

Jan. 16, 1962

J. GOLDBERG ET AL

3,017,103

SERVICE-CHARGE CALCULATION SYSTEM

Filed Nov. 24, 1958

6 Sheets-Sheet 1

NUMBER OF CHECKS	UNDER \$100	\$100 TO \$199	\$200 TO \$299	\$300 TO \$399	\$400 TO \$499	\$500 TO \$599	\$600 TO \$699	\$700 TO \$799	\$800 TO \$899	\$900 TO \$999
0	.50	.36								
1	.57	.43	.29							
2	.64	.50	.36							
3	.71	.57	.43	.29						
4	.78	.64	.50	.36						
5	.85	.71	.57	.43	.29					
6	.92	.78	.64	.50	.36					
7	.99	.85	.71	.57	.43					
8	1.06	.92	.78	.64	.50					
9	1.13	.99	.85	.71	.57					
10	1.20	1.06	.92	.78	.64	.50				
11	1.27	1.13	.99			.57				
12	1.34	1.20	1.06			.64	.50			
13	1.41	1.27	1.13				.57			
14	1.48	1.34	1.20				.64	.50		
15	1.55	1.41	1.27					.57		
16	1.62	1.48	1.34					.64	.50	
17	1.69	1.55	1.41						.57	
18	1.76	1.62	1.48						.64	.50
43	3.51									2.25
44	3.58									2.32
45	3.65									2.39
46	3.72									2.46
47	3.79									2.53
48	3.86									2.60
49	3.93									2.67
50	4.00	3.86	3.72	3.58	3.44	3.30	3.16	3.02	2.88	2.74
EARNING VALUE	0	.14	.28	.42	.56	.70	.84	.98	1.12	1.26

FIG. 1.

CAN NAME AND ADDRESS	S+CB	-S ₁ DEBIT	-S ₂ DEBIT	-S ₃ DEBIT	+S ₃ CREDIT	+S ₂ CREDIT	S - CB
NOT USED							
[END ACCOUNT MARK] (ADD)							
-S ₁ DEBIT	-----	S+CB					CC AN

FIG. 2.

JACOB GOLDBERG
BONNAR COX
INVENTOR.

BY

Lyon & Lyon

ATTORNEYS

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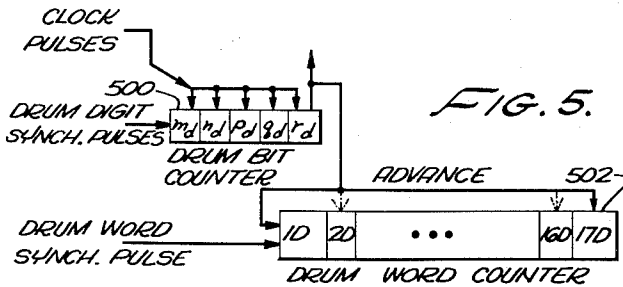
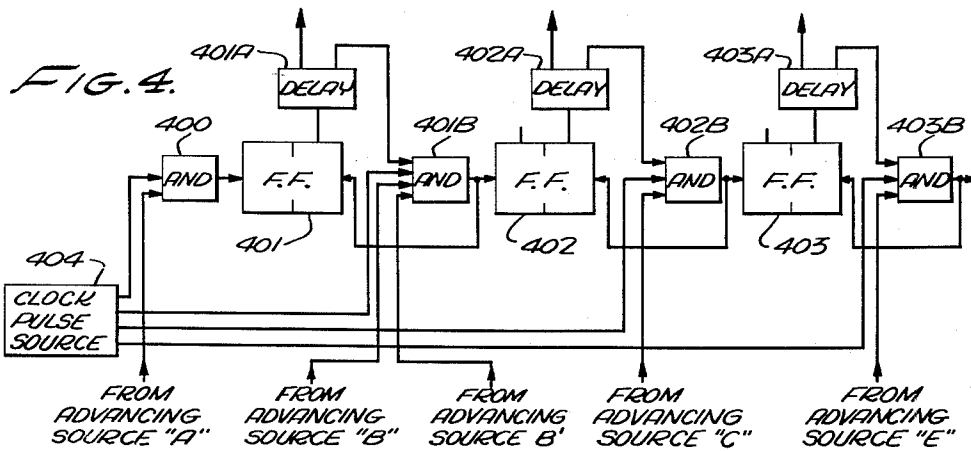
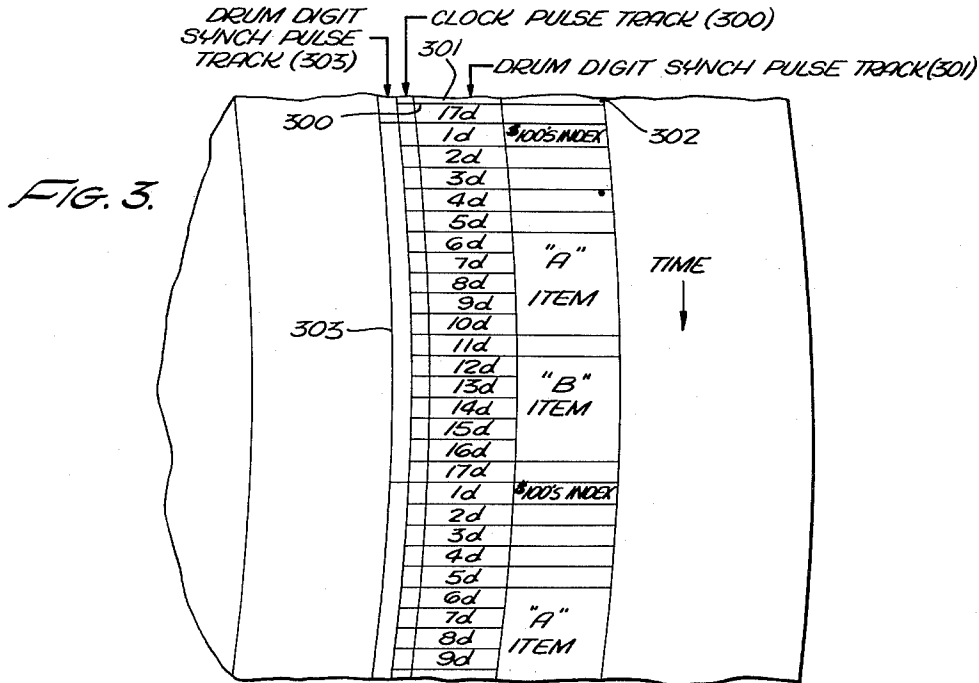
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JACOB GOLDBERG
BONNAR COX
INVENTORS

BY

Lyon Lyon
ATTORNEYS

Jan. 16, 1962

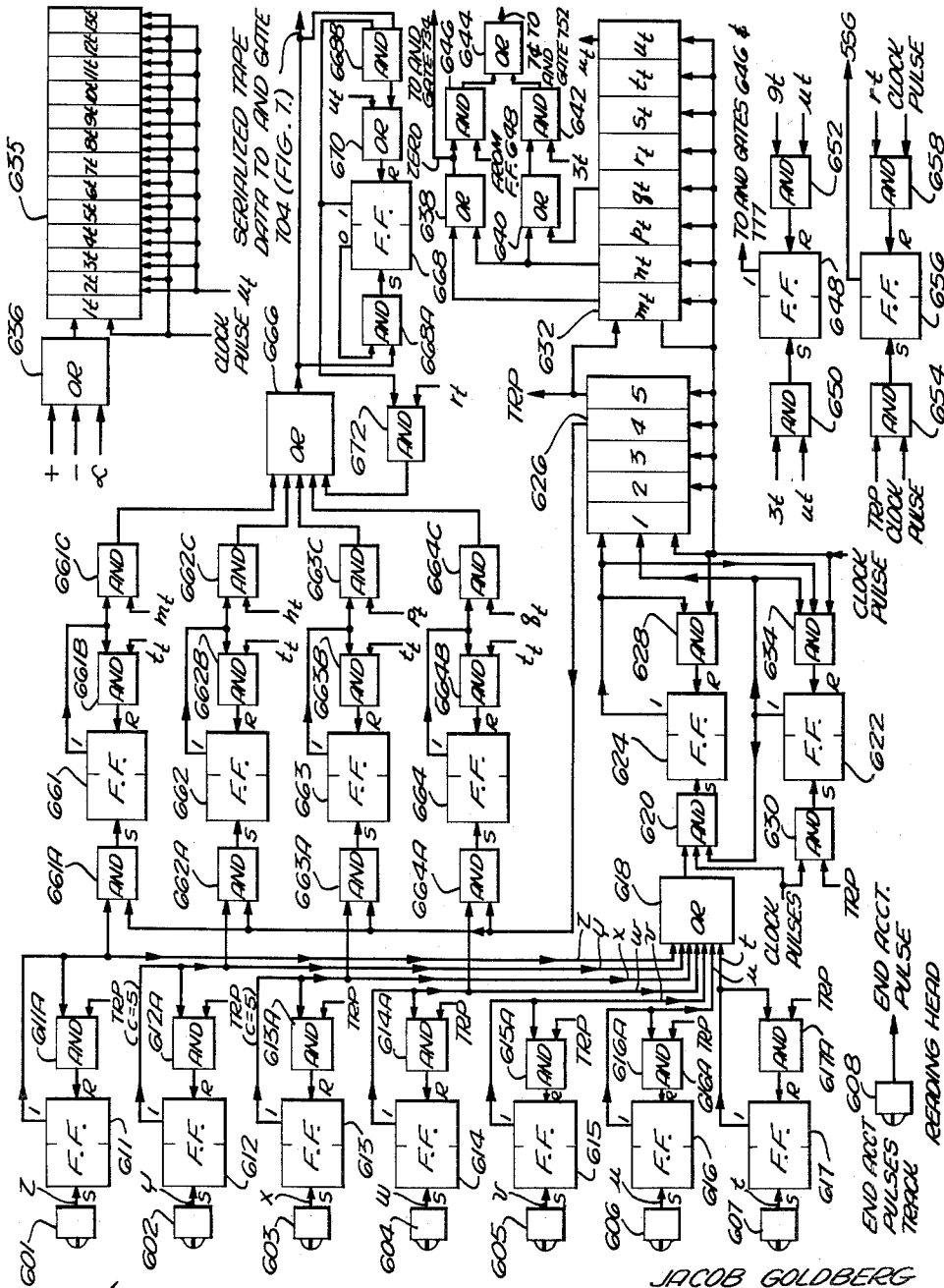
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TAPE
READ
AMPS.

FIG. 6.

JACOB GOLDBERG
BONNAR COX
INVENTORS

BY

Lyon Lyon

ATTORNEYS

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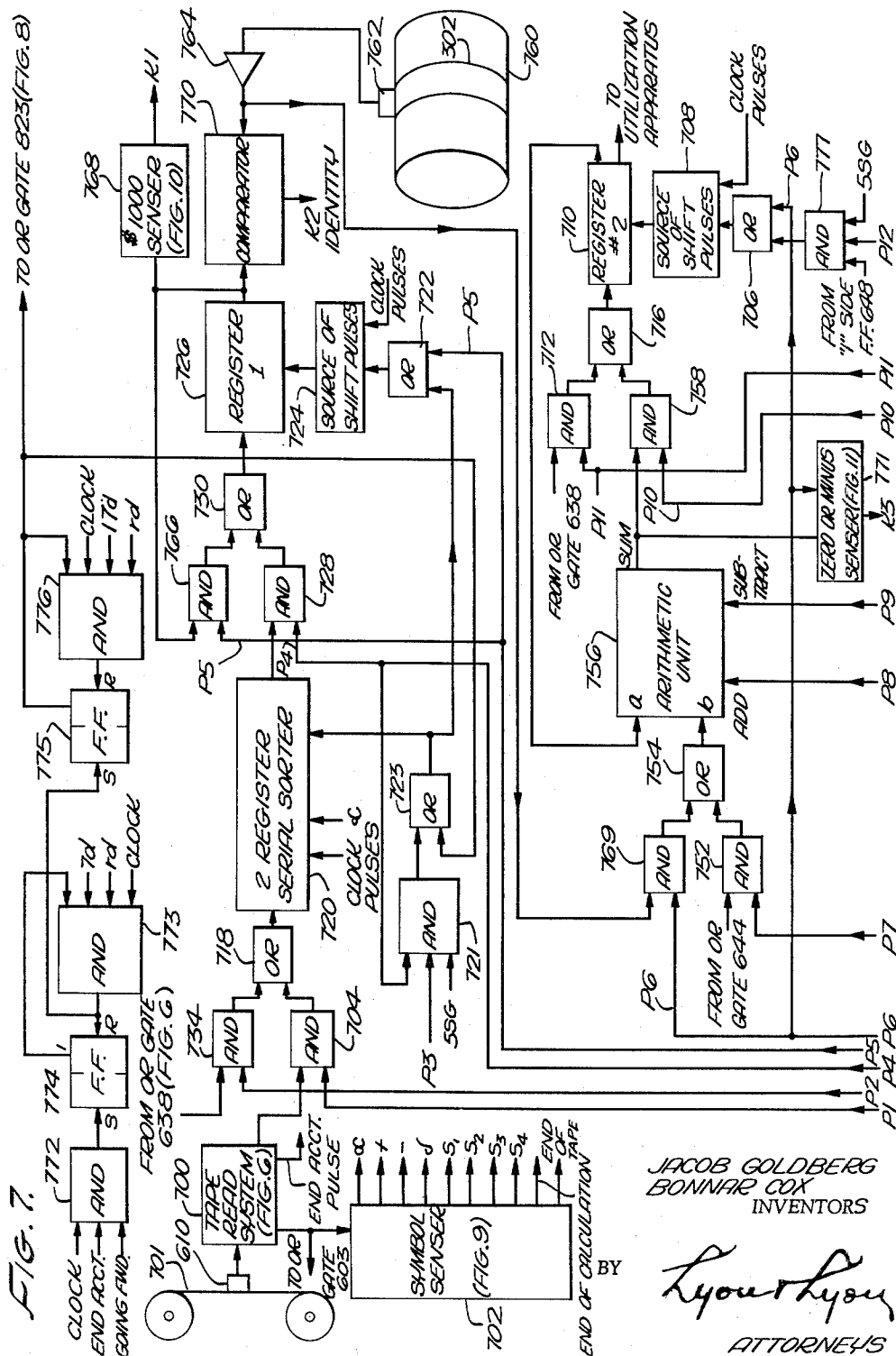
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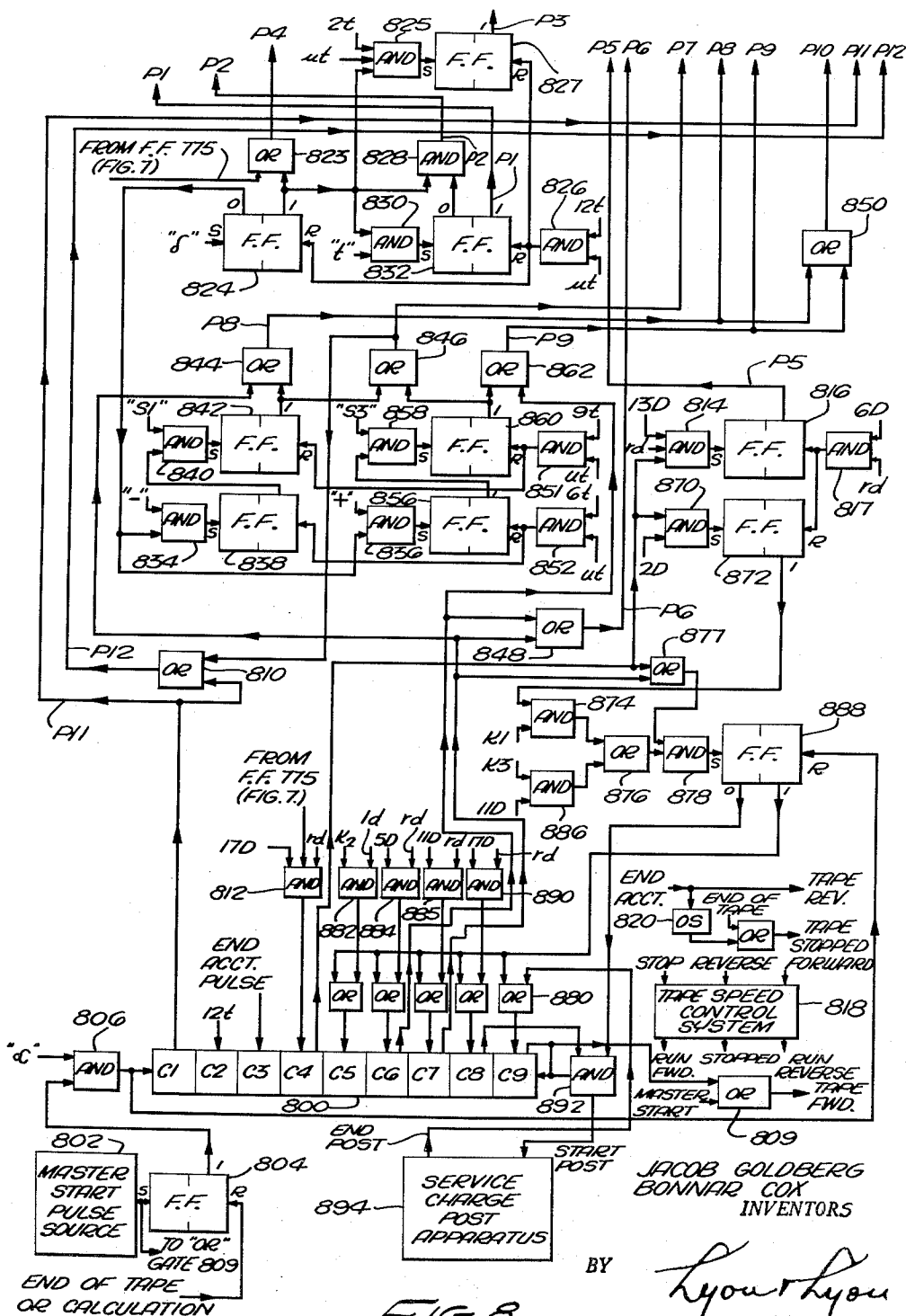
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JACOB GOLDBERG
BONNAR COX
INVENTORS

BY

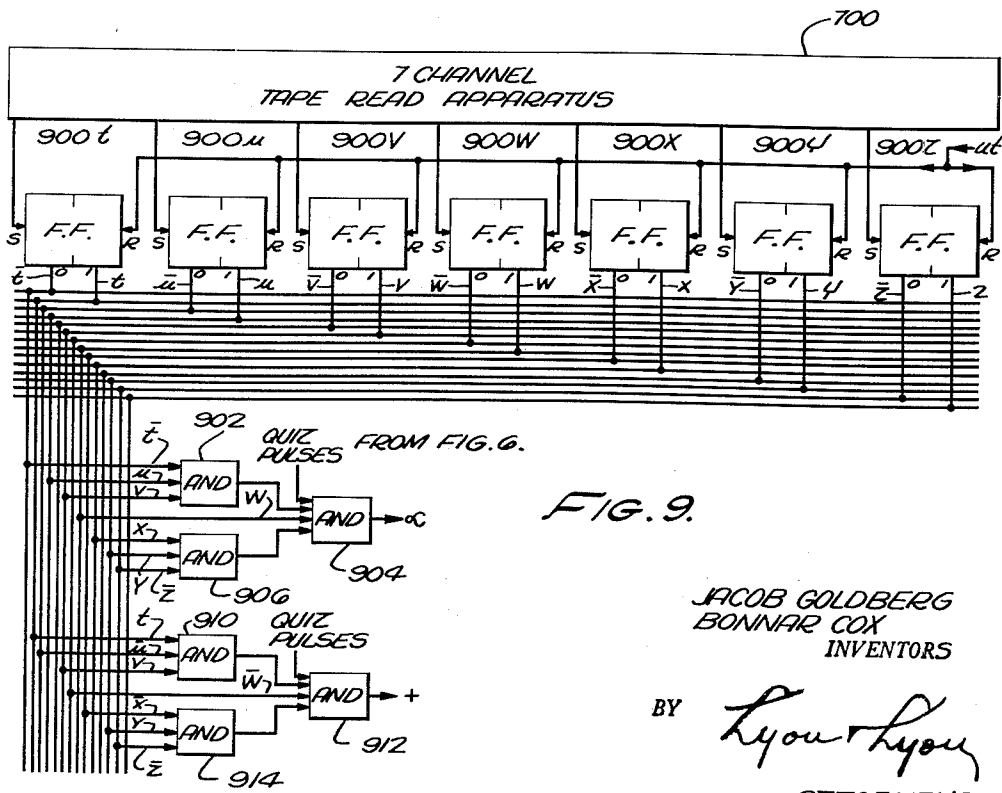
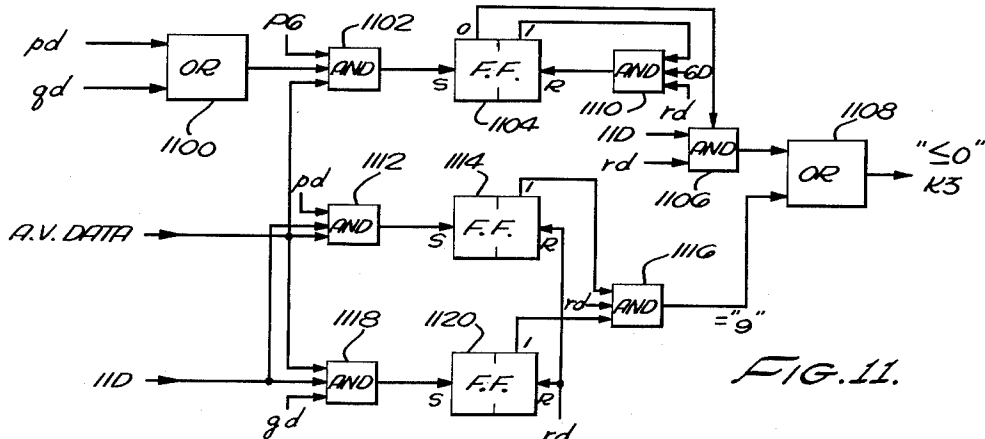
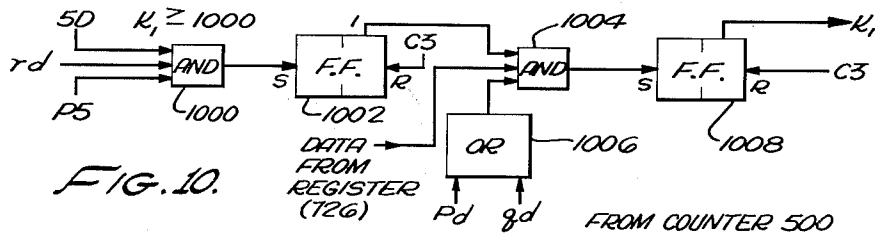
Lyons Lyons

ATTORNEYS

J. GOLDBERG ET AL
SERVICE-CHARGE CALCULATION SYSTEM

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6 Sheets-Sheet 6



JACOB GOLDBERG
BONNAR COX
INVENTORS

BY

Lyon Lyon

ATTORNEYS

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3,017,103

SERVICE-CHARGE CALCULATION SYSTEM

Jacob Goldberg and Bonnar Cox, Palo Alto, Calif., assignors to General Electric Company, New York, N.Y., a corporation of New York

Filed Nov. 24, 1958, Ser. No. 775,835

12 Claims. (Cl. 235-176)

This invention relates to electronic information-handling machines and, more particularly, to an improved calculating system for use in information-handling machines employed in accounting transactions.

This application is a continuation in part of application filed June 3, 1957, Serial No. 663,046, now abandoned by Jacob Goldberg and Bonnar Cox, for Service-Charge Calculation System.

One of the operations which is performed in the banking business is one termed "service-charge calculation." The service-charge calculation consists of a charge periodically made against commercial checking accounts which have maintained a balance less than a predetermined minimum during the service-charge period. For those accounts, the charge is based upon the minimum balance reached during the period in question, the number of checks used, and a predetermined constant value.

An object of the present invention is to provide a system for automatically performing a service-charge calculation.

Yet another object of the present invention is the provision of a novel and unique arrangement for obtaining automatically a service-charge calculation.

Still another object of the present invention is the provision of apparatus for automatically calculating a service charge which can be integrated with other data-handling machines for accounting processes.

These and other objects of the invention are achieved in a system wherein for each different account there is stored on an elongated storage medium a list of the items for which service charges are to be calculated. Also periodically stored in the elongated storage medium is the current balance of each of these accounts. Means are provided for scanning through the record of the data stored for each account, detecting whether or not a balance falls below a predetermined minimum, as well as counting up the number of items for which a service charge is to be made. Subsequent to this, a look-up operation in a service-charge table is performed, and with the data derived thereby the service charge is thereafter calculated.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a typical commercial checking account service-charge chart;

FIGURE 2 shows the preferred layout for the storage of data on magnetic tape;

FIGURE 3 shows an arrangement for recording service-charge table information on a magnetic drum;

FIGURE 4 is a block diagram illustrating the type of counter employed in this invention;

FIGURE 5 is a block diagram of a drum-digit-timing counter required in the invention;

FIGURE 6 is a block diagram of a tape bit and digit counter required in the invention;

FIGURES 7 and 8 are block diagrams of an embodiment of the invention wherein FIGURE 7 shows the apparatus in the data-flow paths and FIGURE 8 shows the apparatus for generating control signals;

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FIGURE 9 is a block diagram illustrating the type of symbol sensor employed in the invention;

FIGURE 10 is a detailed block diagram \$1000 sensor employed in the invention; and

FIGURE 11 is a detailed block diagram of a zero or minus sensor employed in the embodiment of the invention.

In the explanation of the invention that follows there is described an accounting procedure in banks in which a service-charge calculation for checks used is made, based upon charges shown in a chart. A specific chart is shown merely by way of illustration and to simplify the explanation of the invention. This is not to be held to be a limitation upon the invention, since the principles to be described may be used with other charts and for other applications.

FIGURE 1 shows a typical commercial checking account service-charge chart. At the top of the chart there is listed the minimum-balance group, and in a column for each minimum-balance group is shown the charge to be made for the number of checks used within such group. The earning value for such minimum balance is shown at the bottom of the chart in the associated columns. The charges shown in the chart are made up as follows: There is a basic charge of seven cents for each check which is used. To this basic seven-cent charge is added an additional 50-cents charge. From this total, there is subtracted the earning value of the minimum balance. It is the usual practice to post the service charge each month and to look at the minimum balance which was reached during such period for the purpose of determining what the service charge should be. It should also be noted that for each minimum-balance class, if less than a specified number of checks has been written, there is no service charge whatsoever.

It is the usual banking practice to identify each depositor of the bank by an account number. For the purpose of this invention, it is required that a continual record be kept for each depositor, which consists of the daily activity for that depositor's account, followed by a balance figure at the end of the day. This is in accordance with the usual banking practice also. Such information can be transferred in any number of well-known means to a storage medium, such as paper tape, magnetic tape, magnetic drum, or magnetic cores. In the embodiment of the invention to be described, it is preferred that the data for each account be stored on magnetic tape. This is not to be construed as a limitation, but merely exemplary.

Referring now to FIGURE 2, there may be seen a typical desired arrangement for recording the activity for an account on magnetic tape. Of course, it is understood that data recorded on magnetic tape is not visible; however, in order to assist in an understanding of this invention, the items stored on the magnetic tape are written out for the purposes of explanation. An account commences with an alpha symbol, which is followed by the numerals of the account number here represented as "αAN." There are twelve number digits provided for each account number. This is followed, where required, by the name and address of the account. The beginning of the activity-recording region is signified by a beta symbol. Each activity region will first have the amount or balance with which the account starts the recording period. Thus, a beta symbol is followed by a delta symbol, indicative of the fact that the numbers that follow immediately thereafter will represent a current balance. A delta is followed by a + or - symbol, indicative of whether the current balance is positive or negative (overdrawn account). Thereafter, the activity for a day or any other suitable period is recorded, at the termination of which another current

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balance is recorded. Thus, for the particular day represented in FIGURE 2, the activity for this account consisted of three debit items (which may have been checks which were cashed) and two credit items. For recording a debit item, first a minus sign is recorded. This is followed by an S_1 symbol. The S_1 symbol indicates that the debit item is one for which a charge should be made. This is then followed by numbers representing the amount of the debit.

The two S_1 debit items are followed by an S_2 debit, which is a type of debit item for which no charge should be made. This type of debit item may be, for example, a result of an authorization to the bank to deduct from the account an amount to be converted to savings bonds. The S_2 debit item is followed by a $+S_3$ symbol, followed by a credit amount. The $+S_3$ symbol indicates a credit entered by the bank to offset an improper debit; thus the count of debits for service charge must be reduced by one. The S_3 credit item is followed by a $+S_4$ credit item. This is indicative of the fact that no charge should be made for whatever item follows the $+S_4$ symbol.

The recording for the day's transactions are then completed by a current balance, which for the type of situation shown is negative, indicating that more money has been withdrawn than was on deposit. The record of the activities for the next day is made thereafter, consisting of the transactions occurring during that day, followed by the current balance at the end of that day. The last of the recorded current balances is followed by a pulse, which is recorded in a track adjacent to the tracks in which the item activity is recorded. This pulse may be termed an end-account mark. Each time an activity entry is made, this pulse is moved further along the track, to mark the new position at which the account recording ends. A suitable system for recording and moving these pulses and using them for the purpose of verification of data which has been written is shown, described, and claimed in an application by these inventors for a Magnetic Tape Writing System, Serial No. 624,308, filed November 26, 1956, and assigned to a common assignee.

As briefly described previously, the arrangement for calculating the service charge to be made is to scan through all the activity data for an account to obtain the minimum balance for that account for the recorded period. In this search, a negative balance is interpreted as a zero balance. Simultaneously with such scanning, the number of debit items for which a charge is to be made is obtained, consisting of the items for which charges are to be made diminished by the items in the class for which a credit is given. Next the minimum balance which has been selected is inspected to see if it is less than a thousand dollars. If it is equal to or greater than a thousand dollars, no service charge is computed and the apparatus proceeds to inspect the next account.

If the minimum current balance which has been selected is less than a thousand dollars, then the fifth digit of this minimum current balance, which is the one in the hundreds position, counting from the least-significant position of the digits (cents), is employed to assist in obtaining information from a table for use in the service-charge calculation. The service-charge table is stored in another medium, which uses the information provided by the fifth digit in the current-balance amount selected to locate the required data in this auxiliary memory.

Reference is now made to FIGURE 3, which shows one arrangement for the layout of the service-charge table on a rotating or cyclic memory, which is a magnetic drum. One of these tracks 300 has clock pulses recorded thereon. A second track 301 has one pulse recorded for every five clock pulses. These are termed drum-digit-sync pulses and are respectively designated between 1d and 17d to define the extent of space allo-

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cated for recording two numbers. A third track 303 has one pulse recorded therein for every 17 drum-digit-sync pulses. These pulses are designated as drum-word-sync pulses and are recorded at the end of the space allocated for two numbers and before the space for the succeeding two numbers. The two numbers are respectively designated as an "A" item and a "B" item. A different "A" item and a different "B" item are required for each hundreds-of-dollars index. It should be noted that only ten entries of the A and B type are required to specify an entire service-charge table. Thus, there are ten storage spaces with drum-word-sync pulses and ten different sets of drum-digit-sync pulses designated by 1d through 17d. Opposite each first storage location, designated by the pulse 1d, there is stored on a track 302 a number from zero to nine (represented by five binary bits) representing the hundreds-of-dollars value in a minimum current balance. In the locations which are designated by the 6d through 10d pulses, there is stored a dollars-and-cents value which is designated as the "A" item. The 11d storage space is blank, but the space between 12d and 16d has stored therein a second dollars-and-cents value, which is identified as the "B" item. The 17d storage space is empty. Thus, for each one of the ten entries in the table there is stored the hundreds of dollars co-ordinate, followed by an "A" item, and then followed by a "B" item.

In the operation of this system, after a fifth-significant digit of the minimum current balance has been selected, this is compared with the hundreds of dollars co-ordinates on the drum. Upon coincidence being obtained, an "A" item is read out from the drum, and this is subtracted from a computed value consisting of the product of the number of items for which there is to be a charge times seven cents. If a positive balance results, then to this positive balance there is added the value of the "B" item, which is read thereafter. The sum is the service charge. If after the "A" item subtraction there is no remainder or it is negative, then it is indicative of the fact that no service charge is to be made for this particular account. The apparatus is then instructed to proceed to the next account.

The manner of calculating the "A" value in designing the table is determined for each hundreds-of-dollars co-ordinate by considering the chart in FIGURE 1. The first number of checks for which a charge is made is found under each hundred-dollars range. This is multiplied by seven. Thus, considering the \$400 range, or fourth co-ordinate, the number of checks for which a service charge is first to be made is five. This is multiplied by seven, providing the value of 35 cents for A. The B number, corresponding to an A number, is computed by taking the value of A, adding 50 cents, and then subtracting the credit for the hundred-dollars balance. Thus, in effect, the addition of B compensates for the previous subtraction of A from the calculated product of seven times the number of items for which a charge is to be made, and thereby the correct service charge is provided.

By way of illustration, the value of A for the four-hundred-dollar range is 35 cents, to which 50 cents is added, leaving a total of 85 cents. The credit for the four-hundred-dollar range is 56 cents, and, subtracting this from 85 cents, leaves 29 cents as the value of B. Thus, assuming that a minimum balance for an account were somewhere within the area of \$400 to \$499 and 16 checks were used, the calculation arrived at upon looking through the transactions recorded on tape would be seven cents times 16, or \$1.12. Subtracting the value of A from this leaves 77 cents. Adding the value of B leaves \$1.06, which, if reference is made to the chart, is the correct charge. Obviously, if only four checks were used, when the value of A were subtracted from 28 cents, a negative

result would have been obtained, and thus no charge would have been made.

	A	B
0.....	00	.50
1.....	00	.36
2.....	.07	.29
3.....	.21	.29
4.....	.35	.29
5.....	.70	.50
6.....	.84	.50
7.....	.98	.50
8.....	1.12	.50
9.....	1.26	.50

The above indicates the A and B values which are stored in association with the hundreds-dollar value.

For the operation of the embodiment of this invention, several counters are required. These counters are of the type which are described and claimed in an application by James E. Heywood, entitled Gated-delay counter, Serial No. 400,645, now Patent No. 2,858,429 filed December 28, 1953, and assigned to this assignee. A block diagram exemplifying the type of counter is shown in FIGURE 4. It includes a plurality of succeeding count stages 401, 402, 403, each one of which comprises the well-known flip-flop circuit having a set and reset stable state and being capable of being driven from one to the other of these states by input pulses. The output of each flip-flop stage, when in its set condition, is applied to an associated delay network 401A, 402A, and 403A. Output from this delay network, besides being applied to other required apparatus, is also applied to an associated AND gate 401B, 402B, and 403B. The AND gate is the well-known coincidence type of circuit which requires a simultaneous presence of all of its inputs before it can provide an output. To initiate operation of the counter, an AND gate 400 is provided. This starting AND gate 400 applies its output to set flip-flop 401 when a clock pulse is received from a source 404 and also a signal is received from a source identified as "Advancing Source A." Each one of the other AND gates 401B through 403B has its output applied to the set succeeding stage of the counter and to reset the preceding stage of the counter. One input to each of these other AND gates is an output from the delay circuit driven by the preceding stage of the counter.

A second input to the AND gates 401B, 402B, 403B can be from the clock-pulse source 404. This clock-pulse source represents the well-known synchronizing pulse source employed in data-handling systems. It can be either a stable oscillator or, as in the present invention, the output from track 300 on the magnetic drum on which are recorded pulses which are read continuously. The purpose of the clock-pulse source is to synchronize the operation of the system. If desired, a third input to the advancing AND gates before they can advance the counter may be required, and, as exemplified in FIGURE 4, consists of an input from an advancing pulse source. This may be a single source connected to all the AND gates in the same manner as the clock-pulse source. This may also be more than one input from more than one advancing-pulse source. For example, AND gate 401B requires a pulse not only from advancing source B, but also from advancing source B'.

In order to simplify the drawings herein to facilitate an understanding thereof, counters which will be shown hereafter will not be shown in detail of the one in FIGURE 4. Instead, a counter will be represented as shown in FIGURE 5, which is a block diagram of the counters required for providing timing pulses for the embodiment of the invention. The first count state of each counter cannot be entered until the input signals represented by the labeled arrows directed into the first counter state are provided. Thereafter, the count in each counter advances in response to the set condition of a preceding counter stage and the input signal or signals represented by the

labeled arrows shown pointing to the particular counter state. Actually, FIGURE 5 shows two counters. One is a drum-bit counter 500, which is advanced through each one of its five stages, respectively designated as m_d , n_d , p_d , q_d , r_d , in response to pulses read from the clock track 300 on the drum. This counter is a continuously recycling one. It is set into its first count condition by the coincident arrival of one of the drum-digit-sync pulses 1d through 17d and a clock pulse. Each time it achieves its fifth count condition, also designated as " r_d " state, it provides an advance-pulse output to the drum-digit counter 502. The drum-digit counter 502 is one having 17 separate count states, respectively designated as states 1D through 17D. The drum-digit counter first count state occurs in response to a drum-word-sync pulse and an r_d pulse. Thereafter, the drum-digit counter 502 advances in response to each successive r_d pulse, thus indicating the 17 digit intervals in a word, respectively as outputs 1D through 17D. In the succeeding drawings, outputs from the counter 502 will be designated as 1D, 12D, or whatever count condition of this counter is required for operation of the system. Outputs from the drum-bit counter are represented as m_d , n_d , p_d , q_d , and r_d .

FIGURE 6 is a block diagram representing the tape-reading apparatus and counters which are operated by the tape-reading apparatus. By way of example, it will be assumed that the tape has seven tracks from which a parallel data readout is made. An eighth track is used for the end-account pulse marker. There are eight tape-reading heads and amplifiers 601-608 associated with the respective eight tracks for reading. The data-reading heads and amplifiers also have their output leads respectively designated by the letters t , u , v , w , x , y , z for identifying data-bit positions in a tape-data digit. The output at the reading amplifiers 601-607 are respectively applied to associated flip-flops 611-617. If a one bit is read in a track, the associated one of the flip-flop circuits 611-617 will be set to its one state. If a zero is read, the flip-flop circuits 611-617 are not affected. The flip-flop circuits 611-617 are reset by associated AND gates 611A-617A. These AND gates provide the required reset output when their respective inputs comprise the "one" state of the associated flip-flop and a TRP signal pulse. The derivation of this pulse will be described infra.

The set outputs of flip-flops 611-617 are all applied to an OR gate 618. The output from OR gate 618 is applied to an AND gate 620. Upon the occurrence of a clock pulse therewith and a set output from a flip-flop 622, AND gate 620 can set a flip-flop 624. The set output of flip-flop 624 is applied as one of the required inputs to enable a counter 626 to enter into its first count state and also as one of the required inputs to enable an AND gate 628 to reset flip-flop 624. The other required input to AND gate 628 is a clock pulse. Thus, flip-flop 624 remains set for the interval between two clock pulses. The clock pulse that resets flip-flop 624 also enables counter 626 to enter its first count condition when flip-flop 622 is set.

Counter 626 has five count stages and is successively stepped through these in response to successive clock pulses, after once having been driven to its first count condition. The fifth count stage output, designated as TRP, is the one which enables an AND gate 630, upon the occurrence of the next clock pulse, to set flip-flop 622. This fifth count stage TRP output is applied to all AND gates 611A-617A for resetting all flip-flops 611-617, and also to a second counter 632 to enable it to advance in response to successive clock pulses.

The set output of flip-flop 622, besides being applied to AND gate 620 and the input counter stage 626, is also applied to an AND gate 634. Upon the occurrence of the next clock pulse, AND gate 634 is enabled to reset flip-flop 622.

From the above description, it will be seen that flip-flop 622 is set and all flip-flops 611-617 are reset when

counter 626 reaches its fifth count state. Thereafter, any data pulses that are read set the flip-flops 611-617 associated with the tracks on the tape in which data pulses occur. The flip-flops 611-617 retain their set and reset conditions, representative of the data which has been read, until counter 626 again reaches its fifth count. OR gate 618 provides an output which sets flip-flop 624 to thereby enable counter 626 to commence counting as soon as any data pulse has set any one of flip-flops 611-617. The set output of flip-flop 624 also enables flip-flop 622 to be reset. The result of the operation of the structure described is to provide a timed collection interval during which seven bits of data must be read into the seven flip-flops 611-617. At the end of that interval, counter 626 resets all the flip-flops 611-617, and a new data-bit collection interval is established. This system is employed to avoid the effects of skewed tape, which without such timed data-bit collection interval can cause erroneous data to be read. This arrangement is described and claimed in Patent No. 2,793,934, by Donald K. Reynolds.

The set conditions of the flip-flops 611-617 are entered into other flip-flop circuits, as will be more fully described in connection with FIGURE 9, for the purpose of staticizing the data that has been read from the tape.

Referring back to FIGURE 6, output from the fifth count stage of counter 626 is applied, together with a clock pulse, to the first count stage of counter 632. This enables the counter to count through a complete count cycle in response to succeeding clock pulses. The outputs of the successive count stages of counter 632 will be respectively designated as m_t , n_t , p_t , q_t , r_t , s_t , t_t , and u_t . Each time a digit is read from the tape, counters 626 and 632 are advanced through a complete cycle. It should be noted that tape speed is considerably slower than drum speed and so that a large number of clock pulses are obtained from the drum during the interval required to move the tape from one recorded digit to the next. Counter 632 is known as the tape-bit-timing counter.

Still another counter 635, known as a tape-digit counter, is employed providing digit-timing-pulse outputs. This counter has thirteen count stages and provides thirteen outputs, respectively designated 1 t through 13 t . The counter is enabled to enter its first count state by the recognition of either a +, a -, or an alpha symbol being read from tape by apparatus designated as a symbol sensor (shown in detail in FIGURE 9). These symbols are applied to an OR gate 636, the output from which, together with a clock pulse, is applied to the counter 635 first stage. Thereafter, counter 635 advances in response to clock pulses and successive u_t outputs from counter 632. Since one u_t output is obtained for each digit read from the tape, counter 635 is known as the tape-digit counter.

The m_t and n_t outputs of counter 632 are applied to an OR gate 638, the output of which is a series of binary-coded decimal zeros. The outputs of the counter states n_t and q_t are applied to an OR gate 640, the output of which goes to an AND gate 642. This AND gate has as its second required input the 3_t output of counter 635.

Its output goes to an OR gate 644. As a second, or alternative, input to the OR gate 644, there is also applied the output of an AND gate 646. The two required inputs to this AND gate 646 are the output of the OR gate 638, as well as the output of a flip-flop 648, when in its set, or one, condition. Flip-flop 648 is set by output from an AND gate 650, the inputs to which are respectively a 3_t output of counter 635 and a u_t output of counter 632. The flip-flop 648 is reset upon receiving the output of an AND gate 652, the input to which is a 9_t output of counter 635 and a u_t output of counter 632. Thus, OR gate 644 can provide an output at 3_t time, representing a binary-coded decimal 7, and, during 4_t through 9_t times, provides binary-coded decimal zeros. The

structure described constitutes a zero generator and a seven-cents generator.

Another signal is required in the operation of this invention, which is designated as the 5SG pulse. This signal is initiated by the application of a TRP pulse from counter 626 and a clock pulse to an AND gate 654. The output of AND gate 654 is applied to set a flip-flop circuit 656. Flip-flop 656 stays set until r_t time, when AND gate 658, in response to r_t and clock-pulse inputs, resets flip-flop 656.

In the embodiment of the invention to be described, the numeric data is handled in serial form. Further, the numeric data is in the form of an excess-three binary coded decimal code, with the least-significant digit occurring first in the serial form. The tape has seven bits for each digit, in order to provide sufficient code variations to represent alphabetic and symbol data, as well as numeric data. The numeric data is represented by the w , x , y , z , bits and is read by the heads 601 through 604 over the associated tracks. Since this numeric data is read in parallel fashion from the tape, it is necessary to serialize these four bits, and, in accordance with the usual information-handling machine practice, a fifth or parity bit is added to provide an even parity for each numeric digit.

The serialization of parallel data is a well-known technique. It is illustrated in FIGURE 6 by structure comprising four flip-flops 661, 662, 663, 664, respectively set or not by outputs of associated AND gates 661A, 662A, 663A, 664A and reset by outputs of associated AND gates 661B, 662B, 663B, 664B. AND gates 661A, 662A, 663A, 664A respectively are connected to receive the set outputs of flip-flops 611, 612, 613, 614 and the output of the fourth stage of counter 626, whereupon the digit represented by the set or not-set states of flip-flops 611-614 are entered into flip-flops 661-664.

AND gates 661C, 662C, 663C, and 664C have one of their inputs respectively connected to the set output sides of flip-flops 661, 662, 663, and 664. These AND gates are enabled to provide outputs serially by respectively receiving m_t , n_t , p_t , q_t outputs of counter 632. Thus, an OR gate 666, to which all the AND gates 661C-664C outputs are connected, will provide as its output a sequence of pulses representative of the one states of flip-flops 661-664. At t_t count time of counter 632, AND gates 661-664B receive a t_t output, and those of these AND gates that are also receiving a set output from the associated flip-flop circuit can reset this flip-flop circuit. The output of OR gate 666 comprises serialized tape data.

A parity bit is now added to the four serialized bits of tape data. This is performed by a flip-flop circuit 668, which can be driven to its set state by the output of an AND gate 668A and to its reset state by the output of an OR gate 670. The OR gate 670 has as its inputs either a u_t pulse from counter 632 or the output of an AND gate 668B. The enabling inputs to AND gate 668A comprise the output of OR gate 666 and the zero or reset output of flip-flop 668. Thus, whenever a one bit occurs in the output of OR gate 666, and if flip-flop 668 is reset at the time, it will be set by the output of AND gate 668A. The next one bit in the output of OR gate 666 will enable AND gate 668B to provide a resetting output to flip-flop 668, providing flip-flop 668 is in its set condition. Thus, flip-flop 668 remains set if an odd number of one bits are read for each digit and will be left reset for each digit if it contains an even number of one bits. At r_t time of counter 632, its r_t output is applied to an AND gate 672. If at that time flip-flop 668 is still in its set state (odd number of one bits), AND gate 672 is enabled to provide an output to OR gate 666, which thereby adds it to the pulse train as an even-parity digit. At u_t time, OR gate 670 resets flip-flop 668, if not already reset.

At this time reference is made to the representation of data on the tape shown in FIGURE 2. The δ symbol is one digit and occurs during the 1_t state of counter 634. The succeeding $+$ sign is one digit and occurs during the 2_t state of counter 634. The following current balance is 10 digits long and occupies the 3_t through 12_t states of counter 634. Thereafter, in the daily transactions, a $+$ or $-$ sign is one digit, the S symbol is one digit, and the actual credit or debit requires 10 digits and occurs during 3_t through 12_t times of counter 634.

FIGURES 7 and 8 taken together are block diagrams of the invention. FIGURE 7 shows the apparatus required in the data-flow paths of the invention, and FIGURE 8 is a block diagram of the apparatus required for providing control signals for those data-flow paths. Referring now to FIGURE 7, a tape-reading system 700 reads data from the tape 701 and applies the output to a rectangle 702, representative of a symbol sensor, to an AND gate 704 and to the OR gate 603 in FIGURE 6. The tape-reading system is the one shown in FIGURE 6 and a symbol sensor is shown and described in more detail subsequently in FIGURE 9. The serialized data is applied to an AND gate 704, and parallel data is applied to the symbol sensor 702. The function of the symbol sensor is to generate a recognition output when any one of the symbols is read. These symbols include alpha, plus, minus, delta, S_1 , S_2 , S_3 , S_4 , end-of-calculation, and an end-of-tape symbol. The tape-reading system 700 provides a separate output when, as was described previously, the reading head 608 over the additional track reads the pulse indicative of the fact that the last item for the account has been read.

The serialized binary-coded decimal output of the tape-read system is applied to an AND gate 704. In order for this AND gate to further transfer its data input, it must also receive an input from apparatus which is found on FIGURE 8. It should be noted that a number of leads extend between FIGURE 7 and FIGURE 8. These leads are correspondingly identified by the letter "P," followed by a number. Thus, the input to AND gate 704 is a P_1 lead, which, in FIGURE 8, extends from the set output of a flip-flop 832.

The sequence of operation of the system is controlled by a counter 800, having nine count stages which are respectively designated as C_1 , C_2 - C_9 . As pointed out previously, this is the same type of counter as is shown in FIGURE 4. The required advancing inputs to the respective counter stages are shown as arrows directed into the counter stage to which it advances if all other required inputs are present. It will be understood that except for state C_9 , as will be later explained, an advancing cannot occur before a previous count state is reached.

The service-charge calculation is initiated by obtaining a pulse from a source, here designated as the master-start pulse source 802. This source can be any suitable switch or apparatus in an information-handling machine which automatically provides the initiating signal when the calculation is required. The master-start pulse source output is applied to a flip-flop 804, driving it to its set condition. It also starts the magnetic tape running forward by being applied to an OR gate 809, the output of which is applied to tape-control apparatus 818. Flip-flop 804 is reset by a suitable signal, either indicating that the end of the calculation process has been reached, or that the end of the tape which is being processed has been reached. Either of these signals are obtained from the symbol sensor 702, recognizing the code markings on the tape. The output of flip-flop 804, when it is set, is applied to an AND gate 806. A second required input to this AND gate 806 is the output provided upon the sensing of an alpha symbol by the symbol sensor 702. It will be recalled from FIGURE 2 that the alpha signifies the beginning of an account. Counter 800 is set by the output of AND gate 806 to its C_1 count condition.

The output of the AND gate 806 is also applied to reset to its "charge" representing state a flip-flop 838, which as will be subsequently described is used to establish whether or not a charge is made.

Counter 800, when in its C_1 count condition, provides an output to an OR gate 810, as well as to a P_{11} lead. The output of this OR gate energizes a P_{12} lead, which is connected to an OR gate 706 in FIGURE 7. The OR gate output is applied to energize a source of shift pulses 708. The output of the source of shift pulses is applied to a shift register 710, designated as register 2. The shift register is of the type shown and described in an article by Louis D. Stevens and James H. Knapton, entitled Gate-Type Shifting Register, in "Electronics" Magazine, vol. 22, Part II, pp. 186-192, December 1949, published by McGraw-Hill Book Company. The source of shift pulses is any well-known oscillator circuit which is keyed on and maintained oscillating in synchronism with clock pulses, as long as an output is received from OR gate 706.

As previously indicated, the output of counter 800, when in its C_1 state, also energizes a P_{11} lead. This lead enables an AND gate 712 to apply zero-representative signals received from the output of OR gate 638 in FIGURE 6 to the OR gate 716, from whence they are entered into register 710. The output of the zero generator OR gate 638 consists of decimal zeros in a suitable binary code. The entry of decimal zeros into the shift register replaces information previously in the register, thus effectively erasing this information unless it is directed elsewhere from the shift register. Thus, the C_1 state of counter 800 serves, by energizing leads P_{11} and P_{12} , to fill register 2 with decimal zeros.

Filling with zeros occurs during the interval from the time that the alpha symbol is sensed until the time a 12_t output is received from counter 634. It will be recalled that counter 634 advances one count for every digit which is read from the tape, following a word-starting symbol. At 12_t time, counter 800 is advanced to its second, or C_2 , count condition. It remains in the C_2 count condition until an end-account pulse is read by the tape-read system 700. This transfers counter 800 into its C_3 count condition.

The C_3 count state serves as a waiting state to provide synchronization between the tape timing circuits and the drum timing circuits. As soon as a coincidence occurs between a $17D$ digit count and an r_d digit count from the drum, indicating the start of a standard drum word, state C_3 is terminated and state C_4 starts. It will be recalled that counter 502 provides the $17D$ output and counter 500 provides the r_d output. It is these two outputs that are applied to an AND gate (FIGURE 8) 812, the output of which advances the counter from a C_3 to a C_4 count condition.

The C_4 state of the counter is a search state and this search state remains until the particular data on the drum identified by the hundred-dollar digit of the derived minimum current balance has been found.

This co-ordinate is located in the following manner. Referring to FIGURE 7, it will be recalled that the tape-read system reads tape data into AND gate 704. This AND gate output is applied to an OR gate 718. It should be noted that data which is read includes the balances for each day, which balances are identified by the symbol delta, followed by a plus or minus sign, followed by the balance. The output of the OR gate 718 is applied to a two-register serial sorter 720. The two-register serial sorter is sorter of the type described and claimed in an application by the present inventors, Serial No. 423,558, filed April 16, 1954, for Data Sorting System, now Patent No. 2,798,216. The serial sorter 720 selects the lowest one of the succession of numbers which is applied to its input. Briefly described, the two-register serial sorter includes two shift registers plus associated circuitry whereby a comparing circuit compares one number entered into one register and being circulated with another number

being entered into the other register. The decision of the comparing circuit as to the lower number operates, upon the next number for comparison being applied to the input, to circulate the contents of the register having the lower number while such next number is being entered into the other register in place of the one found to be the higher number of the two. Each time the two-register serial sorter is energized to perform a comparing operation, the contents of the register being circulated are read out during the circulation operation, this being the lowest number found to the time of that operation. The two-register serial sorter also includes circuitry which functions to enter the first number received into one register; the second number received is then directed to the second register, while being compared with the number in the first register. The α signal provides this instruction. Thereafter, operation of the sorter is as described, with control being in the comparator.

Once the tape is started running forward in response to a master start pulse, it continues running forward until an end-account pulse is sensed. This end-account pulse will cause the tape to stop and then reverse itself.

In order to carry out the proper tape-motion operations, a tape-speed-control system is required. This may be any well-known arrangement for controlling the motors and capstans employed in moving tape in response to pulse signals. A preferred arrangement is described and claimed in an application by the present inventors for Control Apparatus, Serial No. 599,089, now Patent No. 2,867,791 filed July 20, 1956, and assigned to a common assignee. For the purposes of this application, a tape-speed control system is represented by the rectangle 813 and it has three inputs. Energization of one input results in the tape motion being stopped. Energization of the second input results in the tape being run backwards, and energization of the third input results in the tape being run forward. The outputs of the tape-speed control system, aside from the actual mechanical control of the tape, will be energization of a first line, indicating that the tape is running forward; energization of a second line, indicating that the tape is stopped; and energization of a third line, indicating that the tape is running in reverse. An end-account signal energizes the reverse lead of the tape-speed-control system. It also energizes a one-shot multivibrator 820, which is a well-known unstable state multivibrator, and this one-shot at some predetermined time after it is driven from its stable to its unstable state, returns to its stable state, providing an output. This output is applied to an OR gate 822, the output of which is applied to the tape-stop input lead of the tape-speed-control system to stop the tape. This positions the tape properly within the account space of the account just processed and before the next account for which a service-charge calculation is to be made. Thus, the tape can be started running forward, can write the calculated service charge and new account balance, if desired, after sensing the end-account mark, and can sense the next alpha symbol representative of the beginning of the next account.

Referring now again to the commencement of operations, when the tape, which is running forward, passes the name-and-address region of the tape, and while counter 800 is still in the C_2 count condition, a delta symbol, signalling the beginning of a current balance, will be read. It should be recalled that each current balance entry is preceded on the tape by a delta symbol. This will cause flip-flop 824 to be driven to its set condition. The set output of this flip-flop energizes a P_4 lead through an OR gate 823. It also enables an AND gate 825 to set a flip-flop 827 when u_t and u_t outputs are received from the counters 634 and 632. The set output of flip-flop 827 energizes a P_3 lead. Referring now to FIGURE 7, the P_3 and P_4 leads are connected to an AND gate 721. When a 5SG pulse occurs (FIGURE 6), AND gate 721 stays open or the time for 5 bits to occur. These 5 bits overlap m_t , n_t , p_t , q_t , and r_t . Since flip-flop 827 remains on until 12_t , u_t , ten sets of 5SG's will pass through AND

gate 721, thus overlapping or gating ten digits of tape data being read out in the 5-bit drum code. AND gate 721 output is applied to an OR gate 722, the output of which is employed to energize a source of shift pulses 724, whereby a register 726, designated hereafter as "register one," commences to enter any input data. The output of AND gate 721 is also applied through an OR gate 723 to energize the two-register serial sorter 720 to proceed with its sorting operation. The P_4 lead is connected to an AND gate 728, which is between the output of the two-register serial sorter 720 and the input to the register 1. When the P_4 lead is energized, the AND gate 728 is opened to apply any output to an OR gate 730. The output of the two-register serial sorter is the lowest of the numbers applied to its input through OR gate 718. Flip-flops 824 and 827 are reset by the simultaneous occurrence of the 12_t and u_t counter outputs applied to an AND gate 826. It will be recalled that the 12_t and u_t outputs are the outputs of counters 632 and 634 in FIGURE 6, which are energized respectively responsive to the bits and digits being read from the tape. Thus, each time a delta symbol is recognized, flip-flop 824 is set and after the elapse of 12 digits it is reset. The length of each current balance is 12 digits.

Flip-flop 824, when set, also applies its output to two AND gates 828 and 830. AND gate 830 will set a flip-flop 832 if a plus symbol recognition output is derived from the symbol sensor 702 while it is energized. A P_1 lead is energized by the set, or "one," output of flip-flop 832. This enables AND gate 704 to enter through OR gate 718 into the sorter 720 the data being read at the time, consisting of a current balance. AND gate 826 resets both flip-flops 824 and 832 at 12_t and u_t time, which occurs after the current balance has been read.

It should be noted that it is not desirable that a negative number enter the two-register serial sorter. Therefore, provision must be made to prevent the entry of a negative current balance. For the purposes of this sorting routine, all that is needed is that a zero be entered into the serial sorter in place of a negative minimum balance. In order to enter a zero into the two-register serial sorter, the output of OR gate 638, comprising zero-representative signals, is connected to AND gate 734. This AND gate is enabled only when the P_2 lead is energized. The output of AND gate 828 energizes the P_2 lead. The AND gate 828 is energized when the set output of flip-flop 824 and the reset output of flip-flop 832 are simultaneously present. This occurs only when a current balance which is negative is read, since AND gate 830 will not be able to set flip-flop 832. Thus, the minimum balance read out of the two-register serial sorter into the register 1 will be a zero.

As the tape continues to be run through the activity portion, the two-register serial sorter, each time the P_3 and P_4 leads are energized, will enter into register 1 the lowest of the minimum balances read to that time. When the end-account pulse is sensed, operations are commenced to insure that register 1 will contain the minimum balance for the account. It should be noted that when a zero is entered into the two-register serial sorter and the P_2 lead is energized, the P_1 lead is not energized, and thus tape data is not entered into the sorter at the time when zeros are being entered. The above description shows how the minimum current balance is derived.

When an end-account pulse is sensed (FIGURE 7) together with a clock pulse and a signal from the tape-speed control, indicative that the tape is going forward, an AND gate 772 sets a flip-flop 774. The set, or one, output of this flip-flop, together with a clock pulse and 7_d and r_d inputs (drum counters), are applied to enable an AND gate 773 to set flip-flop 775. The set, or one, output of flip-flop 775 is connected to OR gate 723 to thereby energize the serial sorter to transfer out the lowest minimum balance and to energize the shift-pulse source 724 so that this may be entered into the shift register 726.

The one output of flip-flop 775 also is applied to OR gate 823 (FIGURE 8) to energize the P_4 lead and thereby open AND gate 728. Flip-flop 774 is reset to its zero state at 7_d , r_d through AND gate 773 at clock-pulse time. Flip-flop 775 is maintained in its set state until it is reset by the output of AND gate 776 in response to the occurrence of a clock pulse and 17_d , r_d time. Thus, the sorter operates to transfer out the lowest minimum balance which has been found to the register 726. Thus, an interval sufficient to enable a readout of the lowest minimum balance found is provided, and, if it was not entered into the shift register 726 pursuant to a previous readout, it is definitely entered at this time.

It was pointed out previously that while the minimum current balance is being selected, the product of seven cents times the number of items for which such charge must be made is also being calculated. The reset output of flip-flop 824, which exists when a current balance is not being read, is applied to an AND gate 834 and a second AND gate 836. If a minus symbol is seen by the symbol senser, then AND gate 834 is enabled to set flip-flop 838. The output of flip-flop 838, when in its set condition, is applied to an AND gate 840. If an S_1 symbol is recognized by the symbol senser, AND gate 840 can apply its output to set a flip-flop 842. The output of flip-flop 842 is applied to OR gates 844 and 846. This causes the energization of a P_7 and a P_8 lead.

The P_7 lead, as shown in FIGURE 7, enables the output of OR gate 644, which represents seven cents, to pass through an AND gate 752 and through an OR gate 754 to one input designated as "b" of an arithmetic unit 756. It will be recalled that OR gate 644 emanates decimal 7 at 3_t time, followed by decimal zeros at 4_t , 5_t , 6_t , 7_t , 8_t and 9_t . An arithmetic unit of the type required for adding or subtracting the binary code used is well-known and suitable circuit arrangements are shown and described, for example, in chapter 13 of a book entitled High-Speed Computing Devices, by Engineering Research Associates, published by McGraw-Hill Book Company. By energization of an "add" control lead through P_8 , the arithmetic unit will add the a and b inputs and produce an output sum. By energization of a subtract-control lead through P_9 , the arithmetic unit will subtract the a and b inputs and produce the difference.

The output of OR gate 846, besides energizing the P_7 lead, also energizes the P_{12} lead through OR gate 810. The P_{12} lead output is applied to an AND gate 777. This AND gate, when a 5SG output and the output from the one side of flip-flop 648 are received, through OR gate 706 energizes the source of shift pulses 708, to enable a shift-out of the information in the register 710 to the "a" terminal of the arithmetic unit. It will be recalled that a C_1 time of counter 800, register 710 was filled with zeros. Thus, the initial entry into the arithmetic unit from register 2 is zero. The energization of the P_8 lead instructs the arithmetic unit to add the numbers being applied to the a and b terminals at the time. The b terminal input is seven cents. Thus, it will be seen that whenever an item is associated with a minus and S_1 symbol, indicative of the fact that a charge should be made, seven cents is added to the amount in register two.

The output of the arithmetic unit, consisting of the sum, is entered into register 2, replacing the amount which is stepped out therefrom into the arithmetic unit. AND gate 758 is enabled to pass the arithmetic sum when a P_{10} lead is energized. This occurs when either OR gate 844 or OR gate 862 are activated, since the outputs of both OR gates, in addition to the functions previously described, are both applied to an OR gate 850, the output from which actuates the P_{10} lead. By the time of completion of the reading of a debit item at 12_t and u_t time, AND gate 852 will have received a 6_t and u_t output from the tape bit and digit counters 632 and 634. AND gate 852 then applies its output to reset flip-flop 838. AND

gate 851 resets flip-flop 842 at 9_t , u_t counts. This timing results in the accumulation of a six-digit sum in register two.

In the event that a credit item is seen, then the plus symbol output of the symbol senser is applied to an AND gate 836, which also receives a set output from flip-flop 824, enabling it to set flip-flop 856. This flip-flop applies its set output to an AND gate 858. If an S_3 symbol is seen, then AND gate 858 can set flip-flop 860. It will be recalled that an S_3 symbol indicates the fact that a deduction of seven cents is to be made from whatever charges were calculated up to that time. The output of flip-flop 860, when in its set condition, is applied to OR gate 862, as well as to OR gate 846. The output of OR gate 862 excites a P_9 lead and also, through OR gate 850, excites the P_{10} lead. Referring to FIGURE 7, it will be seen that the P_9 lead instructs the arithmetic unit to subtract the numbers applied to its a and b inputs. Since the P_7 lead has also been energized, the amount which is stepped out of register two into the arithmetic unit is reduced by seven cents from the seven-cent generator. The resulting difference is again entered into register two. At 6_t , u_t time AND gate 852 resets flip-flop 856; and at 9_t , u_t time AND gate 851 resets flip-flop 860. Thus, it will be seen how the tape has its contents simultaneously scanned to derive therefrom the minimum current balance and to compute the product of seven cents and the number of items for which a charge is to be made.

When the end-of-account pulse is received, the two-register serial sorter 720 has the minimum current balance for the account and register 2 has a number which is the product of seven times whatever the number of items to be charged for is. As the result of the end-of-account pulse having been read, the counter 800 state 3 is entered into which is the waiting state permitting synchronization with drum pulses. Upon the occurrence of $17D$ and r_d output from the drum bit and digit counter and the "one" state of flip-flop 775, AND gate 812 provides an output, advancing counter 800 to its C_4 count. As previously described, the output of the C_4 count state is applied to an AND gate 814 and upon the occurrence of the $13D$ and r_d counts, flip-flop 816 is set, energizing the P_5 lead, which remains energized until the occurrence of a $6D$ and r_d count output. The $6D$ and r_d outputs are applied to an AND gate 817, the output of which resets flip-flop 816 and de-energizes the P_5 lead.

The drum 760 rotates continuously and the head 762 continuously reads the output of the track 302 (FIGURE 1) into an amplifier 764. Energization of the P_5 lead, when the proper conditions arise, enables the register 1 to circulate its contents, since both the shift pulse source 724 is energized for the interval required between $13D$, r_d and $6D$, r_d and an AND gate 766, which is in the path between the input and the output of the register 1, is opened. Simultaneously with the circulation of the contents of the register 1, a thousand-dollar senser 768 senses the amount being circulated to determine whether or not it is equal to or exceeds a thousand dollars. If this is the case, then a K_1 lead is energized. The output of this K_1 lead, as will be shown later, serves the function of terminating the service-charge operation and directing the apparatus to go to the next account.

As the data in register 1 is circulated, each time the hundred-dollar digit occurs, it is compared by means of a comparator 770 with the hundred-dollar index, which is read from the drum track 302. This can be readily achieved since the fifth digit from the least-significant digit in the register will always be the hundreds-of-dollars amount and the system is synchronized from clock pulses derived from the drum. Upon an identity in the hundred-dollars index and minimum-current-balance hundred-dollar digit being achieved, an output from the comparator 770 is obtained, consisting of the energization of a lead identified as K_2 .

Referring now to FIGURE 8, an AND gate 870,

upon the occurrence of the 2D count in the drum digit counter and also the counter being in its C_4 count condition, causes a flip-flop 872 to be set. Both flip-flops 872 and 816 are reset each time the 6D, r_d combined input is applied to AND gate 817. The set output of flip-flop 872 is applied to an AND gate 874, which if a K_1 input is applied thereto, significant of the fact that the minimum current balance exceeds a thousand dollars, applies its output to an OR gate 876. The output of the OR gate 876 is applied to an AND gate 878, which is previously primed through an OR gate 877 by the fact that counter 800 is in its C_4 count condition. The output of AND gate 878 sets flip-flop 888. The set output of flip-flop 888 is indicative of the fact that no charge should be made and is applied to an OR gate 880 and to OR gates 881, 883, 885, and 887, whereby the counter 800 is rapidly transferred to its C_9 , or last, count condition, effectively skipping through the intermediate count conditions. This results in no charge being made for the account in question, and also energizes an OR gate 809, the output of which instructs the tape to commence running forward again to the next account.

In the event that no K_1 output is obtained, indicative of the fact that the minimum balance for the account was not a thousand dollars or over, there will be a K_2 output from the comparator 770. The counter is stepped to its succeeding, or C_5 , count condition when both the K_2 lead is energized and a 1D count output occurs, both of which are applied to an AND gate 882. The C_5 state is a waiting state between the time that comparison with the drum table is found and the time that the first A item actually appears on the drum. As shown in FIGURE 3, this occupies the time between 1D and 6D. The time just prior to the arrival of the correct A item is signified by the output of an AND gate 884, which occurs when a 5D and an r_d output are applied thereto. This transfers the counter 800 to its C_6 count condition. Its output at that time energizes OR gate 848 and OR gate 862. The output of OR gate 862, besides energizing the P_9 lead, also energizes OR gate 850, which serves to energize the P_{10} lead. The output of OR gate 848 energizes the P_6 lead.

Referring to FIGURE 7, the energization of the P_9 lead instructs the arithmetic unit that a subtraction should take place. The energization of the P_6 lead first serves to enable the shift-pulse source 708 through the OR gate 706 to shift the contents of register 2 to the a input terminal to the arithmetic unit and also serves to enable an AND gate 769 to receive the output of the drum track which occurs at that time. This output, of course, is the A item. It is entered through OR gate 754 into the b input terminal of the arithmetic unit simultaneously with the entry into the arithmetic unit from register 2 of the amount calculated by multiplying by seven cents the number of items for which a charge is to be made.

Counter 800 remains in its C_6 count condition until the 11D, r_d time, which, referring to FIGURE 3, is the time which occurs at the end of the A item. At that time, counter 800 is transferred to its C_7 count condition. The subtraction which has taken place is terminated, and the output of the arithmetic unit has now been stepped into the register 710.

It should be noted that while output from the arithmetic unit is being transferred to the register 710, it is sensed to determine whether or not it is zero or negative by a zero or minus sensor 771. This sensor 771 is enabled by the signal on the P_6 lead. If a negative amount is sensed, or a zero, then a lead designated as K_3 is energized by the zero and minus sensor. The K_3 lead is connected to an AND gate 886 shown in FIGURE 8. AND gate 886 at 11D time, if the K_3 lead is energized, applies its output to OR gate 876. OR gate 876 output is connected to AND gate 878. The second required input to AND gate 878 is the output of OR gate 877, which is received

at C_7 count time. AND gate 878 output serves to set the flip-flop 888 to indicate no charge.

If the K_3 lead is not energized, then the C_7 count condition serves to energize both the OR gate 844 and OR gate 848, whereby the leads P_6 and P_8 are energized. Lead P_{10} is also energized through OR gate 850 by output from OR gate 844. Energization of the P_8 lead instructs the arithmetic unit to add the data being applied to its a and b input terminals. The P_6 lead also enables the source of shift pulses to shift the contents of register 2 into the arithmetic unit and to receive the output of the arithmetic unit. The energization of the P_{10} lead is necessary to enable AND gate 758 to transfer the data from the output of the arithmetic unit into the register. Accordingly, what occurs is that the "B" item, which is entered into the arithmetic unit, is added to the difference resulting when the A item is subtracted from the calculated item, resulting in the correct service charge. This is entered into register 2.

At 17D, r_d time, AND gate 890 transfers the counter into its C_8 count condition. At this time, the output of C_8 is applied to an AND gate 892. This AND gate requires as its second enabling input an output from flip-flop 888, indicative of the fact that a charge is to be made. AND gate 892 output is applied to apparatus identified as "service-charge-post apparatus" 894. This can be any desired apparatus which can serve either to apply the contents of register 2 to an output printer device, to transfer the contents of register 2 to another storage system in which it may be associated with the account number, or any other desired operation. The end of any such operation may be signaled by a pulse applied to OR gate 880, whereupon the counter enters its C_9 count condition and instructs the tape with the output derived at that time to start processing the next account.

Apparatus which has been described as a symbol sensor 702, thousand-dollar sensor 763, zero or minus sensor 771, will now be respectively described and shown in FIGURES 9, 10, and 11. The following table illustrates a code which may be used for the symbols employed herein. The letters t, u, v, w, x, y , and z are positioned above each bit location in the binary code.

	t	u	v	w	x	y	z
alpha.....	0	1	1	1	1	1	0
plus.....	1	0	1	0	0	0	0
minus.....	0	0	1	1	1	1	1
delta.....	1	0	0	0	0	0	1
S_1	1	0	1	1	1	1	0
S_2	1	0	1	1	1	0	1
S_3	1	0	1	1	1	1	1
S_4	1	0	1	1	0	1	1
End-of-tape.....	0	1	0	1	1	1	1
0.....	---	---	---	0	0	0	1
7.....	---	---	---	1	0	1	0

In the embodiment of the invention which was constructed, an excess-three binary decimal code was employed for numbers, with the w, x, y, z bits having numeric significance. For the purposes of service-charge calculation, only four bits of each digit read from the tape were entered into the apparatus, as shown in FIGURE 6, although seven bits were read. A fifth even parity bit was generated.

Referring now to FIGURE 9, there will be seen an illustration of a typical symbol sensor, as well as the tape data serializer and staticizer which may be employed. There are seven channels employed on the tape in order to have the symbols shown. The tape-read system 700 provides one output for each channel (derived from the set outputs of the seven flip-flops 611-617) and each one of these outputs is applied to an associated flip-flop 900 t , 900 u , 900 v , 900 w , 900 x , 900 y , and 900 z . The outputs of each one of these flip-flops have been respectively designated for the set condition as t , for the reset condition as $\bar{t}$, or $w, \bar{w}$, etc. If a one appears in a channel, the associated flip-flop is set. If a one does not appear in a channel,

the associated flip-flop remains reset. All flip-flops 900*t* through 900*z* are reset upon the occurrence of a u_i pulse. This insures that the flip-flops are available for the next character or symbol sensing.

The flip-flops 900*t*-900*z* staticize the character symbol or digit read from the tape so that a parallel presentation of electrical signals representative thereof is made.

The AND gate arrangements shown in FIGURE 9 for symbol sensing are those for the symbols alpha and +. In order to simplify the explanation herein, the arrangements required for the remaining symbols will not be shown. However, it will be clearly understood from the description of the manner of sensing symbols alpha and + how these other arrangements may be readily constructed.

Regarding the code for alpha, it consists of 0111110. This, in the flip-flop notation used would be $\bar{t}$, u , v , w , x , y , $\bar{z}$. Considering the first three digit positions in the sensing of alpha, an AND gate 902 provides an output only when its input receives the simultaneous presence of t , u , v . It will be noted that this represents the first three digit positions of alpha. The $\bar{t}$, u , v inputs are received from flip-flops 900*t*, 900*u*, and 900*v*. The output of AND gate 902 is applied to an AND gate 904. Another AND gate 906 will provide an output only when its input receives a simultaneous application of pulses from flip-flops 900*x*, 900*y*, and 900*z*, corresponding to x , y , and $\bar{z}$. It will be seen that this takes care of the last three digits of the alpha-code representation. AND gate 906 output is applied to AND gate 904. The remaining digit position w is handled by requiring the application to AND gate 904 of a w output from flip-flop 900*w*. AND gate 904 has as its last required input a quiz pulse from the output of counter 626, shown in FIGURE 6.

In order to sense the presence of a + symbol, three more AND gates are employed, a first one of these 910 senses the simultaneous presence of t , $\bar{u}$, and v from the outputs of flip-flops 900*t*, 900*u*, and 900*v*. The output of AND gate 910 is applied to a succeeding AND gate 912. Another AND gate 914 provides an output when it receives $\bar{x}$, y , and $\bar{z}$ as its inputs, which are simultaneously present; $\bar{w}$ serves as the third required input for AND gate 912. Upon the application of a quiz pulse and upon the presence of an output from AND gate 912, the fact that a plus has been sensed is evidenced. It will thus be seen from the above illustrative symbol sensor description that any one of the symbols may be sensed, employing three AND gates which respond to the proper pattern of outputs from the flip-flops 900*t* through 900*z*. For example, the minus symbol would be sensed by the presence at a first AND gate of $\bar{t}$, v , w , at a second AND gate the presence of an x , y , and $\bar{u}$, and a z is applied to a third AND gate together with the outputs of the other preceding two AND gates. A delta symbol would use one AND gate to sense the simultaneous presence of t , $\bar{u}$, z , a second AND gate would sense the presence of $\bar{v}$, $\bar{w}$, $\bar{x}$, and a third AND gate would receive the output of these two plus a quiz pulse, plus a $\bar{y}$ output.

FIGURE 10 is a detailed block diagram illustrating structure for the \$1000 sensor 768 shown in FIGURE 7. The circuit includes an AND gate 1000, which is enabled to set a flip-flop circuit 1002 when it receives a 5D and r_d pulse from drum counters 500 and 502 as well as P_3 lead energization. The set output of flip-flop 1002 is applied to an AND gate 1004. It should be noted at this time that flip-flop 1002 is set just after the fifth, or hundreds, digit has occurred and will be reset by the C_3 count state of counter 800, i.e., just before the circulating and comparing operation is to occur again.

AND gate 1004 has applied thereto the data from register 726 and the output of an OR gate 1006. OR gate 1006 provides output pulses upon receiving p_d and q_d outputs from counter 500. These are the bit positions for

the binary zeros in the excess-three code representation of a zero digit. This location of binary zeros is peculiar only to the digit zero. If the data has ones in these locations during p_d or q_d time, it is indicative of the fact that the digit being sensed has a value other than zero, indicative of a number equal to or exceeding \$1000. Thereby, OR gate 1004 is enabled to set flip-flop 1008. The set output of flip-flop 1008 provides the K_1 signal. The flip-flop is reset when it receives a C_3 output from counter 800.

FIGURE 11 is a detailed block diagram illustrating structure for a zero or minus sensor 772. An OR gate 1100 provides an output when energized by a p_d or q_d count output of counter 500. The reasoning for selecting these count outputs is the same as is explained for OR gate 1006 in FIGURE 10. An AND gate 1102 has applied to its inputs the output of OR gate 1100, the P_3 lead, and the output of the arithmetic unit 756. AND gate 1102 can therefore provide an output for setting flip-flop 1104 only if the arithmetic data has a value other than zero. The reset or zero output of flip-flop 1104 is connected to an AND gate 1106. At 11D, r_d time this AND gate, in the presence of a zero output from flip-flop 1104, can provide a K_3 signal output through an OR gate 1108, indicative of having sensed the value zero as the result of a calculation to determine the amount of service charge. Flip-flop 1104 is reset by an AND gate 1110, which is actuated to provide the required reset signal by 6D, r_d count inputs and the flip-flop being in its set condition.

An AND gate 1112 is enabled to set a flip-flop 1114 in the presence of p_d and 11D count inputs and any "ones" in the arithmetic data being sensed at that time. The set output of flip-flop 1114 is one of the inputs applied to an AND gate 1116. An AND gate 1118 is enabled to provide a set output to flip-flop 1120 in response to an 11D and q_d count input as well as any "ones" in the arithmetic data being sensed at that time. The set output of flip-flop 1120 is a second required input to AND gate 1116. The AND gate 1116 will thereafter provide a K_3 signal to OR gate 1108 at r_d time. Flip-flops 1114 and 1120 are reset at r_d time. Since any quantity represented in the excess-three code utilized herein which has a negative value has a nine digit (1100) during 11D time, the sensing by AND gates 1112 and 1118 as to the existence of ones, in the 11D digit position and p_d and q_d bit position within that digit position, in the arithmetic data indicates a negative number and results in a K_3 signal being provided.

There has accordingly been shown and described herein a novel and useful arrangement for calculating the service charge which is to be made for an account which has drawn a number of checks or items for which the charge is to be made. The calculation involves establishing the minimum balance, as well as the number of items for which the charge is to be made, determining from that minimum balance whether any charge is to be made. Thereafter, calculation is entered into, employing a calculation table which is stored on a memory for the purpose of providing the service charge. Although the memory is the rotary type, it will be well understood that the data provided by the fifth-significant digit or the hundreds digit can readily serve as an address information from which the data can be derived from other types of storage.

We claim:

1. In a system wherein there is recorded on a storage medium for each customer over a predetermined interval signals representative of the account activity including signals representing items handled, and signals representing periodic current balance entries, a system for calculating the service charge to be made for handling items for a customer having less than a predetermined minimum balance, which charge is to be based upon a minimum fee plus a fixed charge per item less a credit based on the minimum balance value, said system comprising means for selecting from said storage medium the signals representing the minimum balance occurring for a customer, means for determining whether the minimum

balance represented by said minimum balance value signals exceeds a predetermined value and to provide a signal indicative thereof, means responsive to said signal indicating the minimum balance exceeding a predetermined value to terminate further service-charge calculation for said customer, means for identifying item signals for which a charge is to be made, means for generating a set of signals representing a fixed charge for an item, means for accumulating a set of said signals representing fixed charges for each time identified by said means for identifying item signals to produce electrical signals representative of the fixed charge sum, a source of signals representing different first and second values and associated identifying signals representing minimum balance values, each said first value being the product of the lowest number of items for a minimum balance for which a charge is to be made and said fixed charge, each said second value being the sum of said first value and said minimum fee less the credit for said minimum balance value, means for comparing for identity the minimum balance signals obtained by said means for selecting the minimum balance value with the minimum balance signals at said source, means for extracting signals representing a first and second value from said source in accordance with an identity being established by said means for comparing, means for obtaining signals representing the difference between the value represented by said fixed-charge sum signals and the first value extracted by said means for extracting to provide difference signals, means responsive to said difference signals being representative of a zero or a negative quantity to terminate further service-charge calculation, and means to add said second value signals to said difference signals to obtain signals representing the service charge for said customer.

2. In a system wherein there is recorded on a storage medium for each customer over a predetermined interval signals representing the customer account activity including signals representing items handled, and signals representing periodic current-balance entries, a system for calculating the service charge to be made for handling items for a customer having less than a predetermined minimum balance, which charge is to be based upon a minimum fee plus a fixed charge per item less a credit based on the minimum balance value, said system comprising means for selecting the signals representing the minimum balance occurring in an account, means for sensing whether said selected minimum balance signals equals or exceeds said predetermined minimum balance and for providing a first output signal indicative thereof, means responsive to said first output signal to terminate further service-charge activity for said account, means for identifying the signals representing items for an account for which a charge is to be made, means responsive to said means for identifying for establishing signals representing the value of the product of the number of items for which a charge is to be made and the fixed charge per item, means to establish signals representing a first precalculated value determined by the product of said fixed charge per item and the minimum number of items for the minimum balance selected for which a service charge is made, means for subtracting from said signals representing said established value said signals representing said first precalculated value, means for sensing whether or not the result of said subtraction are signals representing zero or less than providing a second output signal indicative thereof, means responsive to said second output signal to terminate further service-charge activity for said account, means to derive signals representing a second precalculated value which is the sum of said first precalculated value plus said minimum fee less the credit based on the selected minimum balance value, and means to add to said signals representative of a difference, signal representing said second precalculated value to obtain the service charge for the account.

3. In a banking system wherein there is recorded on

a storage medium for each depositor over a predetermined interval signals representing the account activity including signals indicative of checks handled together with signals representing periodic current-balance entries, a system for calculating the service charge to be made for handling checks for a depositor having less than a predetermined minimum balance, which service charge is to be based on a minimum fee plus a fixed charge per check less a credit based on the minimum-balance value, said system comprising means for selecting signals representing the minimum balance value occurring in an account, means for sensing whether said selected signals representing the minimum balance equals or exceeds said predetermined minimum balance and for providing a first output signal indicative thereof, means responsive to said first output signal to terminate further service-charge activity for said account, means for identifying the signals indicative of checks of an account for which a charge is to be made, an arithmetic unit, means responsive to said means for identifying signals indicative of checks to apply said fixed charge signals to said arithmetic unit to be added each time a check is identified whereby signals representative of a first sum is generated, storage means for storing signals representing a table of data consisting of a different first and a second value associated with a different minimum balance, each said first value being the product of the lowest number of checks for a minimum balance for which a charge is to be made and said fixed charge, each said second value being the sum of said first value, and said minimum fee less the credit for said minimum balance value, means responsive to all the signals indicative of checks for a account having been identified to select signals representative of a first value and a second value from said storage means which are associated with a minimum balance equivalent to said selected minimum balance, means to apply said signals representative of a first value to said arithmetic unit to be subtracted from said first sum representative signals, means to sense whether or not the resultant signals representing the difference is zero or less and to provide an output signal indicative thereof, means responsive to said second output signal to terminate further service-charge activity for the account, and means to apply said second value representative signals to said arithmetic unit to be added to said resultant signals representing the difference to obtain signals representing the service charge for the account.

4. In a banking system wherein there is recorded on an elongated storage medium signals representing the account activity data of a plurality of depositors the recording for each account being delineated by signals representing a begin-account symbol at the beginning, and an end-account signal pulse at the end, the account activity including signals representing the amounts of checks for which a charge is to be made each of which is preceded by signals representing a charge symbol, and signals representing periodic current balances each of which is preceded by signals representing a current-balance symbol, a system for calculating the service charge to be made for each account which is to be based upon a minimum fee plus a fixed charge per check, less a credit based on a minimum-balance value, said system comprising means for reading the data signals from said elongated storage medium, sorting apparatus for obtaining signals representing the lowest value of those value representative signals applied to its input, means responsive to the reading of signals representing a current-balance symbol to enter the following signals representing a current balance into said sorting apparatus whereby the signals representing a minimum current balance for the account are obtained, means responsive to the value represented by said minimum current balance representative signals being below a predetermined level to terminate further service-charge calculation for this account, means responsive to the reading of signals

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representing charge symbols to accumulate fixed charge representative signals for each symbol, storage means for storing signals representing a table of data consisting of a different first and second value associated with a different minimum balance, each said first value being the product of the lowest number of checks for a minimum balance for which a charge is to be made and said fixed charge, each said second value being the sum of said first value and said minimum fee less the credit for said minimum balance value, means responsive to said end-account pulse being read for obtaining signals representing a first and a second value from said storage means which are associated with a minimum balance equivalent to the one selected by said sorting apparatus, means for obtaining signals representing the difference between said accumulated fixed charges and said first value, means responsive to said difference representative signals being representative of zero or less to discontinue further service-charge activity for said account, and means to add said signals representing said second value to said difference representative signals to obtain the service-charge representative signals for said account.

5. In a banking system wherein there is recorded on an elongated storage medium signals representing the account activity data of a plurality of depositors the recording for each account being delineated by begin-account representative signals at the beginning and an end-account pulse at the end the account activity including signals representative of checks for which a charge is to be made each of which is preceded by signals representing a charge symbol, and signals representing periodic current balances each of which is preceded by signals representing a current balance symbol, a system for calculating the service charge to be made for each account which is to be based upon a minimum fee plus a fixed charge per check, less a credit based on a minimum balance value, said system comprising means for reading the data representative signals from said elongated storage medium, means for identifying signals representing symbols which are read and for providing an output identifying the symbol, sorting apparatus for obtaining the lowest value representative signals of those applied to its input, means responsive to identification of signals representing a current-balance symbol to enter the following current-balance representative signals into said sorting apparatus whereby signals representing the minimum current balance for the account is obtained, means responsive to the value of said minimum current balance represented by signals being below a predetermined level to terminate further service-charge calculation for this account, an arithmetic system, means responsive to identification of charge symbol signals to instruct said arithmetic system to accumulate signals representing fixed charges, storage means for storing signals representing a table of data consisting of a different first and second value associated with a different minimum balance, each said first value being the product of the lowest number of checks for a minimum balance for which a charge is to be made and said fixed charge, each second value being the sum of said first value and said minimum fee less the credit for said minimum balance value, means responsive to the reading of said end-account pulse by said data-reading means to select signals from said table representing a first and a second value which are associated with a minimum balance equivalent to the one selected by said sorting apparatus, means responsive to signals representing a first value having been selected to instruct said arithmetic system to subtract said selected first value representative signals from said accumulated fixed charge representative signals, means responsive to the result of said subtracting being signals which represent a zero or a negative value to terminate further service-charge calculation, and means to instruct said arithmetic system to add said selected second value representative signals to said subtraction re-

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sult to thereby obtain the service charge for said account.

6. In a banking system as recited in claim 5 wherein said storage means storing a table of data includes a magnetic drum on which said data is stored, means for continuously reading said data from said drum, the first and second values stored on said drum being stored in a manner to be indexed by one digit in a minimum balance, comparator means, means to apply the required digit from the minimum balance selected by said sorting apparatus and output by said means for continuously reading to said comparator, and means responsive to output from said comparator indicative of an identity to enable subsequent output from said means for continually reading to be entered into said arithmetic system.

7. In a banking system as recited in claim 5 wherein said arithmetic system includes a shift register, an arithmetic circuit having a first and a second input terminal, an output terminal, an add-instruction terminal and a subtract-instruction terminal, means coupling the output terminal of said arithmetic circuit to said shift register input, means coupling the output of said shift register to said first input terminal, and said means responsive to identification of signals representing a charge symbol to instruct said arithmetic system to accumulate fixed charges includes a fixed-charge-signal generator, means including a closed-gate circuit coupling said charge-signal generator to said second input terminal, and means responsive to the identification of said charge symbol to open said gate circuit to permit a charge signal to pass, to transfer the contents of said register to said arithmetic circuit and to energize said arithmetic circuit add-instruction terminal.

8. In a banking system wherein there is recorded on an elongated storage medium signals representing the account activity data of a plurality of depositors the recording for each account being delineated by signals representing a begin-account symbol at the beginning and an end-account pulse at the end, the account activity including signals representing checks for which a charge is to be made each of which is preceded by signals representing a charge symbol, signals representing items for which a credit against service charges is to be given each of which is preceded by signals representing a credit symbol, and signals representing periodic current balances each of which is preceded by signals representing a current-balance symbol, a system for calculating the service charge to be made for each account which is to be based upon a minimum fee plus a fixed charge per check, less a credit based on a minimum-balance value, said system comprising means for reading the data representative signals from said elongated storage medium, means for identifying signals representing symbols which are read and for providing an output identifying the symbol, sorting apparatus for obtaining the lowest value representative signals of those signals applied to its input, means responsive to identification of signals representing a current-balance symbol to enter the signals representing the following current balance into said sorting apparatus whereby signals representing the minimum current balance for the account is obtained, means responsive to the value of said minimum current balance being below a predetermined level to terminate service-charge calculation for this account, an arithmetic system, means responsive to identification of signals representing a charge symbol to instruct said arithmetic system to provide signals representing an accumulation of fixed charges, means responsive to identification of signals representing a credit symbol to instruct said arithmetic system to subtract a credit charge represented by signals from the accumulated credit charges represented by signals, storage means for storing signals representing a table of data consisting of a different first and second value associated with a different minimum balance, each said first value being the product of the lowest number of checks for a minimum balance for which a charge is to be made and said

fixed charge, each second value being the sum of said first value and said minimum fee less the credit for said minimum balance value, means responsive to the reading of said end-account pulse by said data-reading means to select from said table signals representing a first and a second value which are associated with a minimum balance equivalent to the one selected by said sorting apparatus, means responsive to signals representing a first value having been selected to instruct said arithmetic system to subtract said first value representative signals from said signals representing accumulated fixed charges, means responsive to the result of said subtraction providing signals representative of zero or negative values to terminate further service-charge calculation, and means to instruct said arithmetic system to add said second value representative signals to said subtraction result signals to thereby obtain signals representing the service charge for said account.

9. In a system wherein there is recorded on a storage medium for each customer over a predetermined interval signals representative of the account activity including signals representing items handled, and signals representing periodic current balance entries, a system for calculating the service charge to be made for handling items for a customer having less than a predetermined minimum balance, which charge is to be based upon a minimum fee plus a fixed charge per item less a credit based on the minimum balance value, said system comprising means for selecting from said storage medium the signals representing the minimum balance occurring for a customer, means for determining whether the minimum balance represented by said minimum balance value signals exceeds a predetermined value and to provide a signal indicative thereof, means responsive to said signal indicating the minimum balance exceeding a predetermined value to terminate further service-charge calculation for said customer, means for identifying item signals for which a charge is to be made, means responsive to said means for identifying item signals for establishing signals representing the value of the product of the number of items identified by said means for identifying and the fixed charge per item, and means responsive to said minimum balance value signals and said signals representing the product of the number of items identified and the fixed charge per item for establishing signals representative of said service charge for said customer.

10. In a system wherein there is recorded on a storage medium for each customer over a predetermined interval signals representative of the account activity including signals representing items handled, and signals representing periodic current balance entries, a system for calculating the service charge to be made for handling items for a customer having less than a predetermined minimum balance, which charge is to be based upon a minimum fee plus a fixed charge per item less a credit based on the minimum balance value, said system comprising means for selecting from said storage medium the signals representing the minimum balance occurring for a customer, means for determining whether the minimum balance represented by said minimum balance value signals exceeds a predetermined value and to provide a signal indicative thereof, means responsive to said signal indicating the minimum balance exceeding a predetermined value to terminate further service-charge calculation for said customer, means for identifying item signals for which a charge is to be made, means responsive to said means for identifying item signals for establishing signals representing the value of the product of the number of items identified by said means for identifying

and the fixed charge per item, means responsive to said minimum balance value signals for generating first electrical signals representative of the product of the lowest number of checks for said minimum balance for which a charge is to be made and said fixed charge and second electrical signals representative of the sum of the product represented by said first electrical signals and said minimum fee less the credit for said minimum balance value, means for subtracting said first signals from said signals representing the product of the number of items identified and the fixed charge per item to provide difference signals, and means for adding said second signals to said difference signals for obtaining signals representing the service charge for said customer.

11. In a system as recited in claim 10 wherein said means responsive to said minimum balance value signals for generating first and second electrical signals includes a storage means for storing signals representing a table of data comprising different first and second signals respectively associated with different minimum balance value signals, means for comparing for identity said different minimum balance value signals in said storage means with said electrical signals representative of said minimum balance, and means responsive to an identity being determined by said comparing means for extracting as electrical signals the first and second signals from said storage associated with said minimum balance providing identity.

12. In a system wherein there is recorded on a storage medium for each customer over a predetermined interval signals representative of the account activity including signals representing items handled, and signals representing periodic current balance entries, a system for calculating the service charge to be made for handling items for a customer having less than a predetermined minimum balance, which charge is to be based upon a minimum fee plus a fixed charge per item less a credit based on the minimum balance value, said system comprising means for selecting from said storage medium the signals representing the minimum balance occurring for a customer, means for identifying item signals for which a charge is to be made, means for generating a set of signals representing a fixed charge for an item, means for accumulating a set of said signals representing fixed charges for each item identified by said means for identifying item signals to produce electrical signals representative of the fixed charge sum, means responsive to said minimum balance value signals for generating first electrical signals representative of the product of the lowest number of checks for said minimum balance for which a charge is to be made and said fixed charge and second electrical signals representative of the sum of the product represented by said first electrical signals and said minimum fee less the credit for said minimum balance value, means for subtracting said first signals from said signals representing the product of the number of items identified and the fixed charge per item to provide difference signals, and means for adding said second signals to said difference signals for obtaining signals representing the service charge for said customer.

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