding reading sensors **54** of reading device **50**. In presence of a ticket to be read, positive voltage is applied to support **51** via operated Ry5. Hence whenever a sensor **54** contacts support **51** through a punched hole, its transistor is rendered conductive, operating the associated coincidence relay Ry2.

The stepping solenoids of the respective reading switches S2 are connected to line **90** via their interrupter switches **62**, the lines **92**, the normally closed switches A of the respective coincidence relays Ry2 and the lines **91**. So long as relays Ry2 are idle, as shown, those connection produce continuous stepping of the reading switches S2. That stepping movement of each S2 causes corresponding rotary drive of the ticket reading sensor **54**. All three sensors **54** typically scan simultaneously over their respective series of mark positions on the ticket. As each of the sensors reaches the recorded mark a coincidence signal is supplied via the sensor and one of the lines **95**, rendering the transistor Tr2 conductive and operating Ry2. That relay operation opens the circuit to line **92**, terminating the described stepping operation of that reading switch S2. All of the reading switches therefore are stepped to positions corresponding to the recorded marks on ticket **42**, and remain at those positions until reading relay Ry1 is released.

ELAPSED TIME COUNTING MECHANISM

With reading relay Ry1 in normal released condition, power is supplied by its switch A not only to line **70** but also to the line **80**. The three counting switches S3M, S3H and S3D have each a deck A with a single switch terminal at zero position. The notch control **82** engages that terminal whenever the switch is displaced from zero position. Power is thereby transmitted from line **80** to the switch operating solenoid **84** via the interrupter switch **85**, producing repeated stepping movements of the counting switch until it is returned to zero position. Accordingly, under normal conditions the three counting switches S3 are maintained at zero position, as shown in FIG. 1. Upon insertion of a ticket to be read, that control is disabled by lifting of power from **80**. Counting switches S3 are then controlled instead in accordance with the stepping action of reading switches S2, already described.

During the stepping action of each reading switch S2, the power pulses delivered to stepping solenoid **60** through switch **62** are supplied also via the line **96** and one of the switches B, C or D of operated Ry1 to stepping solenoid **84** of the corresponding counting switch S3. That is to say, each stepping solenoid **84** of a counting switch S3 is connected in parallel with the stepping solenoid **60** of the corresponding reading switch S2. Full response of S3 to each pulse from the interrupter of S2 is insured by slowing the response of S2, both by reducing the effective voltage by series connection of zener diode **D15**, and by shunting through diode **D16** the inductive voltage that the solenoid generates when the circuit is interrupted. Since each of the reading switches S2 was initially at a position representing present time, the number of steps imparted to it and to the corresponding counting switch corresponds to the difference between present time and the start time that was recorded on ticket **42**.

However, that number of counts does not directly represent the elapsed time between the recording and reading operations, since, in preferred from of the invention, reading elements **54** scan the sequence of mark positions on the ticket in ascending order, represented in FIG. **1** by clockwise movement. The present invention overcomes that difficulty by the simple expedient of translating the stepping action of counting switches S3 to provide an output that represents the complement of the number of steps, rather than the number of steps itself. As will become clear presently, that complementing

function requires only that the successive switch positions of counting switches S3 be numbered counterclockwise, in contrast to their clockwise stepping movement. That complementary numbering is indicated for the A decks of counting switches S3.

The complementing action just described requires that correct account be taken of the normal carry function that occurs in any counting operation involving multiple digits. For a normal carry, one count is added to each digit when the digit of next lower significance advances to zero. The present invention provides the functional equivalent of that conventional carry, under the special condition of the described complementary numbering system, by adding a count to the stepping action of each counting switch except when the digit of next lower significance passes to or through zero position during the reading action or has no count at all. That carry may be added in any desired manner to the direct count recorded by counting switches S3. In the preferred system of FIG. 1 the carry is accomplished by providing circuitry which normally produces a carry for both the hours and days digits, in combination with circuitry for disabling that normal carry in response to passage of the appropriate reading switch S2 to or through zero position. The carry is also disabled whenever the total count for the digit of next lower significance is zero.

The combination of the direct count and the described carry will be referred to as the effective count. It represents the effective numbers of intervals between mark positions traversed by the respective sensors S4 in moving forward from their present time positions to coincidence with the ticket code marks that represent the starting time. The elapsed time is obtained by complementing the effective count.

The present illustrative circuitry for producing the required carry counts includes the capacitor C4, which is normally charged via switch B of idle relay Ry2D. Upon completion of the scan operation for all three digits, leading to operation of all three coincidence relays Ry2, C4 is connected via the B switches of all three relays and the lines 100 and 102 to the line 104. From that line two parallel circuits are provided (under suitable conditions) for supplying carry pulses to the stepping solenoids 84H and 84D. Those circuits include the A switches of the respective carry inhibit relays Ry3M and Ry3H. Those circuits also include in series the respective lines 105, the B decks of the counting switches S3, the lines 106 and the delay devices 110H and 110D comprising the relays Ry4H and Ry4D. Hence a carry pulse is delivered to stepping solenoid 84H of the hours counter, for example, only if carry inhibit relay Ry3M is idle and only if the minutes counter S3M has performed at least one counting step. A corresponding condition applies to delivery of a carry pulse to stepping solenoid 84D of the days counter.

Carry inhibit relays Ry3M and Ry3H have their windings connected in series with the respective silicon controlled rectifiers SCR1 and SCR2 between the line 90 and ground. Each SCR has its gate connected to the line 107 and is controlled from the B deck of the corresponding reading switch S2M or S2H. Each of those decks has a rotary selector element 108 that charges the capacitor C5 from line 90 via the contact at the prezero position, and discharges that capacitor into the line 107 upon reaching the zero position. The resulting pulse on line 107 triggers the SCR into its high conduction mode, operating the carry inhibit relay Ry3. That relay continues operated due to the holding action of the SCR until power is deleted by release of Ry1 upon removal of the ticket from reading device 50. Therefore, if either reading switch S2M or S2H passes to or through zero position during a reading operation, the associated carry inhibit relay Ry3 is operated, and remains operated after reading has been completed. The carry pulse for the digit of next higher significance is therefore stopped at switch A of the operated carry inhibit relay.

Also, if there is zero count in reading either the minutes or hours digit, counting switch S3M or S3H remains at zero position throughout the counting operation, and the carry pulse to the digit of next higher significance is stopped at the open switch of the B deck of that counting switch.

On the other hand, if neither of those carry inhibiting conditions exists, a carry pulse is supplied from C4 via one or both of the delay relays Ry4 to the counting switches S3, that carry action taking place after completion of the regular count. The purpose of the time delay relays is to insure correct operation of the counting steppers 84 by allowing full recovery of their ratchet mechanisms after completion of the regular count and before the carry count pulse is injected. Whereas many types of delay mechanisms might be employed, the illustrated delay relays are simple and reliable, and have the further advantage of deriving the step pulses for the respective steppers 84H and 84D from the independent capacitors C6H and C6D, rather than from the common capacitor C4. The charge on C4 can readily operate the two relays in parallel, which requires far less current than would be needed for operation of two stepping solenoids in parallel. The windings of those relays are shunted by the diodes D1, which slow the release of the relays. Operation of one of the time delay relays charges the associated capacitor C6 to a positive potential, shown as 26 volts, and release of the relay causes discharge of the capacitor through the stepping solenoid 84H or 84D, driving the counting switch S3H or S3D through the desired carry step.

The diodes D2 through D6 are inserted in the positions shown in FIG. 1 to prevent the flow of undesired currents through so-called sneak paths. More specifically, diodes D2 prevent stepping pulses supplied from one of the reading switches S2 to its stepping solenoid 60 from reaching the stepping solenoid of another reading switch via the associated lines 92 and line 90. Diodes D3 prevent stepping pulses supplied to the stepping solenoid 84 of a counting switch S3 via a time delay relay Ry4 from reaching the stepping solenoid 60 of the corresponding reading switch S2 via line 96. Diodes D4 prevent stepping pulses supplied to one of the solenoids 84 during the counting operation, whether via relay Ry1 or via the associated time delay relay Ry4, from reaching another solenoid 84 via the two switch decks A and line 80. Diodes D5 prevent C6 from slowing the stepping action of solenoids 84 in response to positioning and regular counting pulses. Diodes D6 prevent signals from deck A of switches S2 from reaching line 70 during the reading operation when Ry1 is operated.

To summarize briefly the operation of FIG. 1, time switches S1 and reading switches S2 when under normal control are maintained at positions representing present time. Counting switches S3 are normally maintained at zero position. A ticket 42 can be inserted in recording device 40 at any time, which serves as start time for that ticket. Upon later insertion of that ticket in reading device 50, reading switches S2 are transferred to reading control, and are caused to scan progressively in a forward direction over the ticket mark positions from present time to the previously recorded start time. Counting switches S3 are simultaneously stepped from zero to positions that represent, in terms of the described complementary numbering system, the elapsed time. That elapsed time is available as an output on the switch shafts or other coupling devices represented at 120M, 120H and 120D, and can be supplied as input to the cost computing system of FIG. 2, or to any other display, computing or other utilization mechanism that may be desired.

FEE COMPUTING MECHANISM

FIG. 2 represents an illustrative computing system for converting the elapsed time represented by the three counting switches S3 of FIG. 1 to a corresponding cost figure on the basic of a predetermined time-cost relationship. For illustration it is assumed in connection with FIG. 2 that the selected time-cost relation involves the following features:

a. A general charge of 10 cents per one-half hour;
b. A minimum charge of 20 cents;
c. A maximum charge of $1.00 during any one day;
d. Optional availability of a 10 minute grace period.

From the following description of FIG. 2, it will be obvious that a very wide variety of time-cost relations can be handled in accordance with the present invention.

For clarity of illustration, FIG. 2 assumes that switches S3 of FIG. 1 directly carry the additional decks shown in FIG. 2, which are utilized for cost computation. It will be understood, however, that those switch decks of FIG. 2 might be remotely mounted and coupled mechanically, electrically, or otherwise to the appropriate counting switches of FIG. 1. As shown in FIG. 2, the minutes counting switch S3M requires only a single additional deck, denoted C; hours counting switch S3H requires three additional decks, 1, 2 and G; and days counting switch S3D is shown with extra decks C, D and E. FIG. 2 includes also the total fee register which comprises the two rotary switches S4H and S4D. Each of those switches is provided with a grounded stepping solenoid 121 and interrupter switch 123. When energized via a single contact of the switch deck A, solenoid 121 steps S4 clockwise to the position of the energized contact. The contacts represent respective amounts of cost, and are illustratively labeled in terms of cents. Switches S4 include also B decks which function solely as transfer switches, and may be replaced by other coupling mechanisms. The counting switches are shown illustratively in FIG. 2 in respective positions corresponding to zero days, 1 hour and 20 minutes. It is noted, however, that those same counting switches are all shown in FIG. 1 at zero position.

The computing system of FIG. 2 is shiftable by means of the manual switch 122 between a condition in which a grace period of 10 minutes is permitted, and a condition in which no grace period is allowed. The switch is shown in its position for no grace period, and that condition will be first described.

Since the fee is based on a half hour unit, which corresponds to only half of the time unit represented by a full revolution of minutes counting switch S3M, the terminals of computing deck C of the latter switch are divided into two main groups, one including times from 0 to 25 minutes and corresponding to an odd number of half hour intervals, and the other including times from 30 to 55 minutes and corresponding to an even number of half hour intervals. The switch terminals of the first group are connected in parallel to the line 124, which supplies power to the selector of deck 1 of hours counting switch S3H, to which it is connected via the idle relay Ry8, to be described. The terminals of the second group are connected to the line 126, which similarly supplies power to the selector of deck 2 of the hours counting switch. The respective terminals of decks 1 and 2 are connected via the lines 130 through 139 to selected terminals of total fee register S4H, as shown, in accordance with the required time-cost relationship. In the present instance, each terminal of deck 2 is connected, in general, to a terminal of S4H representing a 10-cent higher fee than is the corresponding terminal of deck 1. However, both the 1 and 2 decks have all terminals from 5 to 11 hours connected via the line 130 to the common terminal of S4H that represents the maximum fee of $1.00. Also, the zero terminals of both the 1 and 2 decks are connected via the line 132 to the 20-cent terminal of S4H, corresponding to the prescribed minumum fee.

With the minutes switch recording 20 minutes and the hours switch recording 1 hour, as shown, the time is within the first half hour of the second hour. Power is supplied to deck 1 and then via line 133 to the 30-cent contact of computer drum S4H, corresponding to three half hour intervals. On the other hand, if the minutes switch were in the second half hour, deck 2 would be energized, supplying power via line 134 to the 40-cent position of the fee register, corresponding to four half hour intervals. A corresponding relationship will be seen to hold for each hour count up to 4 hours.

Above 4 hours, all terminals of both decks 1 and 2 are connected to the $1.00 terminal of fee register S4H, providing the required $1.00 maximum charge. It is noted that additional increments of charge can be readily provided, if required, by replacing the switch S4H by a stepping switch having the necessary number of additional positions.

With zero hours count on decks 1 and 2, power is supplied from both those decks to the 20-cent terminal of the fee register. The cost is thus identical regardless of whether the minutes switch deck C is in a position from zero to 25 minutes or in a position from 30 to 55 minutes. Thus, the required 20-cent minumum charge is provided by connection of the zero terminal of deck 1 to the 20-cent terminal of S4H rather than to its 10-cent terminal.

If now switch 122 is considered to be shifted to the position designated "grace," the terminals representing 30, 35 and 40 minutes, respectively, of switch S3M are transferred from line 126 to line 124. That change reduces the charge recorded by register S4H by 10 cents, which is the charge corresponding to one half hour time unit, thus providing a grace period when the elapsed minutes exceed one-half an hour by up to 10 minutes. However, a grace period at the beginning of each hour cannot be provided as simply, since mere transfer of the zero, 5 and 10 minute terminals of S3M from line 124 to line 126 would increase the charge by 10 cents instead of diminishing it.

To provide a grace period at the start of each hour, the present invention provides the additional deck G on the hour counting switch S3H. When a grace period is desired, the first terminals of the minutes switch are connected via the line 128 to the selector of that deck G. Each of its terminals from 1 to 5 hours is connected to the next lower terminal of deck 2. Hence, with the hours switch at 1 hour, for example, as shown, power supplied from deck G to the fee register represents a cost 20 cents less than if supplied via deck 2, and 10 cents less than if supplied via deck 1 as would be the case for no grace period.

Next described is the fee-computing action of day counting switch S3D, as shown illustratively in FIG. 2. During every odd half-day of the elapsed time, deck D of that switch closes a circuit that applies power to the line 125, operating the relay Ry8. Operation of that relay lifts power from decks 1, 2 and G of hours counting switch S3H and connects the lines 124, 125 and 128 via the line 127 to the maximum fee contact ($1.00) of fee register S4H. Hence, during the second 12 hours of each day the fee remains independent of the hours switch. It is noted, however, that if the fee schedule does not reach a daily maximum during the first 12-hour period, relay Ry8 can be arranged to connect lines 124, 126 and 128 to a second set of switch decks, say 1', 2' and G', which are similar to 1, 2 and G of S3H and similarly driven, but which are wired in accordance with the rates for the second half-day. Under that condition, register switch S4H will ordinarily require more than the 12 positions illustrated.

If the elapsed time exceeds 24 hours, deck E of S3D closes a circuit which supplies power to one of the contacts of fee register S4D, stepping that register to the corresponding position and registering a fee of $1.00 for each full day of the elapsed time. That fee is due in addition to the fee registered by switch S4H. Whereas the charge by suitable mechanism, the present illustrative system segregates the two components of the charge, thus facilitating collection of the two components in different manners. For example, mechanism can be provided for collecting the hours charge automatically (FIG. 3), while the days charge is collected by an attendant. In order to alert the attendant for the latter purpose, deck C of switch S3D is arranged to energize the alarm 129 whenever the elapsed time exceeds 24 hours. If desired, the power supplied to alarm 129 can also operate a relay, not shown, which transfers the illustrated connection of the zero terminal of deck 1 of S3H from line 132 (representing a 20-cent fee) to a new line connected to the 10-cent terminal of S4H, thus eliminating the 20-cent minumum charge at the start of each new day.

FEE COLLECTION MECHANISM

With switches S4 representing the total fee due, transfer deck B may be employed to drive an indicating device 149 of any desired type for visually indicating the fee due, for record-

ing the fee due as a charge to be paid later, or for otherwise utilizing the information. The present illustrative system includes mechanism for automatic collection of the hour rate portion of the fee due by means of a coin accepting device of conventional type. That portion of the present system is represented schematically in FIG. 3.

In FIG. 3 the numeral 140 designates a coin acceptor and pulser of known construction. In presence of an activating input signal, on the line 142, coin acceptor 140 displays a "ready" signal and receives coins of any denomination, producing on the line 144 one pulse for each 5 cents worth of coin received. Money so deposited in coin acceptor 140 is initially retained in escrow subject to return to the customer upon deletion of the activating signal. As money is deposited in coin acceptor 140, the fee due register switch S5 continuously represents the amount of the hourly fee remaining to be paid. The money is finally retained only in response to a fee-paid signal supplied via the line 143 from deck B of S5. In absence of an activating signal on lines 142, any coin inserted is simply returned. The activating signal may be developed in any suitable manner, typically indicating coincidence of such conditions as presence of a properly positioned ticket in reading device 50 (FIG. 1) and completion of the computation described in connection with FIGS. 1 and 2.

In the present system, the relay Ry6 has its winding connected on one side to ground via the line 148 and switch B of relay Ry5 (FIG. 1) when the latter is operated by presence of a ticket in reader 50. The other side of the winding of Ry6 is connected to line 146, which receives the carry pulse from line 104 of FIG. 1 upon completion of the ticket reading operation. Ry6 has its winding shunted by the capacitor C7, which delays operation of the relay for a time sufficient to insure completion of any carry steps of counter switches S3, and settling of total fee register S4 of FIG. 2 after the final count. Once operated in response to completion of the computation, Ry6 is held via its switch B until its ground connection is opened by removal of the ticket from reader 50.

The fee count relay Ry7 is energized through switch A of Ry6 and the reject switches 150 and 152, one of which is typically customer controlled to recover money deposited. The second eject switch may be operated automatically in case of power failure in coin acceptor 140. Upon operation of fee count relay Ry7, its switch E supplies an activating signal to coin acceptor 140 by interconnection of the two lines 142, readying that device for operation.

The fee due register switch S5 comprises a stepping switch with stepping solenoid 154 and interrupter switch 155. Deck A of S5 has its 12 switch contacts connected to the respective contacts of transfer deck B of computer switch S4 (FIG. 2) via the cable 156H. In idle condition of fee count relay Ry7, switch B of that relay supplies power to the grounded stepping solenoid 154 via its interrupter switch 155, notch control deck A of S5 and selector deck B of S4, driving S5 always to the position of S4. Upon operation of Ry7, S5 is effectively isolated from S4 and is driven only via the line 158 in response to pulses generated by coin acceptor 140 and validation sensors to be described. Those pulses drive S5 progressively clockwise until, on completion of payment, the fee register is in zero position.

Since coin acceptor 140 typically produces a pulse for each 5 cents deposited, while the present illustrative fee system charges fees in multiples of 10 cents, the pulse counter S6 is arranged to supply one dime pulse on line 158 to fee due register S5 for every two nickel pulses received on line 144 from the coin acceptor. Pulse counter S6 comprises an A deck which drives the switch prior to each computing operation to a home position, which may be any even position. For that purpose power is supplied to the stepping solenoid 160 via its interrupter switch 161 and a circuit that is completed through deck A of switch S6 if the latter is at an odd position, the line 162, and switch C of fee count relay Ry7 when the latter is idle. Upon operation of Ry7, deck A of S6 is isolated from power, so that stepping pulses for solenoid 160 are received only via the line 163. Such pulses may be provided via the line 144 from coin acceptor 140 or via the line 184 from circuitry to be described for taking account of validation marks applied to the ticket. Each such pulse causes S6 to step forward one interval. Deck B of S6 has its selector 168 offset with respect to the switch positions, as shown, so that it contacts the switch terminals only momentarily during each stepping movement of the switch. Alternate terminals of deck B are supplied with power via the line 166 and switch C of Ry7 when the latter is operated. Hence deck B conveys one step pulse via line 158 to stepping solenoid 154 of S5 to every two steps of S6. Each such pulse reduces by 10 cents the indicated fee remaining to be paid.

A visual indicator 159 is coupled mechanically or otherwise to fee due register S5 and indicates continuously the fee remaining to be paid. S5 includes a deck B which receives power via switch A of fee count relay Ry7. Deck B has a single contact at zero position and supplies a signal via the line 157 to an indicator 169 for indicating full payment of the fee. That signal is also supplied via the line 143 to coin acceptor 140, which then captures the deposited coins from escrow. Relay switch A of Ry7 is included in that circuit to prevent a spurious fee paid signal under idle condition of the system, when total fee register S4 of FIG. 2 is at zero position.

VALIDATION ACCOUNTING MECHANISM

FIG. 3 includes circuitry for detecting and taking proper account of validation marks on a ticket. In connection with automobile parking such validations are commonly applied by stores and the like visited by the customer, and represent predetermined cost allowances which the store pays for the customer. The customer is then required to pay only the excess, if any, of the parking charge over the sum of the values of all validations on his ticket.

In accordance with the present invention it is preferred to employ validation marks in the form of gummed stamps of a magnetically permeable metal, such as iron foil, mu metal, iron oxide coated paper, and the like, which can be adhered to a ticket 42 in one or more predetermined positions on the ticket. The stamps can then be detected by providing in association with ticket reader 50 (FIG. 1) a variable reluctance or static reading magnetic head of suitable known type, one such head being typically provided at each validation position of the ticket.

FIG. 3 represents schematically one such validation sensing head at 170 comprising the transformer 171 with U-shaped core having a primary input winding 172 on one leg and a secondary output winding 173 on the other leg. The core is typically positioned below ticket 42 at the position of a validation stamp, indicated schematically at 175 bonded to the ticket by the adhesive layer 176. Secondary winding 173 is connected to an amplifier 177 from which the alternating current output is rectified by the diode D12 and supplied to the winding of validation relay Ry8*a*. In absence of a validation stamp, the primary and secondary of transformer 171 are loosely coupled because of the air gap at the opening of the U-shaped core. In presence of the magnetically conductive stamp, that gap is closed, increasing the output of the transformer. The circuit is so designed that the relay is operated only in presence of a stamp. Three such relays are illustratively shown in FIG. 3. Individual sensors and operating circuits 170*b* and 170*c*, not explicitly shown, are provided for Ry8*b* and Ry8*c*, each at a distinct validation position on ticket 42. Those positions may all be equivalent, or may if desired, represent different respective values. For illustration, it is assumed that the validation positions sensed by relays Ry8*a* and Ry8*b* represent 20 cents each, while that for Ry8*c* represents only 10 cents. Any desired number of validation positions may be provided for.

The validation scanner switch S7 comprises a scanning deck A and power is continuously supplied to the single contact of switch deck A. The stepping solenoid 180 is connected

through the interrupter switch 181 to notch control 182 of deck A and is also connected via the line 185 to the normally open terminal of switch D of fee count relay Ry7. The normally closed terminal of that switch is connected to a power source and the switch arm is connected to grounded capacitor C8. Deck B of S7 has a selector contact 183 connected via the line 184 and line 163 to the stepping solenoid of S6. Four adjacent contacts of deck B of S7 are connected in parallel via the line 179*a* to the normally open switch contact of Ry8*a*, and another four contacts are similarly connected to the normally open contact of Ry8*b*. Ry8*c* is connected to only two switch contacts.

Upon energization of fee count relay Ry7, charged capacitor C8 is discharged via switch D and line 185 into stepping solenoid 180, moving S7 off zero position. Scanning deck A then self-steps a complete revolution until it returns to the home position. Selector arm 183 of deck B correspondingly scans all of its contacts, producing pulses on line 184 at each contact associated with an energized validation sensing relay. Thus, if only Ry8*a* is operated, for example, line 184 receives four pulses; if both Ry8*a* and Ry8*c* are operated, line 184 receives six pulses, each pulse representing 5 cents. Each such pulse steps S6 one interval, and each two such pulses produce a single pulse on line 158, in the manner already described. Hence, fee owed register S5 is advanced the correct distance to subtract from the computed fee the amount represented by the validation stamps. That validation sensing and accounting action takes place essentially immediately upon operation of fee count relay Ry7. The fee indicator 159 then shows the customer the remaining fee due, which he supplies in coin to coin acceptor 140, as already described.

FIG. 3 includes diodes at strategic positions in the circuitry to prevent undesired sneak paths. Thus, for example, D8 and D9 prevent feedback toward S7 and 140 of pulses delivered to stepping solenoid 160 from deck A of S6; D10 prevents C8 from charging via the A deck of S7 during scanning movement of the latter; and D11 isolates the holding voltage on Ry6 from carry delay relays Ry4 (FIG. 1).

It will be evident that a visual indicating device can show coupled to as many of the stepping switches in FIGS. 1, 2 and 3 as may be desired to visually indicate the information represented by the respective switch positions, as has been explicitly illustrated at 159 for fee due register S5. A particular advantage is controlling that register by means of its own stepping solenoid 154, independently of the stepping mechanism for total hourly fee register S4H, is that the total fee indicated by S4H can be continuously displayed to the customer together with the progress of his payment as indicated at 159. On the other hand, it may be considered sufficient to display the total fee to the customer only prior to the start of payment, and to then show him only the amount remaining to be paid. Under that condition, stepping switch S5 can be entirely omitted, transfer deck B of S4H being replaced by a deck similar to and performing the function of deck B of S5. Switch B and an additional switch F of fee count relay Ry7 are then employed for shifting control of total fee register S4H between the fee computation circuitry of FIG. 2 and the fee payment circuitry of FIG. 3. As typically shown in FIG. 3A, switch B of Ry7 opens the connection between the notch control of S5H and its interrupter switch 123 when Ry7 is operated. At the same time switch F completes a circuit from line 158 of FIG. 3 to stepping solenoid 121, bypassing interrupter switch 123. Each fee payment pulse on line 158 then steps fee register S4H clockwise one interval, reducing the indicated fee by 10 cents in a manner essentially equivalent to that already described for fee due register S5 of FIG. 3.

All of that information represented by the stepping switches can also be recorded, if desired, for example, by providing on each stepping switch a transfer deck which drives a suitable printing device. All of those printing devices are preferably energized simultaneously, typically under control of Ry6, or of the fee paid signal on line 157.

A particular advantage of the described mechanism for providing a grace period is that such period is taken account of entirely in computing the fee, not in computing the elapsed time. Hence the grace period computation does not interfere with correct display and recording, if desired, of the full elapsed time.

Similarly, the present system for taking validations into account does not affect the computation of elapsed time. Nor does it affect computation of the regular fee due. Hence the system is capable of indicating and/or recording both of those quantities independently of the number of validations that happen to be carried by each ticket. If is is desired to indicate or record the number of validations on each ticket, the line 179 from each of the validation relays Ry8 can be connected to suitable display or recording apparatus as well as to deck B of S7.

DYNAMIC DETECTION OF VALIDATION MARKS

The validation sensing mechanism shown in FIG. 3 is static in the sense that it detects validation marks on a ticket while the latter is held stationary in defined position. For some purposes it is preferable to detect validation marks dynamically as they pass the sensor, for example, as the ticket is being inserted in to a reading slot. To accommodate a sufficient number of validation marks, the latter may be arranged on the ticket in two or more distinct rows, with separate sensor for reading each row. Such a system is shown illustratively in FIG. 4. That FIG. further illustrates detecting circuitry suitable for detecting marks formed with fluorescent ink on a ticket. As shown, it is assumed that such marks are stamped on the ticket as validation marks. However, marks and sensors of similar type can also be used for recording and reading start time in the general manner represented at 40 and 50 in FIG. 1.

FIG. 4 further illustrates circuitry for algebraically adding numbers by means of stepping switches or equivalent devices. Such circuitry is used in FIG. 4 both for summing the validation counts made by two independent sensing devices, and for subtracting from the total indicated from the amount covered by those validations to obtain the fee due.

In FIG. 4 a typical fluorescent mark detector is shown at 200. A ticket to be read is indicated at 42 with a fluorescent validation mark at 204. That mark is illuminated by a source 205 of ultraviolet light and the visible light resulting from the fluorescence is sensed by the photosensitive transistor Tr4. Even if the light source is filtered to emit only ultraviolet light and the sensor is filtered to receive only visible light, the background response of the sensor is often quite large, due to such causes as nonideal filters and fluorescence by the paper stock or by dirt on the paper. To overcome this problem, a second sensor Tr5 is mounted in position to read only the background radiation, and the two sensors are connected in a bridge circuit with balancing potentiometer R8. The differential bridge signal is supplied to the operational amplifier 208, with biasing resistance R9 and with feedback resistor R10 which determines the gain of the amplifier. The amplified differential signal is further amplified by the power amplifier 210 with output on the line 212. That line is normally at ground potential and receives a positive pulse in response to each validation mark that passes over sensor Tr4. A similar detector, indicated schematically at 202, is mounted in position to sense the second row of validation marks on ticket 42, and produces a pulse on the output line 214 for each mark detected.

The pulses on the lines 212 and 214, representing one validation mark per pulse, are counted by the respective switches S10 and S11, and are summed by those switches in combination with validation summing switch S12. S10 and S11 have respective stepping solenoids 215 and interrupter switches 216. Those switches are normally at zero position, as shown, being returned to that position after each counting operation by reset voltages supplied in any suitable manner. As shown, the reset switch S9 may be considered to be a nor-

mally closed switch of ticket sensing relay RyS of FIG. 1. Upon removal of the ticket from reading position, that switch closes and applies a reset voltage via the lines 218 to the zero contacts of the A decks of S10 and S11. That voltage flows through the notch controls 217 and via the interrupter switches 216 to the stepping solenoids, stepping the switches till they reach zero position. In presence of a ticket to be read, S9 is open and validation pulses are supplied from lines 212 and 214 directly to the respective stepping solenoids, stepping one switch or the other one step clockwise for each pulse.

According to the position of S10, its deck B supplies voltage via its selector 219 to one of the lines 220 and thence to the selector 221 of one or another of the multiple decks of S11. Each of those decks is numbered from 0 to 4 to correspond with the position of S10 through which it is energized. The terminals of each deck of S11 are connected via the lines 224 to respective terminals of deck A of summing switch S12, but with increasing electrical offset for successive decks. Thus, terminals 0 to 4 of deck 0 of S11 are connected to the corresponding terminals of S12; those of deck 1 are connected to terminals 1 to 5, respectively, of S12; those of deck 2 are connected to terminals 2 to 6, respectively, and so on. With the described connections, power is supplied via S10 and S11 to that one of the terminals of S12 that corresponds to the sum of the respective positions of S10 and S11. From the energized terminal, that power is supplied via notch control 228 and interrupter switch 227 to the stepping solenoid 226 of S12, stepping S12 to the position of the energized terminal. Thus the position of S12 corresponds to the sum of the validations on the positioned ticket.

If more or fewer than four validation marks may occur in each row on the ticket, the number of active contacts on deck B of S10 and the number of decks provided on S11 are modified accordingly. Also if more than two rows of validation marks are provided on each ticket, the lines 224 of FIG. 4 may be connected to the selectors of respective decks of a third switch, driven like switches S10 and S11 of FIG. 4, but in response to the third row of marks. The output terminals of that third switch are then connected to selected terminals of S12, with suitable electrical offsets of the type illustrated by lines 224 of FIG. 4.

Deck B of S12 automatically makes effective the number of validations corresponding to the switch position, subtracting the appropriate amount of money from the total fee indicated by the fee computing portion of the system. That subtraction might be carried out in the manner already described in connection with FIG. 3. For that purpose, deck B of S12 can be considered to correspond to the several switches of relays Ry8*a*, Ry8*b* and Ry8*c* of FIG. 3, and can be wired to supply power to a proper number of terminals of deck B of S7. Assuming each validation worth 10 cents, for example, power would be supplied to the selector 231 of deck B of S12 in FIG. 4, as shown; the zero terminal of that deck would be left open; the first terminal would be connected to terminals 1 and 2 of deck B of S7 in FIG. 3; the second terminal would be connected to terminals 3 and 4 of the latter deck, and also via a forwardly biased diode to terminals 1 and 2; the third terminal would be connected to terminals 5 and 6 and via a diode to terminals 1, 2, 3 and 4; and so on. During the scanning revolution of validation scanning switch S7 of FIG. 3, two pulses would then be delivered to the stepping solenoid of S6 for each detected validation mark, subtracting 10 cents from the total fee for each validation.

The validation accounting system of FIG. 4, as shown, however, performs the required subtraction by means of electrical coupling mechanism interposed between the total fee computer and the fee due indicator, switch S13. Switch shaft 230 in FIG. 4 may represent the shaft of switch S4H in FIG. 2, or may be driven with that shaft by any desired type of repeating mechanism. The position of shaft 230 therefore represents the total fee due on account of the minutes and hours portion of the elapsed time, as typically described in connection with FIG. 2 and as indicated illustratively on deck A of S4H in that FIG. Any fee due for elapsed days is neglected for the moment for clarity of description. Switch shaft 230 carries directly, or drives, a plurality of switch decks, denoted in FIG. 4 by the numbers 0 to 8, which are equal in number to one more than the maximum number of validation marks to be accommodated by the system. If that number is large there may not be room for all decks on one switch structure. In that case one or more repeaters may be used. Such a repeater is illustrated in FIG. 4, comprising a selector deck R1 mounted on shaft 230, a notch control deck R2 mounted on the shaft 232 of a second switch structure with stepper 236, and connections 234 between respective terminals of R1 and R2. As illustrated, summing decks 0, 1 and 2 are mounted on shaft 230, decks 7 and 8 are mounted on shaft 232, and the remaining decks 3 to 6, which are omitted for clarity of illustration, may be divided between the two shafts in any convenient manner, for example 3 to 5 on shaft 230 and 6 on shaft 232. To avoid unnecessary operation of repeating stepper 236, repeater deck R1 is energized via the additional deck C of S12 only when six or more validations have been detected.

Each of the summing decks 0 to 8 has a selector which is connected to the corresponding one of the terminals of deck B of S12, receiving power through the selector of that deck only if S12 is at the corresponding position. The 0 summing deck has its terminals connected in one-to-one relation to the respective terminals of the notch control deck A of the fee owed indicating switch S13, as indicated by the cable 240. In absence of any validation marks, with S12 at zero position, S13 is therefore stepped to the same position as shaft 230, and the indicated fee due is the same as the total fee shown by S4H. On the other hand, the terminals of summing decks 1 to 8 are connected with electrical offsets that increase progressively with the number of the deck. With S12 at position 2, for example, summing deck 2 is energized, and S13 is stepped to a position offset two steps from shaft 230 in a clockwise direction, indicating a fee owed that is less than the total fee by 20 cents. The resulting fee owed may indicated in any desired manner, and switch S13 may be provided with one or more additional decks for performing further functions such as producing a "fee paid" signal, as already described in connection with FIG. 3.

VARIABLE TIME-COST SCHEDULE

FIG. 5 represents a modified system for computing the cost that corresponds to an input elapsed time in accordance with a specified time-cost schedule. That system may be considered as a modification of FIG. 2, which it resembles in many respects, so that only the differences require detailed description. As in FIG. 2, the elapsed time input is via three shafts 120M, 120H and 120D which are driven with the respective minutes, hours and days counting switches S3M, S3H and S3D of FIG. 1. Those shafts carry switch decks, as shown, which are labeled and will be described as parts of the respective counting switches. Deck C of S3M corresponds in function to the similar deck C of FIG. 2. Decks 1 and 2 of S3H correspond to decks 1 and 2 of FIG. 2. The additional deck 3 allows each hour to be divided into three parts for cost computation, rather than only two parts as in FIG. 2. Deck G of S3H provides a grace period at the start of each hour in the same general manner as in FIG. 2. Decks D and E of S3D correspond generally to the similarly designated decks of FIG. 2, but with deck D performing also essentially the function of relay Ry8 of FIG. 2. Deck C of S3D of FIG. 2 is omitted in FIG. 5 for clarity.

The output from the computation system of FIG. 5 is via the two switches denoted S4¢ and S4$, which correspond generally to S4H and S4D of FIG. 2. However, instead of keeping the hours cost and the days cost separate, as in FIG. 2, the present system provides an automatic carry of dollars from the hours cost over to the days cost, permitting greater flexibility of cost schedules. The dollars carried over from the hours computation and the dollars due on account of elapsed

days are summed by switch decks 0, 1, 2 and 3 of S4$, in the general manner described in connection with FIG. 4. The outputs on the switch shafts S4¢ and S4$ may be displayed directly or via suitable repeaters, or may operate any desired utilization device.

The illustrative time cost schedule represented in FIG. 5 calls for a general charge of 20 cents for each 20 minutes of elapsed time, but with that charge increased to 40 cents for the first 20 minutes and to 30 cents for the second 20 minutes of each day. Also, there is a maximum charge of $2.00 per day. A grace period of 10 minutes is allowed at the start of each cost increment.

The selector of deck C of S3M is normally supplied with positive voltage via the line 250, subject to the hours count, as will be described. Each of the switch terminals is connected to one or another of the selector decks of S3H. Those connections are made through the multiterminal connector J, with elements JA and JB, and through the multiterminal connector K, with elements KA and KB. The terminals of element JA are permanently wired to the respective switch terminals of deck C in one-to-one relation, as indicated by the cable 252. The terminals of KB are permanently wired to the respective selector decks of S3H via the lines 254. The interconnections between JB and KA typically comprise a harness 256 containing the wires shown in the FIG.

For clarity in following the wiring, each connector terminal is labeled with the switch terminal to which it is permanently connected. On the switch side of the connector is given the number of that switch terminal, increasing in the direction of rotation of the switch. On the harness side of the connector is given the value in time or cost that corresponds to that switch terminal. The complementary enumeration of the value steps with respect to the switch movements, explained in connection with FIG. 1, is clearly evident from that designation.

Harness 256 and the two attached connector elements JB and KA comprise a separable component of the system which can conveniently be replaced by a corresponding assembly whenever a different wiring configuration is desired. Thus the operator can readily modify the system to correspond to any desired time-cost relation merely by plugging in the proper harness assembly selected from a stock of clearly marked alternative components with which he is provided by the manufacturer of the equipment. The simplicity of that operation minimizes the possibility of human error in shifting the system from one schedule to another. Whereas the replaceable connector assembly just described, like others to be described, typically includes a wire harness between two connector elements, it will be evident that other apparatus may be used, such as a large plug, pegboard, patch panel, switch selector panel or any convenient means of varying the interconnections of two sets of terminals between two or more predetermined configurations.

In the present system, each of the terminals of the multiple decks of S3H is connected in a similarly variable manner to a selected terminal of switch S4¢ and/or to a selected selector of the multiple decks of S4$. More particularly, each of the numbered switch decks of S3H has its terminals connected in one-to-one relation to the respective terminals of the corresponding connector element L1A, L2A or L3A, as indicated schematically by the cables 261, 262 and 263, respectively. Each terminal of deck G of S3H is connected to the terminal of deck 3 that represents the next lower number of hours, as indicated by the cable 264, labeled "offset." The zero terminal of the deck is connected via the line 265 to the single terminal of connector LGA, which is shown separate from L3A for clarity of description, but can in practice be incorporated with it. In fact, all of the connectors designated L can well comprise a single unit.

Each terminal of the B elements of the L connectors is connected via the lines designated generally as 270 to selected terminals of connector elements N¢A and N$A. Those connections conform to a particular time-cost schedule, and the schedule can be changed in the manner already indicated, by substituting a different assembly of connector elements with suitable interconnecting harness. Spurious effects due to sneak paths in the connections 270 are prevented by inserting diodes in each connection.

The terminals of the B element of connector N¢ are connected permanently in one-to-one relation via the cable 280 to the respective terminals of total cost switch S4¢, which represents the cents component of the total cost. The switch shaft 282 carries a notch control through which its stepper 281 is energized to step the switch to any energized switch contact. The switch shaft also drives an output device of any desired type, shown schematically at 284. That device may, for example, include a repeater deck and indicator, as in FIG. 2, and automatic collection mechanism such as that shown in FIG. 3.

The four terminals of connector element N$B are connected permanently via the lines 288 to the selectors of the respective decks 0, 1, 2 and 3 of summing switch S4$, which also acts as a total cost switch for the dollars component of the total cost, driving an output device 285.

In its summing capacity, S4$ combines the dollar input represented by any energized terminal of connector element N$B with the dollar input represented by any selected terminal of connector element PB. Those terminals are controlled by the days counting switch S3D through its deck E. Each terminal of that deck is connected permanently via the cable 289 to the corresponding terminal of connector element MA. Connections between elements MB and PA are made via the lines 294, which typically form a harness that is interchangeable in the manner already described. The present connections 294 are further described below. Connections from the terminals of PB are made permanently via the cable 290 to respective corresponding terminals of deck 0 of S4%. Decks 1, 2 and 3 are similarly connected to deck 0, as indicated schematically by the cables 291, 292 and 293, but with successive offsets in the direction of higher dollar values. That is, for example, the 5 dollar terminal of deck 0 is connected to the 6 dollar terminal of deck 1, to the 7 dollar terminal of deck 2 and to the 8 dollar terminal of deck 3. The zero terminals of decks 1, 2 and 3 are open, as are the 1 dollar terminals of decks 2 and 3 and the 2 dollar terminal of deck 3.

Switch S4$ has a stepper solenoid 300 and an interrupter switch 301, by which it is driven to the position that is defined by (a) the deck that is energized via one of lines 288 in response to the position of deck C of S3M and (b) the terminal of that energized deck that is connected to the selector of deck E of S3D. That drive action might be accomplished by grounding the latter deck selector through the solenoid and interrupter and by providing a notch control on each of the decks of S4$ to complete a stepping circuit until that switch reached the defined position. That arrangement, however, is found to present a problem in the elimination of sneak paths. That difficulty is completely avoided by the circuitry shown, which drives stepper 300 in a manner that is complementary to that just described. In stead of using notch controls on the four decks of S4$ to close a stepping circuit at all switch positions except the defined one, selectors are used on all four decks, and the stepper is energized until the defined position closes a disabling circuit. That is accomplished by means of the inverting relay 10. Power is supplied to stepper 300 via the normally closed relay switch and interrupter 301. The relay winding is connected on one side to ground and on the other side via the line 304 to the selector of deck E of S3D. With that arrangement S4$ is stepped repeatedly until a circuit is closed through the above defined switch contact, operating Ry10 and disabling stepper 300.

With the hour divided into three cost periods, as in the schedule used illustratively for FIG. 5, the grace period is obtained in the same general manner as in FIG. 2. In connecting lines 256 between connector elements JB and KA, the terminals for 20 minutes and 25 minutes are considered as part of the first 20-minute period, and the terminals for 40 and 45 minutes are considered as part of the second 20-minute

period. The terminals for 0 and 5 minutes, however, are treated separately from the rest of the third 20-minute period, being connected to the selector of deck G of S3H, the function of which is effectively to apply a negative carry to the hours count, as described in connection with deck G of FIG. 2. That carry is readily taken care of by the described offset connections of cable **264** for all but the zero terminal of deck G. That terminal is effective only during the first grace period at the very start of each time period, for which the cost is necessarily zero. The zero terminal of deck G is therefore connected via connector LG to the zero cents terminal of connector element N¢A and also to the zero dollars terminal of N$A. A zero cost indication is thereby insured. As a matter of fact, that particular connection might be made a part of the permanent wiring of the system, without going through harness **270** at all. For that connection would be required for any time-cost schedule involving a grace period at the start of each hour, and with any schedule not using such a grace period deck G of S3H would never be energized, so that the connection would be ineffective. However, the connection is included in harness **270** in the present FIG. for clarity of illustration of the principle of the present system.

In wiring harness **270** it is convenient to prepare a table of cost increments and total cost for each time increment that requires consideration. For the present illustrative schedule of 40 cents for the first one-third hour, 30 cents for the second one-third hour and 20 cents for each subsequent one-third hour to a maximum of $2.00 per day, such a table is as follows:

Hour	⅓ hour	Cost increment	Total cost
0	1	$.40	$.40
0	2	.30	.70
0	3	.20	.90
1	1	.20	1.10
1	2	.20	1.30
1	3	.20	1.50
2	1	.20	1.70
2	2	.20	1.90
2	3	.20	2.00
3	1	.00	2.00

it is noted that the connections for the first three entries of the table energize the zero dollars terminal of connector N$ as well as the proper terminals of N¢, so that dollars indicator **285** will positively show zero dollars. By observation of the illustrated connections in accordance with this table, and by comparison with the corresponding connections in FIG. 2, it will be evident that a very wide variety of specific time-cost schedules can be accommodated by a system of the present general type.

The fact that days counting switch S3D steps one position for each half-day, rather than for each day, is taken account of somewhat differently in the present system from that of FIG. **2**. In both cases the maximum charge for each 24-hour period of the total elapsed time is reached during the first 12 hours of that period. During the second 12 hours of each day the cost therefore remains fixed at the prescribed daily maximum, which is $2.00 in the present schedule. Accordingly, during the second half of each day, the hours counting and computing system half of each day, the hours counting and computing system is entirely disabled, and the cost is derived entirely from S3D. The hours system is disabled by opening line **250** which normally supplies power to deck C of S3M. For that purpose, power is supplied to line **250** via deck D of S3D, connection being made only via the even position terminals of that deck. Line **250** is thus energized during the first 12 hours of each day of the elapsed time, and is open during the second 12 hours.

With line **250** open, the described operation of S4¢ is entirely disabled, and the four decks of S4$ can receive no power via connector N$ and lines **288**. Instead, the line **310** supplies power from all the even numbered terminals of S3D to deck O of S4$, causing the latter switch to step to the position corresponding directly to any terminal of connector P that is connected to line **304** via deck E of S3D. Connection is also made from line **310** via the line **312** to the zero terminal of S4¢, causing that switch to step to zero position. The diodes D30 and D31 prevent energization of line **310** via connector N$ and N¢ during normal operation.

USE OF SOLID STATE COMPONENTS

FIG. **6** shows a modification of the elapsed time computation system of FIG. That modification illustrates the use of solid state components for driving two stepping switches effectively in parallel and for generating and conditioning the carry pulses. Those solid state components replace many of the relays of FIG. **1**, and illustrate the great variety of circuit techniques that may perform the fundamental functions involved in the present invention. In FIG. **6**, as in FIG. **1**, present time is continuously represented by the respective positions of the minutes, hours and days time switches S1M, S1H and S1D, which are clock-controlled via the shafts **21**. The actual clock control mechanism and the ticket marking device **40** and ticket reading device **50** are typically as shown in FIG. **1**, and are not repeated in FIG. **6**. Components in FIG. **6** which correspond to components of FIG. **1** are generally designated by the same numerals.

In their reset or following mode, reading switches S2M, S2H and S2D and the coupled ticket reading sensors of device **50** are driven with the respective time switches S1, and are shifted to their reading mode by reading relay Ry1 in response to insertion of a proper ticket to be read. When in reading mode, each of the switches S2 is continuously stepped forward until the coupled sensor detects the recorded ticket mark representing the start time for that ticket. The elapsed time switches S3M, S3H and S3D are stepped forward in unison with the respective reading switches, moving from zero to positions that represent in complementary numbers the elapsed time for the ticket. After completion of that reading operation, the elapsed time switches for hours and days are moved one further step each if the count of the digit of next lower significance has had a finite stepping movement that did not move to or through zero position. Output of the computed elapsed time may be via the three shafts **120M**, **120H** and **120D** for the respective digits.

In FIG. **6** each of the stepping solenoids of the three reading switches S2 is controlled by a silicon controlled rectifier or thyristor SCR3, which is directly connected in series with the solenoid **60** and interrupter **62** between a positive voltage source and ground. The thyristor has the property, as already pointed out in connection with SCR1 and SCR2 in FIG. **1**, that when turned on by a positive signal at its gate, it will remain on until power is removed from its power terminals. In the present series circuit, the interrupter of the stepping switch removes power from the circuit after completion of each step, idling the thyristor. If a continuous positive signal is applied to the gate, the stepper will operate repeatedly. If the signal should be removed in the middle of a stepping cycle, the thyristor will remain in conduction until opening of the interrupter after completion of the step. Also, if a short positive pulse is applied as input signal to the gate, the thyristor is turned on and remains on until the step has been completed.

During reset mode, voltage is supplied via switch A of ready relay Ry1 and line **70** to the selector of each time switch S1 and thence via one of the wires **67** to the corresponding terminal of each reading switch S2. Unless S2 is at the same position as S1, that voltage is supplied via the notch control of S2 and the current limiting resistor R11 to the gate of SCR3, energizing the stepper repeatedly until the notch is aligned with clock time. Resistance R14 is a ground return for the thyristor gate. Diode D16 prolongs each current pulse in the solenoid.

During the ticket reading mode, read relay Ry1 applies posi-

tive power to line 90, and thence via a line 96 and resistors R12 and R13 to the gate of each SCR3, turning the thyristor on and initiating stepping action of each reading switch S2. That stepping continues until stopped by detection of a mark by ticket reader 50 (FIG. 1). Upon detection of a mark, a positive voltage is supplied from the reader via one of the lines 95 to the base of transistor Tr10, which corresponds generally to Tr2 of FIG. 1. The sensor signal causes the transistor to conduct heavily, effectively grounding the junction between R12 and R13. The energizing signal is thereby removed from the gate of SCR3, preventing further stepping of S2. Resistance R13 prevents Tr10 from grounding reset signals supplied to SCR3 via R11.

In the present system elapsed time switches S3M, S3H, and S3D are controlled, like the reading switches, by thyristors connected at SCR4 in series with the respective stepping solenoids 84 and interrupters 85 between a power source and ground. During reset mode, switches S3 are returned to zero position by positive voltage signals supplied to the thyristor gates via switch A of Ry1, line 80, D4, and the zero switch terminals and notch controls of the A decks of the respective switches. During reading mode those signals are cut off by Ry1, and stepping signals are received via the respective lines 350 in response to stepping action of the reading switches S2. During stepping of each reading switch S2, a square wave is generated at the junction between its stepping solenoid 60 and interrupter switch 62. When either the interrupter or the thyristor SCR3 is nonconducting that junction is at substantially the supply voltage of +V, while during energization of the solenoid the junction is essentially at ground. That square wave is supplied via resistor R10 to the base of the transistor Tr11, which receives power from line 90. That transistor serves both to invert the square wave and to cut it off completely during reset mode, when power to the transistor is cut off by Ry1. The inverted square wave is differentiated by the capacitor C10, and the resulting positive going pulse is delivered to the gate of thyristor SCR4 substantially at the start of each stepping cycle of the reading switch S2. Elapsed time switch S3 therefore initiates a step for each reading step of S2, and the holding action of SCR4 insures that S3 completes each such step regardless of the energization time of S2. However, it is still useful to slow the deenergization of S2 by shunting its solenoid with diode D16 to insure completion of each step by S3 before initiation of the subsequent step by S2. The described circuit reliably causes the elapsed time stepper to follow the reader stepper accurately in a one-to-one count.

FIG. 6 includes modified circuitry for generating and delivering carry pulses to elapsed time switches S3H and S3D subject to the conditions already described. Upon detecting the time mark on the ticket, each sensor 54 of reading device 50 (FIG. 1) delivers a positive signal via line 95 to the base of Tr10, grounding the junction of R12 and R13 and terminating stepping of S2 as already described. Any one of the three transistors Tr10 that has not received a sensor signal remains cut off, and will have a positive voltage at its collector which is transmitted via the diode D40 to the line 352. That positive voltage is normally applied to the bases of the two gating transistors Tr12, rendering those transistors conductive and effectively grounding their collectors so that the capacitors C11 are discharged. When all sensor signals have been received, the positive voltage is removed from line 352, cutting off transistors Tr12 and allowing their collectors to go positive. Capacitors C11 are then charged from the respective lines 96 via the series resistors R17, R18 and R19. When the emitter of unijunction transistor Q1 reaches the threshold value, C11 discharges through Q1, generating a positive going carry pulse across R20.

That pulse is transmitted via the diode D41 and line 105 to deck B of the corresponding elapsed time switch S3. That deck inhibits the carry, as in FIG. 1, if the switch is still at zero position, indicating that there has been no count for that digit. In presence of an active count, the pulse is delivered via line 106 to the gate of the thyristor SCR4 that controls the switch S3 for the digit of next greater significance, producing a carry step for that digit.

Inhibition of the carry when the count for the digit of next lower significance passes to or through zero is effected by the inhibiting thyristor SCR5 under control of the B deck of reading switch SCR5 is connected between the junction of R17 and R18 and ground, and its gate is connected via the current limiting resistance R21 to a contact of deck B of S2 that is offset between the positions that represent the highest and the lowest values of the digit. The switch selector 358 is dimensioned to engage that contact only while moving between those tow positions. The resulting positive pulse turns on SCR5, effectively grounding the junction of R17 and R18 and preventing the charging of C11. That inhibiting action is held by SCR5 until power is removed by idling of Ry1, typically upon removal of the ticket from the reading device.

The carry pulse generator comprising C11 and Q1 has the advantage of incorporating directly the required pulse delay for insuring that both S2 and S3 will fully complete the normal count before the carry pulse is delivered to the stepper of S3. However, C11 and Q1 form a relaxation oscillator that will continue to supply pulses if not turned off. Delivery of only a single carry pulse is insured by supplying that pulse via the diode D42 and the line 356 to the gate of carry inhibiting thyristor SCR5. The turning on of that thyristor promptly disables the pulse generator by removing its power source.

In carrying out the invention it may be desirable to employ rotary stepping switches or their equivalent having a number of positions different from 12, the latter number having been used only as illustration. For example, it is often convenient to employ 24-position switches. The minutes switch can then provide 24 time intervals of 2½ minutes each, the hours switch 24 intervals of 1 hour each, and the days switch 24 intervals of 1 day each. In addition to the greater accuracy in obtaining the minutes component of the elapsed time, that arrangement permits evident simplifications in the computation of cost for the days component. If it is desired to limit the days component to three weeks, only 21 positions of the days switch need to be used, and circuitry may be provided for stepping the switch past the three unused switch positions without affecting any of the computations. For example, during the reading mode, as the 24-position days reading switch is stepped past the positions for 22, 23 and 24 days, delivery of a stepping pulse to the elapsed time switch S3D can be prevented by passing it through an additional switch deck provided on S2D which opens the circuit at the required positions. Such a deck may include a single contact and a notch control with a notch wide enough to embrace three switch positions and phased to open the circuit at 22, 23 and 24 days.

Whatever the number of switch positions, the time intervals represented by the various digits may vary widely. For example, the "minutes digit" may involve actual intervals of 5 minutes, 2½ minutes, or other values which are not necessarily submultiples of an hour. That is especially true if it is not required that a "customer" be able to read the code representations of the time. As an illustration, the minutes digit might involve 10 steps of 9 minutes each, and the hours digit 16 steps of 1½.

A particular advantage of the present concept of instrumentation is the ease with which all computed values, both intermediate and final, can be indicated visually, recorded, or otherwise utilized. A simple shaft output from each switch is a direct illustration of the availability of such data. Alternatively, additional switch decks may be provided and wired to decode the data into decimal or other form, as may be required for a particular use. FIG. 7 represents schematically an illustrative decoder for data developed by a 24-position switch, not explicitly shown, which drives the shaft 380. The two decoding switch decks A and B are coupled to that shaft, and are wired as shown, so that the switch selectors distribute

power to the 10 units lines 382 and to the three 10-lines 384 in such a way as to represent the switch information in decimal digital form via those lines. Each line may be connected to an individual display device, as indicated at 386, or may supply the decoded data to any desired utilization system. The data may be transformed in a similar manner into any desired type of code. Such additional decoding and output decks are typically provided for each of the time switches S1 to record the time when a ticket is issued and also when it is read; for the reading switches S2 and the elapsed time switches S3 to record the time read from each ticket and the computed elapsed time; for the cost switches S4, the validation switches S7 or S11, and the fee due switches S5 or S13 for recording those data in connection with each ticket processed.

Whereas the invention is capable of providing an overall system, comprising typically the portions shown in FIGS. 1, 2 and 3, the principles of the invention are also valuable when applied to only a portion of the overall computation, for example when the problem at hand involves only certain aspects of the complete process, or when some phases are carried out by different techniques.

I claim:

1. A time computation system for representing the elapsed time between a start time and a finish time, comprising in combination:

means for positioning a ticket on which a start time has been recorded in a machine readable code in terms of a plurality of digits, the ticket having for each digit an ordered series of mark positions corresponding to the respective possible values of that digit, and the value of each digit being indicated by the position on the ticket of a mark;

a search element for each digit, movable sequentially over the corresponding series of mark positions of a positioned ticket and responsive to coincidence with a mark on the ticket;

clock mechanism normally causing the search elements to move forwardly in the direction of advancing time to maintain them at respective positions corresponding to present time;

drive means for acting at a selected finish time in presence of a positioned ticket to drive the search elements forwardly from their said present time positions over the respective series of possible mark positions to produce coincidence with the marks on the ticket; and

output means for registering the effective numbers of intervals between adjacent mark positions traversed by the respective search elements during the last said drive movements and for representing the elapsed time in terms of the complements of said numbers, the sum of each number and its complement equaling the corresponding number of possible digit values.

2. A system as defined in claim 1, and in which:

said drive means act to shift the search elements stepwise over the mark positions;

said output means include means for counting the effective numbers of steps for the respective search elements;

said counting means including carry means for introducing a carry for each digit not of least significance whenever the digit of next lower significance has an active count that does not shift between the highest and lowest values of that digit; and

means for representing the elapsed time in terms of the complements of the total counts for each digit.

3. A system as defined in claim 2, and in which:

said carry means comprise means normally introducing a carry for each digit not of least significance; and

means for disabling each such carry in response to zero count for the digit of next lower significance and also in response to shifting of the search elements for such digit between the mark positions for its highest and lowest values.

4. A system as defined in claim 1, and in which:

said mark positions for the respective digits are arranged on the ticket in concentric circles of different diameter; and

said search elements comprise respective supports movable about a common axis perpendicular to the plane of a positioned ticket and coaxial with respect to said circles, and mark sensors mounted on the respective supports in position to detect marks in the respective circles.

5. A system as defined in claim 4, and in which said output means include:

a rotary switch for each digit, having a plurality of angularly spaced switch positions and having electrical stepping means energizable to shift the switch one step in a forward direction;

means normally acting to maintain the switches at respective zero positions;

means controlled by said drive means for energizing the stepping means of each rotary switch in response to each driven movement of the corresponding search element between adjacent mark positions; and

means for representing the elapsed time in response to the positions of the rotary switches.

6. A system as defined in claim 5, and in which said means for energizing the stepping means comprise:

an interrupter switch coupled to each rotary switch;

a silicon controlled rectifier connected in series with the stepping means and the interrupter switch across a source of power; and

means controlled by said drive means for generating a positive voltage signal in response to each said shift of the search element and to supply the signal to the gate of the silicon controlled rectifier.

7. A system as defined in claim 4, and in which:

said drive means act to shift the search elements stepwise over the mark positions;

said system includes carry means for additionally energizing the stepping means of each rotary switch for a digit not of least significance to produce a carry step under control of the movement of the search means for the digit of next lower significance; and

said time representing means represent the elapsed time in terms of the complements of the numbers of steps made from zero position by the respective rotary switches.

8. A system as defined in claim 7, and in which said carry means include:

first circuit means for each digit not of least significance acting normally to produce one additional energization of the stepping means of the corresponding rotary switch;

second circuit means for disabling each first circuit means in absence of any stepping movement of the search element for the digit of next lower significance; and

third circuit means for disabling each first circuit means in response to stepping movement of the search element for the digit of next lower significance between the positions corresponding to the highest and lowest values for that digit.

9. A system as defined in claim 4, and in which said drive means comprise:

a rotary stepping mechanism for each digit coupled to the corresponding sensor support and having a plurality of angularly spaced positions corresponding to the respective mark positions on a positioned ticket, each stepping mechanism being electrically energizable to produce a step;

circuit means normally acting in presence of a positioned ticket to repeatedly energize each stepping mechanism; and

means for disabling the circuit means with respect to each stepping mechanism in response to detection of a mark by the corresponding sensor.

10. A system as defined in claim 4, and including:

a rotary switch for each digit, having a plurality of angularly spaced positions corresponding to the respective mark positions on a positioned ticket and having switch contacts at each switch position and stepping means ener-

gizable to shift the switch stepwise in a forward direction;
coupling mechanism for driving the corresponding sensor support in accordance with the switch movement;
said clock mechanism comprising means for providing a code representation of present time in terms of a code corresponding to said machine readable code;
circuit means including the switch contacts for comparing that code representation for each digit with the position of the corresponding rotary switch; and
means normally acting to energize each switch stepping means in absence of such coincidence.

11. A system for computing a cost corresponding to an elapsed time expressed in minutes and hours, the minutes being represented by the position of a minutes shaft having x angularly spaced rotary positions representing successive intervals of $60/x$ minutes each, and the hours being represented by the position of an hours shaft having angularly spaced positions that represent successive hours, the cost increasing stepwise at intervals of $60/y$ minutes over at least a portion of the total cost range, where x/y is an integer n, said system comprising in combination:
a rotary minutes switch coupled to the minutes shaft and having a selector that contacts a terminal corresponding to each shaft position, the terminals forming y groups of n terminals each;
a rotary hours switch coupled to the hours shaft and including y ordered decks corresponding to the respective y groups of minutes switch terminals, each deck having a selector that contacts a terminal corresponding to each shaft position;
circuit means interconnecting each terminal of the minutes switch to a selector of an hours switch deck, at least the final terminal of each said terminal group being connected to the selector of the corresponding hours switch deck; and
output means for representing the successive cost steps within said range portion and including an output terminal for each such step, means connecting the successive output terminals respectively to successive hours switch terminals taken alternately from the y decks in order, and output circuit means connected to the selector of the minutes switch for energizing one of the output terminals via said hours switch connections, the output terminal so energized representing said cost.

12. A system as defined in claim 11, and in which:
said hours switch includes an additional deck having a selector that contacts a terminal corresponding to each shaft position, each such terminal being connected to the next preceding terminal of the last of said y hours switch decks;
a selected number of the initial terminals of the first said group of n terminals of the minutes switch being connected in parallel to the selector of said additional switch; and
selected numbers of the initial terminals of each of the other groups of n terminals of the minutes switch being connected to the selector of the next preceding one of the y hours switch decks, thereby providing for the respective cost steps grace periods corresponding in length to said selected numbers of terminals.

13. A system for computing a cost corresponding to an elapsed time between a start time recorded on a ticket and a finish time, with credit for validation marks applied to the ticket, said system comprising in combination:
means for positioning a ticket on which a start time has been recorded in a machine readable code, said ticket carrying one or more validation marks;
means acting at a finish time to read the start time recorded on the positioned ticket and to compute the elapsed time;
means for computing the cost corresponding to the elapsed time in accordance with a predetermined fee schedule, and for representing the computed cost in terms of the position of a rotary switch having a position for each increment of cost, said rotary switch including stepper to step the rotary switch in the direction of decreasing cost;
means for detecting the validation marks on the positioned ticket;
a rotary scanning switch having a selector drivable over a plurality of contacts corresponding to respective cost increments;
means for energizing a selected number of contacts of the scanning switch under control of each validation mark detected on the positioned ticket;
means acting to drive the scanning switch over its contacts only after completion of said cost computation;
means acting to energize the stepper of the first said rotary switch in response to engagement of the energized contacts by the selector of the scanning switch; and
means for indicating the cost corresponding to the resulting position of the rotary switch as a fee due.

14. A system for computing a cost corresponding to an elapsed time between a start time recorded on a ticket and a finish time, with credit for validation marks applied to the ticket, said system comprising in combination:
means for positioning a ticket on which a start time has been recorded in a machine readable code, said ticket carrying one or more validation marks;
said ticket positioning means including guide means for guiding a ticket to reading position along a predetermined path;
means acting at a finish time to read the start time recorded on the positioned ticket and to compute the elapsed time;
means for computing the cost corresponding to the elapsed time in accordance with a predetermined fee schedule, and for representing the computed cost in terms of the position of a rotary switch having a position for each increment of cost;
said rotary switch including a plurality of ordered selector decks, each having contacts for respective increments of cost;
a sensor for detecting validation marks on the ticket sequentially as the ticket moves along the path;
a rotary counting switch normally at a start position with successive switch contacts connected to the respective said deck selectors, and means for stepping the counting switch from start position sequentially in response to each mark detected by the sensor for energizing the selector of the deck that corresponds to the number of validation marks detected;
a plurality of output lines corresponding to respective increments of fee due,
circuit means connecting the output lines to respective contacts of the switch decks to be energized selectively in accordance with the existing value of the difference between the computed cost and the value of the detected validation marks; and
means for indicating the cost corresponding to the output line so energized.

15. A cost computing system as defined in claim 11 and in which said circuit means include switch mechanism switchable among a plurality of alternative conditions in which different selected pluralities of said minutes switch terminals are connected to the selector of each said hours switch deck in accordance with different predetermined cost schedules.