

June 20, 1944.

C. SMITH

2,352,027

CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

26 Sheets-Sheet 1

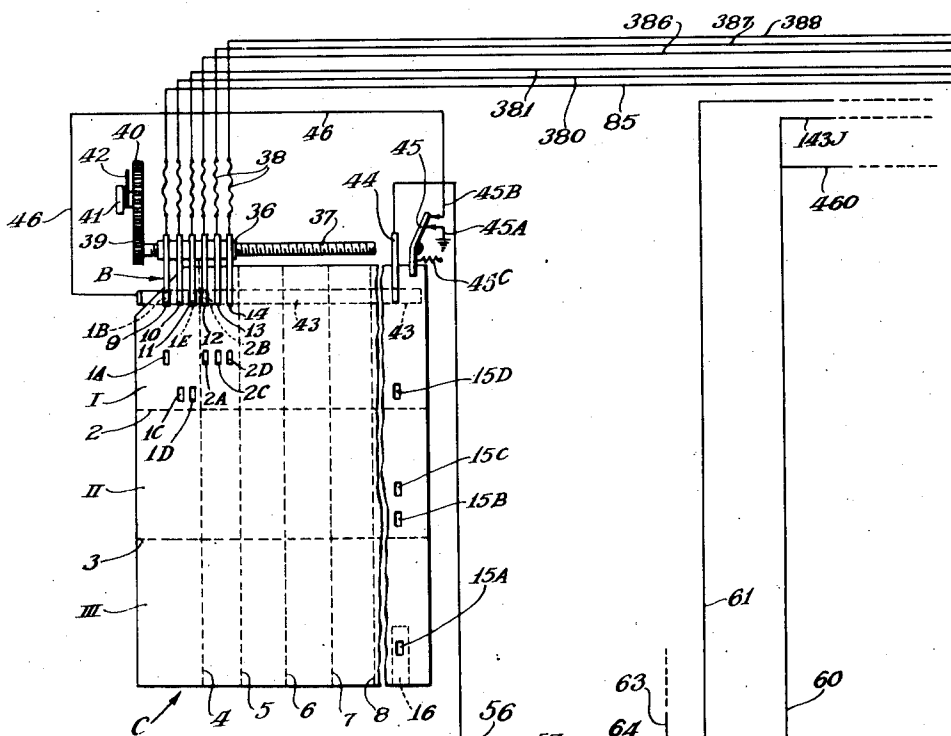
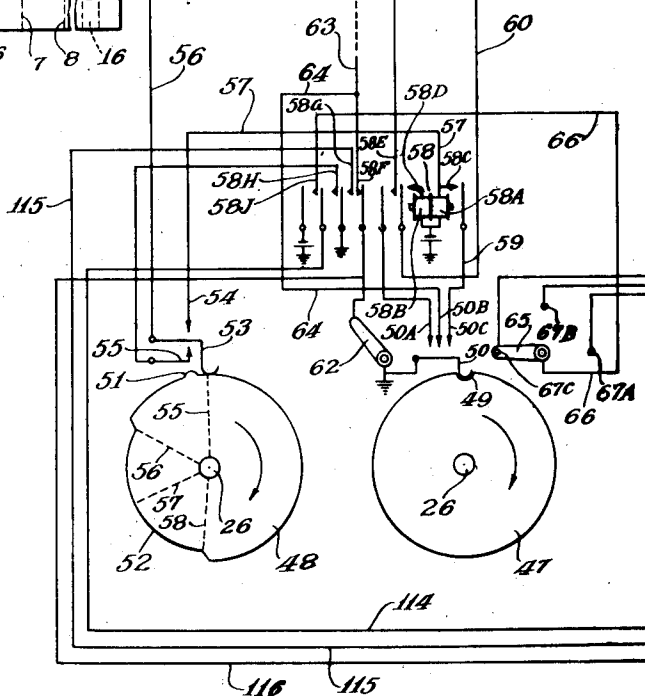


FIG. 1.

FIG. 2.

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



Inventor:
Clyde Smith
By *Reck, Wallace and
Cannon*
Attorneys

June 20, 1944.

C. SMITH

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FIG. 3.

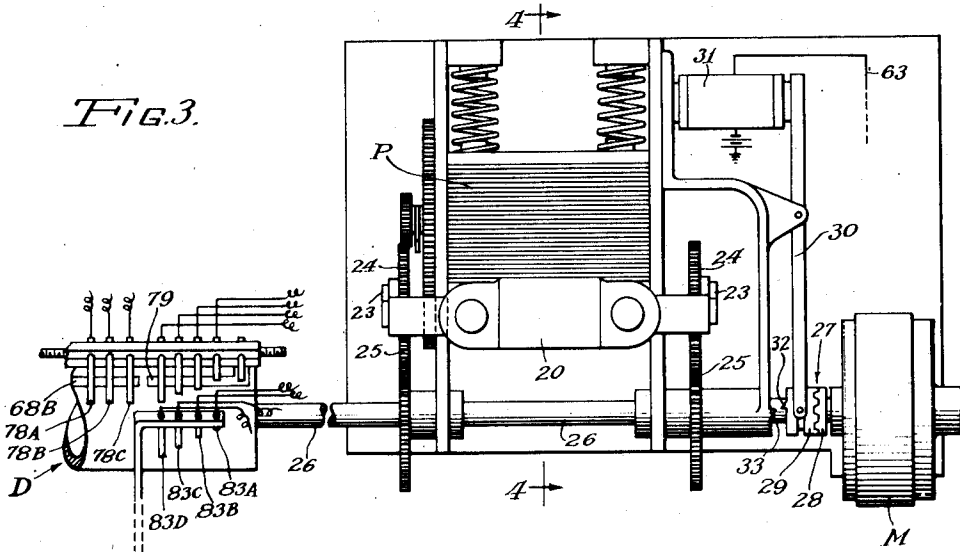


FIG. 4.

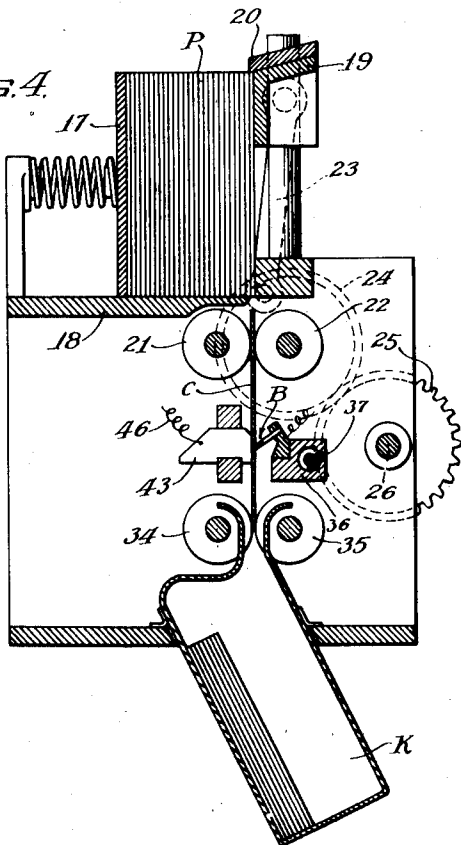
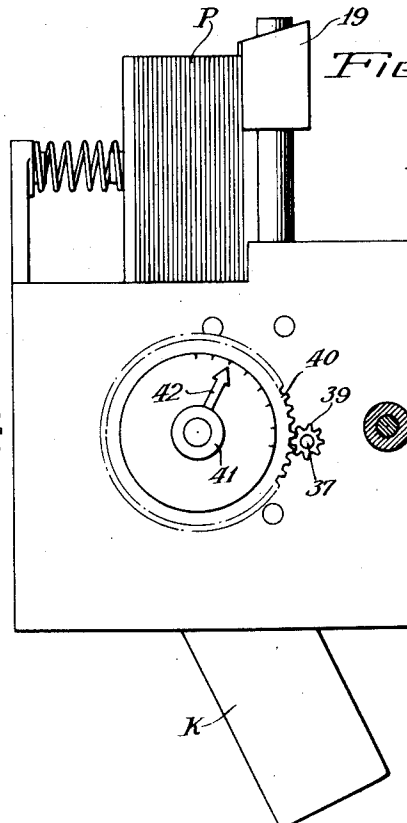


FIG. 5.



Inventor:
Clyde Smith
By Bech, Wallace and Cannon
Attorneys

June 20, 1944.

C. SMITH

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CALCULATING AND PRINTING MACHINE

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26 Sheets-Sheet 3

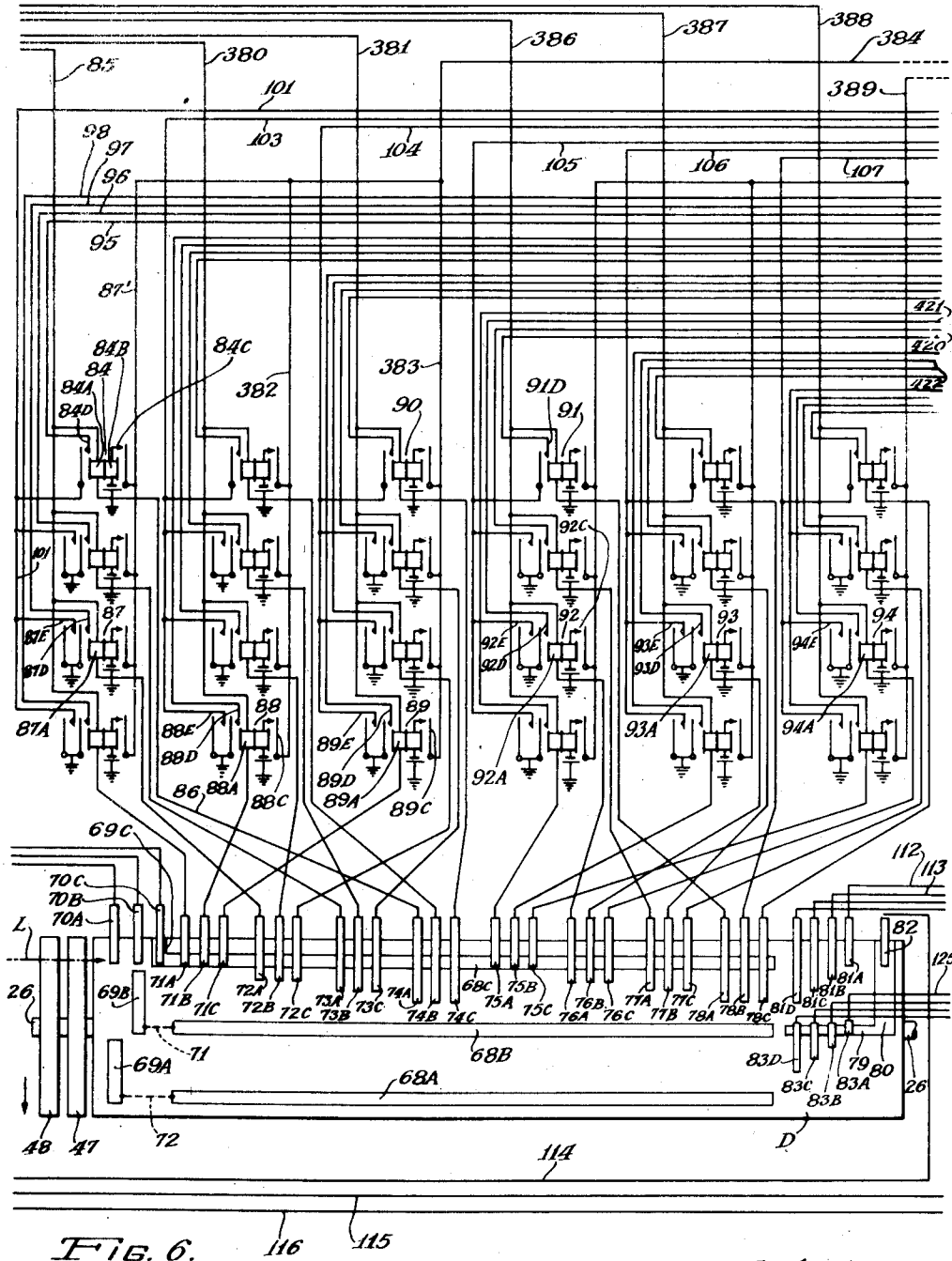


FIG. 6.

Inventor:
Clyde Smith
By Zelt, Wallace and Cannon
Attorneys

June 20, 1944.

C. SMITH

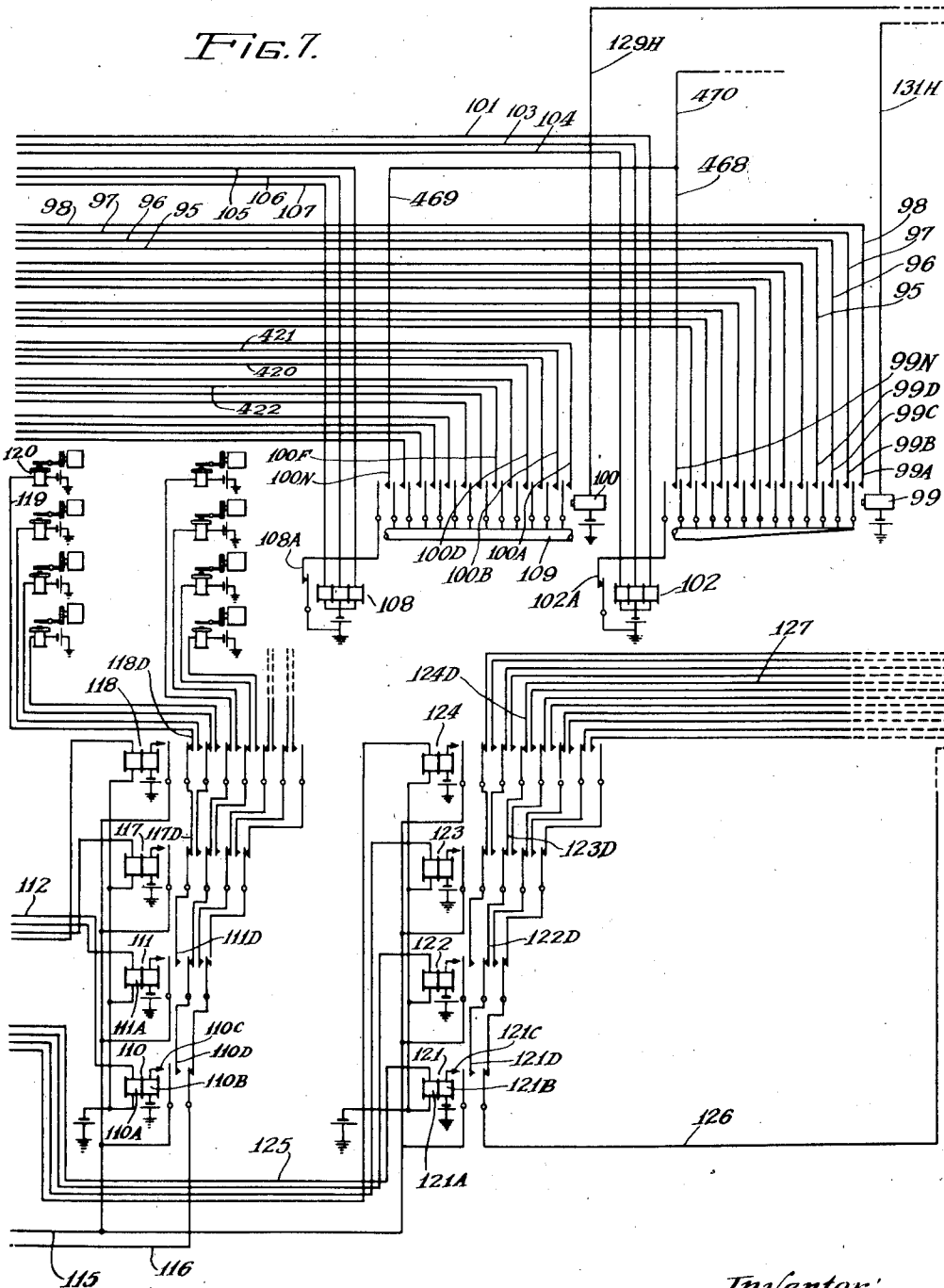
2,352,027

CALCULATING AND PRINTING MACHINE

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FIG. 7.



Inventor:
Clyde Smith

By *Belt, Wallen and Cannon*
Attorneys

June 20, 1944.

C. SMITH

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CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

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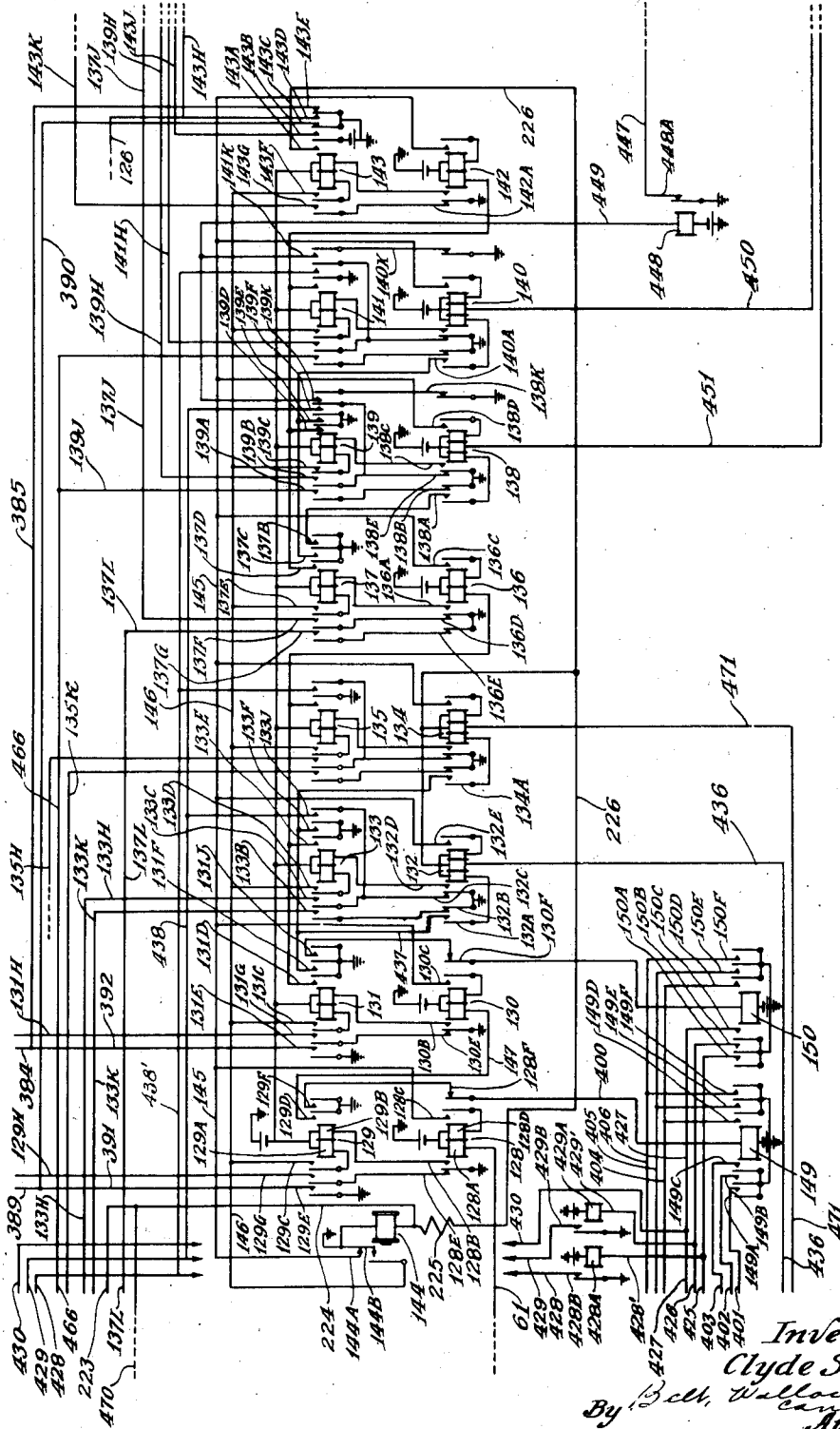


FIG. 8.

Inventor:
Clyde Smith
By Bell, Wallace and
Cannon
Attorneys

June 20, 1944.

C. SMITH

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CALCULATING AND PRINTING MACHINE

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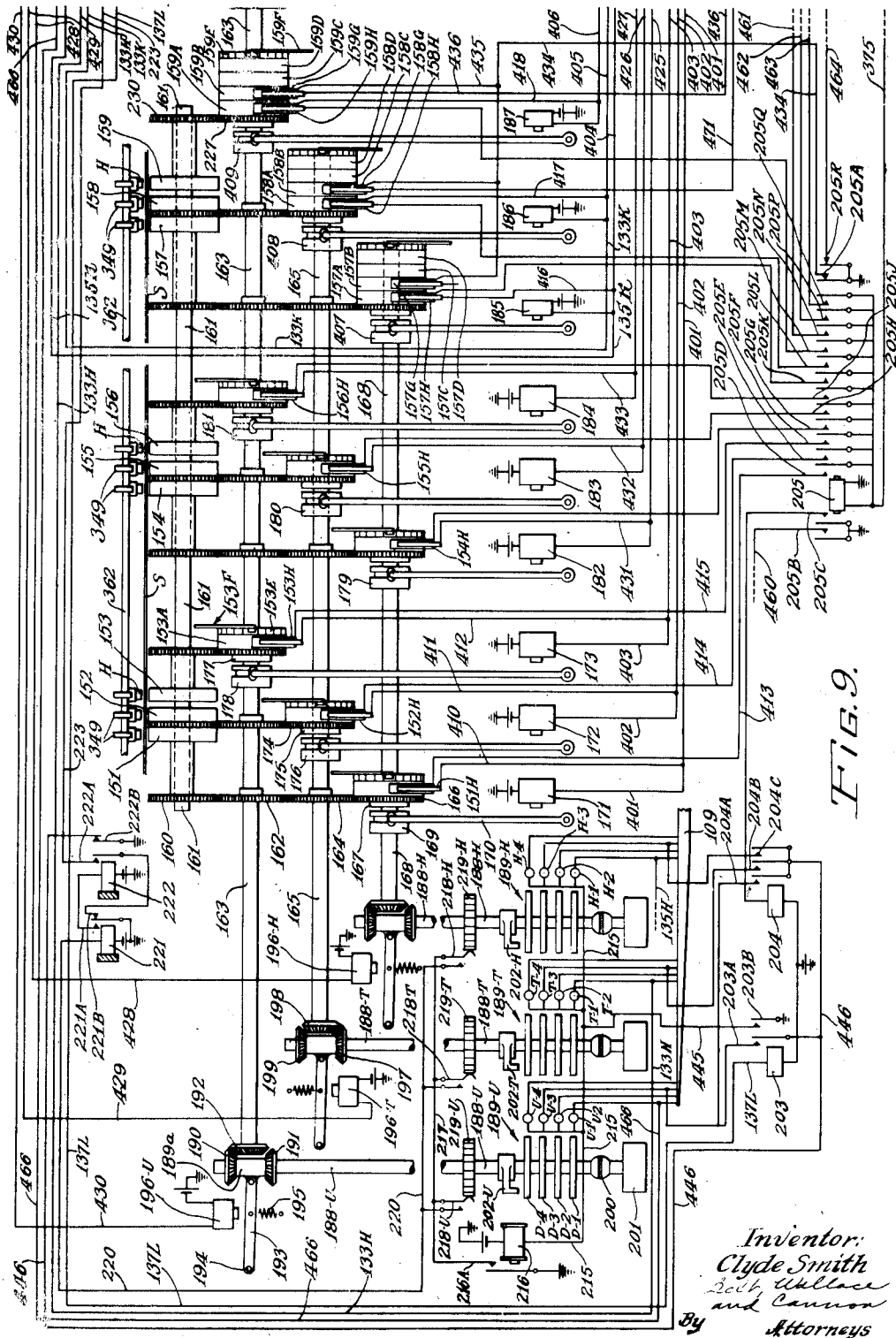


FIG. 9.

Inventor:
Clyde Smith
2666 Wallace
and Cannon
Attorneys

June 20, 1944.

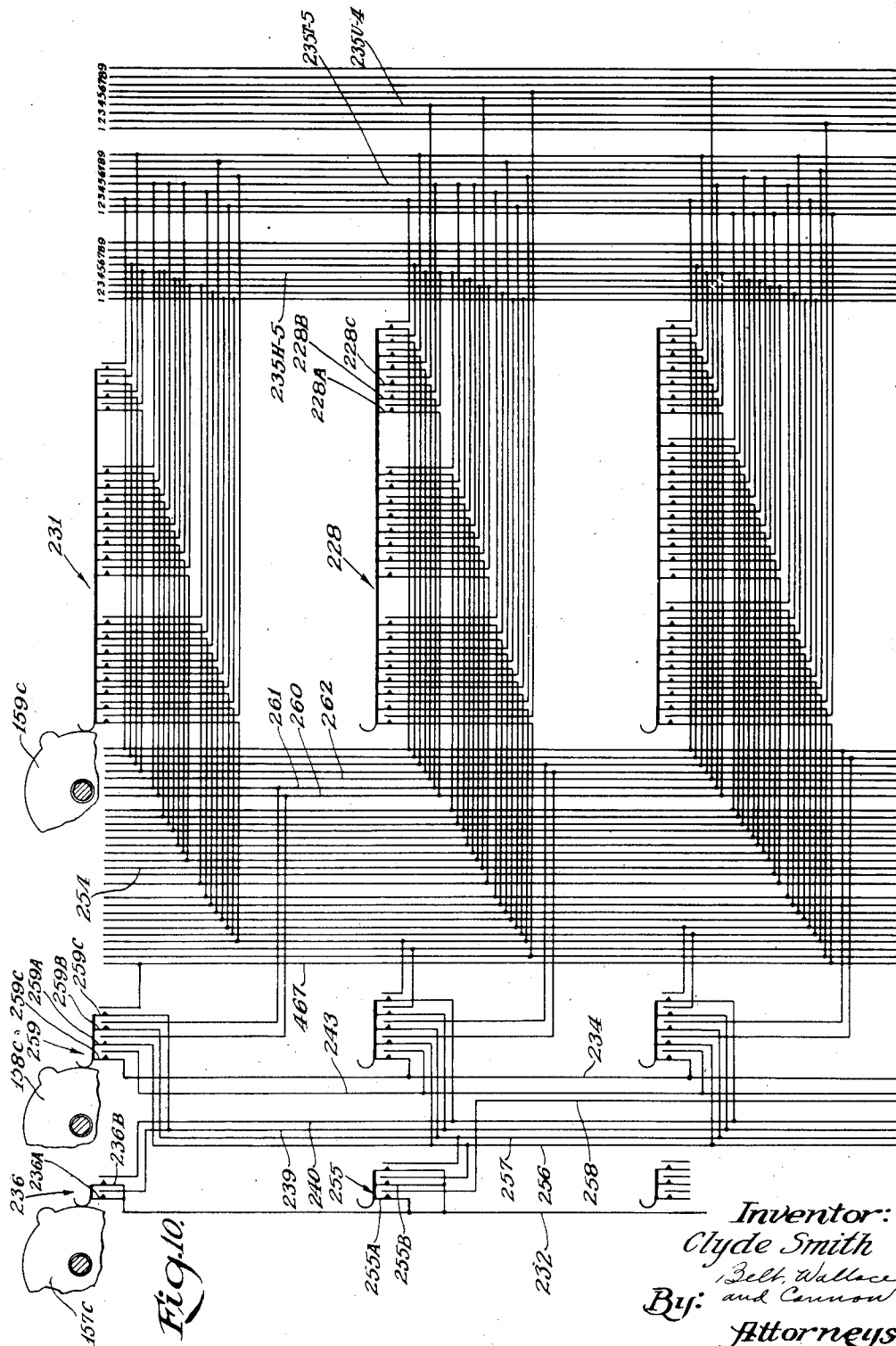
C. SMITH

2,352,027

CALCULATING AND PRINTING MACHINE

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Inventor:
Clyde Smith
Belt, Wallace
By: and Cannon
Attorneys

June 20, 1944.

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CALCULATING AND PRINTING MACHINE

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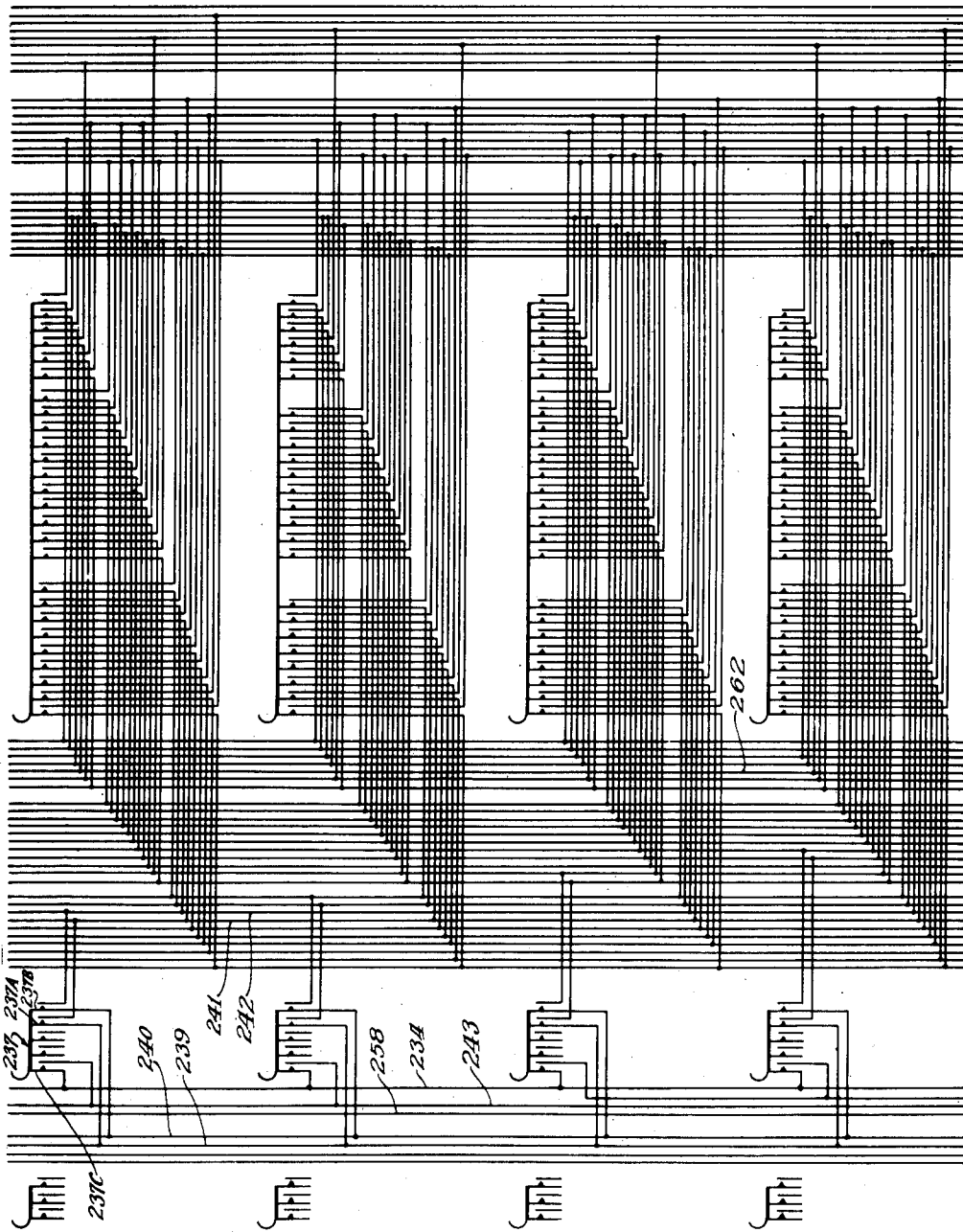


Fig. 11.

Inventor:
Clyde Smith
By: Bell, Wallace
and Cannon
Attorneys

June 20, 1944.

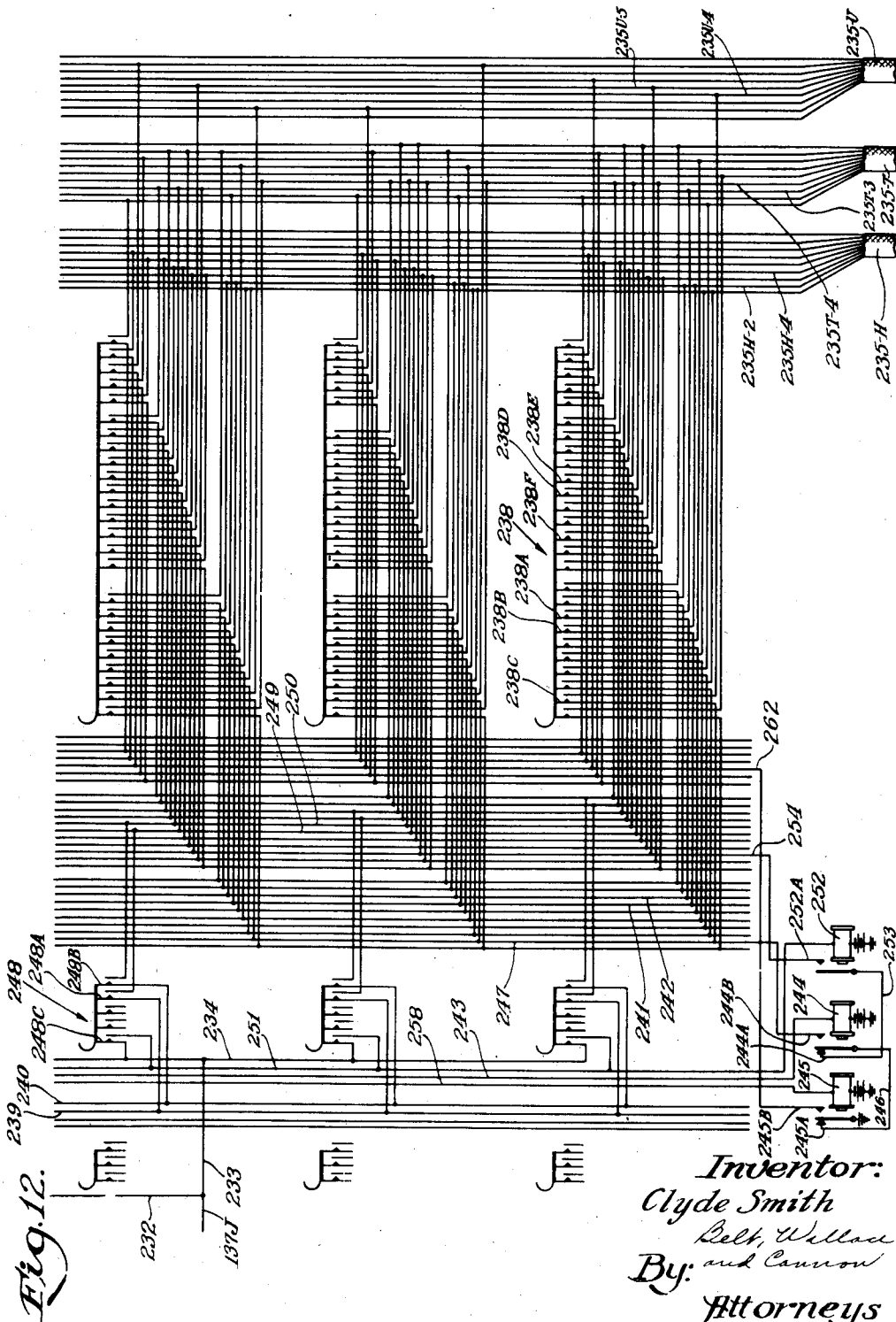
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CALCULATING AND PRINTING MACHINE

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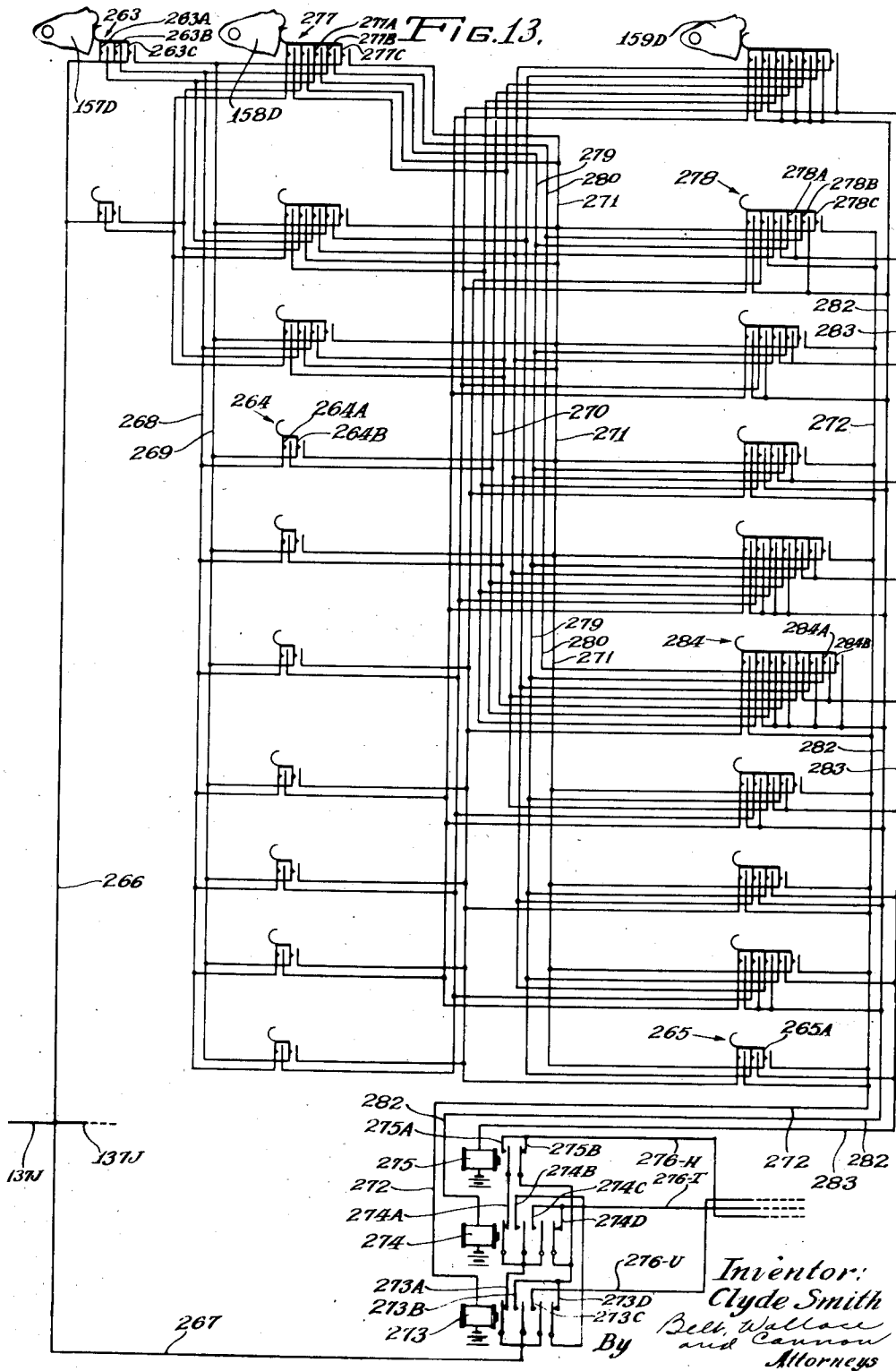
C. SMITH

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CALCULATING AND PRINTING MACHINE

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June 20, 1944.

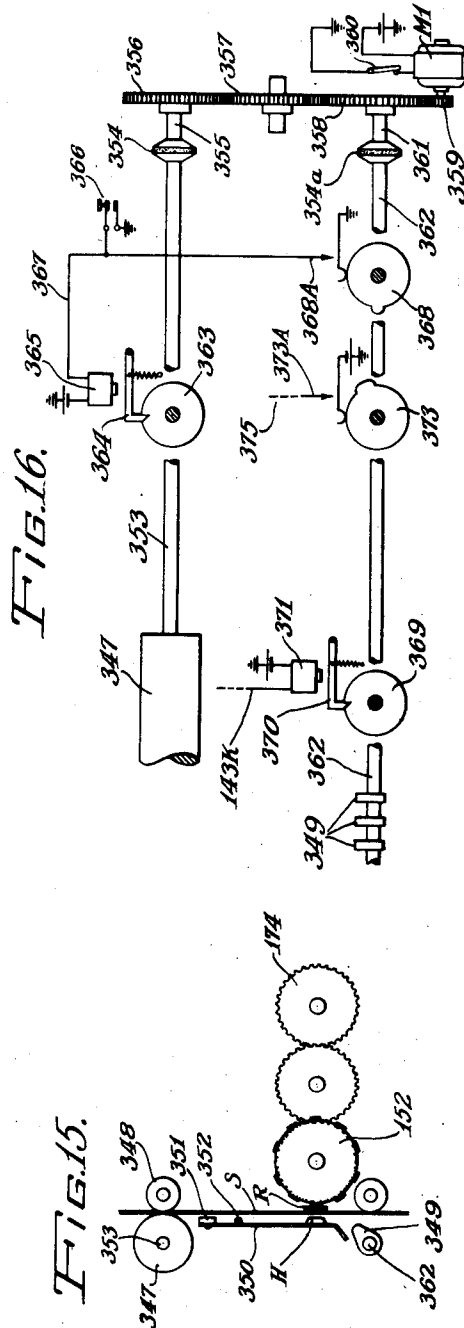
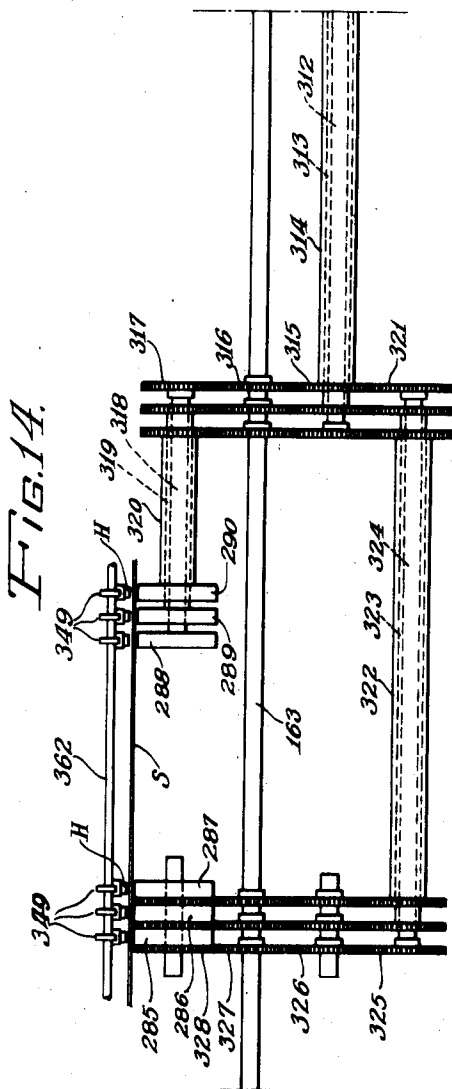
C. SMITH

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CALCULATING AND PRINTING MACHINE

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26 Sheets-Sheet 11



Inventor:
Clyde Smith
By Bell, Wallace and Cannon
Attorneys

June 20, 1944.

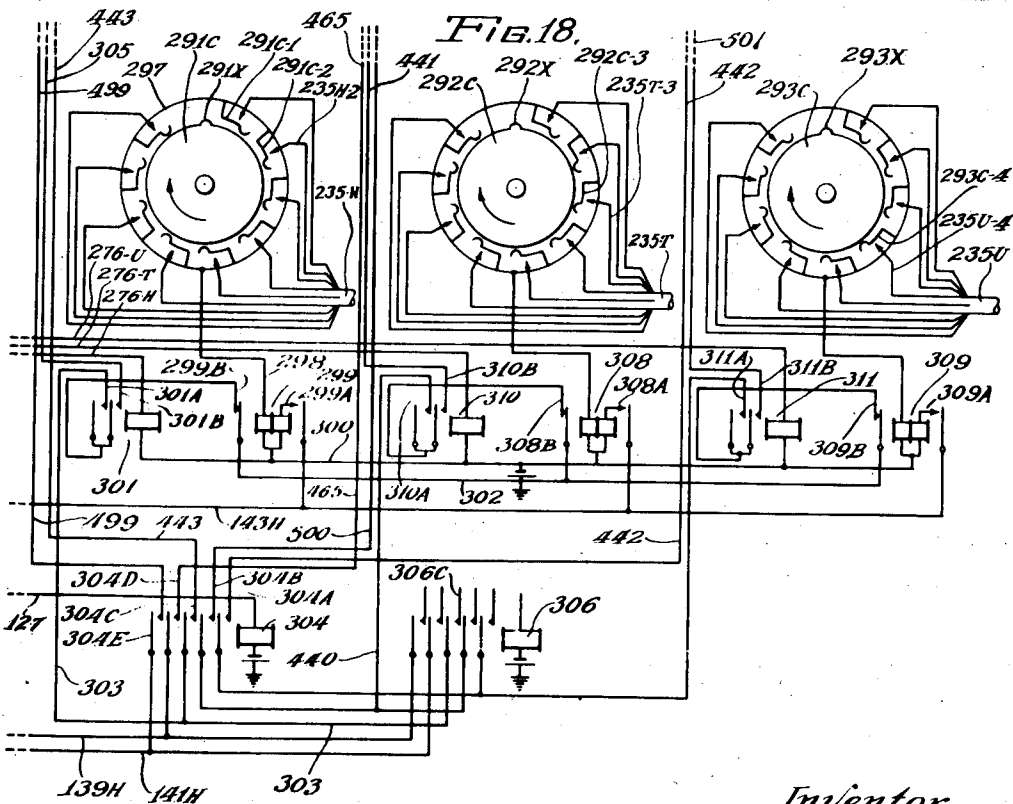
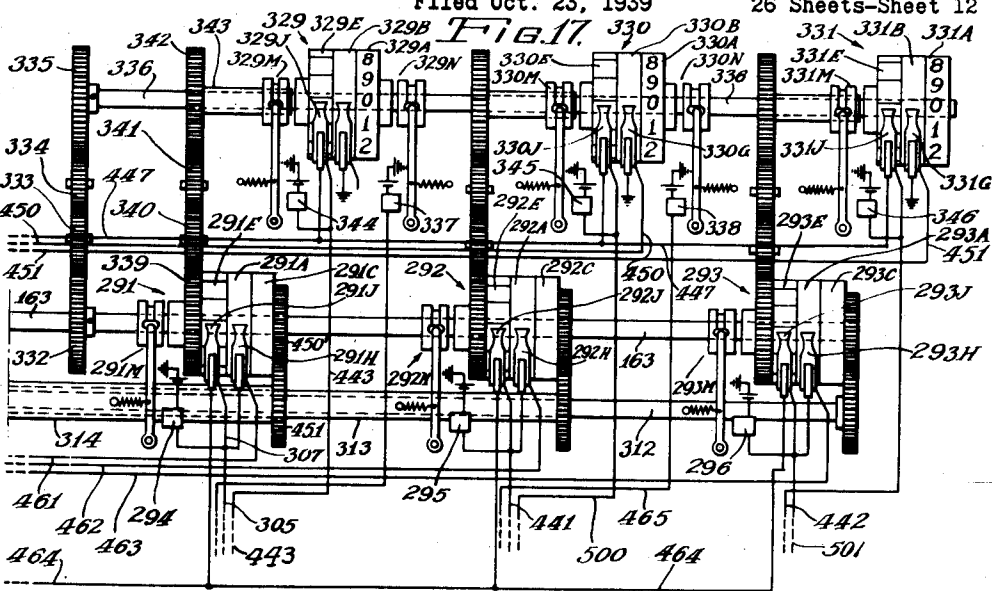
C. SMITH

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CALCULATING AND PRINTING MACHINE

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Inventor
Clyde Smith
By *Selt, Wallace and Cannon*
Attorneys

June 20, 1944.

C. SMITH

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CALCULATING AND PRINTING MACHINE

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FIG. 19A

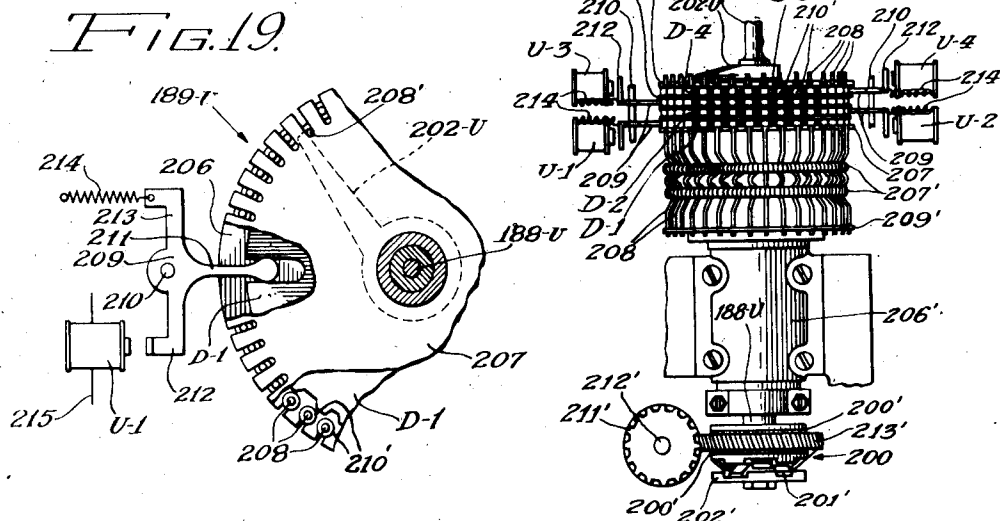


FIG. 20.

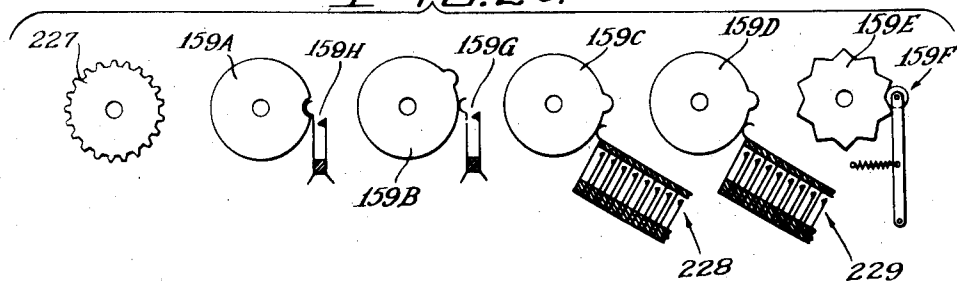
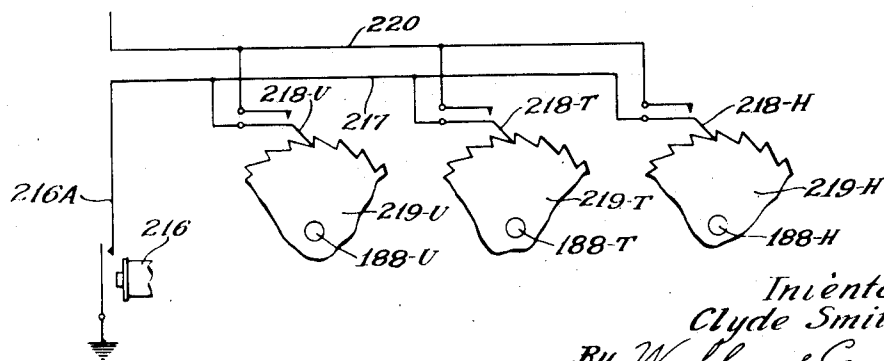


FIG. 21.



Inventor:
Clyde Smith
By Wallace & Cannon
Attorneys

June 20, 1944.

C. SMITH

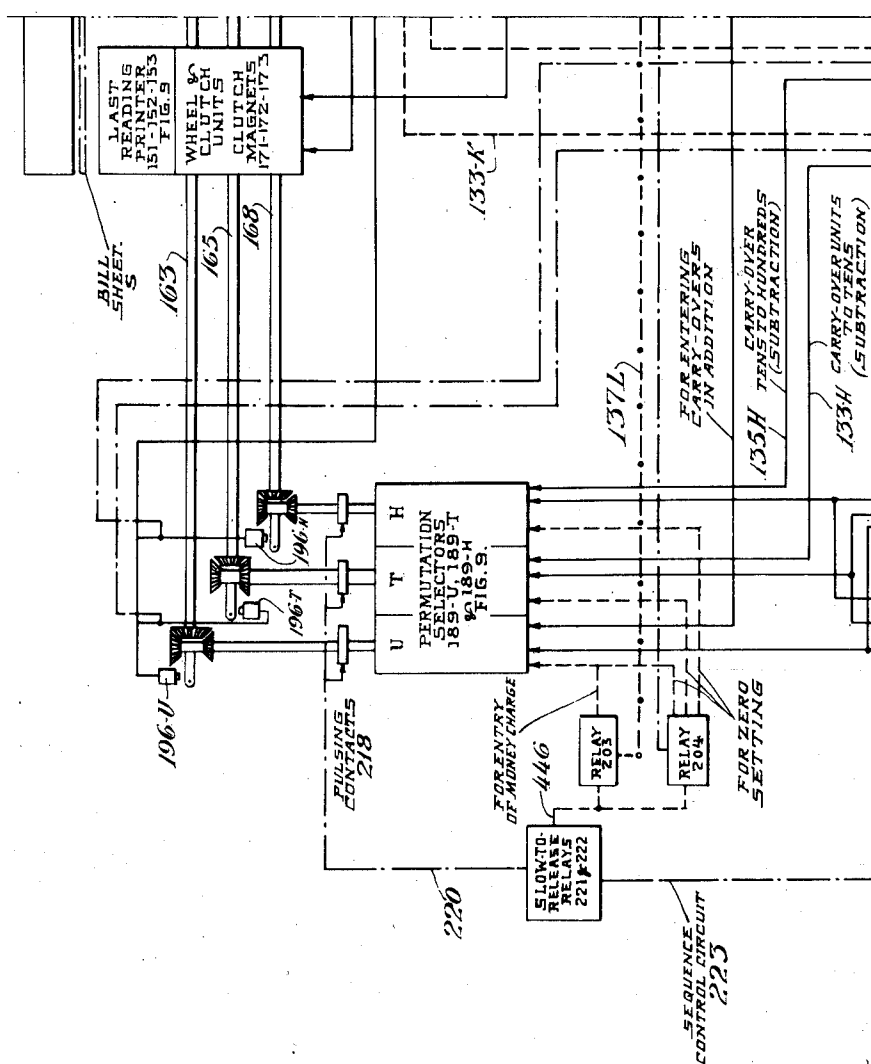
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CALCULATING AND PRINTING MACHINE

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FIG. 2.



Inventor,
Clyde Smith

By *Wallace & Cannon*
Attorneys.

June 20, 1944.

C. SMITH

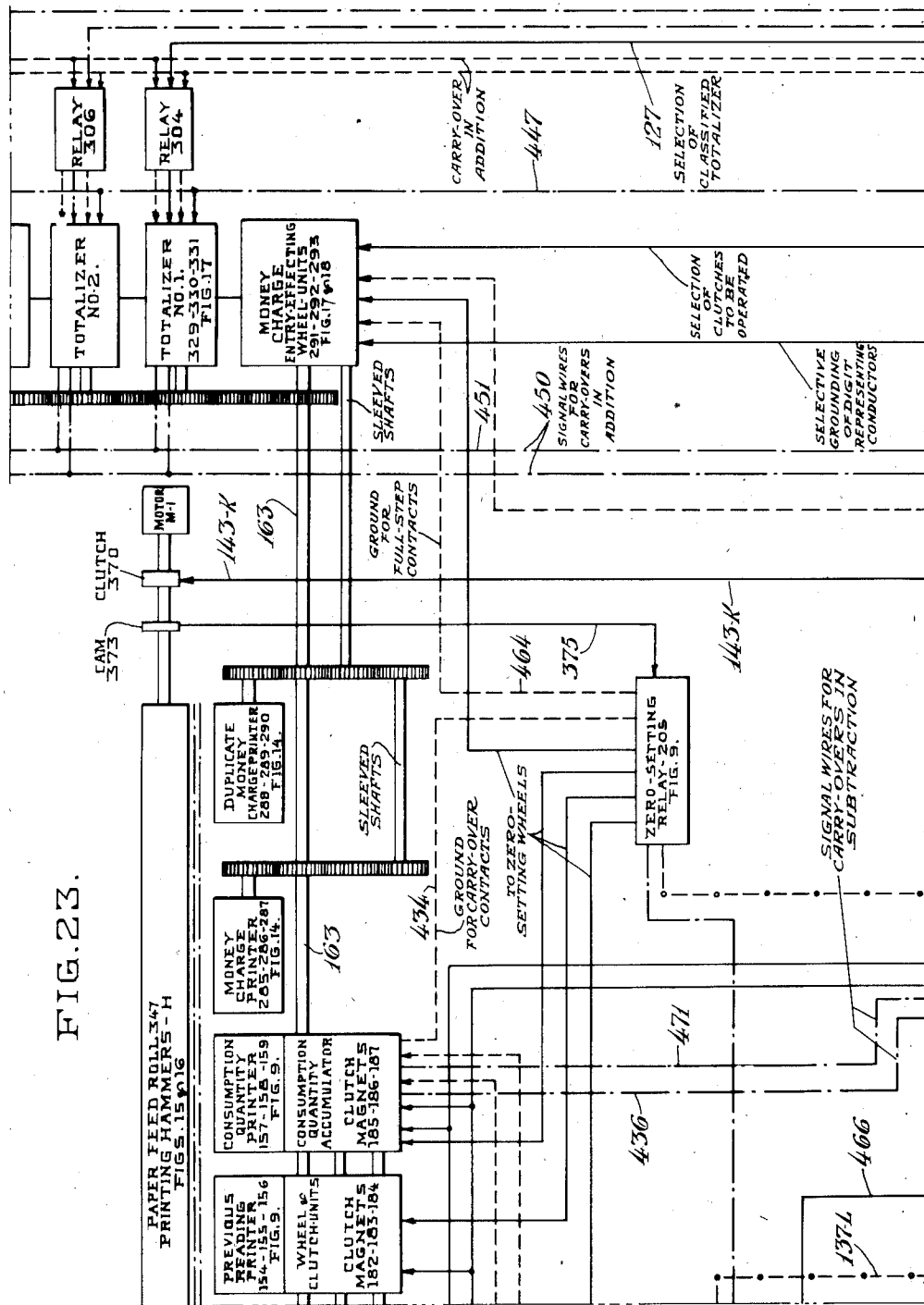
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CALCULATING AND PRINTING MACHINE

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FIG. 23.



Inventor:
Clyde Smith
 By *Wallace & Cannon*
 Attorneys

June 20, 1944.

C. SMITH

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CALCULATING AND PRINTING MACHINE

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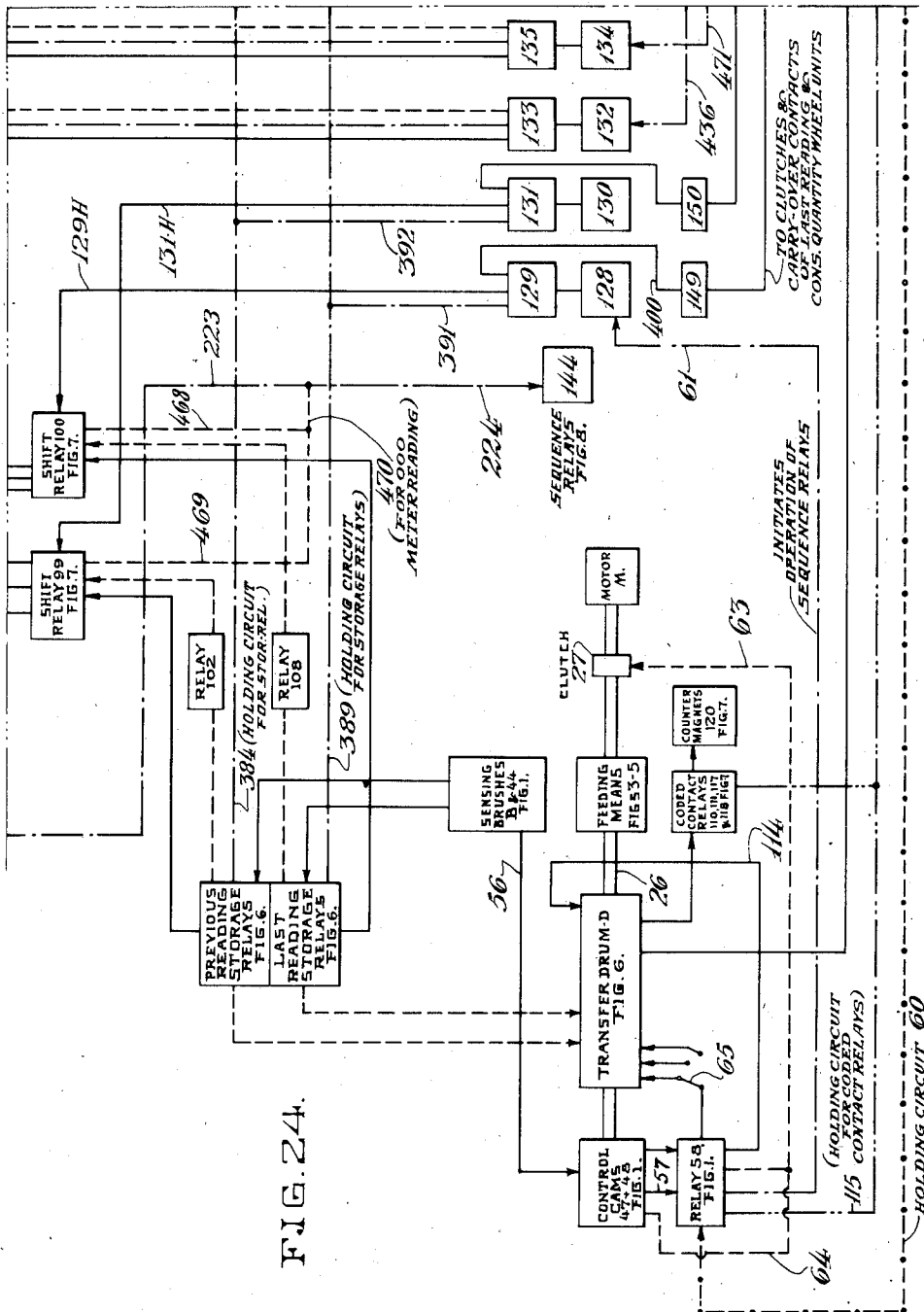


FIG. 24.

Inventor:
Clyde Smith
By Wallace & Cannon
Attorneys

June 20, 1944.

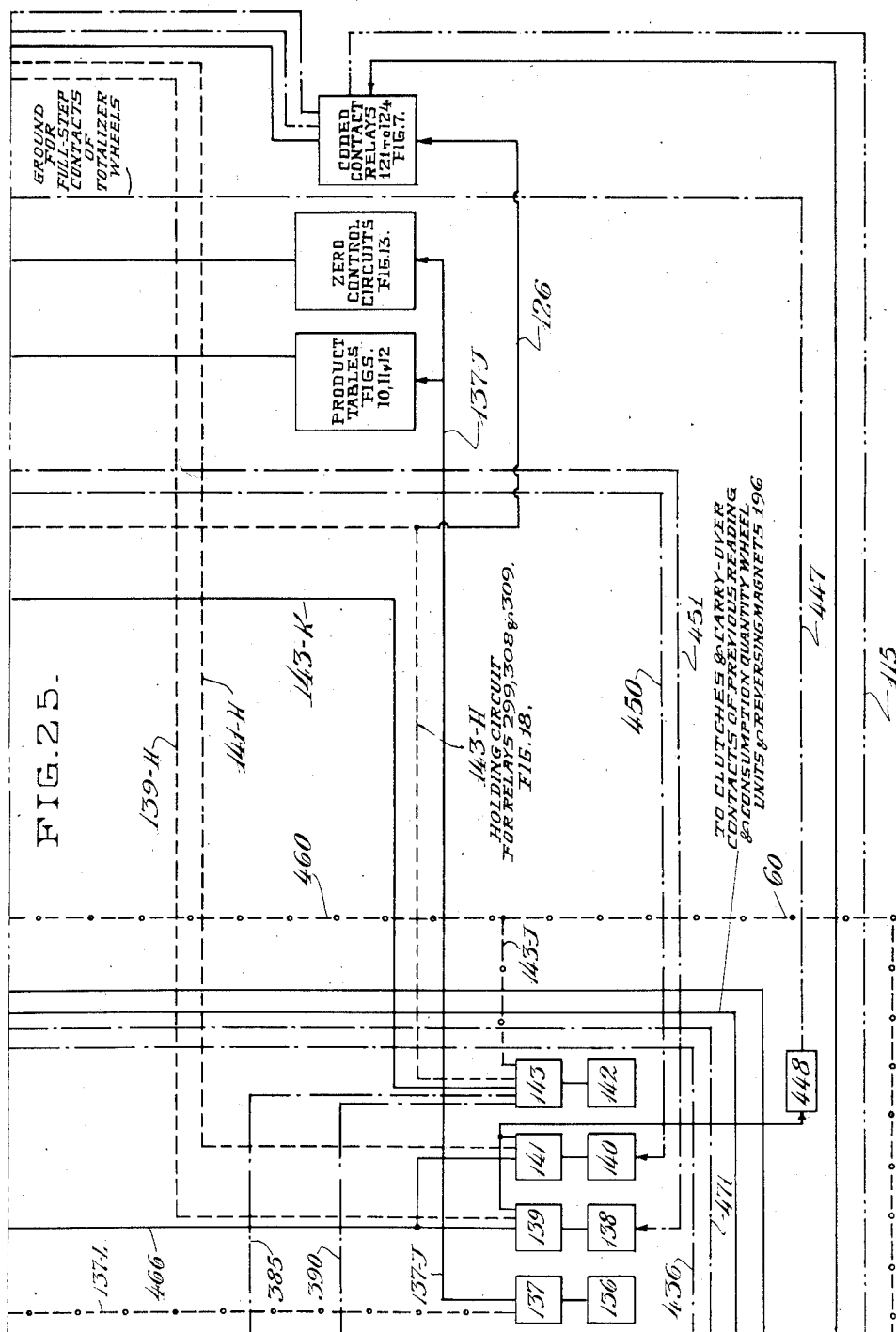
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2,352,027

CALCULATING AND PRINTING MACHINE

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June 20, 1944.

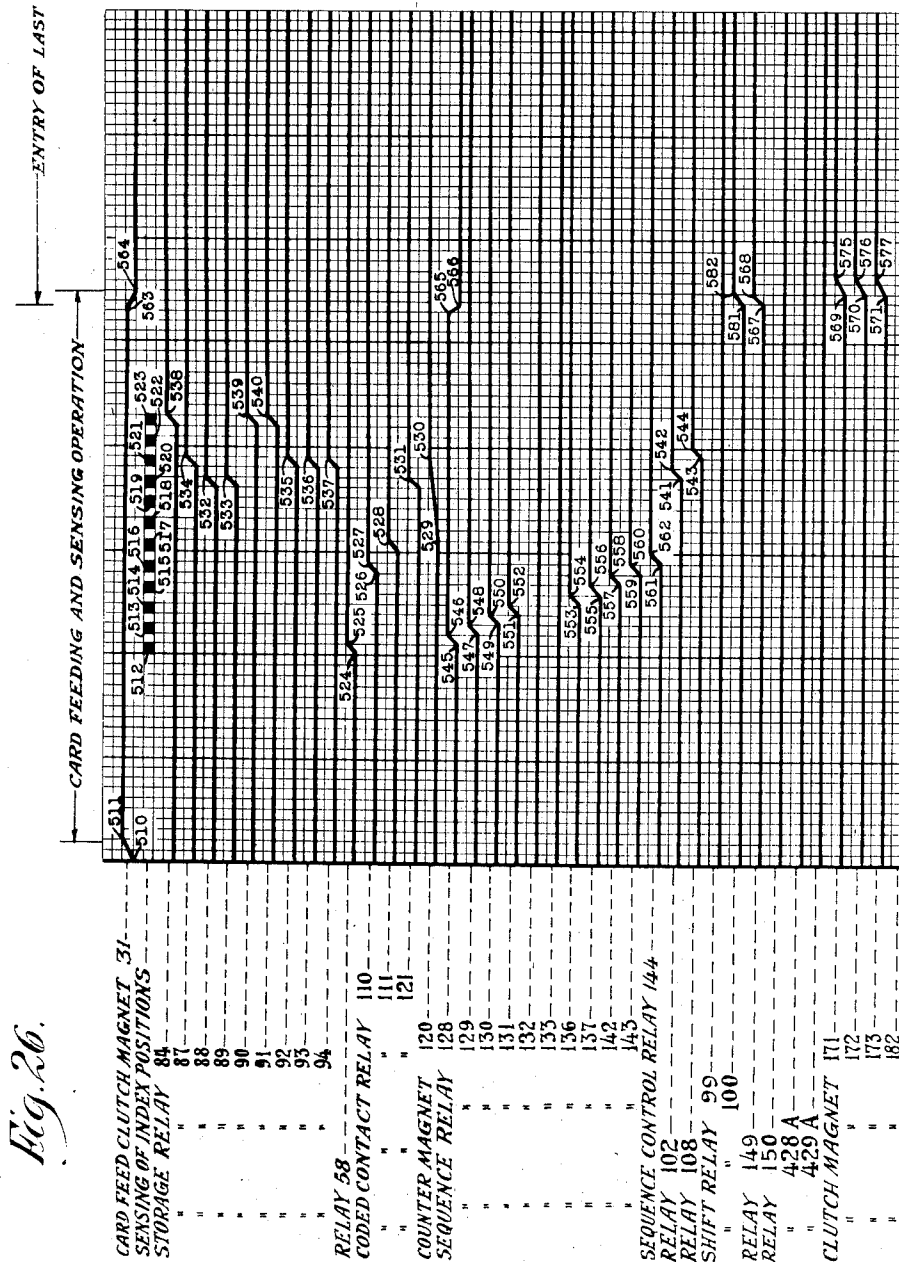
C. SMITH

2,352,027

CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

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INVENTOR.
Clyde Smith
BY *W. Alice & Cannon*
ATTORNEYS.

June 20, 1944.

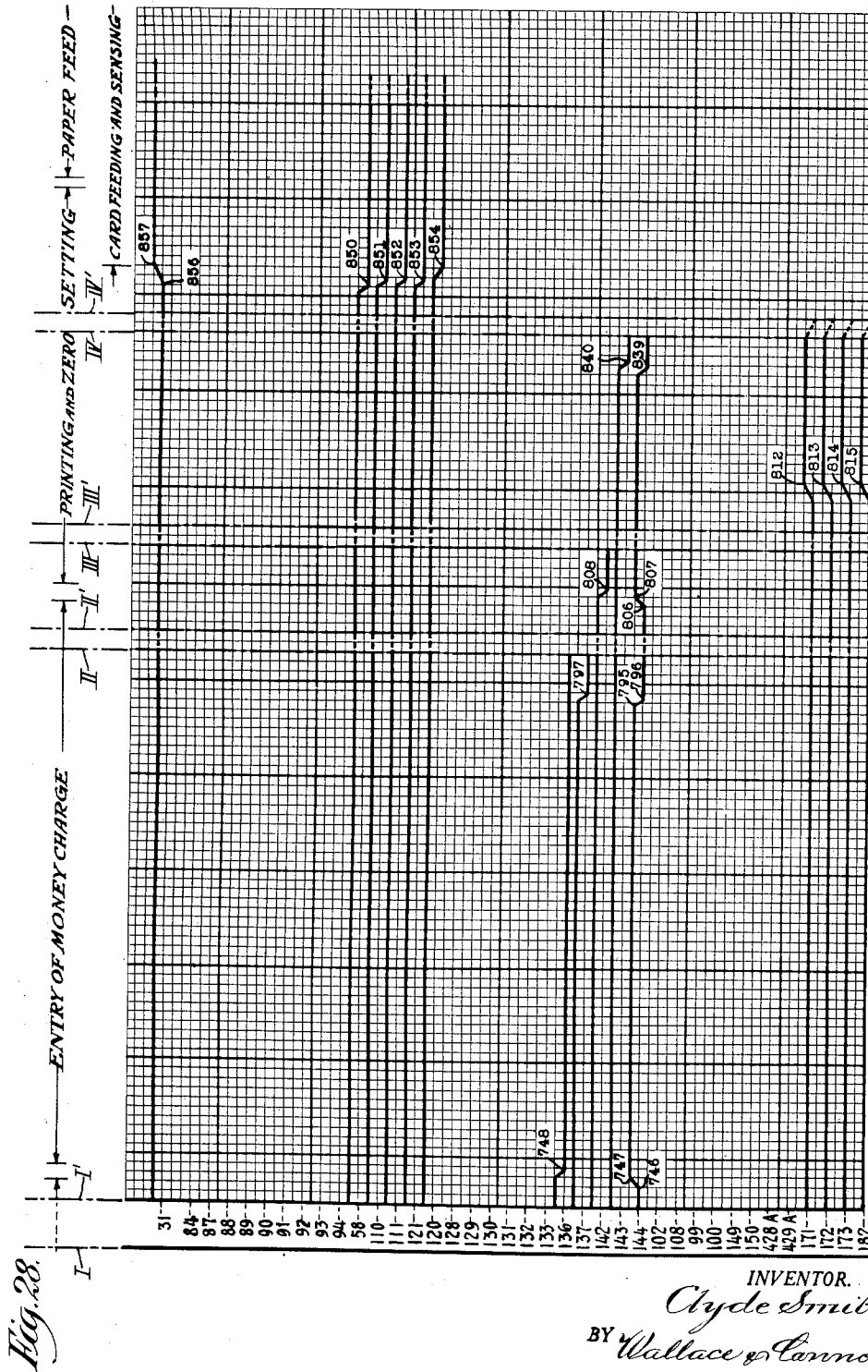
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CALCULATING AND PRINTING MACHINE

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June 20, 1944.

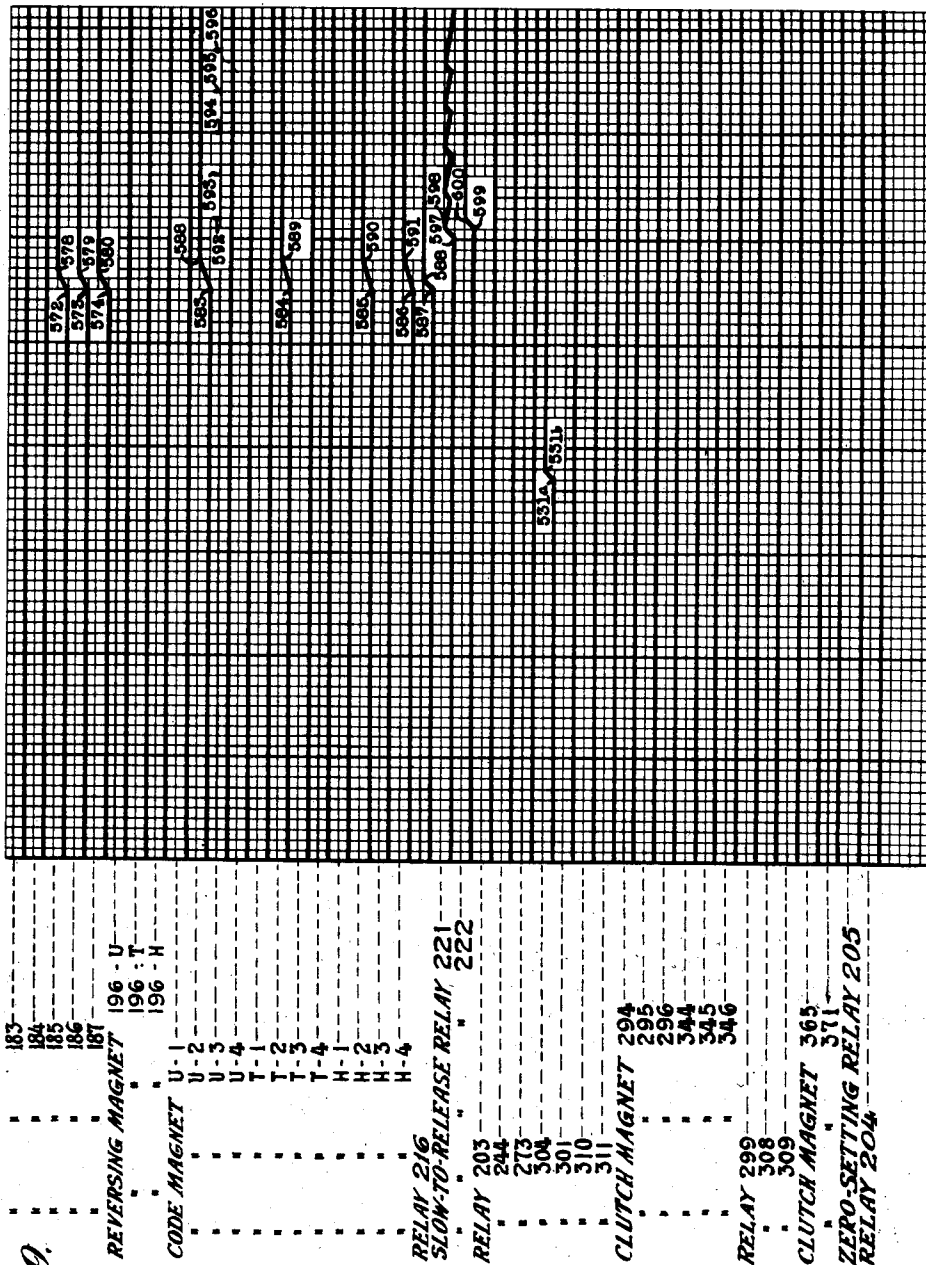
C. SMITH

2,352,027

CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

26 Sheets-Sheet 21



INVENTOR.
Clyde Smith
BY *Wallace Cannon*
ATTORNEYS.

June 20, 1944.

C. SMITH

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CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

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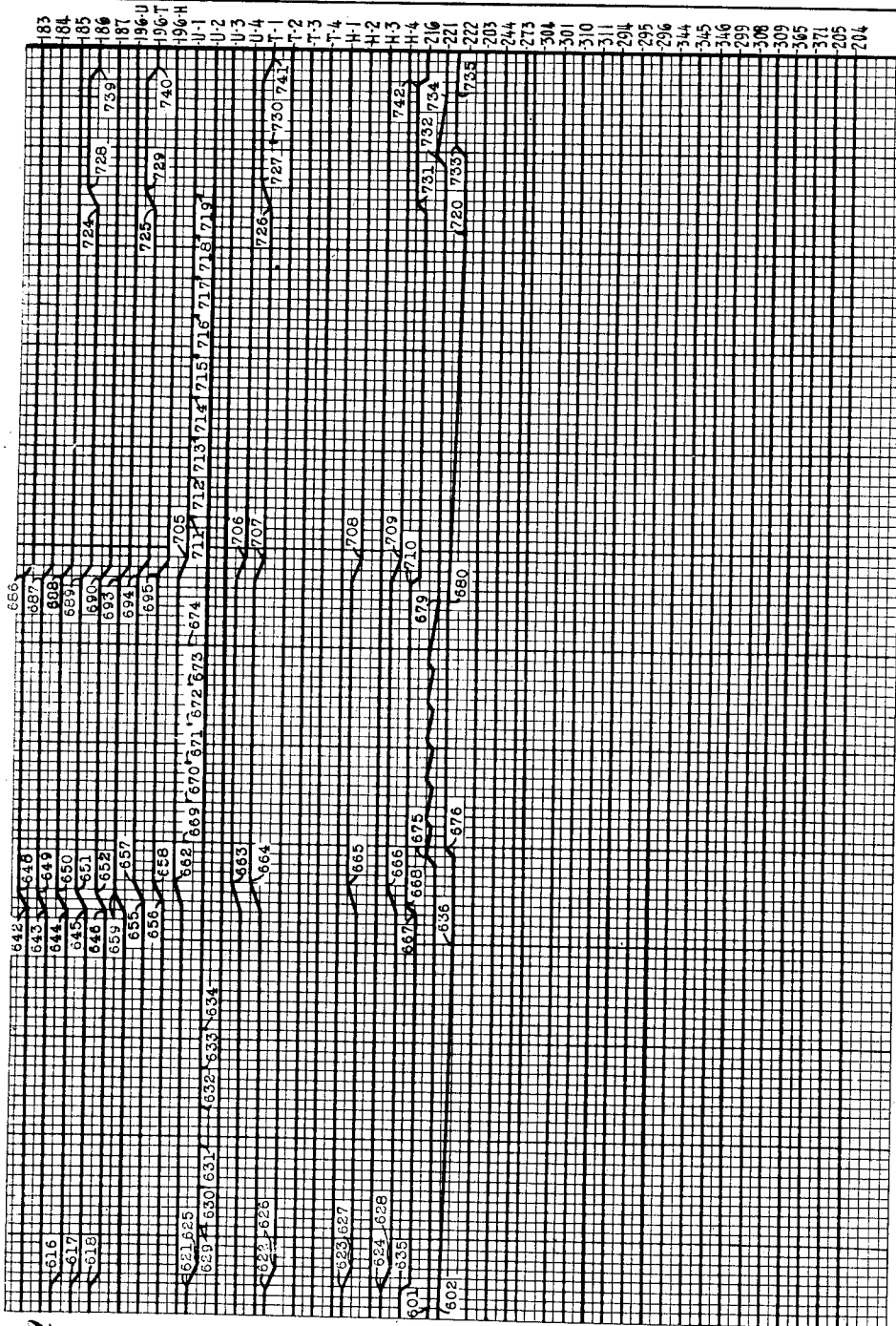


Fig. 20

INVENTOR.
Clyde Smith
BY Wallace & Garrison
ATTORNEYS.

June 20, 1944.

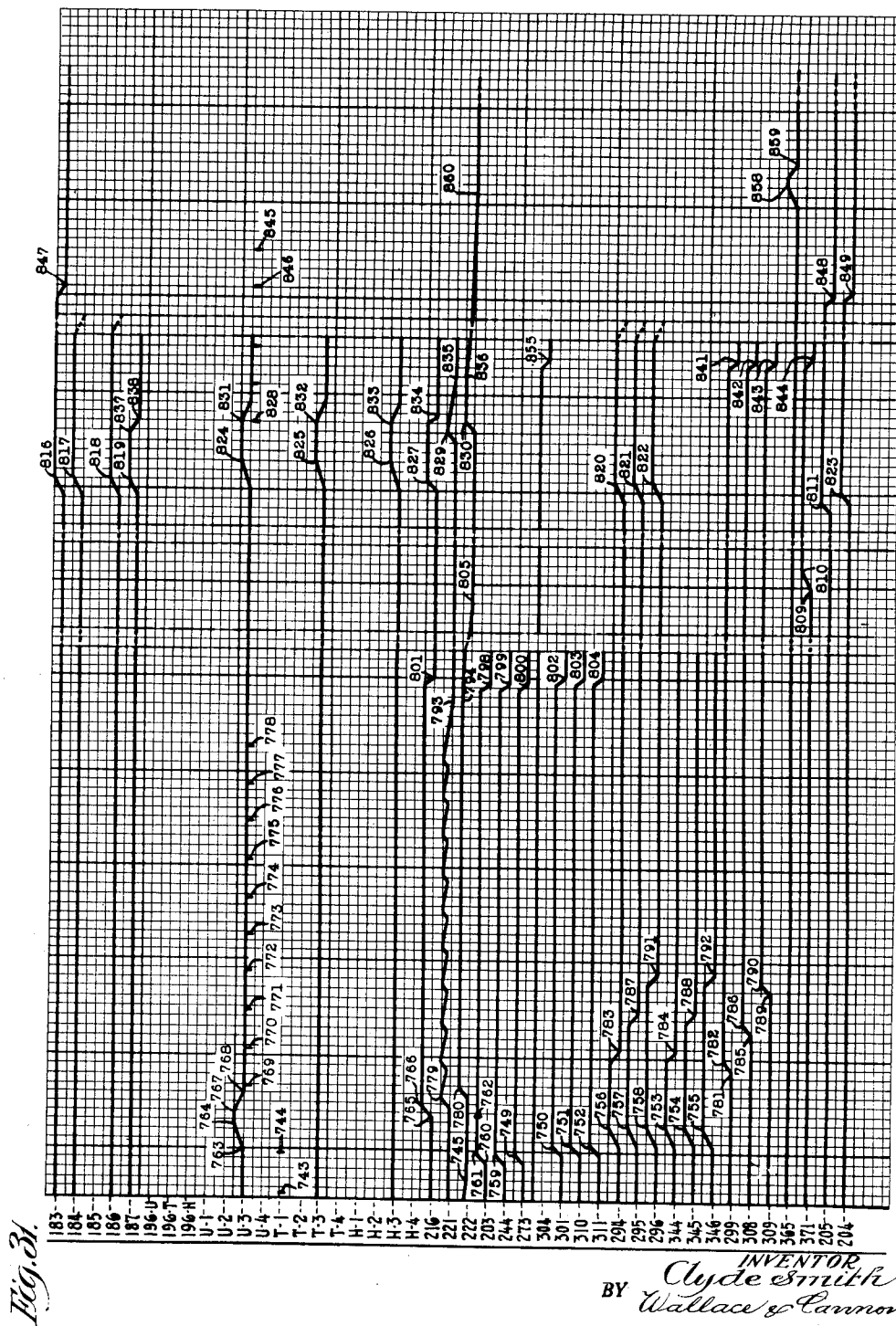
C. SMITH

2,352,027

CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

26 Sheets-Sheet 23



INVENTOR,
BY *Clyde Smith*
Wallace & Cannon
ATTORNEYS.

June 20, 1944,

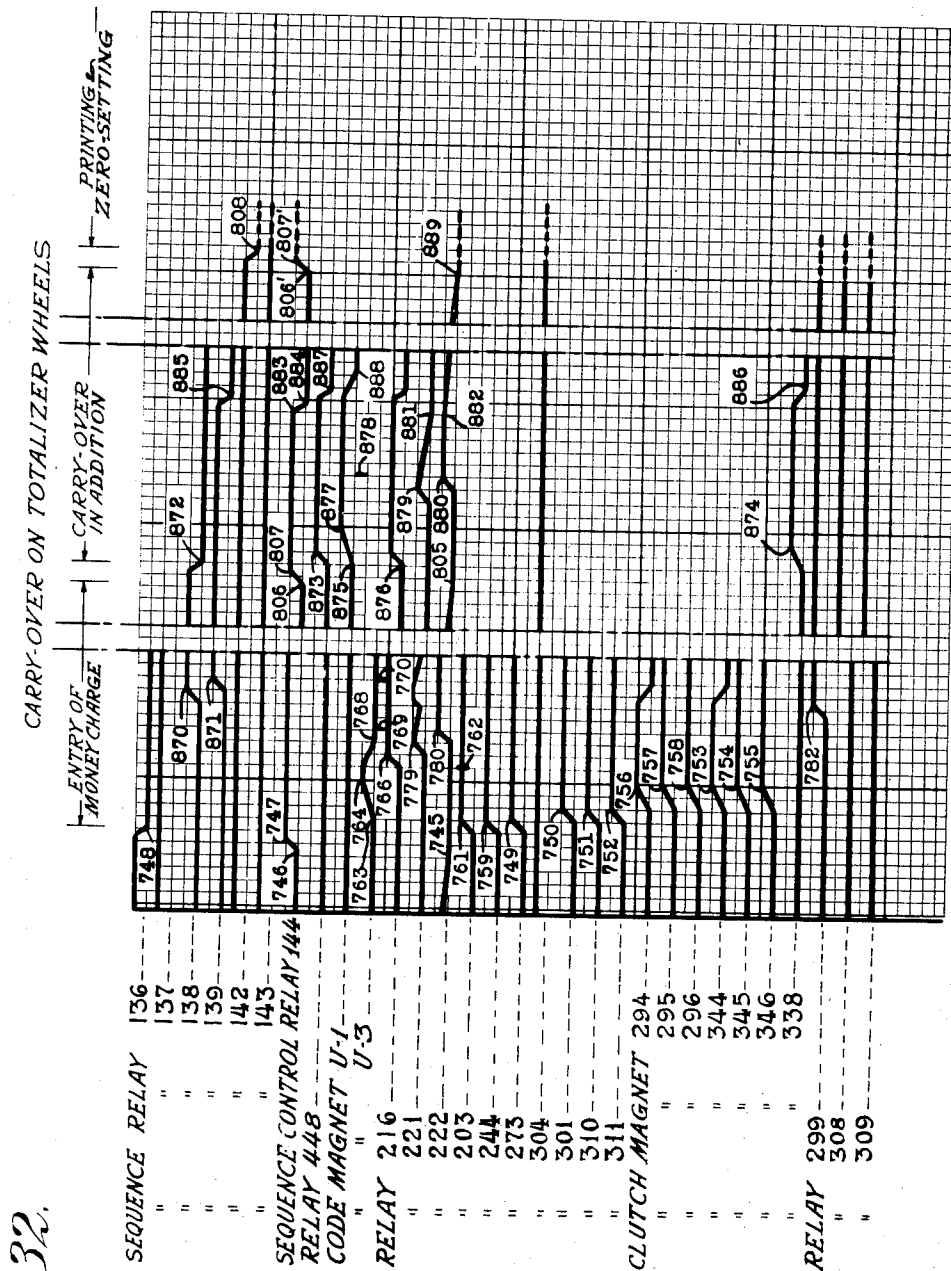
C. SMITH

2,352,027

CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

26 Sheets-Sheet 24



INVENTOR.

Clyde Smith

BY Wallace & Cannon
ATTORNEYS.

June 20, 1944.

C. SMITH

2,352,027

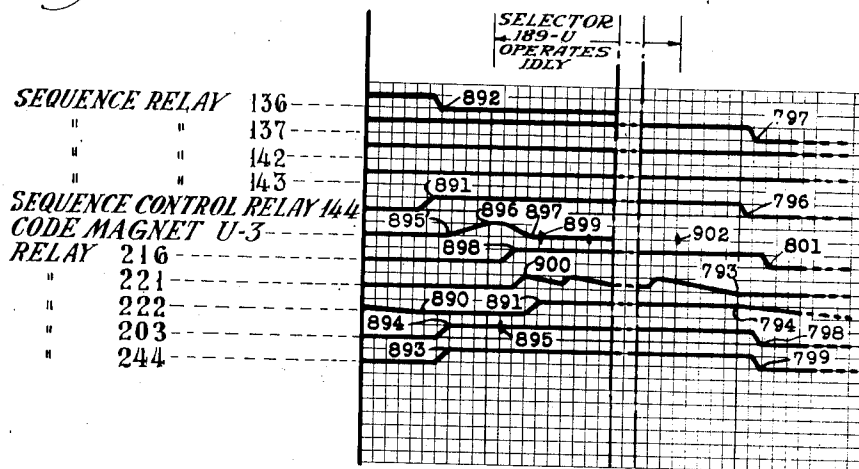
CALCULATING AND PRINTING MACHINE

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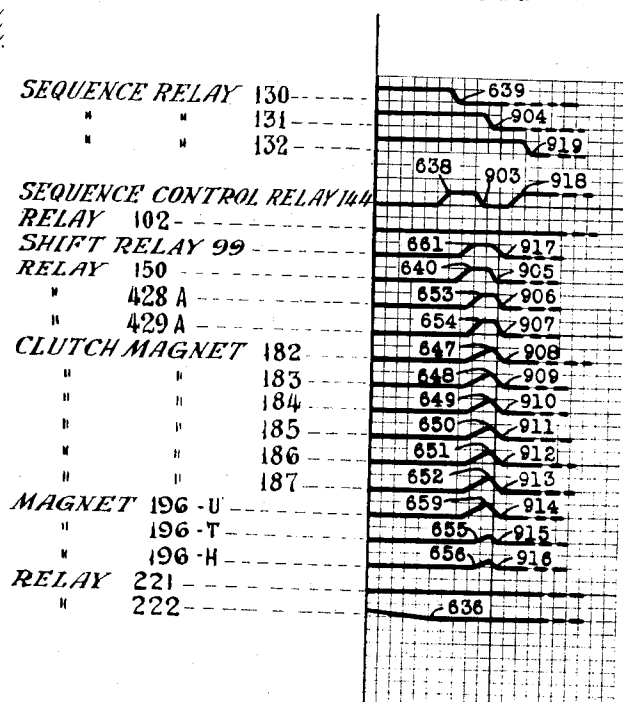
Fig. 33.

OPERATION WITH ZERO CONSUMPTION



OPERATION WITH PREVIOUS
METER READING 000

Fig. 34.



INVENTOR.

Clyde Smith
BY
Wallace, Gorman
ATTORNEYS.

June 20, 1944.

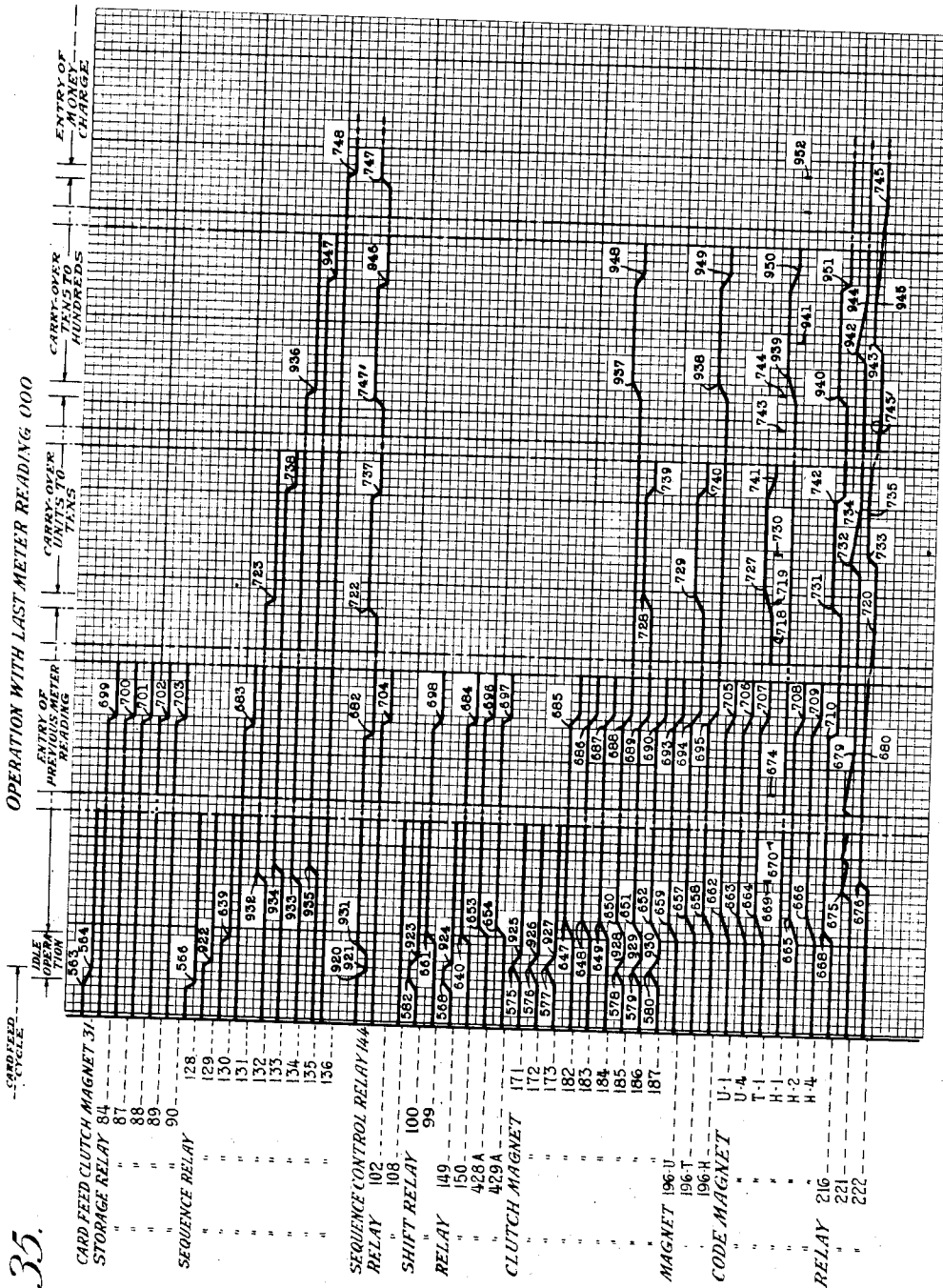
C. SMITH

2,352,027

CALCULATING AND PRINTING MACHINE

Filed Oct. 23, 1939

26 Sheets-Sheet 26



INVENTOR.
Clyde Smith
BY *Wallace & Gorman*
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,352,027

CALCULATING AND PRINTING MACHINE

Clyde Smith, Hopkinsville, Ky., assignor to Addressograph-Multigraph Corporation, Cleveland, Ohio, a corporation of Delaware

Application October 23, 1939, Serial No. 300,786

20 Claims. (Cl. 235—61.8)

This invention relates to printing machines and particularly to calculating, accounting, and billing devices, operable under control of record cards or like control devices, for use therewith.

It has been the practice heretofore to derive numerical data to be printed on a bill or other sheet from representations thereof on a record card or cards and to directly set up printing means under control of such representations and thereby print the data. Such procedure necessitates that those numerical data, which are the results of computations involving items pertaining to the particular customer for whom the bill or statement is to be prepared, shall have been previously computed and representations thereof afforded, for example by means of perforations, in the record card that is to be utilized to control printing operations.

For example, where a public utility bill for the consumption of a commodity as electrical energy is to be prepared, the money charge for such commodity consumption during the billing period is usually obtained by multiplying the quantity consumed within that period by a series of factors according to a sliding rate scale, such quantity being ascertained by another computation in which the reading of the customer's meter at the beginning of the billing period is subtracted from the meter reading at the close of the period. Heretofore it has been customary to effect the foregoing computations in a machine or machines independent of the machine in which the printing of the bill or the like is carried out and those data entering into or resulting from such computations which were to be printed on the bill were represented on a record card or the like, such card or the like being manually prepared for use in the printing machine either as the foregoing computations were made or from sheets onto which the data were copied as the computations were prepared for and made, either of which and kindred procedures were time-consuming and expensive.

An object of the present invention is to eliminate the time-consuming and expensive operations of punching or otherwise entering on record cards or the like representations of numerical data which result from computations entailing other data, and in place thereof to employ only the representations of the basic data in a card or the like and to effect computations and enable printing of the computed data, as well as of the basic data if desired, in a single machine.

Frequently it may be desirable to derive intelligence from a record card and hold such in-

telligence in storage until such time as it will be needed to govern a machine operation. Moreover, where data are represented in code on the record card or the like, it has been proposed to derive such data from the card or the like by means of reading devices and to temporarily preserve this data, until it can be interpreted by suitable devices and the decoded intelligence read out to the registering or recording apparatus. The principal advantage of code representation of items on the card is that more items can be represented thereon than would be the case if conventional digital notation were employed. Thus, in a card having twelve index point positions per column, there would ordinarily be accommodation for only one digit in each column. This can be extended, by the use of a four-unit code, to three digits per column. This feature has given rise to a further proposition whereby cards having superpositioned zones or decks defined by such sectioning of the card columns are analyzed zone by zone, and the data derived from each zone are stored in a separate group of storage devices, as shown, for instance, in United States Letters Patent 2,105,291. An outstanding disadvantage of such prior constructions, however, is that all portions of the intelligence derived and stored from the record card are read out simultaneously to the registering or recording apparatus.

In view of this difficulty, it is another object of this invention to store a plurality of numerical items derived from a record card or the like, and to release the stored items at selected times to computing, recording, printing or like apparatus.

Among the objects of this invention are to derive and store data pertaining to last and previous meter readings or the like from coded representations thereof in record cards or the like; to subsequently translate and read out stored representations of a last meter reading or the like and to set up printing means and a register under control thereof; to additively effect entry of the data represented by such representations in a consumption quantity accumulator or the like; to subsequently translate and read out stored representations of other data such as a previous meter reading and set up printing means and a register under control thereof; to subtractively enter such other data into said consumption quantity accumulator or the like; to effect any carry-overs incident to such last entry; and to equip said consumption quantity accumulator or the like with printing means whereby the differ-

ence between the two meter readings or the like ascertained therein may be printed.

Further objects are to pass a record card or the like rapidly and uninterruptedly through a sensing station and to effect computations entailing data represented by representations sensed at said sensing station subsequent to passage of the card or the like from the sensing station; to enable data represented by representations sensed at said sensing station, and data ascertained by computations based upon such data, to be printed subsequent to passage of the card or the like through said sensing station; and more specifically to pass a card bearing coded representations of last and previous meter readings rapidly and uninterruptedly through a sensing station and to thereafter compute a consumption quantity based upon the aforesaid meter readings and a money charge based upon such consumption quantity; and to enable the last and previous meter readings, the consumption quantity, and the money charge to be printed subsequent to the passage of the aforesaid card or the like from the sensing station.

Still further objects are to employ a record card or the like divided into zones and to so arrange the card or the like that a plurality of columns of data representations may be arranged in each zone, preferably with the columns in the respective zones in alignment one with the other; and to enable the data representations in the respective zones to be selectively rendered effective in setting up storage means or the like during passage of such a record card or the like through sensing position in a machine.

Yet further objects are to provide a plurality of devices that will be operative to govern the sequence of performance of machine functions; to render such devices operative during the initial function in a cycle of operation of the machine as, for example, the initial card feeding operation in the machine; and to enable such devices to initiate a succeeding cycle of operation of the machine upon the completion of a given cycle of operation.

Further objects of the invention are to enable data represented on record cards or the like to be divided into classes; to count or otherwise accumulate data respectively pertaining to each of such classes during the passage of a plurality of record cards or the like bearing representations of the classified data through the machine; and, more specifically, to enable the customers of a public utility or the like, to which data represented by perforations or the like in record cards or kindred devices pertain, to be divided into classes; to count the number of such customers or the like in each of such classes when a plurality of record cards or kindred devices of the aforesaid character are passed through a machine; and to classify data computed from data represented on record cards or the like and to separately accumulate such data in accumulators or the like respectively pertaining to various classifications into which the data is classified.

Another object of this invention is to represent data by perforations or the like in record cards or kindred devices and to so arrange a machine in which such cards or kindred devices are to be used that selected normally effective perforations or the like may be rendered ineffective, for example under control of means in the cards or kindred devices, during passage of the cards or kindred devices through the machine.

Other and further objects of the invention are

to insure accurate and synchronous operation of certain interrelated mechanisms in a machine of the character to which this invention pertains as, for example, the card feeding and intelligence storing apparatus; to employ a common entry effecting means for a plurality of different registers, accumulators or the like and to selectively establish operative relation among such common entry effecting means and a register, accumulator or the like to receive an entry and the means governing or determining the nature of the particular entry; to employ permutation devices as a common entry effecting means; to enable such permutation devices to simultaneously effect entries into more than a single register, accumulator or the like; to enable one or more of such permutation devices to be employed for the purpose of effecting a predetermined operation such as, for example, setting a shaft or the like in operation to make a single complete revolution; to also employ an entry effecting means of such nature that once it is set in operation it will remain operative unless and until a predetermined condition, as for example, one indicative of a particular numerical value, is encountered and to thereupon interrupt operation of the entry effecting means whereby a register, accumulator or the like will be set in accordance with such predetermined condition; to enable an entry effecting means of the last referred to character to be employed under a plurality of conditions, and an object ancillary to this is to select from among a plurality of devices operative to set the entry effecting means in operation such means as will bring about an operation in accordance with entailed conditions, as for example, to utilize certain means for setting the entry effecting means in operation when a significant digit is to be entered in a register, accumulator or the like and to select other means when a zero is to be entered; and to provide means whereby duplicate operations may be effected as, for example, the printing of corresponding amounts on a bill or the like at different positions thereon.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show a preferred embodiment and the principle thereof and what I now consider to be the best mode in which I have contemplated applying that principle. Other embodiments of the invention embodying the same or equivalent principle may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings,

Fig. 1 is a partially schematic view showing the manner in which a perforated record card is fed through sensing position in the machine and also showing the sensing brushes and certain control cams;

Fig. 2 is a chart of the four-unit code employed in preparing the record cards;

Fig. 3 is a plan view of the card feeding mechanism and in which part of the electrical connections associated with the card sensing brushes is also shown;

Fig. 4 is a vertical sectional view taken substantially on the line 4-4 of Fig. 3 and illustrating the manner in which a record card traverses the sensing brushes;

Fig. 5 is a side elevation of the apparatus shown

in Fig. 4 showing part of the card column selecting device;

Fig. 6 is a partially schematic view of the storage apparatus and transfer drum;

Fig. 7 is a schematic view of certain shift relays and coded contact relays;

Fig. 8 is a schematic view of a group of sequence relays and allied relays, showing the interconnections for same;

Fig. 9 is a partially schematic plan view of a portion of the printing means, showing the last reading, previous reading and consumption quantity printing wheels and associated entry-effecting means;

Figs. 10, 11 and 12, taken together, comprise a wiring diagram of electrical connections of the sliding rate scale product table;

Fig. 13 is a wiring diagram of zero controlling electrical connections;

Fig. 14 is a plan view of the money charge printing wheels of the printing means and associated parts;

Fig. 15 is a side elevation of the printing means;

Fig. 16 is a partially schematic elevation of the control cam assembly for the printing means;

Figs. 17 and 18, taken together, comprise a partially schematic view of a classified totalizer and the entry-effecting means for the money charge printing wheels;

Fig. 19 is a fragmentary sectional view of a permutation selector for positioning the type wheels shown in Fig. 9;

Fig. 19A is a plan view of a permutation selector;

Fig. 20 is a detail view showing parts of a consumption quantity accumulator number wheel assembly;

Fig. 21 is a schematic view of a portion of a sequence control circuit;

Figs. 22 to 25, inclusive, taken together, constitute a comprehensive scheme of connections for the machine; and

Figs. 26 to 35, inclusive, are timing charts of various machine operations. Of these, Figs. 26 to 31, inclusive, taken together, comprise a timing chart of a typical series of machine operations. The other views illustrate special operations, as indicated thereon.

GENERAL DESCRIPTION

While the invention disclosed in the following specification is capable of use in a wide variety of business machines, a preferred embodiment thereof has been selected for purposes of illustration. This preferred construction comprises a machine adapted to expeditiously perform public utility billing operations.

In the preparation of bills for customers of a public utility, use is made of certain data, such as meter readings, which are ascertained by inspection of a meter or the like located on the customer's premises, such meter providing a visual indication of the amounts of a commodity, such as electrical energy that are being consumed by the customer. It is customary for the utility to said a representative to the customer's premises once a month for the purposes of having the meter read. When a bill is to be prepared for that customer, the previous meter reading is subtracted from the present or last taken meter reading and the difference, if any, thus ascertained is known as the consumption quantity. This consumption quantity is then utilized to determine a money charge to be made on the basis of what is known as a sliding rate scale table. For

example, the first 50 units of consumption may be charged for at the rate of 6¢ per unit, the second 50 units at the rate of 5¢ per unit and the remainder at the rate of 4¢ per unit. The sum of such products is then billed to the customer.

In the machine of this invention a perforated record card bearing representations of monthly meter readings is utilized, there being one such record card for each customer. A number of separate fields are provided on the card for accommodating representations of the several meter readings that have been or are to be taken and preferably twelve such fields are provided. The machine is adapted to selectively sense on the card representations of the last meter reading recorded and the representations of the one previous to that. The intelligence so sensed is stored in storage devices and thereafter the machine performs a sequence of operations as follows:

In the first sequential operation of the machine, the last meter reading is transmitted from the storage devices in which it has been entered to a set of printing wheels, the last reading printer, which are set in accordance with the numerical value of such entry. An equal entry is concurrently effected in additive manner into an accumulator, known as a consumption quantity accumulator, which in turn controls a printer called a consumption quantity printer.

In the second sequential operation of the machine the previous meter reading is transmitted from the storage devices in which it has been entered to a set of printing wheels, the previous reading printer, which wheels are set in accordance with the numerical value of such entry. An equal entry is concurrently effected in a subtractive manner into the aforesaid consumption quantity accumulator.

The third and fourth sequential operations of the machine are dependent. Thus if the subtraction of the previous meter reading from the last meter reading involves a carry-over from the units order to the tens order, this is done in the third sequential operation and if such subtraction involves a carry-over from the tens order to the hundreds order, this is done in the fourth sequential operation. After such carry-over operations, if any, are effected, the wheels of the consumption quantity printer will have been positioned to the exact value of the difference between the two meter readings, or the consumption quantity for which the customer is to be charged.

In the fifth sequential operation of the machine, a money charge based upon the consumption quantity is ascertained by an apparatus known as a product table which is adapted to, in effect, perform multiplication on a predetermined sliding rate scale basis for any variable quantity within its capacity. The thus determined money charge is entered into a money charge printer and an equal entry is concurrently effected into a selected classified totalizer which accumulates all charges made to customers in a particular classification.

The sixth and seventh sequential operations of the machine are reserved for carry-over operations which may be entailed in the accumulation of classified customers' charges.

The eighth sequential operation of the machine is one in which printing of the last and previous meter readings, consumption quantity, and money charge is effected onto a bill or other record sheet. Also during this sequential operation, the printing wheels are all restored to their zero positions

after printing has been effected therefrom, certain other operative devices in the machine are released, and as a final step the succeeding billing operation for a new customer is initiated, this being attended by introduction of a new record card into the machine.

In order to accommodate meter readings on the card in as compact an area as possible, the meter readings are represented in code on the card and to further economize in space, the card is zoned. Hence when a card is fed into the machine for sensing, it will be necessary to select not only a particular group of columns on the card but also a certain zone for the meter readings corresponding to the selected monthly periods. To this end means are provided for enabling both column and zone selection.

Suitable translating means are provided for decoding the meter readings which have been stored, as aforesaid.

Additional features of this machine reside in the provision of novel means for, in effect, rendering ineffective all data representations on a record card or the like in response to a special representation in the card. The machine is also responsive to a special representation in the card or the like for counting the meters or the like by types and the customers or the like by classes.

In the following, a description is first set forth of the various working parts of the machine shown in the drawings and thereafter an explanation of the operation thereof is given.

RECORD CARD AND CODE—FIGS. 1 AND 2

The record card C shown in Fig. 1 is of a type well-known in the art to which this invention pertains. The card is usually provided with eighty separate columns extending transversely of the card, each column having a capacity for twelve index point positions. In the present instance, where a four-unit code is being employed, each column is divided into three sections, thus providing the card with three superpositioned zones, I, II and III, the portions of the card columns lying within each zone having four index point positions apiece.

Additionally the card columns may be grouped so that, for example, the first three columns, counting from the left, will form one group, the next three columns will form another group, and so on. It will be understood that such zoning of the card and grouping of the columns as has just been referred to can be effected without making any substantial changes in such perforated record cards as are now in commercial use. Thus the broken lines 2 and 3 which separate the zones I and II and II and III, respectively, as shown in Fig. 1, are merely illustrative and it should be noted that the spacing between index point positions in the respective card columns have not been changed in any way. Similarly, the broken lines, as 4, 5, 6 and 7, Fig. 1, which segregate various groups of columns, are likewise illustrative and do not indicate any change in the spacings between the card columns themselves.

It will be noted in Fig. 1 that the left-hand portion of the record card C has been shown divided into twelve small fields to the left of the line 7. Thus, there is a field at the upper left-hand corner of the card, defined by the broken lines 2 and 4 together with the left-hand and top edges of the card, another field defined by the broken lines 2, 3 and 4 together with the left edge of the card, while still another field is defined by the lines 3 and 4, together with the left-

hand and bottom edges of the card. Similarly, the lines 2 and 3 cooperate with the lines 4, 5, 6 and 7 and the top and bottom edges of the card to define additional fields so that there are twelve fields altogether, to the left of the line 7. Each such field comprises three columns having four index point positions per column. This arrangement accommodates representations of three characters in four-unit code. Additionally, there have been provided three fields defined by the lines 2, 3, 7 and 8 and the top and bottom edges of the card. The purposes of these various card fields will be explained presently.

A suitable code for indicating digits of numerical quantities is shown in Fig. 2. Thus, a perforation at the lowermost position, only, in a four-unit column represents the digit 1, a single perforation in the third from the bottom position in a four-unit column represents the digit 2 and perforations at the first and third positions from the bottom in a card column represent the digit 3, and so on, in accordance with the scheme suggested in Fig. 2. This arrangement has been utilized to represent a customer's monthly meter readings taken throughout the year on the record card C of Fig. 1 so that each of the twelve fields referred to hereinabove, to the left of line 7, accommodate one such monthly meter reading. Thus, the field in zone I lying at the extreme left, as viewed in Fig. 1, may be allocated to the meter reading taken in the month of January, while the field lying in zone I between the lines 4 and 5 may be allocated to the month of February. The field immediately to the right of the last-mentioned field would be for the month of March, and the field to the right of this last field would be for the month of April.

The reading for the month of May, as in the case of readings for certain other months referred to hereinafter has been shown in two positions on the card for a reason which will be explained presently, and it is in this connection that the additional set of three fields on the card between the broken line 7 and 8 thereon has been provided. Thus, the reading for May will appear in zone I between line 7 and 8 and also in zone II to the left of line 4. Continuing in zone II, from left to right, the readings for June, July, August and September are located in the fields between the lines 4 and 5, 5 and 6, 6 and 7, and 7 and 8, respectively. The reading for September is duplicated in zone III to the left of line 4. Continuing in zone III, from left to right, the readings for October, November and December and January will be allocated to the fields between lines 4 and 5, 5 and 6, 6 and 7, and 7 and 8, respectively.

Referring particularly to the two fields in zone I to the left of the line 5, which fields pertain to the months of January and February, it will be noted that in the extreme left-hand column of the first field there are two perforations 1A and 1B in the second and fourth positions from the bottom line 2 (the perforation 1B being disposed behind a sensing brush 9). The perforations 1A and 1B represent the digit 4, as can be seen by referring to the chart, Fig. 2. In the next column to the right in this field there is a single perforation 1C in the lowermost position, this perforation being indicative of the digit 1. In the third column from the left there are two perforations 1D and 1E in the first and fourth positions therein (perforation 1E being obscured by a brush 11), these perforations being indicative of the digit 6. Thus, the meter read-

ing represented for the month of January is 416.

Proceeding to the field for the month of February, in the extreme left-hand column there are two perforations 2A and 2B in the second and fourth positions, respectively (the latter perforation being obscured by a brush 12), and these perforations represent the digit 4. In the next two columns to the right there are single perforations 2C and 2D in the second positions therein, these being representative of the digit 5. Hence the meter reading represented for the month of February is 455.

In addition to the fields reserved for meter readings, there are shown in Fig. 1, in the extreme right-hand portion of the card, three fields bounded by the edges of the card and separated by the broken lines 2 and 3. In the lowermost of these latter three fields there is shown a perforation 15A, the purpose of which is to indicate that the card is "active" or in other words, that the meter readings represented therein are to be effective in a billing operation. If for any reason it is desired to render the card perforations inactive, the perforation 15A may be covered up as by an adhesive strip 16 represented in dotted outline, but for purposes of the present description, it will be assumed that the perforation 15A is not so covered.

In zone II, in the present example, there have been shown two perforations 15B and 15C in the first and second positions respectively, these perforations representing the type of meter in a public utility arrangement, or they could be representative of such items as age of person, type of policy and so on, if the machine is to be adapted to some other type of billing. In zone I, there is a perforation 15D in the lowermost position, this perforation being representative of a customer's classification, which information is employed in the classification of customers' charges.

CARD FEEDING AND SENSING APPARATUS AND ALLIED PARTS—FIGS. 1, 3, 4 AND 5

The card feeding mechanism, best shown in Fig. 4, includes a card magazine comprising a spring-urged back plate 17 which tends to force a pack of cards P, which cards are supported on edge on a plate 18, toward a reciprocating picker block 19 which is mounted for vertical sliding movement. The block 19 includes a card picker 20 that is adapted, upon downward movement of the block 19 to push the first card as C in the pack P below the level of the horizontal plate 18 and into the bite between a pair of feed rolls 21 and 22. Reciprocatory movement is imparted to the block 19 and card picker 20 by links 23 pivoted at their lower ends to the faces of gears 24 and at their upper ends to the block 19. The gears 24 mesh with gears 25 fast on a shaft 26. The shaft 26 is under control of a clutch, generally designated 27, Fig. 3, said clutch including an element 29 splined to the shaft 26. The engagement of the elements 28 and 29 of the clutch 27 is effected by rocking the lever 30, this lever being in reality an armature of an electromagnet 31. Thus, energization of the electromagnet 31 serves to engage the clutch parts 28 and 29, and deenergization of said magnet disengages these parts. When clutch element 29 is released, it permits the shaft 26 to rotate under its momentum until a lug 32 on the part 29 engages a stationary lug 33 whereupon further rotation of the shaft 26 is prevented and the card picker is arrested in its uppermost position shown in Fig. 4.

As the card C is fed downwardly by the feed rolls 21 and 22, it traverses a set of sensing brushes generally designated B, Figs. 4 and 1, and then passes through a pair of lower feed rolls 34 and 35 and into a card collector K. The brushes B in the present instance comprise two sets of three brushes each, such as the brushes 9—10—11 and 12—13—14, Fig. 1, each set of brushes being aligned with a group of three card columns. Thus, as the card C traverses the brushes B in its downward movement, the brushes 9, 10 and 11 sense the perforations in the extreme left-hand field in zone III first, the most left-hand field in zone II second, and the extreme left-hand field in zone I lastly. In each field, the bottom digital positions will be sensed first and the top positions last. The brushes 12, 13 and 14 perform a similar function as regards the three vertically aligned fields between the lines 4 and 5, in the order III—II—I.

It will be noted that the brushes B are fixed on a collar 36 that is screw-threaded to an adjusting screw 37. By rotating the screw 37, the brushes B can be shifted to any desired vertical field of the card, thus enabling selection of the card columns which are to be effective. The brushes 9 to 17, inclusive are provided with flexible leads as 38 so that electric connections to these brushes will not be disturbed by movement thereof.

A pinion 39 is fast to the end of the adjusting screw 37, Figs. 1 and 5 and a large gear 40 provided with a knob 41 is meshed with the pinion 39. By rotating the knob 41 and gear 40, the pinion 39 and screw 37 may be rotated to thereby shift the threaded collar 36 and brushes B. A pointer 42 and suitable scale, or the like, are provided for the purpose of accurately locating the brushes in a desired vertical field of the card.

A single fixed brush 44 is provided in position to cooperate with perforations as 15A at the right-hand end of the card C as shown in Fig. 1. Also, in position to cooperate with the card C, there is provided a pivoted rocker 45 which serves as a card detector, the lower end of said rocker being urged into cooperative relation with the card by a spring 45C. If the presence of a card is detected, the rocker 45 will establish a circuit from the grounded contact 45A to the contact 45B.

Referring to Figs. 1 and 4, it will be seen that the brushes B and 44 cooperate with a horizontal contact bar 43. Whenever a card is detected by the rocker 45, ground is established through a conductor 46 to the contact bar 43, so that as long as a card is passing beneath the sensing brushes, there will be ground available on this bar, but if a card fails to feed at the proper time, ground will be withheld from the contact bar 43 during the time when the brushes should be sensing a card.

Assuming that ground is on the bar 43, each time a sensing brush contacts the bar 43 through a perforation such brush will be grounded during the interval in which the brush is contacting the bar 43. The perforations in the card thus control grounding of the brushes in accordance with the intelligence represented by such perforations.

In Fig. 3, it will be seen that the shaft 26 extends beyond the card feed mechanism and that a drum D is mounted thereon. Referring to Fig. 6, it will be seen that in addition to the drum D, there are also mounted on the shaft 26 a pair

of control cams 47 and 48. As shown in Fig. 1, the control cam 47 is circular and is provided with a notch 49 in its periphery and a rider 50, when the cam 47 is in its normal position, is adapted to enter the notch 49. However, when the shaft 26 starts to rotate and the cam 47 moves away from its normal or zero position, the rider 50 moves out of the notch 49 and supplies ground to contacts 50A, 50B and 50C. These contacts then remain grounded until the cam 47 has returned to its zero position. Cam 48 is substantially circular in outline and is provided with a lobe 51 and a dwell 52. The lobe 51 is designed to establish contact between a rider 53 and a contact 54 shortly after the cam 48 moves away from its zero position, the direction of movement of cams 47 and 48 being clockwise as viewed in Fig. 1.

Inasmuch as the drum D and the cams 47 and 48 are mounted on the same shaft as that which drives the card feed mechanism, namely shaft 26, and since there is a one-to-one ratio between the gears 24 and 25, Fig. 4, the drum D and cams 47 and 48 rotate in synchronism with the passing of a card as C past the sensing brushes, and this synchronous relationship is further insured by properly timing the rotation of the feed rolls 21 and 22. Hence, during the first 180 degrees of rotation of the shaft 26 after it has been set into operation by energization of the electromagnet 31, Fig. 3, the card C traverses the sensing brushes as B and the cams 47 and 48 and drum D will be going through their first 180 degrees of rotation.

As shown in Fig. 1, the periphery of the cam 48 has been divided into three sections, bounded by broken lines 55, 56, 57 and 58, throughout the first 180 degrees thereof. The segment between the lines 55 and 56 will rotate past the rider 53 during the interval when the bottom zone III of the card C is traversing the contact bar 43, the segment defined by lines 56 and 57 will be rotated past the rider 53 while zone II of the card C is traversing the contact bar 43, and the segment between lines 57 and 58 on the cam 48 will be rotating past the rider 53 while zone I of card C is traversing the bar 43. After the lobe 51 has passed the rider 53, and while this rider is still in contact with that portion of the periphery of cam 48 disposed between the lines 55 and 56, there will be no contact between rider 53 and either of the associated contacts 54 or 55. However, when the rider 53 descends into the dwell included between the lines 56 and 58, it will engage the lower contact 55, and this relation will continue throughout the interval when zones II and I of the card C are being fed past sensing position.

It is to be noted that the cams 47 and 48 are shown in their normal or zero positions whereas the card C is shown in a position in which it is about ready to be fed away from sensing position. Therefore, the cams 47 and 48 are not shown in their true positions with respect to the position of the card C, this being done for purposes of this description.

At the start of the card feeding operation, while zone III of the card C is moving into sensing position, the cams 47 and 48 will be rotated clockwise away from their zero positions. Lobe 51 on cam 48 is so located thereon that it engages rider 53 with contact 54 at the instant the brush 44 is sensing the lowermost index point position in the column with which it is aligned. Assuming that perforation 15A is present in the

card, in the lowermost position of the column to the extreme right as shown, ground will be extended from the contact bar 43 through perforation 15A to the brush 44, thence through a conductor 56 to the rider 53, which is now engaging upper contact 54 due to the position of lobe 51, and thence through a conductor 57 to the winding 58A of a double winding relay 58. The two windings 58A and 58B of relay 58 are connected on one side to battery, as shown, and are cumulative in their action so that either one or both of these windings, when energized, will cause the relay 58 to actuate its several contacts. Hence when the sensing brush 44 detects a perforation as 15A, ground will be impressed upon the winding 58A and the relay 58 will thereupon energize and actuate its contacts.

Contact 58C is connected to conductor 57 which leads to winding 58A and when this contact is closed, a holding circuit is established through the winding 58A, conductor 59, and now closed cam contact 50C, which holding circuit will remain established until the rider 50 again descends into the notch 49 in the cam 47. Contact 58D in closing connects the winding 58B to a conductor 60 to thereby provide another holding circuit through this conductor, such circuit being completed in a manner described hereinafter.

Contact 58E in closing connects the cam contact 50A with a conductor 61 to effect certain controlling functions described hereinafter. Likewise, the normally open contacts 58G and 58H will close.

Normally closed contact 58F serves to connect a grounded starting switch 62, when the latter is closed at the start of machine operation, with a conductor 63, Figs. 1 and 3, leading to the electromagnet 31 of the card feeding mechanism, when the relay 58 is deenergized. After the relay 58 becomes energized, contact 58F opens to relieve conductor 63 of this source of ground, but conductor 63 is now connected to ground through another conductor 64 and the cam contact 50B, and this source of ground will continue until contact 50B again opens upon completion of one revolution by the cam 47.

Contact 58J when closed, impresses battery upon one terminal of a manually operable selecting switch 65, Fig. 1, through a conductor 66. Switch 65 has three selective positions. Thus, it may connect the conductor 66 with any one of the contacts 67A, 67B or 67C. Such selection of the contacts 67A, 67B and 67C determines which of the three zones I, II or III, respectively, of the card C are to be effective, as will appear hereinafter.

STORAGE APPARATUS AND TRANSFER DRUM—FIG. 6

The drum D is cylindrical in shape and is of suitable insulating material. It is mounted on the shaft 26 preferably adjacent the cams 47 and 48. Longitudinal conducting strips 68A, 68B and 68C are embedded in the surface of the drum D and are so positioned thereon that when the shaft 26 is set in operation at the commencement of a card feed cycle, the strip 68A will pass a predetermined sensing station, indicated by the dot-dash line L, Fig. 6, at the instant when the lowermost index point positions in zone III of the card C, Fig. 1 are positioned over the contact bar 43. The strip 68B will pass the line L simultaneously with passage of the lowermost index point positions of zone II of the card C over the contact bar 43. Similarly, the contact strip 68C

will pass the line L simultaneously with passage of the lowermost index point positions in zone I of the card C over the contact bar 43.

Also embedded in the surface of the drum D are other relatively short conducting strips 69A, 69B and 69C, these latter strips extending circumferentially for limited distances around the drum D and at right angles to the strips as 68A. The strips 69C and 68C are interconnected and a brush 70C, which is positioned so that its lower end rests on the surface of the drum D along the line L, is mounted in alignment with the strip 69C. Another brush 70B is in alignment with the strip 69B and this strip is connected to the strip 68B by an intermediate conductor 71 which is disposed beneath the surface of the drum D so as not to contact the brush 70C at any time. Similarly, a brush 70A is mounted in alignment with the strip 69A, and this strip is connected to strip 68A by an embedded conductor 72, so that brushes 70B and 70C cannot be brought into contact with the conductor 72 at any time.

Brushes 70A and 70B, like brush 70C, are mounted in such a way that their lower ends rest on the drum D along the line L. The strips as 69A and 69B extend circumferentially upward from their respectively connected strips as 68A and 68B, as viewed in Fig. 6, but are preferably made short enough so that they do not overlap the strips 68B and 68C, respectively. Therefore, brush 70A will be in contact with strip 69A and connected strip 68A only while card zone III is being sensed. Brush 70B will contact strips 69B and 68B only while card zone II is being sensed, and brush 70C will contact strips 69C and 68C only while card zone I is being sensed. Brushes 70A, 70B and 70C are respectively connected to contacts 67A, 67B and 67C, Fig. 1, so that the position of the selecting switch 65 determines which of the brushes 70A, 70B or 70C is to be impressed with battery from relay contact 58J, and therefore which card zone is to be effective.

A set of brushes, 71A, 71B and 71C mounted in side by side relation, is disposed with the lower ends of the brushes resting on the drum D along the line L. Hence whenever the lowermost index point positions in any zone on the card C are passing over the contact bar 43, the brushes 71A, 71B and 71C will be contacting one of the strips 68A, 68B or 68C.

Another set of brushes 72A, 72B and 72C is disposed with the lower ends of the brushes resting on the drum D in an advanced position, in the direction of rotation of the drum D, beyond the brushes as 71A, and the brushes as 72A contact a strip as 68C, at a time when the next to the lowest index point positions in a card zone are passing over the bar 43. Similarly, a third set of brushes 73A, 73B and 73C is disposed in a further advanced position in the direction of rotation of the drum D beyond the brushes as 72A so that the brushes as 73A contact a strip as 68C at a time when the third from the lowest index point positions in a card zone, are traversing the bar 43. A fourth set of brushes 74A, 74B and 74C is mounted in yet further advanced position on the drum D, in the direction of rotation thereof, beyond the brushes as 73A, so that the brushes as 74A contact a strip as 68C at the instant when the top-most index point positions in a card zone traverses the bar 43.

A set of brushes 75A, 75B and 75C is positioned in longitudinal alignment with the brushes 71A, 71B and 71C so that the brushes as 75A contact

a strip as 68C at the instant when brushes as 71A are contacting the same strip. Similarly, there is a set of brushes 76A, 76B and 76C positioned in alignment with the brushes as 72A. A set of brushes 77A, 77B and 77C is mounted in alignment with brushes as 73A, and a set of brushes 78A, 78B and 78C is aligned with brushes as 74A.

A longitudinal conducting strip 79 is connected to a transverse circumferentially extending strip 80 on the drum D. A brush 81A is mounted in position to contact the strip 79 at the instant when the lowermost index point positions in card zone II are passing over the bar 43, Fig. 1. Other brushes 81B, 81C and 81D are provided for contacting the strip 79 when the second, third and top index point positions, respectively, in card zone II are traversing the bar 43.

Strip 80 extends for a sufficient distance around the drum D that it will remain in contact with a brush 82 during the interval when the card zones II and I are passing sensing position. Another set of brushes 83A, 83B, 83C and 83D is positioned in circumferential alignment with the set of brushes including the brush 81A transversely of the drum D, but farther on in the direction of rotation of the drum, so that the brush 83A will be contacting the strip 79 when the lowermost index point positions in zone I of the card C are in sensing position. Similarly, brushes 83B, 83C and 83D will be contacting the strip 79 while the second, third and top index point positions of card zone I, respectively, are in sensing position.

The storage apparatus, in the illustrated embodiment of the invention, comprises sets of double-winding relays as 84, Fig. 6, there being shown in this instance four vertically aligned storage relays in each set since the present apparatus is designed for use with a card perforated in accordance with a four unit code and a sensed coded intelligence is, in the present apparatus, stored in coded form. The set of four vertically aligned relays at the extreme left in Fig. 6 pertains to the hundreds order of the previous meter reading. The next set to the right pertains to the tens order of the previous meter reading and the third set of storage relays from the left pertains to the units order of this meter reading. Thus, the first three sets of storage relays, from the left, Fig. 6, constitutes a storage group for the previous meter reading.

The three sets of storage relays to the right in Fig. 6 constitute a storage group for the last month's meter reading. The manner in which numerical entries derived from the card C are stored in the relays included in the storage apparatus shown in Fig. 6 will be explained in greater detail subsequently. For present purposes, if the value of the digit in, say, the hundreds order of the previous meter reading is such that a perforation as 1B, Fig. 1, is disposed beneath a brush as 9 at the instant when the top-most index point positions in a selected card zone are in sensing position, ground will be extended from the bar 43 through perforation 1B, brush 9, and a conductor as 85, Figs. 1 and 6, at the instant when a brush as 74A, Fig. 6, is contacting a strip as 68C to thereby energize a storage relay as 84 as will now be explained.

It will be noted that the brush 74A is connected to one side of the winding 84A of the storage relays 84 by a conductor 86. Assuming that the switch 65, Fig. 1, has closed circuit from

battery at contact 80J of relay 88 to the contact 87C, Fig. 6, and thence to brush 70C, Fig. 6, and contact strip 88C, there will now be a completed circuit from ground at bar 43, Fig. 1, through conductor 88 and the left-hand winding 84A of the storage relay 84 and thence to battery at strip 88C on the drum D at the instant when a perforation as 1B in the card C has reached sensing position. This will cause the storage relay 84 to energize and close its several contacts. Closure of contact 84C of the relay 84 connects one side of the winding 84B to a conductor 87', the other side of this winding being supplied with battery as shown. Conductor 87' is part of a holding circuit, traced in detail hereinafter, and so long as ground is maintained on this conductor, the relay 84 will remain energized or locked up through its contact 84C even though the perforation as 1B, Fig. 1 in the card C has moved away from sensing position.

Again, assuming the card C to be perforated in the two left-most fields in zone I in the manner shown in Fig. 1, which is to say, representative of a meter reading of 416 for the month of January and a reading of 455 for the month of February, the storage relays which will be thus energized and locked up during passage of the card C through sensing position will be as follows (assuming the switch 85 to be set to the position shown in Fig. 1 for rendering effective the zone I of card C):

In the first set of storage relays to the left, Fig. 6, the second from the bottom relay 87 and the top-most relay 84 will be energized and locked up to represent the digit 4 according to the code of Fig. 2. In the second set from the left, relay 88, and in the third set from the left, relays 89 and 90, will be locked up to represent the digits 1 and 6, respectively, for the tens and units orders, just as the energized relays 84 and 87 in the first set represent the digit 4 in the hundreds order of the previous reading (January). The reading for the month of February is 455. Hence in the third set of storage relays from the right, Fig. 6, the relays 91 and 92, and in the second set the relay 93, and in the first set from the right relay 94, will be locked up to represent the last reading, 455 (February).

It will thus be seen that the digits sensed by the previous reading brushes 9, 10 and 11, Fig. 1, are entered in the storage relays in the first, second and third sets from the left, respectively, in Fig. 6, and that the digits sensed by the last reading brushes 12, 13 and 14 are entered in the third, second and first sets of storage relays from the right, respectively.

If the last reading had been that for the month of May, the previous reading brushes 9, 10 and 11 would be located in the April field in zone I between the lines 6 and 7, while the last reading brushes 12, 13 and 14 would be in the May field in zone I between the lines 7 and 8. For the succeeding billing period the previous reading would be that for the month of May and the last reading would be that for the month of June. In this event the brushes B are returned to the position shown in Fig. 1 and the switch 85 is set to contact the stud 67B so that the brushes 9, 10 and 11 now become effective to sense only the digits represented in the field in zone II left of the line 4 for the previous reading (May) while the brushes 12, 13 and 14 sense only the digital values in zone II in the field lying between the lines 4 and 5 for the last reading (June).

It will be seen from the above that where the

card is divided into a plurality of zones in which fields are located correspondingly to the various meter readings, the arrangement of brushes as B on a common collar 36 can be conveniently utilized if the meter readings for certain months are duplicated, as is the reading for May, so that in one instance the reading for May lies to the right of the previous month's reading and in the other instance to the left of the last month's reading. In this way the brushes 9, 10, 11 will always sense the previous reading, and the brushes 12, 13 and 14 will constantly sense the last reading and hence, referring to Fig. 6, the first three sets of storage relays to the left will always store the previous reading and the first three sets of relays to the right will always store the last reading without any change in electrical connections between the brushes B and the storage relays being necessitated from month to month.

20 SHIFT RELAYS AND CODED CONTACT RELAYS—FIG. 7

It will be noted in Fig. 6 that each of the storage relays as 84 is provided with a contact as 84D, which contact is adapted to close circuit to a conductor as 95 when the relay as 84 is energized. There is a set of four conductors 95, 96, 97 and 98 leading from the contacts as 84D of the relays as 84 in the first set of storage relays to the left in Fig. 1. Inasmuch as there are altogether six sets of such storage relays employed, there are twenty-four conductors as 95 leading from the contacts as 84D of these various relays. These conductors appear also in Fig. 7 where they lead to contacts of shift relays as 99 and 100. For example, the conductor 95 leads to a contact 99D, conductor 96 leads to a contact 99C, conductor 97 leads to a contact 99B and conductor 98 leads to a contact 99A of shift relay 99. Those conductors which correspond to the storage relay group for the previous meter reading lead to contacts of the shift relay 99 while conductors pertaining to the storage relay group for the last meter reading lead to contacts of the shift relay 100. Like contacts, as 99A and 100A, of the shift relays 99 and 100 are multiplied to the same conductors in the cable 101.

Referring again to the storage relays in Fig. 6, the lowermost three relays in each set are provided with contacts as 87E of the relay 87. The contacts as 87E in each set of storage relays are multiplied to a common conductor as 101. Hence, if any of the lowermost three relays in a particular set is energized, ground is extended from a closed contact as 87E to a conductor as 101. In this connection it should be stated that closure of a contact as 84D of the uppermost relay 84 in a set of storage relays is not effective to extend ground to a conductor as 95 unless some one of the other relays in that set has closed its contact as 87D for, as can be seen by reference to Fig. 6, the contacts 87D and 87E are grounded when closed and the contact 84D must obtain its ground through the conductor 101 leading from contacts as 87E. According to the code shown in Fig. 2, if a zero is to be set up, none of the three lowermost relays in the corresponding set of storage relays will be energized. Hence under these conditions ground will not be extended to the common conductor 101 since this conductor can only be grounded through a contact as 87E of some one of the lower three relays in the particular set of storage relays.

The conductor 101 leads to one winding of a triple-winding relay 102, Fig. 7. A similar conductor 103 leads from contacts as 88E of the

lowermost three storage relays in the second set from the left, Fig. 6. A conductor as 104 leads from contacts as 88E of the storage relays as 89 in the third set of storage relays from the left. Each of the conductors 101, 103 and 104 connects to a separate winding of the relay 102, Fig. 7. Hence if a previous meter reading is 000, none of the conductors 101, 103 or 104 will be grounded and therefore the relay 102 will remain deenergized but if there is a significant digit in any of the digital orders of the previous meter reading, at least one of the conductors 101, 103 and 104 will be grounded and the relay 102 will thereupon be energized.

A set of conductors 105, 106 and 107 leads from contacts as 92E, 93E and 94E in the three sets of storage relays in the last reading group and the conductors 105, 106 and 107 are respectively connected to the windings of a triple-winding relay 108, Fig. 7. Hence if the last meter reading is 000, the relay 108 will fail to energize since none of the conductors 105, 106 or 107 will be grounded by the storage relays but again the appearance of a significant digit in any digital order of this meter reading will result in grounding of at least one conductor and the energization of relay 108.

The contacts of shift relays 99 and 100 are normally open, but when closed these contacts connect conductors as 95, 96, 97 and 98 with conductors in a cable 109, this cable leading to permutation devices for effecting entries into the last reading, previous reading and consumption quantity registers, as will be explained under the heading, "Operation."

The brushes as 81A and 81B on the transfer drum D connected by conductors as 112 and 113 to windings as 110A and 111A of relays as 110 and 111, Fig. 7. The other ends of the windings of these relays are connected to battery so that whenever ground is extended through a card perforation as 15B, Fig. 1, brush 44, conductor 56, cam contact 55, relay contact 58H and a conductor 114, Figs. 1 and 6, to the brush 82 at the instant when the conductive strip 79 on the drum D is under the brush 81A, the circuit established through conductor 112 to the winding 110A of relay 110 will cause this relay to energize and actuate its contacts. Similarly, a perforation in the position indicated by 15C in the card C will result in relay 111 becoming energized. Contacts at 110C of relay as 110, when closed, complete a circuit from battery through windings as 110B of these relays to a common conductor 115, Figs. 7, 6 and 1, thence to ground at the relay contact 58G, when relay 58 is energized. Thus, in the present example, the presence of perforations 15B and 15C in the card C will cause relays 110 and 111 to lock up through their contacts as 110C and thereby establish a selected circuit as follows:

From switch 62, Fig. 1, ground is extended through conductor 116, Figs. 1, 6 and 7, through contact 110D of relay 110, contact 111D of relay 111, normally closed contact 117D of relay 117, normally closed contact 118D of relay 118, and conductor 119 to a counter magnet 120 which, in effect, actuates a counter for indicating the number of cards bearing perforations in positions as 15B and 15C, Fig. 1. The contacts of the relays 110, 111, 117 and 118, Fig. 7, are interconnected according to a definite pattern so that ten possible selections can be effected according to a four-unit code, and ten counters as 120 are provided to count the number of individual selections effected. It will be understood that the magnets as 120 are made sufficiently slow-to-energize to enable the code contacts of the relays as 110 to

be positioned in accordance with the pattern of the card perforations to which said relays are responsive, prior to the time any of the aforesaid magnets can attain an effective state of energization, thereby preventing the possibility of false indications due to premature energization of a counter magnet before the relay contacts have been set. This procedure is referred to herein as counting types of meters but, of course, is capable of wide application in other fields of use as will be understood by one skilled in the art.

Another set of relays 121, 122, 123 and 124, having contacts interconnected in a manner similar to that in the case of relays 110, 111, 117 and 118, is provided and the latter relays are responsive to perforations as 15D in the zone I of the card C aligned with the brush 44, Fig. 1. In the present example a perforation as 15D will be effective when the transfer drum brush as 83A, Fig. 6, is contacting the strip 79 to cause ground to be extended through a conductor 125 to the winding 121A of the relay 121. This relay thereupon energizes, closing its contact 121C, and thereupon locks up through its winding 121B, contact 121C and common conductor 115 which is grounded at this time by closed contact 58G of the relay 58, Fig. 1. This completes a path from conductor 126 through closed contact 121D of relay 121, contact 122D of relay 122, contact 123C of relay 123 and contact 124D of relay 124 to a conductor 127 which, in a manner to be explained, in the present instance effects the selection of a totalizer for accumulating the money charge.

SEQUENCE RELAYS—FIG. 8

The relays shown in Fig. 8 include paired sequence relays as 128 and 129 which are arranged to be energizable and deenergizable in a chain for controlling the performance of machine functions. Energization of the relays in the chain is initiated by applying ground to a conductor 61 leading to the winding 128A of the double-winding relay 128. Application of ground to the conductor 61 is, in the present instance, effected by energization of the relay 58, Fig. 1, and closure of the contact 58E thereof while the cam 47 is in an off-zero position. Inasmuch as both windings of relay 128 are connected to battery, the grounding of conductor 61 results in energization of the winding 128A of relay 128 and closure of the contact 128B thereof. This extends ground to the winding 129B of the relay 129 initiating energization of the latter relay. Closure of contact 128C of sequence relay 128 connects one side of the winding 128D thereof to a conductor 145 which leads to a normally closed contact 144A of the sequence control relay 144, thereby establishing a holding circuit for the sequence relay 128 so long as contact 144A is closed.

Sequence relay 129 will be held energized at such time from contact 128B of relay 128, but when sequence control relay 144 becomes energized, as will occur subsequently, ground will be provided for the winding 129A of relay 129 through contact 129C, a conductor 146 and contact 144B of relay 144. In this connection it should be noted that contacts 144A and 144B are what are known as make-before-break contacts, which is to say, contact 144A will open after contact 144B closes when relay 144 is energized and contact 144A will close before contact 144B opens when relay 144 is deenergized. Thus, when relay 144 is first energized in a manner to be described, the winding 129A of the upper sequence relay 129 will be energized prior to deenergization of winding 128D of sequence relay 128 so that while

the holding circuit through winding 128D of relay 128 will be broken, the holding circuit for the relay 129 will remain intact so that opening of contact 128B has no effect upon the relay 129.

Closure of contact 129D of relay 129 causes relay 130 to be energized in a manner similar to that in which relay 128 was energized, that is, ground will be extended through a conductor 147 from contact 129D to one winding of the relay 130. Relay 130, energizing, causes energization of relay 131 in a manner similar to that in which the relay 129 was energized.

The sequence relay pair 128 and 129 is for controlling the entry of the last meter reading into the last reading printer and consumption quantity accumulator, as will be explained hereinafter. Sequence relay pair 130 and 131 controls the entry of the previous reading into the previous reading printer and consumption quantity accumulator. The sequence relay pair 132 and 133 is adapted to be inserted into the chain of energized sequence relays whenever a need arises for effecting a carry-over from units to tens orders in the consumption quantity accumulator and sequence relay pair 134 and 135 performs a similar function if an entry is to be made from tens to hundreds orders in the consumption quantity accumulator as a result of the subtraction of the previous meter reading from the last meter reading, an example of the manner in which this is accomplished being presented hereinafter.

Relays 136 and 137 together control the computation of the money charge for the particular customer and the entry of such amount into the money charge printer and into the selected classified totalizer. Sequence relay pairs 138 and 139, 140 and 141 control entries of carry-overs into the classified totalizer if the occasion should arise for effecting such carries.

Relay pair 142 and 143 controls zeroizing of all printing wheels and as a final step, the initiation of the succeeding card feeding operation.

Relay 148 is an auxiliary relay operating in conjunction with sequence relays 128 and 129 during the last reading entry-effecting operation. Relay 150 is an auxiliary relay supplementing the action of sequence relays 130 and 131 during the previous reading entry-effecting operation. Relays 428A and 429A operate under control of relay 150.

Relay 448 is not in the regular chain of sequence relays and is an auxiliary relay which operates in conjunction with sequence relays 138, 139, 140 and 141 during entry of carries into the totalizer.

When a particular machine function controlled by a pair of sequence relays is to be initiated, the lower relay in that pair such as the relay 128 of the pair 128—129 is deenergized and during the course of the operation that follows, the upper relay as the relay 129 will be deenergized, and when the next function is to ensue, the lowermost relay in the next energized pair to the right in Fig. 8, such as the relay 130, will drop off. Deenergization of the sequence relays in the order indicated is effected by alternate energization and deenergization of the control relay 144. Thus each time the relay 144 is energized, it removes ground from the conductor 145, and the lowermost relay in the first energized pair, from the left in Fig. 8, as the relay 128, will be released due to breaking of its holding or stick circuit. Each time the relay 144 is deenergized ground will be removed from the conductor 146, 75

and the mate of the previously deenergized sequence relay, as the relay 129, will deenergize due to breaking of its stick circuit. After the relays 128, 129, 130 and 131 have been deenergized in the order named, the lowermost relay in the next energized pair will be released. For example, if the next energized pair is 134 and 135, the relay 134 will be deenergized next, then the relay 135, followed by the relays 136 and 137. If none of the relays 138, 139, 140 and 141 have been energized, the relay 142 will be the next to deenergize, followed by the relay 143. It will thus be noted that each time the lower relay of a pair is to be released the control relay 144 will be energized to effect such release and each time the upper relay of a pair is to be released the relay 144 is deenergized.

Examples of the operation of sequence relays shown in Fig. 8 are set forth hereinafter.

20 LAST READING, PREVIOUS READING AND CONSUMPTION QUANTITY PRINTERS AND ASSOCIATED PARTS—FIG. 9

The printing wheels for printing the last meter reading are designated by the reference characters 151, 152 and 153, those for printing the previous reading are designated 154, 155 and 156, and those for consumption quantity 157, 158 and 159.

30 The bill or other sheet to be printed upon is designated S and an edgewise view thereof is included in Fig. 9. The sheet S is fed downwardly between the type wheels and the printing hammers as H, Figs. 9 and 15, a suitable ribbon R being disposed between the type wheels and the sheet S.

As shown in Fig. 9, the type wheel 151 is connected by a sleeve to a gear 160 rotatably mounted on a stationary shaft 161. Gear 160 meshes with a gear 162 rotatably mounted on a shaft 163, which latter gear meshes with a gear 164 rotatably mounted on a shaft 165. Gear 164 meshes with a gear 166 that is fast to a clutch element 167 rotatable on a shaft 168. A driving clutch element 169 is splined to the shaft 168 and is movable into engagement with the element 167 by a clutch shift rod 170 which is schematically represented as being under the control of a clutch magnet 171 so that when said magnet is energized, the separable parts of the clutch 169 will be urged into engagement.

Type wheel 152 is connected by a similar train of gearing to a gear 174 attached to a clutch element rotatable on the shaft 165. The driving clutch element 176 is under control of a clutch magnet 172 which functions similarly to the magnet 171. Type wheel 153 is geared to a clutch element 177 rotatable on the shaft 163 and the driving element 178 of this clutch is controlled by a magnet 173.

60 The clutching elements for the type wheels 154, 155, 156 which constitute the previous reading printer respectively cooperate with clutch members 179, 180 and 181 on the shafts 168, 165 and 163, these clutches being under the control of magnets 182, 183 and 184, respectively.

The consumption quantity printer comprising type wheels 157, 158 and 159 is controlled by clutch magnets 185, 186, and 187 in the same manner as the last reading wheels 151, 152, 153 are controlled by the magnets 171, 172 and 173, respectively.

The center wheel of each printer assembly, as the wheel 152, is rotatably mounted on the stationary shaft 161 while the outer wheels as 151,

153 are connected by sleeves to gears as 160 which are rotatable on the shaft 161, the purpose of this being to bring the type wheels closely together to effect printing of items such as numerical quantities. The type wheels 151, 154 and 157 are driven from shaft 160. The type wheels 152, 155, 158 are driven from shaft 165 and the type wheels 153, 156 and 159 are driven from the shaft 163. Shaft 163 is employed for entering digits in the units order into any of the printers 151-152-153, 154-155-156, and 157-158-159. Shaft 165 is similarly employed in effecting entries of digits in the tens orders of these printers, and shaft 160 effects entries of digits in the hundreds orders.

Extending transversely of the shaft 163 is a shaft 188-U and on this latter shaft there is mounted a sleeve 189a carrying at either end thereof bevel gears 190 and 191, which are rotatably but non-slidably mounted on sleeve 189a and slidably but non-rotatably mounted on the shaft 188-U. These gears are adapted to mesh with bevel gears as 192 on the end of the shaft 163. However, the length of the sleeve 189a is such that only one of the gears 190 or 191 can mesh with the gear 192. An arm 193 is pivotally connected at one end to the sleeve 189a and at its other end to a stationary pivot 194. A spring 195 tends to urge the arm 193 in such a direction that it carries the bevel gear 190 into engagement with the bevel gear 192 so that rotation of the shaft 188-U in a predetermined direction will rotate the shaft 163 in a corresponding direction. However, when the arm 193 is moved against the action of spring 195 by energization of a magnet 196-U, the bevel gear 191 is carried into engagement with the bevel gear 192 so that rotation of the shaft 188-U in the same direction will drive the shaft 163 in the opposite direction.

The shaft 188-U forms part of a permutation selector member generally designated 189-U, which is of the type shown in United States Letters Patent 1,821,110, to Morton et al. The construction of this selector member will be described more fully in connection with Figs. 19 and 19A but for the present, the selector member 189-U functions to cause rotation of the shaft 163 in an amount proportional to the value of the digit to be entered in the units order of a printer. When the last reading is to be entered into the printer 151-152-153, the sleeve 189a is in the position shown in Fig. 9 so that the shaft 163 is driven in its forward direction by the shaft 188-U in an amount equal to the units digit to be entered in the wheel 153. However, when the previous reading is to be entered into the previous reading register 154-155-156, the magnet 196-U is energized so that the shaft 163 is driven in its reverse direction to enter the units digit in the wheel 156. This reversal of direction of the shaft 163 is provided in order that the units wheel 159 of the consumption quantity printer can be driven first forwardly in accordance with the last reading and then backwardly in accordance with the previous reading so as to display the difference between the two, this being described more fully hereinafter.

A similar arrangement is employed with respect to the shaft 165 for the tens order entries. Thus, a shaft 188-T, which is a part of a permutation selector member 189-T, cooperates with the shaft 165 in much the same manner as shaft 188-U cooperates with the shaft 163. There is a difference, however, in that the bevel gear 197 which corresponds to the gear 191 on the shaft 188-U, 75

is normally in mesh with the bevel gear 198 on the shaft 165 so that the shaft 165 is normally driven in a direction the reverse of that of the shaft 163. This compensates for the difference in number of gears interposed between the type wheel 152 and the driving gear 174 therefor in comparison with the type wheel 153 and its driving gear on the shaft 163. Hence by this arrangement type wheels in the same printer are driven in the same direction at all times. The energization of the magnet 196-T causes the bevel gear 197 to move out of mesh with the gear 198 and another bevel gear 199 corresponding to the gear 190 to move into engagement with the gear 198. Magnets as 196-U and 196-T are deenergized when a last reading is to be entered and are energized when a previous reading is to be entered.

An arrangement similar to that for the units order is provided for the hundreds order selector 189-H, which is to say, a shaft 188-H is employed in a manner similar to that of the shaft 188-U and a magnet 196-H is utilized to effect reversals of rotation of the shaft 168 for last and previous reading entries as in the case of the magnet 196-U. The shaft 168 rotates in the same direction as the shaft 163 since the gearing interconnections between the type wheel 151 and its driving gear are equivalent with respect to directions of rotation to those for the type wheel 153.

Shafts as 188-U are connected by friction clutches as 200 to driving means as 201 which may comprise individual motors or gear boxes, belt connections, or the like. Each shaft as 188-U is provided with a stop arm as 202-U which is selectively positioned, by means to be described presently, in accordance with the value of the digital entry to be effected by movement of the shaft as 188-U. When the stop arm as 202-U is arrested, the clutch as 200 slips while the shaft 188-U is being maintained stationary by stoppage of the arm 202-U. The stop arm as 202-U is normally maintained in zero position, but when a numerical entry is to be effected, the arm is released and allowed to rotate to the selected position and is then arrested, and the arc through which the arm travels determines the extent of rotation of the shafts 188-U and 163. The stop arms 202-T and 202-H function in a similar manner.

Each selector as 189-U is provided with four code discs as D-1, D-2, D-3 and D-4. Magnets for the units order, U-1, U-2, U-3 and U-4 are provided to actuate the respective code discs. A similar set of magnets T-1, T-2, T-3 and T-4 is provided for manipulating the respective code discs of the selector 189-T in the tens order. A set of magnets H-1, H-2, H-3 and H-4 is provided for purposes of manipulating the respective code discs in the selector 189-H in the hundreds order. The magnets for operating the code discs are respectively connected to individual conductors leading out of the cable 109, Figs. 9 and 7, these conductors being connected at their other ends to contacts of the shift relays 99 and 100, Fig. 7, as explained under the heading, "Shift relays and coded contact relays." The conductors in cable 109 therefore serve to interconnect the code magnets with contacts as 84D or 91D of the various storage relays, Fig. 6, when a shift relay 99 or 100 is energized.

The code disc selectors operate to translate code representations of digital values, stored in the storage relays of Fig. 6, into numerical values according to straight digital count, as will be ex-

plained in greater detail in connection with Figs. 19 and 19A.

Relays 203 and 204, shown in the lower part of Fig. 9, are adapted, when energized, to effect energization of certain of the code disc magnets in a manner to effect complete rotations of shafts as 103 during the money charge entering and zero-setting operation as will be explained. Relay 205 is a zero-setting control relay.

PERMUTATION SELECTORS, SEQUENCE CONTROL CIRCUITS, AND PRINTING WHEEL ASSEMBLIES—FIGS. 9, 19, 19A, 20 AND 21

A fragmentary end elevation of a permutation selector such as the selector 100-U, Fig. 9, is presented in Fig. 19, and a plan view of the complete selector is shown in Fig. 19A. The shaft 100-U is journaled near one end in a suitable bearing member 206' carried by the frame of the machine. The code discs as D-1 are mounted so as to be rockable on the shaft as 100-U, but are held against axial movement by slotted circular plates 206 and end plates 207. The code discs as D-1 are provided with notches in their peripheries, such notches being spaced irregularly in such a fashion that by rocking the code discs in various combinations, the alignment of notches in the several discs can be varied in accordance with the code employed. Axially extending pins or thin rods 208 are supported at one end in a supporting member 209' and are disposed about the periphery of the selector. These pins are urged radially inwardly by suitable means such as garter springs 207' and are guided in the slots in plates 206 and 207. Rollers 210' carried by the pins 208 bear on the notched peripheries of the several code discs, as shown in Fig. 19, and if all of the rollers 210' of a particular pin 208 are aligned with notches in the discs D-1 to D-4, inclusive, the constant tension exerted upon the pin 208 by the springs 207', Fig. 19A, causes this pin (that is, the rollers 210' thereof) to seat in the aligned notches. For any particular setting of the code discs, only one of the pins 208 will be permitted to seat in the notches in the discs, the other pins being restrained against seating in the notches due to lack of alignment of such notches.

T-shaped levers as 209 are provided for rocking the code discs, these levers being pivoted as at 210 and having arms as 211 extending into suitable slots in the discs as D-1. Another arm 212 of the lever 209 serves as an armature of the corresponding code selector magnet as U-1. A third arm 213 is fastened to a spring 214 anchored to the frame of the machine.

When all the magnets as U-1 are deenergized, a home stop pin 208' is in position to engage the stop arm as 202-U. However, if any of the T-levers 209 are actuated by their magnets against the action of their retaining springs 214, the pin 208' is cammed out of the slots in the code discs and the arm 202-U and shaft 100-U are thereupon free to rotate, said shaft being driven by means of a friction clutch 200, Figs. 9 and 19A, until said arm engages one of the pins 208 which has been allowed to seat in the code disc notches. The means 201, Fig. 9, for driving the shaft 100-U includes a constantly driven shaft as 212', Fig. 19A, on which a worm 211' is mounted to mesh with a worm gear 213' that is loosely mounted on the shaft 100-U. The faces of the worm gear 213' are gripped by annular friction elements 200', one of which is fixed on the shaft 100-U and the other of which is slidable on said

shaft under the influence of a spring 201' disposed between it and a fixed collar 202'. The friction elements 200', spring 201' and collar 202' constitute the aforesaid clutch 200 which frictionally interconnects the driving means with the shaft 100-U. When the stop arm 202-U is engaging a selected pin 208, the worm gear 213' slips over the faces of the clutch elements 200', but when such pin is retracted, the shaft 100-U is driven by the gear 213' until the arm 202-U again encounters a pin 208 in active position.

When the stop arm is to be restored to home position, the code magnets as U-1 are deenergized and the armatures 212 thereof are released to the action of springs 214. This enables the springs to restore the code discs, thereby camming said pin 208 radially outwardly from engagement with arm 202-U, which then completes the balance of its revolution and comes to rest against the home stop pin 208', Fig. 19, that will then be in position to engage it. It will be seen from the foregoing that the permutation selectors as 100-U are of substantially the same construction and operate on the same principle as the code disc selector disclosed in the aforesaid Morton et al. patent, No. 1,821,110, except that the code discs are adjusted by individual electromagnets instead of by a common electro-mechanical device. Inasmuch as the selectors are utilized only for setting up numerical quantities, only four code discs are employed, and the code discs are so arranged that the stop arm as 202-U may be arrested at any selected one of ten points equally spaced throughout a complete revolution of the stop arm, depending upon the manner in which the electromagnets as U-1 to U-4 are energized. Such selectors are commonly provided with a sufficient number of pins 208 to enable alphabetical printing to be performed in addition to the printing of numbers, and where, as in the present instance, only numerical printing is to be performed, the excess pins 208 may be omitted if desired.

As shown in Fig. 9, all of the code magnets are connected on one side to a common conductor 215 leading to the winding of a relay 216, the other side of this winding being supplied with battery. Therefore, the application of ground to the winding of any code magnet as U-1 through a conductor in cable 100 will complete circuit from ground through the winding of such code magnet and the relay 216 to battery. Relay 216 will thus be energized concurrently with energization of any of the code magnets.

Relay 216, in closing, applies ground on contact 216A and conductor 217, which conductor is multipled to contacts 218-U, 218-T and 218-H. The latter contacts are respectively mounted to be operated by toothed wheels 219-U, 219-T and 219-H, Figs. 9 and 21, fast on the shafts 100-U, 100-T and 100-H of the code selectors. So long as wheels as 219-U are stationary, contacts as 218-U will remain open, but when these wheels are rotating, contacts as 218-U will alternately close and open. If relay 216 is energized at this time, which is to say, if any of the code magnets are operative to position any of the shafts as 103, Fig. 9, ground will thus be periodically extended to a conductor 220, Figs. 9 and 21, leading to a slow-to-release relay 221. Upon the first closure of a contact as 218-U, while relay 216 is energized, the relay 221 will energize to open its contact 221B and close its contact 221A, thereby extending ground to the winding of another slow-to-release relay 222. Relay 222 thereupon

energizes and closes its contact 222A and opens its contact 222B.

The intervals between successive closures of contacts as 218-U are too short to permit slow relay 221 to fully deenergize while toothed wheels as 218-U are rotating, but upon stoppage of the wheels 218-U, 218-T, and 218-H, the relay 221 eventually releases and opens its contact 221A thereof, thereby initiating deenergization of slow relay 222. Due to the long release time of relay 222, the contact 221B of relay 221 will close while contact 222A of relay 222 is still closed, and ground will thus be momentarily extended through the latter contact to a conductor 223, Figs. 9 and 8, which connects to a conductor 224 leading to one side of the winding of sequence control relay 144, being connected thereto intermediate a resistor 225 and said winding. The other side of the winding of relay 144 is grounded. Battery for relay 144 is obtained through resistor 225, conductor 226 and contact 143A of final sequence relay 143.

The grounding of conductors 223 and 224 in the manner above described short circuits sequence control relay 144 and causes this relay to release, inasmuch as substantially the entire battery voltage will then be absorbed in the resistor 225. This in turn releases a sequence relay as 129 in the upper row of sequence relays.

When slow relay 222, Fig. 9, ultimately deenergizes, it opens contact 222A and relieves the conductors 223 and 224 of ground. This permits sequence control relay 144 to reenergize and release a sequence relay as 130 in the lower row of sequence relays, to thereby initiate performance of the succeeding machine function, as explained more fully hereinafter.

It is to be noted that relay 216, Fig. 9, is energized when the selected code magnets are energized. Ordinarily, after these magnets are deenergized, and conductor 215 relieved of ground, relay 216 deenergizes and opens contact 216A, and ground cannot be extended to the winding of slow relay 221 while the stop arms as 202-U are being restored to their home positions, even though contacts as 218-U are alternately closed and opened as a result of such movements of the associated selector shafts and toothed wheels. However, as will be demonstrated in connection with the description of the money charge entering operation, it is possible to ground the winding of relay 216 from a source other than through the code magnets so that this relay will remain energized throughout an entire revolution of a selector shaft as 188-U during such entry operation.

Fig. 20 shows some of the details of a consumption quantity accumulator number wheel assembly associated with the type wheel 159, Fig. 9, of the consumption quantity printer. It will be understood that similar wheel assemblies are provided in conjunction with type wheels 157 and 158 of this printer, corresponding parts being designated by reference characters bearing the same suffixes, as 158A and 159A, and so on.

The type wheel 159 is connected by a sleeve to the gear 230, which meshes with a gear 227, Figs. 9 and 20, rotatable on the shaft 163. Attached to gear 227 in side by side relation, and likewise rotatable on the shaft 163, are a number of cams 159A, 159B, 159C and 159D, and a star wheel 159E. Cam 159A is known as a zero-setting wheel, and associated therewith is a pair of contacts 159H, which contacts are open only when the wheel 159A (likewise, type wheel 159) is in

zero position, as shown in Fig. 20, and which are closed whenever the wheel 159A is off zero.

Cam 159B comprises a carry-over wheel, and it is provided with a lobe thereon intermediate the positions corresponding to the digits 0 to 9, so that whenever the type wheel 159 is rotated subtractively beyond zero position, wheel 159B will momentarily close a pair of contacts 159G.

Cams 159C and 159D are contact-closing wheels for the purpose of selectively closing multiple contact switches as 228 and 229. It is to be understood that ten such switches as 228 are arranged in numerical significance or order around the periphery of the wheel 159C in equally spaced relation, and a set of ten switches as 229 is similarly arranged about the wheel 159D. The wheels 159C and 159D select for operation certain of said switches in accordance with the numerical entry in printing wheel 159. The functions of the switches as 228 and 229 are explained in connection with the circuits shown in Figs. 10, 11, 12 and 13.

The star wheel 159E is for the purpose of accurately centering the printing wheel 159. It is provided with ten lobes corresponding to the digits 1 to 9 and 0, these lobes being positioned intermediate the positions on the wheel respectively corresponding to said digits. A jockey roller, generally designated 159F, is yieldingly urged against the periphery of wheel 159E, and should the type wheel 159 be moved to a position slightly exceeding or falling short of a selected position thereof, the jockey roller will exert a camming action on a lobe of the star wheel 159E to thereby correct the setting of the entire printing wheel assembly.

As mentioned hereinabove, the wheel assemblies for the type wheels 157 and 158 are similar to those for the wheel 159, these being the three type wheels of the consumption quantity printer. For the type wheels of the last reading printer 151-152-153 and previous reading printer 154-155-156, much simpler arrangements may be employed. For example, in the case of the type wheel 153 there is merely provided a zero-setting wheel 153A and contacts 153H, and a star wheel 153E and jockey roller 153F, this arrangement also being resorted to for the other type wheels 151, 152, 154, 155 and 156.

PRODUCT TABLES—FIGS. 10, 11 AND 12

The product table shown in these figures includes multiple contact switches as 228, Figs. 10 and 20 which are adapted to be selectively rendered operative by contact-closing wheels as 159C of the consumption quantity printing wheel assemblies. It will be understood that such multiple contact switches are actually arranged about the periphery of the wheel 159C in positions to be actuated by the lobe thereon. However, for sake of convenience, all those switches which pertain to the same order of digits have been shown in vertical alignment and arranged in digital significance. Thus, the switch generally designated 231 pertains to the digit 0. The switch 228 pertains to the digit 1 and so on up to the digit 9.

A similar arrangement of multiple contact switches controlled by a contact closing wheel 159C, Figs. 10 and 9, is provided for the tens order digits and another group of multiple contact switches controlled by the wheel 157C, Figs. 10 and 9, is provided for the hundreds order.

The contacts of the various multiple contact switches are interconnected in such a way that the numerical quantity represented by the selected

positions to which the wheels 157C, 158C, 159C are adjusted, may be, in effect, multiplied according to a sliding rate scale product table, this being accomplished by selections of circuits representing a pre-computed amount based on the consumption quantity the wheels are set to represent. The particular arrangement shown is such that if any quantity up to or including the quantity 50 is set up on these wheels, such quantity will be, in effect, multiplied by a factor of 6 in a manner to be explained presently. For quantities greater than 50 and up to or including the quantity 100, the first 50 units will be, in effect, multiplied by the factor 6 and the remainder over and above 50 is, in effect, multiplied by a factor of 5 and the resultant amount will be the sum of the products thus, in effect, ascertained.

The product table shown in Figs. 10, 11 and 12 has a capacity for handling variable factors up to 125. For all quantities over 100 and up to or including 125 set up on the wheels 157C, 158C and 159C, the circuit selections are such that the first 50 units are, in effect, multiplied by 6, the second 50 units by 5 and the remainder over and above 100 are, in effect, multiplied by 4 and the resultant amount is the sum of the three products derived in the aforesaid multiplications.

This scheme provides for what is known as breaking down of consumption and rate step multiplication in a single operation, such practice being highly advantageous in public utility billing. In the course of operation of the machine, the consumption quantity ascertained by subtracting the previous meter reading from the last meter reading is set up on the type wheels 157, 158 and 159, Fig. 9 and also on the contact-closing wheels 157C, 158C, 159C, Fig. 10 and in a manner to be described, ground is extended to conductors 232, 233 and 234, Figs. 10, 11 and 12 at the appropriate time after such consumption quantity has been set up. The selected product is represented by selectively grounding digital conductors leading to the cables 235-H for the hundreds order, 235-T for the tens order, and 235-U for the units order, Fig. 12.

For example, if the consumption quantity is 39 (for which according to the illustrated table the rate is 6), the wheel 157C in the hundreds order will be positioned so that the lobe thereon closes the zero switch generally designated 236, Fig. 10. In the tens order the wheel 158C is positioned to effect closure of a switch 237, Fig. 11, pertaining to the digit 3 in the tens order of 39. In the units order the wheel 159C is positioned to close the switch 238, Fig. 12, that pertains to the digit 9 in the units order of 39. After these wheels have been set up, ground is extended to conductors 232 and 234 for the means which control the particular machine function that is being carried out, as explained in detail hereinafter. Conductor 232 is connected to one contact in each of the pairs 236A and 236B, which are closed when the set-up of the aforesaid wheels is completed, and through these closed contacts ground is further extended to two other conductors 239 and 240. Through the closed contacts 237A and 237B of switch 237 ground is extended from conductors 239 and 240 to two other vertical conductors 241 and 242. These latter conductors are connected to one contact in each of the pairs 238A and 238B of the switch 238 in the units order and inasmuch as these contacts are now closed, ground will be further extended to the second conductor from the left or conductor 235H-2 75

leading into the cable 235-H for the hundreds order of the product. Ground will also be extended to the third conductor from the left or conductor 235T-3 leading into the cable 235-T for the tens order of the product. Grounding of the conductors 235H-2 and 235T-3 signifies that the hundreds and tens order digits of the product are 2 and 3, respectively.

When the conductor 235 was grounded, ground was extended through the closed contact 237C of the switch 237, Fig. 11, to a vertical conductor 243 which conductor, Fig. 12, is connected to one side of the winding of a relay 244, the other side of this relay winding being connected to battery. Relay 244 thereupon energizes to open its contact 244A and close contact 244B. This will enable ground to be extended from a contact 245A of a now deenergized relay 245 through a conductor 246 to the now closed contact 244B, and this ground is extended to a vertical conductor 247. The latter conductor is connected to one contact of a pair 238C in the switch 238 and thus is effective to extend ground to the fourth digital conductor from the left or conductor 235U-4 leading into the cable 235-U for the units order of the product, thereby indicating that the units digit of the product is 4.

It will thus be seen that the product selected for the consumption quantity 39 is 234, which is to say, the money charge for such a consumption quantity is \$2.34. Inasmuch as the quantity 39 is less than 50, the only multiplication which is in effect performed is that of 39 times 6.

Assume now that the consumption quantity has been 79 rather than 39. This would bring such quantity within the second rate step lying between 50 and 100. In this event the wheels 157C, 158C, 159C, Fig. 10, would be set up to close the switch 236 in the hundreds order pertaining to zero, the switch 248, Fig. 12, in the tens order pertaining to 7, and the switch 238 in the units order pertaining to 9. Grounding of conductor 232, in a manner explained hereinafter, would then extend ground through switch 236 and conductors 239 and 240 to the contacts 248A and 248B of the switch 248. Thence ground would be extended to vertical conductors 249 and 250 and from thence through contacts 238D and 238E to the digital conductors 235H-4 leading into the cable 235-H and 235T-4 leading into the cable 235T. This indicates that the hundreds and tens order digits of the amount to be ascertained are both 4. For the units digit ground is extended from conductor 234 to a vertical conductor 251 through the closed contact 248C of the switch 248 and thence to the winding of a relay 252 which relay energizes and closes its contact 252A. Relays 245 and 244 are deenergized at this time so that ground will be extended from contact 245A through conductor 246, contact 244A and conductor 253 to closed contact 252A, thence to a vertical conductor 254 which is connected to one contact of the pair 238F in the switch 238. This is effective to ground a digital conductor 235U-5 leading into the cable 235-U, thereby indicating that the units digit of the amount is 5.

Hence, the amount ascertained from a consumption quantity of 79, by illustrated apparatus, is 445 or \$4.45, this being equal to the sum of 50 times 6 or 300 plus 29 times 5 or 145.

For a consumption quantity extending into the third step, say the quantity 101, circuits will be set up as follows: From conductor 232, Fig. 10, ground is extended through contacts 255A and 255B of the switch 255 in the hundreds order

pertaining to 1 to vertical conductors 256, 257 and 258. Conductors 256 and 257 lead to closed contacts 259A and 259B of the switch 259 in the tens order pertaining to zero so that ground will be extended through these contacts to vertical conductors 260 and 261. From these conductors ground continues through closed contacts 228A and 228B of the switch 228 in the units order pertaining to 1 to the digital conductor 235H-5 in the hundreds order group and 235T-5 in the tens order group.

When the vertical conductor 258 was grounded upon grounding of conductor 232, it caused ground to be applied on the winding of relay 245, Fig. 12. This relay then energized to open its contact 245A and close its contact 245B. Closure of contact 245B extended ground to a conductor 262 which is connected to one of the contacts of the pair 228C, Fig. 10 of the switch 228. Hence ground was extended through this contact to the digital conductor 235U-4 in the units order group.

When conductor 234 was grounded, it caused ground to be extended through the closed contact 259C of the switch 259, Fig. 10 to the vertical conductor 243 which is connected to the winding of relay 244, Fig. 12. Relay 244 thereupon energized to close its contact 244B but this was without effect for contact 244A of the relay 245 was now open so that ground was not available for the contact 244B. However, if the hundreds order digit in a consumption quantity had been 0, the relay 245 would not have energized and in such event, the closure of contact 244B would have been effective to ground a vertical conductor 254 thereby indicating that the consumption quantity lay within the first rate step.

The grounding of the digital conductors 235H-5, 235T-5 and 235U-4 signifies that the amount ascertained based upon a consumption quantity 101 is 554 or \$5.54, which is equal to the sum of 50 times 6 or 300 plus 50 times 5 or 250 and 1 times 4 or 4.

It will be understood that although the product table shown in Figs. 10, 11 and 12 has been adapted to a sliding rate scale of 6¢ per unit for the first 50 units, 5¢ per unit for the next 50 units, and 4¢ per unit for the remainder, this arrangement can be modified to accommodate still other sliding rate scales if desired.

ZERO CONTROLLING CIRCUITS—FIG. 13

For a reason which will appear hereinafter, it is desirable to know in advance in what orders of an amount ascertained from a consumption quantity significant digits and zeros will appear. Thus, an amount as 440 will have a zero in the units order, for an amount as 204, a zero is present in the tens order, while for an amount as 6, zeros are present in the hundreds and tens orders, and so on. The table shown in Fig. 13 is adapted to detect the respective orders in which significant digits and zeros will appear in the final product.

The multiple contact switches as 229, Figs. 13 and 20, are arranged in a manner similar to the switches as 228 of the product table Figs. 10, 11 and 12, that is to say, there will be ten units order switches corresponding to the digits 0 and 1 to 9 controlled by the units contact-closing wheel 159D, Fig. 9. Another set of ten switches is controlled by the tens contact-closing wheel 158D and a third set of switches is controlled by the hundreds wheel 157D. For a consumption quantity of 39, the ascertained amount, as has been

demonstrated hereinbefore, will be 234 and zeros do not appear in any of the three orders of this product. For such a consumption quantity the hundreds order switch 263, Fig. 13, pertaining to zero, is closed by the wheel 157D. The tens order switch 264 pertaining to 3 will be closed by the wheel 158D, and the units order switch 265 pertaining to 9 will be closed by the wheel 159D.

After these switches have been closed, ground is extended at the appropriate time to conductors 266 and 267 in a manner that will be described. From conductor 266, ground is extended through the closed contacts 263A, 263B and 263C of switch 263. Closure of contact 263A is without effect in the present instance. Contacts 263B and 263C now supply ground to vertical conductors 268 and 269, which conductors, through closed contacts 264A and 264B of switch 264 extend ground to the vertical conductors 270 and 271. Grounding of conductor 270 is without effect in the present instance. Grounded conductor 271 extends ground through closed contact 265A of switch 265 to a conductor 272 which leads to the winding of a relay 273. Relay 273 thereupon energizes to open its contacts 273A and 273D and close its contacts 273B and 273C. Inasmuch as conductor 267 is now grounded, the closure of contact 273C is effective to ground a conductor 276-U for indicating that a significant digit is present in the units order of the product.

Closure of contact 273B causes ground to be extended from conductor 267 to a normally closed contact 274D of a relay 274, and to a normally closed contact 275B of a relay 275. Inasmuch as both relays 274 and 275 are deenergized at this time, ground will continue through contacts 274D and 275B to conductors 276-T and 276-H, respectively, for indicating that significant digits are present in the tens and hundreds orders of the product.

Another example of the operation of this network would be where the consumption quantity is 001 for which the ascertained amount or "final product" would be 6. In this event a significant digit is present only in the units order and the tens and hundreds orders contain zeros. Under these circumstances, the switches 263 and 277 in the hundreds and tens orders, respectively, and which pertain to zero in each order and the switch 278 pertaining to 1 in the units are closed.

Grounding of conductor 266, in a manner to be explained, extends ground through contacts 263A, 263B and 263C of switch 263 and thence through contacts 277A, 277B and 277C of switch 277 to the vertical conductors 279, 280 and 271. From these latter conductors ground is extended through closed contacts 278A, 278B and 278C to the vertical conductors 272, 282 and 283, respectively, which lead to the windings of relays 273, 274 and 275. All three relays energize and when ground is applied on conductor 267 circuit is completed through contact 273C of relay 273 to thereby ground the conductor 276-U for indicating that a significant digit is present in the units order of the final product. Closure of contact 273B of relay 273, however, is ineffective in the present instance inasmuch as the relay contacts 274D and 275B are now open so that conductors 276-T and 276-H will not be grounded, and this indicates that zeros are present in the hundreds and tens orders of the final product.

Still another example would be that where the consumption quantity is 005, the final product based thereon being 30, which would mean that

a significant digit is present only in the tens order and that the hundreds and units orders contain zeros. In this event, the "0" switches 263 and 277 in the hundreds and tens orders, respectively, are closed and the "5" switch 284 is closed in the units order. Here, grounding of conductor 266 results in the grounding of the vertical conductors 279, 288 and 271 through switches 263 and 277, as described hereinabove. Grounding of conductor 271 is without effect in the present instance. Grounding of conductors 279 and 288 is effective to extend ground through contacts 284A and 284B of switch 284 to the vertical conductors 282 and 283. This results in the energization of relays 274 and 275.

When conductor 267 is grounded, circuit will not be completed to the conductor 276-U inasmuch as contact 273C is now open. Ground is extended, however, through closed contact 273A to the now closed contacts 274B and 274C of the relay 274. Contact 274C allows ground to be extended to the conductor 276-T. Contact 274B extends ground back to a closed contact 273D of relay 273 but such grounding of the contact 273D is without effect inasmuch as both of the relay contacts 274D and 275B of the relays 274 and 275 are now open, so that the conductors 276-H cannot be grounded.

It will be seen, therefore, that where the consumption quantity is 005, the conductor 276-T will be grounded but conductors 276-U and 276-H will not be grounded. This indicates that the final product, namely 30, has a significant digit only in the tens order. Various other examples could be presented of the operation of the zero controlling circuits of Fig. 13, but it is believed that from the foregoing description the construction and mode of operation of the zero controlling circuits may be ascertained.

MONEY CHARGE PRINTER, CLASSIFIED TOTALIZER, AND ENTRY-EFFECTING MEANS FOR SAME—FIGS. 14, 17 AND 18

As shown in Fig. 14, two sets of money charge printing wheels are provided, one set comprising the type wheels 285, 286 and 287 and the other set comprising the type wheels 288, 289 and 290. Both sets of type wheels are positioned alike and the purpose of this duplication of printing elements for the money charge is to enable said charge to be printed both on the body of the sheet S and on a stub thereof, this being common practice in billing. Each set of type wheels is provided with individual hammers H for making impressions from the type wheels onto the sheet S.

The shaft 163, Figs. 9, 14 and 17, carries a plurality of money charge entry-effecting wheel units, Fig. 17, generally designated 291 for the hundreds order, 292 for the tens order and 293 for the units order. Each such entry-effecting unit is mounted on a sleeve which is rotatable on the shaft 163 and clutches as 291M, 292M and 293M are provided to effect connection of the corresponding units with the shaft 163. Clutch magnets 294, 295 and 296 are provided to control the clutches just mentioned. Each unit as 291 is provided with a zero-setting wheel as 291A which is similar to the zero-setting wheel 159A shown in Fig. 20 and which has contacts 291H similar to the contacts 159H.

Each wheel unit as 291 is likewise provided with a contact closing wheel 291C which is similar to the contact closing wheel 159C in Fig. 20. These contact closing wheels are shown in

elevation in Fig. 18. Arranged about the periphery of each wheel is a series of nine contacts disposed to represent respectively the digits 1 to 9. Each such contact, for example, the contact 291C-2 is connected on one side to a common conductor as 297, which conductor is, in turn, connected by a conductor as 298 to one winding of a double winding relay as 299. Both windings of the relay as 299 are connected on one side to battery by a conductor 300.

Contacts as 291C-2 are adapted to selectively close circuit to conductors as 235H-2 leading from the cable 235-H comprising the units order final product conductors, this cable also appearing in Fig. 12. When an entry is to be effected into a money charge wheel unit as 291, the shaft 163 is caused to rotate through one complete revolution, as will be described fully hereinafter, and the clutch magnet as 294 will be energized at the start of such rotation of the shaft 163 so that the clutch 291M will be initially engaged. The manner in which a clutch magnet as 294, Fig. 17, is energized at the start of a money charge entering operation is as follows:

It will be noted that the conductors 276-U, 276-T and 276-H are continuations of the conductors bearing the same reference characters in the zero controlling circuits, Fig. 13. Assuming that a significant digit is present in the hundreds order of the product, the conductor 276-H will be grounded. This is effective to cause energization of a relay 301, Fig. 1. Relay 301 thereupon closes its contacts 301A and 301B. So long as relay 299 remains deenergized, ground will be supplied to the contacts 301A and 301B of the relay 301 from a conductor 302. Contact 301B is therefore effective to extend ground through conductor 305 to the clutch magnet 294 for engaging the clutch 291M.

Wheel assembly 291 takes motion with shaft 163 and wheel 291C moves from its zero position toward its 1 position, thence to its 2 position, and so on, this rotation being continuous and in so doing it successively closes and opens the digit-representing contacts 291C-1, 291C-2, and so on. When the lobe as 291X on the contact-closing wheel as 291C reaches a "live" contact as 291C-2, which is to say, a contact for which a cooperating final product conductor as 235H-2 is grounded, ground will be extended from said product conductor through the contact as 291C-2 and common conductors 297 and 298 to the left-hand winding of relay 299. The resulting energization of relay 299 opens contact 299B and closes contact 299A thereof. Opening of contact 299B relieves the contact 301B of ground and thereby ground is removed from conductor 305 leading to the clutch 294.

The digital contacts as 291C-2 are preferably so located in relation to the wheel as 291C that the lobe as 291X operates these contacts in advance of the times at which the wheel units as 291 reach the corresponding digital positions. This is to allow time for relays as 299 to act in the manner described. Preferably, this time allowance is made as large as possible, and if the wheel unit as 291 should fail to exactly reach the selected position after ground is removed from contacts as 301B of relay 301, other means function to correct the setting.

To this end, a full step or star wheel 291E is provided on the wheel unit 291 and this wheel is similar to the wheel 159E shown in Fig. 20. Instead of being provided with a jockey roller as 159F, however, the star wheel 291E has a pair

of contacts 291J similar in construction to the contacts 159G, Fig. 20. One of the contact springs 291J is grounded through a conductor 464, Figs. 17 and 9, and the normally closed contact 205R of the zero-setting control relay 205, which relay is deenergized during all entry-effecting operation, while the other is connected by a conductor 387 to the clutch magnet 294 so that the conductors 385 and 387 are thus connected in parallel to this magnet. Hence, although ground is removed from the conductor 385 by opening of relay contact 205B, if it should chance that the wheel assembly falls short of the selected position, ground will continue to be supplied to the clutch magnet 294 through contacts 291J until the wheel unit 291 is more accurately centered at the selected position, whereupon the lobes on the star wheel 291E permit the contacts 291G to open to thereby remove ground from the winding of magnet 294 and permit the clutch 291A to release. Wheel unit 291 thereupon ceases rotating.

Full step wheels 292E and 293E and cooperating contacts 292J and 293J are provided on the wheel units 292 and 293, and said contacts are, like contacts 291J, connected to ground at relay contact 205R, Fig. 9, via conductor 464. These wheels and contacts serve the same purpose for their respective wheel units as the contacts 291J do for the wheel unit 291.

When the relay 299 energized, it closed its contact 299A and through its right-hand winding established a stick circuit which will be more fully described hereinafter. Hence although relay 301 may continue to be held energized from the grounded conductor 276-H, the contact 301B thereof is no longer effective to ground the clutch magnet as 294 once the lobe as 291X and 291C has reached a "live" contact as 291C-2. Relays 308 and 309, which are similar to the relay 299, are provided for the tens and units orders, respectively, and these relays perform the same function as the relay 299, except that these relays are under control of the contact closing wheels 292C and 293C, respectively, and coast with the relays 310 and 311. Relays 310 and 311 in the tens and units orders, respectively, function in a manner similar to relay 301, except that they control the clutch magnets 295 and 296, respectively.

When the wheel units 291, 292, 293 are being selectively positioned under control of their contact closing wheels and the final product-representing conductors in the cables 235-H, 235-G, 235-T, they act through sleeved shafts as 314, 313 and 312, respectively, intermediate gears as 315, 316 and 317, Fig. 14, and other sleeved shafts 318, 319 and 320 to position the money charge printing wheels 288 for the hundreds order, 289 for the tens order, and 290 for the units order, respectively.

Similarly, the wheel units 291, 292 and 293 act through the sleeved shafts 214, 213 and 212, respectively, gears as 321, other sleeved shafts 324, 323 and 322, and intermediate gears as 325, 326, 327 and 328 to position the type wheels 285 for the hundreds order, 286 for the tens order, and 287 for the units order, respectively. Thus, the settings of the wheel units 291, 292, 293, Fig. 17, are transferred, through intermediate shaft and gears, as just described, to the money charge printing wheels 285, 286, 287 and 288, 289, 290. Gears as 316 and 327 are rotatably mounted on the shaft 163 so as not to be effected by rotation of said shaft.

Associated with wheel units 291, 292, 293 are

sets of totalizer wheel units such as those generally designated 329, 330 and 331, respectively, that are mounted on a shaft 336. Each totalizer wheel unit includes a number wheel as the wheel 329A. A full step wheel as 329E and contacts as 329J are provided on totalizer wheel units as 329 and these wheels and contacts are similar to and serve the same purpose as the full-step or star wheels and contacts as 291J on the wheel units as 291, except the full-step contacts as 329J are connected to ground on one side thereof through a conductor 447, Figs. 17 and 8, and the normally closed contact 448A of relay 448.

Each wheel unit as 291 is provided with a gear as 339 which meshes with an idler gear 340 that, in turn, meshes with an idler gear 341 which drives a gear 342 on the shaft 336. A sleeve 343 mounted on the shaft 336 is connected to the gear 342. Splined to the sleeve 343 is a driving member of a clutch 329M for the wheel assembly 329. A magnet 344 controls the operation of the clutch 329M and when this magnet is energized, the totalizer wheel unit 329 takes motion additively with the wheel unit 291.

Clutch magnets 345 and 346 are provided for the tens and units orders, respectively of the totalizer, and function in a manner similar to that of the clutch magnet 344 for the hundreds order. Thus, the magnet 345, when energized, enables the totalizer wheel units 330 to take motion with the wheel unit 292, and the magnet 346, when energized, enables the totalizer wheel unit 331 to take motion with the wheel unit 293.

It will be understood that the totalizer 329—330—331 is but one of a plurality of such totalizers that may be provided, in which case it will be desirable that all such totalizers be driven from the common entry-effecting means 291—292—293. This entails selecting the totalizer to be driven by such entry-effecting means in accordance with the customer's classification. Such selection is accomplished through the medium of a relay as 304 or 306, Fig. 18.

For example, winding of relay 304 is connected by a conductor 127 to a code contact as 124D in Fig. 7. It will be remembered that the relays as 121, 122, 123 and 124 in Fig. 7 effect selection of a classified totalizer into which the customer's charge is to be entered. Assuming that the totalizer corresponding to the relay 304 has been selected, the relay 304 will be energized by grounding of the conductor 127 and ground will be extended from conductor 303, which was grounded from contact 301A of relay 301 when the latter was energized, through contact 304C thereof and a conductor 443 to the clutch magnet 344. Thus the clutch 329M will be engaged and, as is explained subsequently, this engagement will take effect at or before the initiation of rotation of shaft 163 during a money charge entering operation. Similarly if a different selection of a classified totalizer had been effected, the relay 304 would not have been energized from the code contacts as 124D in Fig. 7 but another similar relay such as 306 would have been energized and ground would have been extended from the conductor 303 through a contact as 306C to a clutch magnet corresponding to the clutch magnet 344 associated with the selected totalizer.

When the shaft 163 is set into rotation, it is effective through a gear 332 fast thereon, idler gears 333 and 334 and a gear 335 to drive the shaft 336 on which the wheel units as 329 are mounted. Additional clutch magnets 337 and 338 are provided to operate clutches as 329N and

330N of the hundreds and tens orders totalizer wheel units 329 and 330, respectively, during carry-over entering operations, to clutch said wheel units to the shaft 336, as will be described.

A carry-over contact closing wheel as 330B is provided for each of the totalizer wheel units as 330 and such a carry-over contact closing wheel will be effective to close a carry-over contact as 330G whenever the number wheel as 330A passes from 9 to 0 during the course of an entry therein. In a manner to be explained under the heading, "Carry-over on totalizer wheels," the closure of a carry-over contact as 330G conditions the machine to enter a carry-over of 1 into the next higher order totalizer wheel as 329A.

DETAILS OF PRINTERS—FIGS. 15 AND 16

As shown in Fig. 15, the sheet S to be printed upon is fed downwardly between a pair of feed rollers 347 and 348 until it reaches a position in which the line to be printed upon is aligned with the ribbon R. A hammer as H is provided opposite each printing wheel as 152 and cams as 349 fast on a shaft 362 are provided for actuating the hammers H. Each hammer is mounted on a strip 350 of resilient material, such as spring steel, such strip being secured at one end thereof to a block 351. The other end of the strip 350 is adapted to be engaged by a cam 349 when said cam is rotated in a counterclockwise direction, as viewed in Fig. 15. As the cam 349 thus rotates it bends the strip 350 and draws the hammer H away from the sheet S but when the cam 349 disengages the end of the strip 350, the hammer H is snapped toward the surface of the printing wheel as 152. In the course of such return movement, the spring strip 350 strikes a pin 352 positioned intermediate the hammer H and the block 351 so that the hammer H is snapped sharply against the sheet S, ribbon R and type wheel as 152 and it then restores to the position shown in Fig. 15. The sheet S is thereafter fed from printing position and a new sheet is introduced.

The feed roller 347 is mounted on a shaft 353 which, as can be seen from Fig. 16, is driven through a friction clutch 354 by a drive shaft 355 fast to a gear 356 that is meshed with an idler gear 357. The latter gear meshes with a gear 358 that is driven by a gear 359 on the shaft of a motor M1. Closure of a starting switch 360 sets the motor M1 in operation to drive the shafts 355 and 361 which, through the friction clutches 354 and 354a, tend to drive the shafts 353 and 362. A cam 363 is fast on the shaft 353 and when this cam is in its normal position it is engaged by a latch 364 which fits in a notch in the periphery of the cam 363. A magnet 365 is provided which, when energized, retracts the latch 364 and frees the cam 363 and shaft 353 whereupon the drive shaft 355 becomes effective through the friction clutch 354 to drive the feed roller 347, Figs. 15 and 16.

For initially feeding a blank or sheet into printing position a starting push button 366 is provided and when the contacts of this switch are closed a conductor 367 leading to the winding of magnet 365 is grounded to thereby energize said magnet and effect withdrawal of the latch 364 from the cam 363. The push button switch 366 is preferably opened before the shaft has made a complete revolution so that the latch 364 will drop down into engagement with the cam 363 to lock this cam against movement at the end of a complete revolution thereof. The switch 366 is utilized only in starting and all subsequent ener-

gizations of the magnet 365 are effected automatically by closure of a cam contact 368A which cooperates with a cam 368 on the shaft 362.

Shaft 362 is provided with a cam 369 and latch 370 controlled by a magnet 371. Energization of magnet 371 is momentarily effected in the course of the automatic operation of the machine, in a manner to be explained, to normally withdraw the latch 370 from engagement with the cam 369 to go through one revolution during which the cams 349 actuate the hammers H for printing on the sheet S.

Also in the course of rotation of the shaft 362, the cam 373 thereon will be rotated. Cam 373 is adapted to momentarily close a contact 373A connected to a conductor 375 leading to the zero set control relay 205, Fig. 9, for initiating a zero-setting operation of the machine.

COMPREHENSIVE SCHEME OF CONNECTIONS—FIGS. 22 TO 25

For the purpose of unifying the present disclosure, a schematic showing of all the essential electrical and mechanical connections between the various component parts of the machine is presented in Figs. 22 to 25, inclusive. The reference characters applied to the circuit lines and other parts shown in these views correspond to those used in other drawings of this application to identify like parts, wherever this has been feasible, and in other instances, for example, where there are groups of conductors in a cable or the like, suitable flow lines have been employed to indicate the general manner of interconnection and the function thereof.

Thus, in Fig. 24, there is shown a motor M connected through the medium of a clutch 27 to a drive shaft 26, which shaft is operatively connected to the card feeding means, Figs. 3 to 5, to the synchronizing or transfer drum D, Fig. 6, and to the control cams 47 and 48, Figs. 1 and 6. The card sensing brushes B and 44, Fig. 1, are disposed in operative relation to the cards advanced through the machine by the card feeding means. The brush 44, Fig. 1, controls the relay 58 through the medium of a conductor 56, Figs. 1 and 24, the control cam 48 and a conductor 57, and causes the main control relay 58 to be energized and subsequently locked up through its holding circuit 60 if an active card is sensed by this brush. The brushes B, Figs. 1 and 24, enter the amounts of the last and previous meter readings represented in the selected fields of each active card into the banks of storage relays, Fig. 6, under control of the transfer drum D. The designations on the card representing the type of meter and customer's classification are sensed by the brush 44, and if the card is active, current impulses are transmitted through the conductor 56, contacts of the cam 48 and relay 58, conductor 114, and transfer drum D to the coded contact relays, Figs. 7, 24 and 25, which are responsive to such entries. The coded contact relays as 110 select and energize counter magnets as 120, Fig. 7, in accordance with the type of meter designation, while the coded contact relays as 121 are energized in combinations depending upon the customer's classification for selecting a relay as 304 or 306, Figs. 18 and 23, associated with a classified totalizer as 329—330—331, Fig. 17.

The cam 47 maintains a clutch operating circuit including conductors 64 and 63 for the clutch 27 of the motor M during one complete card feeding cycle, and if the card is active this clutch operating circuit is broken at the end of the cycle to disable the clutch 27. The clutch 27 does not

then become re-energized until the completion of the machine operations that are performed as an incident to the feeding of an active card. The relay 58 also controls the clutch operating circuit 63 in such a manner that if the card is inactive the circuit 63 is continued upon completion of the current card feeding cycle to enable another card to be fed immediately thereafter. A zone selection switch 65 under the control of the relay 58 governs the card sensing operation to the extent that only a selected one of the zones I, II and III of each card C, Fig. 1, is effective, in the manner previously explained.

Relay 58, in energizing in response to the sensing of an active card, closes a circuit 61 which initiates the successive energization and locking up of the sequence relays 128, 129, 130, 131, 136, 137, 142 and 143, inclusive, Fig. 8, culminating in the energization of the sequence control relay 144. This circuit 61 is broken by the control cam 47 at the end of the card feeding cycle to initiate the sequential operations of the machine in a manner more particularly described hereinafter. The sequence relays are paired together and each pair controls a respective sequential operation. Thus the sequence relays 128 and 129 are rendered effective first to control the shift relay 100, Figs. 7 and 24, for enabling the last meter reading to be read out of the bank of storage relays to the permutation selectors 189-U, 189-T and 189-H, Figs. 9 and 22. The sequence relays 128 and 129 also control the relay 149, Figs. 8 and 24, which, when energized, operates the clutch magnets 171, 172 and 173 of the last reading printer, and 185, 186 and 187 of the consumption quantity accumulator and printer, Figs. 9 and 22, for enabling the wheel units of these printers to take motion with the drive shafts 163, 165 and 166 that are operated by the permutation selectors 189. The last reading printer 151-152-153 and the consumption quantity printer 157-158-159, Figs. 9 and 22, are therefore operated to receive entries of the last meter reading, which entries are effected under control of the last reading storage relays through the medium of the permutation selectors. At the conclusion of such entry-effecting operation, the sequence relays 128 and 129 will have been restored to their normal inoperative conditions, thereby breaking the holding circuit for the last reading storage relays and causing these relays to be released.

The sequence control relay 144, Figs. 8 and 24, is under the direct control of the slow-to-release relays 221 and 222, Figs. 9 and 22, which are in turn controlled by the pulsing contacts 218-U, 218-T and 218-H, Figs. 9 and 22, of the permutation selector units, as will be subsequently explained, and this relay 144 is alternately energized and deenergized in the course of operation of the machine to successively release the locked-up sequence relays as the sequential operations progress. By the time the last sequential operation of the machine has been performed, therefore, all of the sequence relays will have been released so that they may thereafter be conditioned for a new series of operations of the machine under control of a new record card.

The sequence relays 130 and 131 together control the operation of entering the previous meter reading into the previous reading printer 154-155-156 and into the consumption quantity printer 157-158-159, Figs. 9, 22 and 23, the previous meter reading being entered subtractively into the consumption quantity accumulator with which the printing wheels 157, 158

and 159 are associated. This entry-effecting operation is brought about following the entry of the last meter reading as aforesaid, the sequence relays 130 and 131 becoming effective to operate the shift relay 99, Figs. 7 and 24, to operatively interconnect the permutation selectors with the previous reading storage relays. The relay 150 is operated to energize the clutch magnets 182, 183 and 184 in the previous reading printer and 185, 186 and 187 in the consumption quantity accumulator and printer. Entry of the previous meter reading ensues and following this, the sequence relays 130 and 131 are restored to their normal inoperative conditions and the previous reading bank of storage relays is cleared.

In a manner to be described in greater detail hereinafter, the relays 102 and 108, Figs. 7 and 24, associated with the previous reading and last reading banks of storage relays respectively, are effective whenever there is a meter reading of 000 to cause the machine to skip the sequential operation in which such meter reading would normally be set up in the printing units; that is to say, the permutation selectors will not be caused to operate idly if there is no significant entry of a meter reading to be effected.

In the event there is to be a carry-over from units to tens order in the course of subtracting the previous meter reading from the last meter reading the sequence relays 132 and 133 become effective, immediately following the sequential operation in which the previous reading was entered, to operate the permutation selector 189-T and the clutch magnet 186 in the tens order of the consumption quantity accumulator for the purpose of entering the subtractive carry into the tens order. Likewise, if a carry-over from tens to hundreds orders is necessitated in the course of subtracting the previous from the last meter reading, the sequence relays 134 and 135 are rendered effective after the carry-over from units to tens orders, if any, has been made, to operate the permutation selector 189-H and the hundreds order clutch magnet 185, Figs. 9 and 23, of the consumption quantity accumulator to enter a subtractive carry into the hundreds order. After these carry-entering operations, if any, have been performed, the consumption quantity accumulator and printer registers the difference between the two meter readings.

After the difference or consumption quantity has been computed by the accumulator 185-186-187, the next operation to be performed is the computation and entry of the money charge based upon this consumption quantity. The sequence relays 136 and 137 control this operation and, among other things, they accomplish this by operating the relay 203, Figs. 9 and 22, to cause the permutation selector 189-U to send its shaft 163 through a complete revolution. The sequence relays 136 and 137 likewise cause appropriate circuits to be extended through the product tables, Figs. 10, 11, 12 and 25, and the zero controlling circuits, Figs. 13 and 25, to so operate the clutches of the money charge entry-effecting wheel units 291, 292 and 293, Figs. 17, 18 and 23, that the aforesaid rotation of the shaft 163 may be utilized to actuate the wheels of the money charge printer 285-286-287, Figs. 14 and 23, and the duplicate money charge printer 288-289-290, Figs. 14 and 23, and thereby adjust the same for subsequently printing the amount of the money charge onto the body and stub portions respectively of the bill sheet S, the exact manner in which this is accomplished being ex-

plained in greater detail hereinafter. Concurrently with such entry of the money charge into the appropriate printing units, the selected totalizer as 328—330—331, Figs. 17 and 23, is rendered operative to be driven by the money charge entry-effecting wheel units 291, 292 and 293 for thereby enabling this amount to be entered into such totalizer. The totalizers are arranged according to customers' classifications as represented by the combinational settings of the code relays 121 to 124, inclusive, Figs. 7 and 25. For example, if a customer has a residential classification, the amount of his bill may be entered into totalizer No. 1, whereas if he is a commercial customer, his bill amount may be entered into totalizer No. 2, Fig. 23, and so on.

The sequence relays 138 and 139 control the operation of effecting a carry-over in addition from the units to the tens order of the selector totalizer, this carry-over being effected by a means independent of the entry-effecting wheel units 291, 292 and 293, Figs. 17 and 23. Similarly, the sequence relays 140 and 141 control the entry of a carry-over in addition from the tens to the hundreds order on the selector totalizer.

The sequence relays 142 and 153 control the final sequential operations including the printing of the data set up on the various printers onto the bill sheet S and restoration of all the printing wheels to their normal zero positions. These operations are initiated when the sequence relays 142 and 143 act to close a circuit including the clutch control conductor 143K for enabling the printing means comprising the hammers H, Figs. 9, 14 and 15, to be operated. Following the printing of the items of data on the sheet S, a cam 373, Figs. 16 and 23, associated with the printing means closes a circuit 376 for operating the zero-setting relay 205, Figs. 9 and 23. This relay thereupon clutches the wheels of all the printer units to the drive shafts 153, 155 and 158 of the permutation selectors, and also operates a relay 204, Figs. 9 and 22, for causing the permutation selectors to send these shafts through a full revolution in the course of which the various printing wheels are restored, the clutch of each such wheel being thrown out when its wheel reaches a zero position. A paper feed roll 347 is likewise actuated for feeding the sheet S away from printing position and substituting a new sheet therefor. The zero-setting relay 205 and the sequence relay 143 jointly control the holding circuit 60 for the relay 58, Figs. 1 and 24, and when the last printing wheel has been restored and the sequence relay 143 has been released, the holding circuit 60 is broken to thereby release the relay 58.

Relay 58, on releasing, reestablishes the circuit 63 which controls the clutch 27, Fig. 3, of the card feeding means. The drive shaft 26 thereupon takes motion and the card feeding means is operated to advance a new card through sensing position. If this card is active, the relay 58 is energized and locked up and a series of machine operations ensues in a manner similar to that just described. However, if the card is inactive, the sequence relays, Figs. 8, 24 and 25, are not operated and the succeeding card is fed, this operation being repeated until an active card is sensed.

OPERATION

In the following description of operation of the machine it will be assumed that the customer had a previous meter reading of 416 for January and a last meter reading of 455 for February, thus leaving a consumption quantity

of 39. Inasmuch as this consumption quantity lies within the first rate step of 50, the money charge corresponding thereto will be 39 times 6¢ or \$2.34.

Following the description of this typical machine operation, there will be presented descriptions of other special operations which may be required in practice.

Preparing machine for operation

The brushes 9 to 14, inclusive, Fig. 1, are manually positioned to cooperate with the first six card columns from the left, Fig. 1, and the selecting switch 65 is adjusted to engage the contact 67C for selecting zone I of the card C. This enables the selection of the January field, in zone I to the left of line 4, for the previous meter reading, and of the February field, in zone I between lines 4 and 5, for the last meter reading.

Circuit is closed to the card feed motor M, Fig. 3, and to the sheet feed motor M', Fig. 16.

A sheet S is initially fed to printing position by momentarily depressing the push button 366, Fig. 16, which momentarily energizes the magnet 365 to withdraw the latch 364 and permit the cam 363 and feed roll shaft 353 to take rotation. This rotative movement is halted at the end of one revolution by engagement of the latch 364 with the cooperating notch in the cam 363. A sheet S will, by such an operation, be fed by the feed roll 347 to printing position.

CARD FEEDING CYCLE AND CONDITIONING OF SEQUENCE RELAYS

The start switch 62, Fig. 1, is closed to initiate automatic operation of the machine and inasmuch as relay 58 is in its normally deenergized condition at this time, circuit is closed from ground through the switch 62, the normally closed contact 66F of the relay 58 and conductor 63, Figs. 1 and 3, to the winding of the card feed clutch magnet 131, which magnet thereupon energizes and engages the clutch 27. Referring to the timing charts, Figs. 26 to 31, inclusive, and particularly to Fig. 26, the initiation of energization of the magnet 131 is represented as taking place at the point in time designated by the reference character 510, and such energization is completed at the point 511, at which time the clutch 27 is fully engaged so that the motor M commences to drive the feed shaft 26. Gear 28, Fig. 4, on the shaft 26, drives the gear 24 which is connected by the pitman 23 to the picker block 19. The picker block 19 descends and the picker 20 thereon pushes the foremost card in the pack P downwardly between the feed rollers 21 and 22. The card continues uninterruptedly in such downward movement until it is ejected into the collector K.

The lowermost or leading edge of the card C engages an arm of the detector 45, Fig. 1, and actuates the detector to cause ground to be applied on the contact bar 43 with which the sensing brushes cooperate. As explained hereinabove, each record card as C has twelve index point positions in each column thereon and these index point positions successively traverse the contact bar 43 and cooperating brushes B and 44. The relative times at which these index point positions are disposed in sensing position are represented on the timing chart, Fig. 26, by the reference characters 512 to 523, inclusive. Since the card C is to be "active," it has been provided with a perforation 15A, Fig. 1, in the first or lowermost index position in the column aligned with the brush 44. Hence as this perforation is

sensed by the brush 44, ground is extended through the conductor 56 leading to the rider 53 of the cam 48. Inasmuch as the cam 48 is mounted on the card feed shaft 46, it rotates in timed relation with the passage of the card C through sensing position, and at the time the perforation 15A is sensed, the lobe 51 on the cam 48 engages the rider 53 and closes circuit from the conductor 56 to the contact 54 and thence through conductor 57 to the winding 58A of the relay 58. Relay 58 thereupon starts to energize at the point 524, Fig. 26, and completes its energization at the point 525. When cam 47 moved off zero position, it grounded its contacts 50A, 50B and 50C, and through contact 50C and the closed relay contact 58C a holding circuit is established for the winding 58A of relay 58, thereby maintaining the relay 58 energized. Through contact 50A, and conductors 64 and 63, Figs. 1 and 3, a holding circuit is maintained for the clutch magnet 31 despite the opening of relay contact 58F upon energization of relay 58.

As card zone II reaches sensing position, the rider 53 of cam 48, Fig. 1, drops into the dwell 52 and closes circuit from brush 44 to contact 55 and thence to the now closed relay contact 58H which is connected through conductor 114 to the transfer drum brush 82, Fig. 6. At the instant the perforation 15B is sensed by the brush 44 (point 516, Fig. 26) the brush 81A on the drum D is electrically contacting the conducting strip 79. Hence a circuit is completed from ground at the contact bar 43, Fig. 1, through perforation 15B, brush 44, brush 82, Fig. 6, strips 80 and 79 on the drum D, brush 81A and conductor 112 to the relay 110, Fig. 7, which relay therefore commences to energize at point 526, Fig. 26, and completes its energization at point 527. In a similar manner, the perforation 15C, Fig. 1, is sensed (point 517, Fig. 26) and effects the energization of relay 111 at point 528 and thus causes a circuit to be extended from ground at the conductor 116 through the code contacts of the relays 110, 111, 117 and 118, to the winding of the counter magnet designated 120 in Fig. 7, in the manner explained under the heading "Shift relays and coded contact relays," supra. Counter magnet 120 thereupon starts to energize at point 529 concurrently with the completion of energization of the relay 111 at point 528.

As stated hereinabove, the counter magnets as 120 are slow enough in their operation to permit relays as 110 and 111 to be fully set up prior to the time energization of such a magnet is completed, so that there will be no false indications. As indicated on the timing chart, Fig. 26, the energization time of the magnet 120 is greater than the time interval during which four successive index positions on the card C are sensed, and the magnet 120 does not fully energize until the point 530 has been attained, whereupon the counter magnet 120 attracts its armature and actuates the ratchet mechanism and its associated counting device for thereby registering the passage of a card bearing a particular meter designation. Holding circuits for the relays as 110 and 111 which have been energized are established through their windings as 110B, contacts as 110C and the common conductor 115 which is connected to ground through the closed relay contact 58G of the relay 58, and such holding circuits are maintained until the relay 58 is subsequently deenergized. Hence the magnet 120 is maintained energized by the relays 110 and 111.

As card zone I reaches sensing position the per-

foration 15D is sensed by the brush 44 (point 520, Fig. 26), and through the previously traced circuit to the transfer drum D, Fig. 6, ground is momentarily extended to the conducting strips 80 and 79. At this time brush 83A is contacting the strip 79 so that circuit from ground is completed through a conductor 125 to the relay 121, Fig. 7. The relay 121 energizes at point 531 and through its winding 121B and contact 121C establishes a holding circuit to ground at the relay contact 58G, Fig. 1, by way of the conductor 115. Energization of the relay 121 indicates that the record card C, Fig. 1, has a certain classification, depending upon the class of customer for whom the meter readings represented on the card C were taken. Inasmuch as there are no other perforations in zone I aligned with the sensing brush 44, none of the relays 122, 123 or 124 is energized and relay 121 therefore is the only relay in this group which is maintained energized. The function of relays 121 to 124 will be explained presently.

Since the selecting switch 65 has been positioned to engage the contact 67C, Fig. 1, corresponding to zone I of the card C, battery derived from the relay contact 58J is applied to the brush 70C, Fig. 6. Hence when the strip 69C on the drum D engages the brush 70C, battery is applied on the strip 69C and this occurs during the time the card zone I is traversing the sensing position. Since no connection is afforded to either of the contacts 67A or 67B, Fig. 1, by the switch 65, the brushes 70A and 70B, Fig. 6, are not impressed with battery, and hence the longitudinal strips 68A and 68B on the drum B are not potentialized at any time during such rotation of the drum D.

When the lowest index point positions in zone I on the card C are in sensing position above the contact bar 43 (point 520, Fig. 26) the transfer drum brushes 71A, 71B and 71C, and 75A, 75B and 75C, Fig. 6, are contacting the now potentialized strip 68C. Perforations 1C and 1D in the tens and units orders respectively of the previous meter reading (January) enable sensing brushes 10 and 11, Fig. 1, in the group B to derive ground from the bar 43. Circuit from ground continues through the brushes 10 and 11 and conductors 380 and 381, Figs. 1 and 6, to the windings as 38A and 39A of the storage relays as 88 and 89 in the second and third sets from the left, Fig. 6. Battery is now available at brushes 71B and 71C which connect to the other sides of the windings 38A and 39A, so that the relays 88 and 89 energize at points 532 and 533, respectively, and lock up through their contacts 88C and 89C, conductors 382 and 383, common conductor 384, Figs. 6 and 8, conductor 385 and the contact 143E of the sequence relay 143 which is normally closed and grounded when sequence relay 143 is deenergized.

When the second from the lowest index point positions in card zone I have reached sensing position, the brushes 72A, 72B and 72C, and 76A, 76B and 76C, Fig. 6, are in contact with the potentialized strip 68C on the drum D. Card perforations 1A, in the hundreds order of the previous meter reading (January), and 2A, 2C and 2D, in the hundreds, tens and units orders of the last meter reading (February), enable the sensing brushes 9, 12, 13 and 14, Fig. 1, to contact the grounded bar 43. Thus ground is extended from these brushes through conductors 385, 386, 387 and 388, respectively, Figs. 1 and 6, to the windings 87A, 92A, 93A and 94A, respectively, of

the relays 87, 92, 93 and 94 in the hundreds set of storage relays for the previous reading group and the hundreds, tens and units sets of storage relays in the last reading group. Relay 87 locks up at point 534 and establishes a holding circuit for itself through the grounded conductor 384 in the same manner as did the relay 88. Relays 92, 93 and 94 energize and lock up at points 535, 536 and 537, respectively, and holding circuits are established for these relays through their contacts as 92C thereof, common conductor 389, Figs. 6 and 8, and conductor 390 to the normally closed and grounded contact 143C of the sequence relay 143.

In the present example, there are no perforations in the third index point positions in zone I. Therefore, when the conducting strip 68C engages the brushes 73A, 73B, 73C and 77A, 77B and 77C on the drum D, ground is not extended through any of the conductors 85, 89, 90, 91, 92, 93 or 94 to the energizing windings of the storage relays, Fig. 6. Hence, although said brushes impress battery upon the exciting windings of the storage relays situated third from the bottom in the various sets, there will not be any energization of such relays.

The uppermost index point positions in card zone I next come into sensing position. Strip 68C of the drum D then engages and impresses battery upon the brushes 74A, 74B and 74C, and 78A, 78B and 78C. These brushes are connected to the left-hand windings as 84A, Fig. 6, of the storage relays as 84 in the uppermost row of storage relays. Perforations 1B, 1E and 2B enable ground to be extended from bar 43 through brushes 9, 11 and 12, conductors 85, 90 and 91 to the other sides of the left-hand windings of relays 84, 90 and 91, Fig. 6, so that these relays then energize and lock up at points 538, 539 and 540, respectively, the relays 84 and 90 locking up through the holding circuit 384 and the relay 91 being locked up through the holding circuit 389 described hereinabove.

The storage relays which are thus locked up in accordance with last and previous meter readings derived from the card, are: for the hundreds order digit (4) of the previous reading, relays 84 and 87; for the tens order digit (1) of the previous reading, relay 88; for the units order digit (6) of the previous reading, relays 89 and 90; for the hundreds order digit (4) of the last reading, relays 91 and 92; for the tens order digit (5) of the last reading, relay 93; for the units order digit (5) of the last reading, relay 94.

When the storage relays 88 and 89 in the previous reading group, Fig. 6, are energized at points 532 and 533, respectively, they close their contacts as 88E and 89E to thereby ground the conductors 103 and 104 which lead to separate windings of the triple wound relay 108, Fig. 7, and hence this relay commences to energize at point 541, Fig. 26, completing such energization at point 542. When the storage relays 92, 93 and 94 in the last reading group, Fig. 6, are energized at points 535, 536 and 537, respectively, they close their contacts as 92E to thereby ground the conductors 105, 106 and 107 leading to windings of the relay 102, Fig. 7, causing this relay to commence energization at point 543, Fig. 26, and complete such energization at point 544. Energization of the relays 108 and 102 at points 542 and 544, respectively, results in the opening of the contacts 108A and 102A, respectively, of these relays, thus indicating that neither of the meter readings is 000.

When contact 58E of relay 58, Fig. 1, closes at 75

point 525, Fig. 26, the cam 47, having rotated away from its zero position shown in Fig. 1 thus closing its contact 58A, causes ground to be extended from this contact through the relay contact 58E and conductor 61, Figs. 1 and 8, to the winding 128A of the sequence relay 128, initiating energization of this sequence relay at point 545, Fig. 26. When sequence relay 128 completes its energization at point 546, it is locked up through its winding 128D, contact 128C, contact 145 and the grounded contact 144A of the sequence control relay 144, which latter relay is deenergized at this time. Also, the contact 128B closes upon energization of the relay 128 and initiates energization of sequence relay 129 at point 547. Upon energizing at point 548, the sequence relay 129 closes its contact 129E and grounds a conductor 391 connected to the conductor 389, Figs. 8 and 6, which is part of the holding circuit for the storage relays in the last reading group. The ground thus applied to the conductor 389 augments the ground supplied thereto by the conductor 390 leading to the contact 143C of the sequence relay 143.

Another of the contacts of sequence relay 129 to close upon energization of this relay at point 548 is the contact 129D, which applies ground on the left-hand winding of the sequence relay 130, Fig. 8, to initiate energization of this sequence relay at point 549, Fig. 26. Upon energizing at point 550 the relay 130 closes its contact 131E to apply ground on a conductor 392 connected to the conductor 384, Figs. 8 and 6, which is part of the holding circuit for the storage relays in the previous reading group, thereby augmenting the ground supplied to this conductor by the conductor 385 leading to the contact 143E of the sequence relay 143. Energization of relay 130 at point 550 also causes its mate, sequence relay 131, to commence energization at point 551, becoming fully energized at point 552.

Sequence relay 132 being deenergized at this time, its contact 132A is open and, therefore, closure of the contact 131F of relay 131 at point 550, Fig. 26, does not affect the relay 132. Inasmuch as relay 132 remains unenergized, its mate, relay 133, likewise remains unenergized. Sequence relay 134 being deenergized at this time, its contact 134A is open and therefore closure of the aforesaid relay contact 131F does not affect relay 134. Sequence relay 135 likewise remains unenergized.

When contact 131D of the sequence relay 131 closes, it extends ground to the left-hand winding of sequence relay 136, Fig. 8, which relay commences to energize at point 553, Fig. 26, and is fully energized at point 554 whereupon it locks up through its right-hand winding, contact 136C, conductor 145, and contact 144A of the sequence control relay 144. Contact 136A, in closing, initiates energization of sequence relay 137 at point 555, such energization being completed at point 556. Sequence relays 138 and 140 being deenergized at this time, their contacts 138A and 140A are open and hence closure of the contact 137B of relay 137 does not affect either of these relays. Hence their mates, sequence relays 139 and 141 likewise remain unenergized.

When contact 137D of relay 137 closes at point 556, it grounds the left-hand winding of the sequence relay 142, Fig. 8, to thereby initiate energization of this relay at point 557. When relay 142 is fully energized at point 558 it causes the sequence relay 143 to commence energization at point 559. When the relay 143 completes its energization at point 560, it opens its contacts 143C

and 143E to relieve the conductors 385 and 386 of ground. However, the removal of this source of ground from the conductors 384 and 389 included in the holding circuits of the storage relays does not effect the release of the storage relays inasmuch as other sources of ground have been established by these holding circuits at the contacts 129E and 131E of the sequence relay 129 and 131, respectively, as aforesaid. When contact 143B of sequence relay 143 closes, it grounds a conductor 143J, Figs. 8 and 1, that is connected to the conductor 60 leading to the now closed contact 58D of relay 58, so that a secondary holding circuit through winding 58B is now provided for the relay 58 so long as the conductor 60 remains grounded.

When contact 143D of relay 143 closes at point 560, it applies ground on a conductor 143H, Figs. 8 and 18, to afford a holding circuit for relays as 299 when they are subsequently energized in the manner to be explained. Conductor 126, which is tapped onto the conductor 143H, Fig. 8, extends ground to the code contacts of the relays 121 to 124, Fig. 7, and when relay 121 is energized at point 531, as aforesaid, a circuit is completed from conductor 126 through these contacts and the selected conductor 127 to the winding of the relay 304, Fig. 18, which is one of a series of such relays provided for the purpose of effecting selection of classified totalizers. Thus, referring to Fig. 23, the relay 304 is operatively associated with the totalizer comprising the wheel units 329, 330 and 331, Fig. 17, while the relay 306, Fig. 18, is allocated to another totalizer, and so on. Relay 304 is therefore potentialized at point 531a, Fig. 29, and energizes at point 531b. If two or more of the relays 121 to 124 had been energized in combination, there would probably be temporary, changing selections of the relays 304 and 306 until a stable condition in the settings of the code contacts of these relays had been attained, whereupon only the selected relay would remain energized. However, as will appear hereinafter, the energization of a relay as 304 has no operative effect until a later time in the course of operation of the machine, and hence such preliminary selections as just described would not affect the proper functioning of the machine.

When sequence relay contact 143A closes at point 560, it impresses battery upon the conductor 226 that is connected to one end of the resistor 225, Fig. 8. The other end of this resistor is connected in parallel with the conductor 224 to the winding of the sequence control relay 144. The other side of this relay winding being grounded, and there being no ground applied on the conductor 224 at this time, relay 144 commences to energize at point 561, Fig. 26, and completes its energization at point 562. Energization of the relay 144 results in the opening of its contact 144A subsequently to the closing of its contact 144B, thus removing ground from the conductor 145 and hence from the winding 128D of the sequence relay 128. Winding 128A of relay 128 is still being maintained energized at this time, however, because of the ground applied on the conductor 61 by the cam contact 50A, Fig. 1, and, therefore, the sequence relay 128 does not deenergize upon the energization of the sequence control relay 144. When relay contact 144B closes, ground is extended to the conductor 146 and this is effective to ground the contact 129C of sequence relay 129 to thereby maintain the winding 129A of this sequence relay energized even though the winding 129B thereof is later

deenergized by opening of the contact 128B of sequence relay 128.

As previously explained, the closure of cam contact 50B, Fig. 1, serves to maintain ground on a conductor 64 which is connected to the conductor 63 leading to the winding of the electromagnet 31 that operates the card feed clutch 27, Fig. 3. The shaft 26 consequently continues to be driven by the motor M until the cam 47, Fig. 1, completes a full revolution and opens its contact 50B, whereupon the magnet 31 commences to deenergize at point 563, Fig. 26. At point 564 the magnet 31 releases the clutch 27 thereby interrupting rotation of the shaft 26 at the end of its 15 revolution and consequently suspending the card feed.

ENTRY OF LAST METER READING

The last meter reading, 455, is to be entered into the last reading printer 151—152—153 and also additively into the consumption quantity printer and accumulator including the type wheels 157, 158 and 159 and connected wheel units, Fig. 9.

When the cam 47, Fig. 1, opens its contact 50C, 25 toward the end of the revolution of the shaft 26, the holding circuit to the winding 58A of the relay 58 is broken. However, this relay still remains locked up through its winding 58B and conductors 60 and 143J, Figs. 1 and 8, leading to the contact 143B of the sequence relay 143, which has been energized by this time.

Opening of the cam contact 50A removes ground from the conductor 61, Figs. 1 and 8, and thereby deenergizes the winding 128A of the sequence relay 128. As previously explained, the winding 128D of this relay was deenergized when the control relay 144 energized at point 562, Fig. 26, and therefore the sequence relay 128 commences to deenergize at point 565. Upon being 40 deenergized at point 566 the sequence relay 128 closes its contact 128F to extend ground from the closed contact 129F of sequence relay 129 through a conductor 400 to the winding of the relay 149, Fig. 8, which relay thereupon commences to energize at point 567, Fig. 26, and completes its energization at point 568 to apply ground on the conductors 401 to 406, inclusive, leading to the windings of the clutch magnets 171, 172 and 173 of the last reading printer 151—152—153, Fig. 9, and the clutch magnets 185, 186 and 187 of the consumption quantity accumulator and printer 157—158—159. These magnets commence energization respectively at points 569 to 574, inclusive, and upon completion of energization at points 575 to 580, inclusive, cause their respective clutches 169, 176, 178, 407, 408 and 409 to be engaged for coupling their respective wheel units to the shafts 163, 165 and 168, Fig. 9.

Grounding of the conductors 401 to 406, inclusive, as aforesaid, also results in the application of ground to conductors 410, 411, 412, 416, 417 and 418, respectively, Fig. 9, that lead to one leaf of each of the zero-setting contacts as 159H, Figs. 9 and 20, of the respective wheel units. It will be recalled that the other leaves of these zero-setting contacts are connected to contacts of the zero-setting relay 205, Fig. 9, which are normally open when this relay is deenergized, and since this relay is inactive until the final sequential operation of the machine, the grounding of the conductors as 410 is without effect at the present time.

When sequence relay 128 deenergizes at point 566 it also closes its contact 128E to extend ground

through the closed contact 129G of the sequence relay 129 and a conductor 129H, Figs. 8 and 7, to the winding of the shift relay 100, initiating energization of this relay at point 581. Relay 100 energizes at point 582 and closes its several contacts to thereby afford an operative inter-connection between the storage relays in the last reading group and the code magnets of the permutation selectors. For example, in the hundreds order, storage relays 91 and 92, Fig. 6, have been locked up and hence ground is extended through the closed contacts 91D and 92D of these relays, conductors 420 and 421, contacts 100D and 100B of shift relay 100, Fig. 7, respectively, and corresponding conductors in the cable 100, Figs. 7 and 9, to the windings of the code magnets H-2 and H-4 in the hundreds order. Similarly, the storage relay 93 in the tens order and the storage relay 94 in the units order apply ground on the conductors as 422 leading to shift relay contacts as 100F to cause the energization of the code magnets T-2 and U-2 in the tens and units orders respectively. Thus, the code magnets U-2, T-2, H-2 and H-4 simultaneously commence to energize at the points 583, 584, 585 and 586, respectively. The relay 210, the winding of which is in series with the windings of all of the code magnets, commences to energize concurrently therewith at the point 587 and completes its energization at point 588, whereupon its contact 210A is closed to supply ground to the pulsing contacts 210-U, 210-T and 210-H associated with the permutation selectors 180-U, 180-T and 180-H, respectively, for the purpose to be presently explained.

Closure of the contact 100N of the shift relay 100, Fig. 7, is without effect in the present instance inasmuch as the relay 100 was previously energized to open its contact 100A. Operation of the machine with a last meter reading of 000 will subsequently be described to more fully explain the function of the relay 100 under these circumstances.

When the selected code magnets are fully energized at points 588 to 591, inclusive, the home stop pins as 200', Fig. 19, of the selectors 180-U, 180-T and 180-H are retracted to release the stop arms 202-U, 202-T and 202-H of these selectors and thereby enable the shafts 180-U, 180-T and 180-H to be driven by their driving means as 201 through the medium of the friction clutches as 200, Figs. 9 and 19A. The selector shafts thereupon commence to rotate and the stop arms as 202-U are advanced through successive digital positions. The times at which these stop arms attain positions representative of significant digits are designated on the timing chart, Fig. 29, by the point 592 for the digit 1, 593 for the digit 2, and so on to the point 596 for the digit 5.

The toothed wheels 210-U, 210-T and 210-H commence rotation with the selector shafts and alternately close and open their cooperating contacts as 210-U. The first closure of any of contacts will occur prior to the instant that the stop arms attain positions representative of the digit 1 (point 592 in Fig. 29). Such closure of the toothed-wheel contacts causes ground to be momentarily extended from the relay contact 210A to the conductor 220 leading to the winding of the slow-to-release relay 221. Hence, at point 597, the relay 221 commences to energize and becomes fully energized at the point 598, whereupon it closes its contact 221A and initiates energization of the slow-to-release relay 222 at point

599, such energization of relay 222 being completed at point 600.

Inasmuch as the last meter reading is 455, all of the stop arms of the selector units continue to rotate in unison until the point 595 representative of the digit 4, Fig. 29, is attained, whereupon the hundreds order stop arm 202-H is arrested by a pin as 200, Fig. 19, of the selector 180-H which will have been disposed in the path of movement of the stop arm 202-H. The stop arms 202-U and 202-T, however, continue to rotate until the point 596 representative of the digit 5 is attained, whereupon they are arrested in like manner. During the interval when the stop arms, or at least one of them, are in motion, the toothed-wheel contacts as 210-U are intermittently closed to cause current impulses to be periodically sent through the winding of the slow-to-release relay 221. The release time of this relay is of such a value that the relay is unable to fully deenergize and release its contact 221A in the period between successive closures of the aforesaid toothed-wheel contacts. Therefore, as indicated in the timing chart, Fig. 29, the relay 221 is in a pulsating state of operation but is not released until after the last selector stop arm as 202-U has been arrested. Hence, the relay 222 remains fully energized until the relay 221 releases at point 601, whereupon the relay 222 commences to deenergize at point 602. The magnets 180-U, 180-T and 180-H, Fig. 9, are all in a deenergized condition during the entry of the last meter reading and hence the selector shafts 180-U, 180-T and 180-H drive their connected shafts 163, 165 and 168 in an additive direction to adjust the type wheels 151, 152 and 153 of the last reading printer to positions in which they present the type characters "4," "5" and "5," respectively, at the printing line opposite the hammers H, Figs. 9 and 15. Likewise, the type wheels 157, 158 and 159 of the consumption quantity printer are adjusted to dispose the type characters "4," "5" and "5" at the printing line.

When relay 221 is released at point 601 it closes its contact 221 B and thereby applies ground on the contact 222A of the slow-to-release relay 222, which latter contact is still maintained closed due to the relatively long release time of relay 222. Ground is therefore extended through the conductor 223 to the conductor 224 leading to the winding of the sequence control relay 144. The winding of the relay 144 is thus short-circuited in the manner explained hereinabove under the heading "Sequence relays" so that the relay 144 commences to deenergize at point 603, Fig. 27. In so doing, it first closes its contact 144A and then opens its contact 144B by the time the point 604 is attained. Opening of contact 144A deprives the conductor 146 of ground and breaks the holding circuit through the winding 129A of the sequence relay 129. The relay 129 is, therefore, deenergized at the point 605 and opens its contact 129F to initiate the deenergization of relay 149 at point 606. Relay contact 129G opens and removes ground from the conductor 129A, thus initiating the deenergization of the shift relay 100, Fig. 7, at point 607. Opening of relay contact 129E deprives the conductor 389 of ground and thus breaks the holding circuit for the storage relays 91, 92, 93 and 94, Fig. 6, in the last reading group, and these relays start to deenergize at points 608 to 611, respectively.

The sequence relays 130, 136 and 142 remain energized through holding circuits including their contacts as 130 C and the common conductor 145

which is connected to ground through the contact 144B of the relay 144. These sequence relays maintain their mates, relays 131, 137 and 143, respectively, energized by supplying ground through contacts as 130B to the right-hand windings of such relays, Fig. 8, notwithstanding that the left-hand windings are now deenergized due to the aforesaid deenergization of the relay 144.

Relay 149 deenergizes at point 612 and initiates the release of the clutch magnets 171, 172 and 173, and 185, 186 and 187 at points 613 to 618, inclusive, respectively. When the storage relays 91, 92, 93 and 94 become deenergized at the points as 619, they open their contacts as 92E and initiate the deenergization of the relay 108, Fig. 7, at point 620. Concurrently therewith, the code magnets U-2, T-2, H-2 and H-4 commence to deenergize at points 621 to 624, respectively, upon opening of the contacts as 92D of the storage relays. When the code magnets are fully deenergized at points 625 to 628, respectively, the pin 208, Fig. 19, that was rendered active in each of the selectors will have been restored out of the normal path of movement of the stop arm as 202-U and the home stop pin as 208' will have assumed an active position. Thereupon the stop arms as 202-U commence to rotate toward their home positions and as indicated in Figs. 29 and 30, they pass through successive digital positions at times designated by the points as 629, 630, and so on, until they have all been restored. Thus, the units and tens stop arms 202-U and 202-T, Fig. 9, are rotated through five digital positions and come to rest at the time indicated by the point 633 in Fig. 30. The stop arm 202-H, however, must rotate through six digital positions and is not restored to its normal zero position until the point 634 is attained (it being recalled that the last meter reading was 455). The relay 216 commences to deenergize at the point 635 concurrently with the initiation of deenergization of the code magnets, since in this instance the winding of relay 216 is in series with the windings of the code magnets and the source of current, and thereby deprives the pulsing contacts as 218-U of ground during the restoring operation.

In connection with the foregoing, it should be noted that the release time of the code magnets as U-2 is preferably made long enough so that the clutch magnets as 171, Fig. 9, will have been released by the time the code magnets are fully deenergized so that there is no possibility of the printing wheels being clutched to the drive shafts 163, 165 and 168 during any part of the restoring movement of the selector arms. Moreover, as will be seen subsequently from the description in connection with the entry of the previous meter reading, the time delay afforded during the deenergization period of the slow-to-release relay 222 enables the stop arms of the selectors to be restored through the maximum angular distance, namely, through nine digital positions, prior to the time these selectors are again operated for effecting the next entry.

ENTRY OF PREVIOUS METER READING

The previous meter reading 416 is represented by locked-up storage relays 84, 87, 88, 89 and 90, of the previous reading storage group. This amount is to be entered into the previous reading printer 154-155-156, Fig. 9, and a concurrent subtractive entry thereof is to be effected into the consumption quantity accumulator and printer 157-158-159.

When the relay 222 is completely deenergized at point 636, Fig. 30, at the end of the operation of entering the last meter reading, it releases its contact 222 to thereby deprive the conductor 223, Figs. 9 and 8, of ground. The shunt around the winding of the sequence control relay 144 is, therefore, broken and this relay commences to energize at point 637, Fig. 27, attaining complete energization at point 638 whereupon it opens its contact 144A subsequent to the closure of its contact 144B. Sequence relays 130, which had previously been held energized through its contact 130C and the conductor 145 leading to the relay contact 144A, is thereupon deenergized at the point 639.

Relay contact 130F, in closing, extends ground from the contact 131J of the sequence relay 131 to the winding of the relay 150, causing this relay to become energized at the point 640. Relay 150 closes its contacts 150A to 150F, inclusive, and grounds the conductors 425, 426, 427, 404, 405 and 406, respectively, leading to the windings of the clutch magnets 182 to 187, respectively, Fig. 9, so that these clutch magnets commence to energize at the points 641 to 646, respectively, Figs. 27 and 30. Upon energizing at points 647, 648 and 649, the magnets 182, 183 and 184 engage their clutches 179, 180 and 181 to couple the type wheels 154, 155 and 156 of the previous reading printer to the drive shafts 165, 166 and 168. The clutch magnets 185, 186 and 187 energize at points 650, 651 and 652 and engage the clutches 407, 408 and 409 to couple the type wheels 157, 158 and 159 of the consumption quantity printer, and the associated wheel units of the consumption quantity accumulator, to the shafts 163, 165 and 168.

Inasmuch as the previous meter reading is to be entered subtractively, provision has been made for reversing the directions of rotation of the shafts as 163 relative to their selector shafts as 188-U. To this end, when the contacts 150A and 150B of the relay 150, Fig. 8, close and apply ground on the conductors 425 and 426, respectively, ground is also extended from these conductors through connected conductors 428' and 429' to the windings of relays 428A and 429A and hence these relays become energized at points 653 and 654, respectively. The contacts 428B and 429B of these relays in closing, extend ground through the conductors 428 and 429, Figs. 8 and 9, to the windings of the reversing magnets 196-T and 196-H, whereupon these magnets are potentialized at points 655 and 656, respectively. Upon energization of the magnets 196-T and 196-H at points 657 and 658, the sleeves controlled by these magnets are shifted to disengage, for example, the bevel gears 197 and 198 on the tens order shafts and engage the bevel gear 199 with the bevel gear 198, a similar action taking place with respect to the hundreds order shafts. Thus, when the selector shafts 188-T and 188-H are subsequently rotated to enter the tens and hundreds order digits of the previous meter reading, the shafts 165 and 168 will be rotated in a direction the reverse of that in which they were driven during entry of the last meter reading. When contact 150C of the relay 150, Fig. 8, closes and applies ground on the conductor 427, ground is immediately extended through a conductor 430, Figs. 8 and 9, to the winding of the reversing magnet 196-U, causing this magnet to become potentialized and subsequently energized at the point 659. Thus the sleeve 189a on the selector shaft 188-U is shifted to bring the bevel gears 191 and 192 into engagement so that the shaft 163

will be driven in its reverse direction during entry of the units digit. Because of the reversals in the directions of rotation of the drive shafts 163, 165 and 168, the order in which the type characters are arranged on the wheels 154, 155 and 156 of the previous reading printer is the reverse of that in which they are arranged on the type wheels 151, 152 and 153 of the last reading printer, or on the type wheels 157, 158 and 159 of the consumption quantity printer.

When sequence relay 130 deenergized at point 639, it closed its contact 130E and extended a circuit from ground through the contact 131G of the sequence relay 131 and a conductor 131H, Figs. 8 and 7, to the winding of the shift relay 99, potentializing this relay at the point 660, Fig. 27. When the shift relay 99 energizes at point 661, it closes its several contacts including the contact 99N. Closure of this contact, however, is without effect in the present instance inasmuch as relay 102 has been previously energized to maintain its contact 102A open. Closure of the remaining shift relay contacts affords operative interconnections between the storage relays in the previous reading group and the code magnets of the permutation selectors. Thus, in Fig. 6, ground derived from the contacts as 84D of the storage relays 84, 87, 88, 89 and 90 is extended through the shift relay contacts to corresponding conductors in the cable 109, Figs. 7 and 9, to the windings of the code magnets U-1 and U-4 in the units order, T-1 in the tens order, and H-2 and H-4 in the hundreds order for entering the quantity 416 (see Fig. 2). These code magnets thereupon become energized at the points 662 to 665, respectively, to initiate the rotation of the selector shafts. Relay 216 is potentialized at point 667 concurrently with the potentialization of the windings of the code magnets, and energizes at the point 668 to supply ground to the pulsing contacts as 218-U, Fig. 9.

Prior to entry of the first digit at the point 669, Fig. 30, the pulsing contacts momentarily close and cause the slow-to-release relay 221 to become energized at the point 675, this in turn causing the energization of the slow-to-release relay 222 at point 676. The selector shaft 188-T is driven through one digital position and is then arrested when its stop arm 202-T encounters a pin as 208, Fig. 19, in the position representative of the digit 1 in the tens order (point 669). The selector shaft 188-H continues to rotate until it reaches the fourth digital position at point 672. The units order shaft 188-U is not arrested until it reaches the sixth digital position at point 674.

In the course of the just described operations the type wheels 154, 155 and 156, Fig. 9, are adjusted to dispose the type characters "4," "1" and "6," respectively, at the printing line. Insofar as the consumption quantity printer is concerned, the type wheel 157 is rotated backwardly through four digital positions and inasmuch as it previously registered the digit 4, it now registers zero. The type wheel 158, having previously registered "5" and being driven backwardly through one digital position, now registers "4." The units type wheel 159 previously registered "5" and it was driven backwardly through six digital positions so that it now registers "9." In the course of passing from its zero position to a position representative of the digit 9, the carry-over contact-closing wheel 159B in the units order momentarily closes its contact 159G and extends ground through a conductor 436 to the

center winding of the triple wound sequence relay 132, Fig. 8. This sequence relay thereupon energizes at point 677, Fig. 27, and in turn energizes sequence relay 133 at point 678. Sequence relay 132, upon energizing, closes its contact 132A and establishes a holding circuit through its left-hand winding, Fig. 8, and the contact 131F of the sequence relay 131, which relay is still energized at this time. The sequence relay 133 is maintained energized not only by the contact 132D of the relay 132 but also by a holding circuit through its contact 133D and the conductor 146 leading to the contact 144B of the sequence control relay 144.

The slow-to-release relay 221, once it is energized at point 675, remains in an operative condition due to the intermittent closure of the pulsing contacts as 218-U, Fig. 9, until the units stop arm 202-U has been arrested, whereupon it deenergizes at the point 679, and initiates deenergization of the slow-to-release relay 222 at the point 680. Contact 221B of the relay 221 closes and extends ground through the still closed contact 222A of the relay 222 and conductors 223 and 224, Figs. 9 and 8, to the winding of the control relay 144. Relay 144 is, therefore, short-circuited and starts to deenergize at point 681. In the course of its deenergization it closes the contact 144A and then opens the contact 144B to break the holding circuit for the sequence relay 131, by the time the point 682 is attained. Sequence relay 131 thereupon deenergizes at point 683 and opens its contact 131J to deenergize the relay 150 at point 684. Ground is thus removed from the windings of the clutch magnets 182 to 187, inclusive, Fig. 9, and the windings of the relays 428A and 429A, Fig. 8, initiating the deenergization of these relays and clutch magnets at the points 685 to 692, respectively. The reversing magnet 196-U, Fig. 9, commences to deenergize at point 693 concurrently with the clutch magnets as 182, and the reversing magnets 196-T and 196-H commence to deenergize at points 694 and 695 upon deenergization of the relays 428A and 429A at the points 696 and 697.

When sequence relay 131 deenergizes at point 683, it also deenergizes the shift relay 99 at point 698, and the storage relays 84, 87, 88, 89 and 90 at points 699 to 703, respectively. Deenergization of the storage relays causes the relay 102 to deenergize at point 704. Likewise, the code magnets U-1, U-4, T-1, H-2 and H-4 are deenergized at points 705 to 709, respectively, subsequent to the release of the clutch magnets as 182, and since relay 216 is in series with the code magnets, it starts to deenergize concurrently therewith at the point 710, thereby withholding ground from the pulsing contacts as 218-U during the restoring operation.

The tens order stop arm 212-T, Fig. 9, of the selector 189-T has the longest distance to travel in returning to home position, namely, through nine digital positions. The times at which the stop arm successively attains these positions is indicated by the points 711 to 719, inclusive, Fig. 30. The slow-to-release relay, Fig. 22, is fully deenergized at the point 720 prior to the time the point 719 is attained and it opens its contact 222A to remove the shunt from the winding of the sequence control relay 144, at point 721, Fig. 27.

CARRY-OVER IN CONSUMPTION QUANTITY SUBTRACTION

The consumption wheels 157, 158 and 159 now display the quantity 049 at the printing line, this

being the result of 455 minus 416 without carry-over. A negative carry of 1 must, therefore, be made into the tens order wheel 158 inasmuch as the true difference between 455 and 416 is 039.

When the sequence control relay 144 energizes at point 722, it releases the sequence relay 132 at point 723 by breaking the holding circuit through the right-hand winding, Fig. 8, of this relay. Relay 132 closes its contact 132B and extends ground through the contact 132B of the sequence relay 133 and the conductor 133K, Figs. 8 and 9, which, in common with the conductor 408, leads to the winding of the clutch magnet 186 in the tens order of the consumption quantity accumulator so that this magnet commences to energize at the point 724. Concurrently therewith, the sequence relay contact 132C closes and extends ground through the contact 133J of the relay 133 to a conductor 438 which is connected to the conductor 429 leading to the tens order reversing magnet 196-T, Fig. 9, potentializing this magnet at the point 725. Likewise, ground is extended through the contact 133C of the sequence relay 133 and conductor 133H to the winding of the code magnet T-1, Fig. 9, in the tens order so that this magnet starts to energize at the point 726.

The code magnet T-1 energizes at point 727 slightly subsequent to the energization of the magnets 186 and 196-T at points 728 and 729, respectively. The stop arm 202-T of the tens order selector 189-T is thereupon displaced through one digital position and is then arrested at the point 730 after having advanced the shaft 155 subtractively through one digital position to effect the subtractive carry into the tens order, so that the type wheel 158 of the consumption quantity printer now displays the character "3" at printing position. In this connection it is to be noted that the energization of the code magnet T-1 at point 727 is appreciably later than the time at which the last selector stop shaft, in this instance 188-T, has been returned to its home position at point 719 during restoration of the selectors following the entry of the previous meter reading. This insures that there will be no false entry due to premature initiation of the carry-over operation, such interrelation in the operation of the parts being achieved due to the relatively long release time of the slow-to-release relay 222.

Relay 216, Fig. 9, was energized at point 731 while the code magnet T-1 was being energized and hence ground is available on the pulsing contact 218-T. Shortly prior to the completion of the advancing movement of the selector shaft 188-T, the contact 218-T momentarily closes to energize the slow-to-release relay 221 at point 732. This is followed by the energization of the slow-to-release relay 222 at point 733. Inasmuch as the shaft 188-T is arrested at point 730, Fig. 30, the slow-to-release relay 221 is not subsequently energized after receiving the initial impulse, and hence it completes its deenergization at point 734, whereupon the slow-to-release relay 222 starts to deenergize at point 735. Deenergization of the relay 221 at point 734 causes the winding of the sequence control relay 144, Fig. 8, to be short-circuited in the manner described hereinabove, at point 736. The consequent deenergization of the relay 144 at point 737 results in the deenergization of the sequence relay 133 at point 738.

As the several contacts of the sequence relay 133 open, the clutch magnet 186, the reversing magnet 196-T, and the code magnet T-1, Fig. 9,

are deenergized at points 739, 740 and 741, respectively, and at the last-mentioned point the selector stop shaft 188-T commences its restoring movement. The relay 216 commences to deenergize at point 742 concurrently with the code magnet T-1, so that ground will not be available to the pulsing contact 218-T during restoration of the selector. In the time interval which elapses between the chart lines designated I and I', Figs. 27 and 28, the stop arm 202-T and selector shaft 188-T are rotated through approximately eight digital positions in their restoring movement, arriving at the eighth position at the point 743, Fig. 31. At the point 744, the ninth position is attained and at this point the arm 202-T is arrested by the home stop pin of the selector 189-T, inasmuch as the digit 1 was previously set up on this selector. Shortly prior to complete restoration of the selector 189-T, the slow-to-release relay 222 deenergizes at point 745 and initiates the energization of the sequence control relay 144 at point 746. The relay 144 energizes at point 747 and releases the sequence relay 136 at point 748 to thereby initiate the money charge entry operation.

ENTRY OF MONEY CHARGE

The money charge corresponding to the consumption quantity 039, or \$2.34 according to the rate schedule for which the product tables, Figs. 10, 11 and 12, are wired, is to be set up on the type wheels 285, 286 and 287, Fig. 14, that print the amount of the bill on the body of the sheet S, and also on the type wheels 288, 289 and 290, which print a duplicate of this amount on the stub of the sheet S. A corresponding entry of the money charge amount is also to be made in a selected totalizer such as 329-330-331, Fig. 17. All of these entries are effected by the wheel units 291, 292 and 293, Fig. 17, which respectively enter digits in the hundreds, tens and units orders.

When contact 136D of relay 136 closes at point 138, it extends ground through a contact 137F of the sequence relay 137 to a conductor 137J, Figs. 8 and 13, which is connected to conductors 266 and 267 of the zero-controlling circuits. The conductor 137J also appears in Fig. 12 where it is connected to the conductors 232 and 233 of the product table circuits. The contact-closing wheels 157D, 158D and 159D, shown in Fig. 13, and the contact-closing wheels 157C, 158C and 159C, shown in Fig. 10, are all included in the consumption quantity accumulator wheel units, an exploded view of one of these wheel units being shown in Fig. 20. Referring to Fig. 9, where the various contact-closing wheels of the consumption quantity accumulator are shown in front elevation without their associated contacts, the wheels 157C and 157D in the hundreds order are in their zero positions; the wheels 158C and 158D in the tens order are in a position to represent the digit 3; and the wheels 159C and 159D in the units order are in a position to represent the digit 9.

Considering first the zero-controlling circuits, Fig. 13, the multiple contact switches 263, 264 and 265 are maintained closed by the lobes on the wheels 157D, 158D and 159D to represent the consumption quantity 039. As has been explained fully hereinabove, the grounding of the conductors 137J, 266 and 267 at point 748, Fig. 28, under the present circumstances, results in the energization of the relay 273, Fig. 13, at point 749, thereby causing ground to be applied on the conductors 276-U, 276-T and 276-H, Figs. 13 and

18, thus indicating that significant digits will be present in all three orders of the product or money charge computed on the basis of the aforesaid consumption quantity. Hence the relays 301, 310 and 311, Fig. 18, are energized at points 750, 751 and 752, respectively, Fig. 31.

It has been explained that the relay 304, Fig. 18, was selected and energized at point 531b, Fig. 29, under control of the coded contact relays 121 to 124, inclusive, Fig. 7, in accordance with the classification of the particular customer for whom the bill is to be prepared. Hence, this relay 304 will maintain its contacts 304A to 304E, inclusive, closed until the final sequential operation of the machine, as will be seen hereinafter. When relay 301 in the hundreds order energizes at point 750, it closes its contacts 301A and 301B and thereupon ground is extended from a conductor 302 through the contact 200B of the relay 200 (which relay is deenergized at the present time) and the closed contacts 301A and 301B to conductors 303 and 305. The conductor 303 leads to a contact 304C of the relay 304 so that ground is continued through this relay contact to the conductor 443, Figs. 18 and 17, leading to the winding of the clutch magnet 344 for the hundreds order number wheel unit 320 of the selected totalizer associated with the relay 304. In like manner, ground is extended through contacts 303B and 300B of the relays 300 and 309, and thence through contacts 310A and 311A of the relays 310 and 311, conductors as 440 leading from these contacts to the contacts 304B and 304A, respectively, of the relay 304, and conductors 500 and 442, Figs. 18 and 17, to the windings of the clutch magnets 345 and 346 for the tens and units order number wheel units 330 and 331, respectively, of the selected totalizer. Hence, the magnets 344, 345 and 346 energize at points 753, 754 and 755, respectively, Fig. 31, and clutch their number wheel units to the sleeves as 343 on the shaft 336, which sleeves are connected through gear trains as 339—340—341—342 to the respective entry-effecting wheel units as 201 in the corresponding orders. Thus selection and conditioning of the totalizers 320—330—331 for operation has been effected. If the relay 306, Fig. 18, had been selected and energized instead of the relay 304, a different totalizer (not shown in Fig. 17 but indicated diagrammatically in Fig. 23) would have been selected to be operated by the entry-effecting wheel units 201, 202 and 203.

Energization of the relays 301, 310 and 311 in the manner explained causes ground to be extended from the relay contacts 200B, 300B and 309B through the relay contacts 301B, 310B and 311B to the conductors 305, 441 and 501 which lead to the windings of the clutch magnets 204, 205 and 206, respectively, of the hundreds, tens and units order entry-effecting wheel units 201, 202 and 203, bringing about the energization of these clutch magnets at points 756, 757 and 758, respectively. The clutches 201M, 202M and 203M, Fig. 17, therefore, are engaged to couple these wheel units to the shaft 163, Figs. 9, 14 and 17.

The contact-closing wheels 157C, 158C and 159C, Fig. 10, of the product table circuits are so positioned that the lobes thereon maintain the multiple contact switches 236 and 237, Fig. 11, and 238, Fig. 12, closed to represent the consumption quantity 039. Under these circumstances, the grounding of the conductor 137J, Figs. 8 and 12, at points 748, Fig. 28, and the consequent grounding of conductors 232 and 233 results,

among other things, in the energization of the relay 244 at point 759. As explained under the heading "Product tables," certain of the digit-representing conductors in the cables 235-H, 235-T and 235-U, Figs. 12 and 18, are grounded, these conductors being 235H-2, 235T-3 and 235U-4. The grounding of these conductors is indicative of the money charge of \$2.34 which is to be entered, and certain of the circularly arranged contacts (namely, 201C-2, 202C-3 and 203C-4) associated with the contact-closing wheels as 201C, Fig. 18, of the entry-effecting wheel units as 201, Fig. 17, are conditioned by such grounding of the digit-representing conductors for controlling the entry of the digits 2, 3 and 4 in the respective orders.

When the conductor 137L, Figs. 7, 8 and 9, is grounded upon closure of the sequence relay contact 136E, the winding of the relay 203, Fig. 9, is potentialized at point 760, and this relay thereupon energizes at point 761, Fig. 31, at which point the contact 203A thereof closes. The contact 203B is delayed in its closure until a slightly later time (point 762), the purpose of such sequential operation of the contacts 203A and 203B being explained presently. Closure of contact 203A completes a circuit from the grounded contact 222B of the slow-to-release relay 222 through the conductor 446 and contact 203A to the winding of the code magnet U-3 of the units order selector 180-U, potentializing this magnet at point 763 and energizing it at point 764. As can be seen by reference to Fig. 2, the energization of the code magnet U-3 alone would ordinarily serve to render the selector 180-U operative for entering a digital value of 2. Stop arm 202-U, shaft 180-U, and toothed wheel 218-U, therefore, start to rotate at point 764. When the relay contact 203B closes at point 762, it extends ground through the conductor 445 to the conductor 215 leading to the winding of the relay 216, potentializing this relay at point 765. At point 766 the relay 216 energizes and closes its contact 216A to supply ground to the pulsing contacts as 218-U, associated with the toothed wheels as 216-U. Furthermore, when the relay contact 203B closes and applies ground directly on the winding of the relay 216, the code magnet U-3 is short-circuited and commences to deenergize at the point 767, completing such deenergization at the point 768.

As indicated on the timing chart, Fig. 31, the release of the code magnet U-3 at point 768, and the consequent restoration of the code disc D-3, Fig. 9, occurs at a time when the stop arm 202-U will have rotated away from its home or zero position and preferably at approximately the time this stop arm attains a position representative of the digit 1 at point 769. Hence the selected stop pin as 200, Figs. 19 and 19A, which would ordinarily have been positioned to arrest the stop arm 202-U in a position representative of the digit 2, is retracted out of the path of movement of such arm before it attains this position at point 770, and consequently the selector shaft 180-U rotates through a complete revolution until the stop arm 202-U is arrested by the home stop pin 200', Fig. 19, at point 770, after having been continuously advanced through ten digital positions. The code magnet U-3 has been utilized in the present instance to so operate the selector 180-U that the shafts 180-U and 163 are caused to rotate through 360 degrees, for the purpose presently to be explained. However, it is apparent that it would be feasible to

employ another code magnet such as U-2 or U-4 for this purpose.

Prior to the time the stop arm 202-U has advanced to the first digital position at point 769, the toothed wheel 219-U momentarily closes its contact 218-U and energizes the slow-to-release relay 221 at point 779, this being followed in turn by the energization of the slow-to-release relay 222 at point 780. As the selector shaft 188-U is advanced successively into the various digital positions at times indicated by the points 769 to 778, inclusive, in the course of its rotation, the contact 218-U repeatedly closes and opens. The contact 203B of the relay 203 maintains ground on the winding of the relay 216 to continue the supply of ground to the contact 218-U by way of the relay contact 216A, so that the slow-to-release relay 221 is repeatedly energized without at any time completely deenergizing until the selector shaft 188-U has come to rest at the end of its revolution (point 778). The slow-to-release relay 222 is, therefore, maintained continuously energized and holds its contact 222B open to deprive the winding of the code magnet U-3 of this source of ground.

It has been mentioned that certain of the circularly arranged contacts associated with the contact-closing wheels 291C, 292C and 293C, Fig. 18, of the entry wheel units 291-292-293, Fig. 17, are conditioned for controlling the entry of the money charge, \$2.34, these contacts being 291C-2, 292C-3, and 293C-4. Since these wheel units are all clutched to the shaft 163, Figs. 9 and 17, they commence to rotate with the shaft and the contact-closing wheels as 291C are concurrently rotated. As the lobe 291X of the wheel 291C closes the contact 291C-2, ground is extended from the conductor 235H-2 through the common conductors 297 and 298 to the exciting winding of the double wound relay 299, potentializing this relay at the point 781. The relay 299 energizes at point 782, opening its contact 299B and closing its contact 299A. Closure of the contact 299A establishes a holding circuit through the holding winding of the relay 229 to the conductor 343H, Figs. 18 and 8, which receives ground at the relay contact 143D. Opening of the relay contact 299B deprives the contacts 301A and 301B of the relay 301 of ground and, therefore, deenergizes the clutch magnets 294 and 344, Fig. 17, at points 783 and 784, respectively, whereupon the wheel units 291 and 329 cease rotation. Preferably the contacts as 291C-2 of the cams as 291C are so located with respect to the normal rest position of the lobe 291X that ample time is allowed to enable the hundreds order wheel units 291 and 329 to come to rest when the shaft 163 has completed exactly two digital steps of movement (point 770). If it should happen that this time allowance is too great and the wheel units have not attained the exact position, the full-step contacts 329J and 291J operate to accurately center the wheel units as described hereinabove.

In a similar manner, the double wound relay 308 in the tens order is potentialized at point 785 when the lobe 292X on the cam 292C closes the contact 292C-3, and this relay energizes at point 786 to close its contact 308A and open its contact 308B. Closure of the contact 308A establishes a holding circuit for the relay 308 by way of the conductor 143H, while opening of the contact 308B results in the deenergization of the clutch magnets 295 and 345 of the wheel units 292 and 330, respectively, at points 787 and 788. 75

Hence, these wheel units come to rest when the shaft 163 has rotated through three digital positions at point 771. Likewise, the relay 309 is potentialized at point 789 when the lobe 293X of the cam 293C closes the contact 293C-4. This relay energizes at point 790, opening the contact 309B and closing the contact 309A. Closure of contact 309A establishes a holding circuit through conductor 343H, while opening of the contact 309B deenergizes the clutch magnets 296 and 346 of the wheel units 293 and 331, respectively, at points 791 and 792, at which time the shaft 163 will have completed four digital steps of movement (point 772).

The result of the aforesaid operations is that the digits 2, 3 and 4 are entered in the totalizer wheel units 329, 330 and 331, respectively. These digits are also set up in duplicate on the type wheels 285 and 288, 286 and 289, 287 and 290, respectively, Fig. 14, which are driven through the above described sleeved interconnections by the entry-effecting wheel units 291, 292 and 293, Fig. 17. It will be assumed for the present that the carry-over contacts as 330G and 331G on the tens and units totalizer wheel units 330 and 331 do not close in the course of the money charge entering operation, which is to say, that the number wheels 330A and 331A are not carried beyond the positions pertaining to the digit 9. Under these circumstances the sequence relays 138, 139, 140 and 141, Fig. 8, remain deenergized. A carry-over operation on the totalizer wheels will be subsequently described.

When the slow-to-release relay 221 deenergizes at point 793, Fig. 31, following the return of the selector stop arm 202-U, Fig. 9, to its zero position and the cessation of movement of the shaft 163 at point 778, it initiates deenergization of the slow-to-release relay 222 at point 794. Contact 221B of the relay 221 closes and grounds out the winding of the sequence control relay 144, Fig. 8, at point 795, causing this relay to deenergize the point 796. The sequence relay 137 is thereupon released at point 797, removing ground from the conductors 137L and 137J and releasing the relays 203, 244 and 273, Figs. 9, 12 and 13, at points 798, 799 and 800, respectively. As relay 203 releases, it opens its contact 203B and releases the relay 216 at point 801. Inasmuch as the conductor 137J, Figs. 8 and 12, has been deprived of ground, ground is no longer available to the product-representing conductors 235H-2, 235T-3 and 235U-4. The release of relay 273, Fig. 13, removes ground from the conductors 276-U, 276-T and 276-H, thereby releasing the relays 301, 310 and 311 at points 802, 803 and 804, respectively. Relays 299, 308 and 309 remain locked up through their holding circuits including the conductor 143H.

In the time interval intermediate the chart lines II and II', Figs. 28 and 31, the slow-to-release relay 222 continues to deenergize, and it becomes completely deenergized at the point 805 whereupon the winding of the control relay 144, Fig. 8, is potentialized at point 806. Upon energization of relay 144 at point 807, the sequence relay 142 is released at point 808.

PRINTING AND ZERO-SETTING; PAPER FEED

The amounts of the last and previous meter readings, 455 and 416, respectively, and the consumption quantity 039 having been set up on the type wheels 151 to 159, inclusive, Fig. 9, of the appropriate printers, and the money charge or bill amount having been set up in duplicate on

the type wheels 285 to 299, inclusive, Fig. 14, for printing this amount on the body and stub of the sheet S, the machine is in readiness for the performance of the printing and zero-setting operations.

When the sequence relay 142 deenergizes at point 808, its contact 142A closes and applies ground on the conductor 143K, Figs. 8 and 16, leading from the contact 143G of sequence relay 143 to the winding of the clutch magnet 371 that controls the cam shaft 362 of the printing unit, this occurring at point 809, Fig. 31. At point 810 the magnet 371 energizes and retracts the latch 370 from the notch in the cam 360. Motor M1 thereupon commences to drive the shaft 362 through the medium of the friction clutch 354a. In the interval of time between the chart lines III and III', Figs. 28 and 31, the hammer actuating cams 349, Figs. 9, 14, 15 and 16, on the shaft 362 draw the hammers H away from the printing line and then release these hammers so that they snap against the sheet S, ribbon R and the aligned type wheels to thereby record on the sheet S the various items set up on these type wheels. The shaft 362 continues to rotate and the cam 373 momentarily closes its contact 373A, thus extending battery through the conductor 375, Figs. 16 and 9, to the winding of the zero-setting relay 205. The other end of this winding being grounded, the relay 205 energizes at point 811, closing its contacts 205B to 205Q, inclusive, and opening its contacts 205A and 205R. Closure of the contact 205B applies ground on the conductor 460, Figs. 9 and 1, that is connected to the conductor 60 which is a part of the holding circuit for the main control relay 58. Hence, relay 58 is maintained energized by the relay 205 even though the sequence relay 143 is deenergized at a later point in the operation.

Opening of the contacts 205A and 205R of the relay 205 removes ground from the conductors 434 and 464, Figs. 9 and 17, leading to the carry-over contacts as 158G of the consumption quantity accumulator and the full-step contacts as 201J of the entry-effecting wheel units 291, 292 and 293. Closure of the contacts 205D to 205Q, inclusive, of the relay 205 establishes a circuit from ground through the winding of the relay 205 to each of the zero-setting contacts of the various entry-effecting wheel units and thence, if such contact is closed, through the connected clutch magnet winding to battery. For example, the contact 205D, in closing, connects the windings of the clutch magnet 171 and the relay 205 in series inasmuch as the zero-setting contact 151H associated with the type wheel 151 is closed because of the off-zero position of this type wheel. Similarly, the clutch magnet of every other entry-effecting wheel unit which has an off-zero setting is connected in series with the winding of the zero-setting relay 205. Hence, holding circuits are established for the relay 205 through such zero-setting contacts until all of the type wheels have been returned to their zero positions. The type wheel 157, Fig. 9, of the consumption quantity printer is standing at zero inasmuch as the consumption quantity is 039 and hence its zero-setting contact 157H is open so that the clutch magnet 185 does not become energized. However, the clutch magnets 171, 172, 173, 182, 183, 184, 186, 187, 204, 205 and 206, Figs. 9 and 17, are respectively energized at the points 812 to 822, inclusive, to clutch their number wheel units to the shafts 163, 165 and 168, as the case may be.

Closure of the contact 205B of the relay 205

applies ground on the winding of the relay 204, Fig. 9, whereupon this relay energizes at point 823 and closes its contacts 204A, 204B and 204C. Circuit is then extended from ground at the contact 222B of the relay 222 through conductor 446 and the just-mentioned relay contacts to the windings of the code magnets U-3, T-3 and H-3. These magnets thereupon energize at the points 824, 825 and 826, respectively, to initiate rotation of the selector shafts 188-U, 188-T and 188-H. Relay 216 being concurrently energized at the point 827, it closes its contact 216A and supplies ground to the pulsing contacts as 218-U. Prior to the time the selector shafts are advanced through the first digital position as represented by the point 828, the contact 218-U momentarily closes and energizes the slow-to-release relay 221 at point 829, which in turn causes the relay 222 to energize at point 830. Contact 222B of relay 222 opens and deprives the code magnets U-3, T-3 and H-3 of ground, whereupon these magnets commence to deenergize at points 831, 832 and 833, respectively. The winding of relay 216 derives its ground solely through the windings of the code magnets in the present instance and hence it, too, is deenergized at point 834, removing ground from the pulsing contacts as 218-U so that the slow-to-release relay 221 cannot be repeatedly energized. Relay 221, therefore, continues to deenergize after the first digital step of movement of the selector shafts and is released at the point 835, whereupon the slow-to-release relay 222 commences to deenergize at point 836.

The sequence control relay 144 is deenergized at point 839 upon the release of the slow-to-release relay 221, and this causes the sequence relay 143 to deenergize at point 840. Contact 143B of relay 143 opens to deprive the conductor 143J of ground, Figs. 8 and 1, but this is without effect upon the relay 58 inasmuch as the conductor 460 has been grounded by the zero-setting relay 205 as aforesaid. Contact 143D opens and removes ground from the conductors 143H, 126 and 127, Figs. 7, 8 and 18, thereby breaking the holding circuit for the relays 299, 308, 309 and 304 and releasing these relays at the points 841, 842, 843 and 855, respectively. Contact 143G opens and removes ground from the conductor 143K, Figs. 8 and 16, deenergizing the magnet 371 at point 844 whereupon the latch 370 is released and engages the periphery of the cam 360 on which it rides until the notch in this cam has again moved into alignment with the nose of the latch.

As the shafts 163, 165 and 168 are driven by the selector units 188-U, 188-T and 188-H, respectively, they advance the type wheels which are clutched thereto, which is to say, all wheels on which significant digits were set up prior to initiation of the zero-setting operation, toward their zero positions. The lowest significant digit was 1, which was set up on the type wheel 155, Fig. 9, in the tens order of the previous reading printer; hence, this type wheel must be rotated through nine digital positions before it attains its zero position. The highest significant digit was 9 on the type wheel 159 of the consumption quantity printer, and hence this type wheel need only be rotated through one digital position to reach its zero position. Prior to the time the drive shaft 163 has moved through one digital position, as indicated by the point 828, Fig. 31, the zero-setting contact 159H associated with the type wheel 159 opens and initiates deenergization of the clutch magnet 187 at point 837. This

magnet deenergizes at point 838 and uncouples the type wheel 159 and its connected wheel unit on the shaft 163 at the instant the type wheel 159 has attained its zero position. In the event that the wheel is not accurately centered, however, the jockey roller 159F cooperates with the star wheel 159E to correct the setting of the wheel.

Drive shafts 163, 165 and 168 continue to advance for a complete revolution until the stop arms 202-U, 202-T and 202-H of the selectors 189-U, 189-T and 189-H attain their home positions at point 845, Fig. 31, after having rotated through ten digital positions. In the course of this advancing movement the zero-setting contacts of the various entry-effecting wheel units open and effect the release of their associated clutch magnets when the corresponding type wheels are returned to their zero positions, most of these operations taking place in the time interval between the chart lines marked IV and IV', Figs. 28 and 31. The last of the wheels to be returned to zero is the type wheel 155, Fig. 9, and its zero-setting contact 155H opens shortly prior to the time at which the shaft 163 has rotated through nine digital positions (point 846). The series circuit through the windings of the clutch magnet 187 and the zero-setting relay 205 is thereupon broken and the magnet 187 deenergizes at point 847. Inasmuch as all of the zero-setting contacts of the various wheel units are now open, the relay 205 releases at point 848 and its contact 205C opens to release the relay 204 at point 849. Contact 205B of relay 205 opens and deprives the conductor 460, Figs. 9 and 1, of ground, thereby effecting the release of relay 58 at point 850.

Contact 58G of relay 58 opens to remove ground from the conductor 115, Figs. 1 and 7, whereupon the previously energized coded contact relays 110, 111 and 121 which had been held locked up through this circuit are released at points 851, 852 and 853, respectively. Deenergization of the counter magnet 120 at point 854 follows the release of the relays 110 and 111, and the ratchet mechanism of the associated counter performs an idle stroke. Contact 58F of the relay 58, in closing, applies ground on the conductor 63, Figs. 1 and 3, and initiates energization of the card feeding clutch magnet 31 at point 856. When the magnet 31 energizes at point 857, it engages the clutch 27 to couple the shaft 26 to the driving motor M, thereby initiating a new card feeding and sensing operation.

Toward the end of the rotation of the cam shaft 362, Fig. 16, the cam 368 momentarily closes its contact 368A to energize the clutch magnet 365 at point 858, Fig. 31, for withdrawing its latch 364 from the notch in the cam 363. The shaft 353 on which the paper feed roll 347 is mounted thereupon takes motion, being driven by the motor M1 through the friction clutch 354 and intermediate gearing, and the printed sheet S, Figs. 9, 14 and 15, is ejected while a new sheet is introduced into the printing mechanism. The magnet 365 deenergizes at point 859 shortly after the shaft 353 commences to rotate and the latch 364 drops back into engagement with the periphery of the cam 363 to ride thereon until the notch in the cam is again brought beneath the nose of the latch, whereupon the shaft 353 and feed roll 347 are arrested.

After all the selector shafts 188-U, 188-T and 188-H, Fig. 9, have returned to their zero po-

sitions at point 845, Fig. 31, the slow-to-release relay 222, Fig. 9, becomes fully deenergized at point 860, thereby removing ground from the conductors 223 and 224, Figs. 9 and 8, and enabling the sequence control relay 144 to become energized if and when the sequence relay 143 is again energized in the course of the following machine operations. It will be noted that initiation of the card feeding operation depends upon the time at which the last type wheel attains its normal zero position and hence this operation could be initiated at approximately the point 828, Fig. 31, if there were no significant digit lower than 9 standing on any of the type wheels prior to zeroizing thereof. However, the duration of the card feeding and sensing operation is preferably such that prior to its completion the selector shafts will have arrived at their zero positions at point 845. Moreover, the timing of the relay 222, Fig. 9, insures that the operations of the machine under control of the sequence relays, Fig. 8, will not commence at least until the point 860 is attained, Fig. 31, at which time the sequence control relay 144 is conditioned for energization upon opening of the relay contact 222A.

CARRY-OVER ON TOTALIZER WHEELS

In the foregoing example of machine operation, it was assumed that no carry-over was required on the totalizer number wheels 329A, 330A and 331A, Fig. 17. For purposes of the present description, however, it will be assumed that the totalizer wheels stood at -108- prior to the entry of the amount -234- thereon. After entry of the latter amount, the wheels 329A, 330A and 331A register -332- which is the sum of 108 plus 234 without carry-over. It is thus necessary to make an additive carry-over of 1 from the units to the tens orders.

The timing chart, Fig. 32, indicates the operation of the relevant parts of the apparatus in effecting a carry-over as just referred to. The relative timing of the operations of certain relays and other members is identical with the relative timing indicated on the timing charts, Figs. 27 and 30, previously described and hence certain points on the two charts bear identical reference characters. Thus, to initiate the operation of entering the money charge, the slow-to-release relay 222 deenergizes at point 745 and causes the sequence control relay 144 to energize at point 747. Sequence relay 136 thereupon deenergizes at point 748, and the relays 203, 244 and 273, Figs. 9, 12 and 13, energize at points 761, 759 and 749, respectively, with the effects hereinabove described, including the energization of the clutch magnets 344, 345, 346, 294, 295 and 296, Fig. 17, at the points 753 to 758, respectively. The code magnet U-3 is energized at point 764 and the selector shaft 188-U thereupon commences to rotate away from its normal zero position. Contact 203B of the relay 203, Fig. 9, closes at the point 762 and shunts the winding of the code magnet U-3 to bring about its deenergization at the point 768, so that the selector shaft 188-U will rotate through 360 degrees. The relays 216, 221 and 222 are energized at the points 766, 779 and 780, respectively, in the manner previously described to control the operation of the sequence control relay 144, Fig. 8, during the money charge entering operation.

The units order number wheel 331A, Fig. 17, which formerly registered the digit 8, attains a position representative of the digit 9 at the point

760, Fig. 32, and thence passes to its zero position at point 770. In passing from 9 to 0 in the course of adding the digit 4 of the money charge to the digit 8 previously registered, the wheel unit 331 momentarily closes its carry-over contact 331G which extends ground through a conductor 461, Figs. 17 and 8, to the center winding of the triple wound sequence relay 138, which relay thereupon energizes at point 870 and closes its contacts 138A, 138C and 138D and opens its contacts 138B, 138E and 138K. Closure of the contact 138A establishes a holding circuit through the left-hand winding of the sequence relay 138, Fig. 8, and contact 137B of relay 127 which is still energized at this time. Contact 138C of the relay 138, in closing, energizes the sequence relay 139 at point 871, Fig. 32. As relay 139 closes its contact 139C, a holding circuit is established through conductor 146 to the grounded contact 144B of the energized relay 144.

At the conclusion of the money charge entering operation, as has been explained hereinabove, the slow-to-release relay 222 releases at point 805 and energizes the sequence control relay 144 at point 807 to thereby release the sequence relay 138 at point 872. Contact 138K of relay 138 closes and extends ground through the contact 138K of relay 139 and a conductor 449 to the winding of the relay 448, Fig. 8, causing this relay to become energized at point 873. Contact 448A of relay 448 is thus opened to remove ground from the conductor 447, Figs. 8 and 17, leading to the full step contacts as 328J of the totalizer wheel units as 328. This prevents the clutch magnets 344, 345 and 346 from being energized by the full-step contacts during the carry-entering operation. Contact 138E of the sequence relay 138 closes and extends ground through the contact 139B of relay 139 to the conductor 139H, Figs. 8 and 18, which is connected in parallel to contacts as 304D of the relays as 304. Relay 304 is still energized at this time inasmuch as it is not released until the final sequential operation of the machine; therefore, circuit continues through relay contact 304D and conductor 465, Figs. 18 and 17, to the winding of the clutch magnet 338. Magnet 338 energizes at the point 874 and engages the clutch 330N to couple the tens order number wheel unit 330 to the shaft 336 which is geared directly to the shaft 163, Figs. 9 and 17.

Contact 138B of sequence relay 138, in closing, applies ground on the conductors 139J and 466, Figs. 8 and 9, which latter conductor leads to the winding of the code magnet U-1. Magnet U-1 and relay 216 commence to energize at points 875 and 876, respectively, and when the magnet U-1 energizes at point 877 the selector shaft 188-U commences to rotate and drives the shaft 163. Stop arm 202-U is arrested at the time indicated by the point 878, Fig. 32, when the shaft 188-U has been advanced through one digital position. Thus, the shaft 163 will have been driven by the selector shaft 188-U in the amount of a single digit and hence the tens wheel unit 330 Fig. 17, of the totalizer is advanced through a digital position so that the number wheel 330A now registers the digit 4 instead of 3. The number wheels of the totalizer, therefore, stand at -342-, which is the correct sum of 108 plus 234. The slow-to-release relays 221 and 222 are energized at points 879 and 880, respectively, due to the momentary closure of the pulsing contact 218-U, Fig. 9, shortly prior to the entry of the carry digit. Inasmuch as there is

no further actuation of the pulsing contact 218-U in the present instance, the relay 221 releases at point 881 and initiates the deenergization of relay 222 at point 882.

The control relay 144, Fig. 8, is short-circuited at point 883 upon deenergization of the relay 138 at point 881, and releases at point 884. Sequence relay 139 releases at point 885 due to the deenergization of relay 144, and opens its several contacts. Contact 139B, in opening, deprives the conductor 139H of ground, thereby removing ground from the conductor 465, Figs. 18 and 17, and deenergizing the clutch magnet 338 at point 886. Wheel unit 330 is thus uncoupled from the shaft 336 so that it is not effected by further rotation thereof. Sequence relay contact 139K opens and releases the relay 448 at point 887. Contact 448A of relay 448 closes and re-establishes ground on the conductor 447, Figs. 8 and 17, leading to the full step contacts as 328J of the totalizer wheel units. It is unlikely that in making a single digital entry any correction of the setting of a totalizer wheel unit as 330 will be required and, therefore, the disabling of the full-step contacts during the carry-entering operation does not materially affect the accuracy of the setting. Moreover, the slight pressure exerted by the spring of each full-step contact upon its co-operating star wheel serves to produce a slight corrective effect upon release of the clutch for such wheel unit.

Sequence relay 138, in opening its contact 138A, releases the code magnet U-1 at point 888. Thereupon the selector shaft 188-U commences to rotate idly toward its home position. After the selector 188-U has thus been zeroized, the slow-to-release relay 222 becomes fully deenergized at point 889 whereupon the sequence control relay 144 energizes at point 807' and releases the sequence relay 142 at point 888 to initiate the printing and zero-setting operations in the manner described hereinabove in connection with Figs. 28 and 31.

The foregoing describes the operation of entering a carry-over into the tens order of the selected totalizer. The sequence relays 140 and 141 operate in a manner similar to that of the sequence relays 138 and 139 to effect a carry entry into the hundreds order of the selected totalizer whenever this is necessary and it is believed that a detailed description of such an operation is not essential to the present disclosure.

OPERATION WITH ZERO CONSUMPTION

When the last and previous meter readings are equal, the consumption quantity is 000 and, therefore, the money charge will likewise be 000 (assuming that no provision is to be made for a minimum charge, an operation which could be effected, for example, in the manner shown and described in my Patent No. 2,176,929).

The contact-closing wheels 157C, 158C and 159C, Figs. 9 and 20, and the contact-closing wheels 157D, 158D and 159D, Figs. 9 and 13, are all restored to zero in the course of the entry of the previous meter reading. Upon completion of this entry, referring to Fig. 33, the slow-to-release relay 222 is deenergized at point 890 and enables the sequence control relay 144 to energize at point 891, whereupon the sequence relay 138, being the next in the chain of operative sequence relays under these circumstances, is released at point 892. Sequence relay contact 136D closes and applies ground on the conductor 137J but this is without effect other than to energize the

relay 244, Fig. 12, at point 883. None of the digit-representing conductors in the cables 236-H, 236-T and 236-U, Figs. 12 and 18, is grounded inasmuch as the product is 000. Likewise, none of the relays 273, 274 and 275, Fig. 13, is energized and hence ground is withheld from the conductors 276-H, 276-T and 276-U, Figs. 13 and 18, so that the relays 301, 310 and 311 cannot energize and the entry-effecting wheel units 291, 292 and 293, Fig. 17, remain uncoupled from the shaft 183.

Sequence relay contact 136E, in closing, applies ground on the conductor 137L, Figs. 8 and 9, causing the relay 203 to become energized at point 884, whereupon the contact 203A thereof closes and potentializes the winding of the code magnet U-3 at point 895. The magnet U-3 energizes at point 896 to effect the release of the stop arm 202-U and thereby initiate rotation of the selector shaft 188-U. The contact 203B of relay 203 closes at point 895' and applies ground on the conductors 445 and 215. The winding of the code magnet U-3 is thus short-circuited and this magnet then deenergizes at point 897 subsequent to the time the stop arm 202-U has advanced away from its home position. The selector shaft 188-U is therefore caused to continue its advancing movement for a full revolution. The relay 216 energizes at point 898 and supplies ground to the pulsing contact 218-U. Upon the subsequent closure of the contact 218-U, shortly prior to the time the selector 189-U has attained a setting representative of the digit 1, at point 899, the slow-to-release relay 221 is energized at point 900 and energizes the slow-to-release relay 222 at point 901.

The selector 189-U operates idly in this instance since no wheel units are clutched to the shaft 183, Figs. 9 and 17, and at the point 902, Fig. 33, the selector shaft 188-U and stop arm 202-U will have returned to their normal home or zero positions, at which point they are arrested by the home stop pin as 208', Fig. 19. The slow-to-release relay 221 subsequently deenergizes at point 793 and initiates deenergization of the relay 222 at point 794. From this point on the operation is identical with that described hereinabove in connection with Figs. 28 and 31. For instance, the sequence control relay 144 is released at point 796 to thereby release the sequence relay 137 at point 797. This results in the release of the relays 203 and 204 at points 798 and 799, respectively, and there is no further effect until the slow-to-release relay 222 releases, following which the printing, zero-setting and paper feeding operations occur.

It will consequently be seen from the foregoing that when the last and previous meter readings are of identical value, the money charge entering operation is idle and the type wheels 285 to 290, inclusive, Fig. 14, all remain at their zero positions.

OPERATION WITH A METER READING OF 000

In the following description it will first be assumed that the last meter reading was 455 and the previous meter reading 000. Referring to Fig. 34, the slow-to-release relay 222 deenergizes at point 636 at the conclusion of the last meter reading entry-effecting operation, as was described previously in connection with Figs. 27 and 30, whereupon the sequence control relay 144 is energized at point 638 to release the sequence relay 130 at point 639. Relay 150 energizes at point 640 and energizes the clutch magnets 182

to 187, inclusive, Fig. 9, at points 647 to 652, respectively. Energization of relay 150 also causes the reversing magnet 196-U to become energized at point 659, and the relays 428A and 429A to energize at points 653 and 654 for initiating energization of the reversing magnets 196-T and 196-H at points 655 and 656, respectively.

When sequence relay 130 deenergized at point 639, it energized the shift relay 99 at point 661; however, since none of the storage relays, Fig. 7, in the previous reading group is energized, none of the code magnets of the selectors 189-U, 189-T and 189-H, Fig. 9, is operated and, therefore, the selector shafts remain stationary. Inasmuch as the previous reading storage relays are all in a deenergized condition, the relay 102 remains unenergized. Therefore, when shift relay 99 energizes at point 661 it closes its contact 99N to cause a circuit to be extended from ground at the closed contact 102A of relay 102, through the conductors 468 and 470, Figs. 7 and 8, to the conductor 224 leading to the winding of the sequence control relay 144. The relay 144 is thus shunted out of circuit and deenergizes at point 903. Deenergization of relay 144 releases the sequence relay 131 at point 904. Opening of the relay contact 131J releases the relay 150 at point 905 and hence the clutch magnets 182 to 187, inclusive, and the reversing magnet 186-U are all released at the points 908 to 914, respectively. Relays 428A and 429A deenergize at points 906 and 907 following the release of relay 150. The magnets 196-T and 196-H do not have sufficient time to attain a state of full energization, and following the deenergization of the relays 428A and 429A at points 906 and 907, respectively, the magnets 196-T and 196-H are deenergized at points 915 and 916.

When sequence relay 131 deenergizes at point 904, it also opens its contact 129G and releases the shift relay 99, Fig. 7, at point 917. Contact 99N of this shift relay thereupon opens and removes ground from the conductor 470, enabling the control relay 144 to energize at point 918. Sequence relay 132 is thereupon released at point 919 to initiate the operation of entering the money charge in the manner hereinabove described.

It will thus be seen that when the previous meter reading is 000, the wheel units of the previous reading printer 154-155-156, Fig. 9, and the consumption quantity accumulator and printer 157-158-159 remain stationary during that portion of the operation in which the previous meter reading is ordinarily entered. Hence, the type wheels 157, 158 and 159 of the consumption quantity printer register the same amount as the type wheels 151, 152 and 153 of the last reading printer, while the type wheels 154, 155 and 156 of the previous reading printer all stand at zero.

It will now be assumed that the last meter reading was 000 (in reality, 1000) and the previous reading 416. The difference between 000 (or 1000) and 416 is 584.

The operation of entering the last meter reading is similar to that previously described for the entry of a meter reading of 000. Thus, in Fig. 7, the relay 108 will be in a deenergized condition at the time the shift relay 100 is energized at point 582, Fig. 35, such operation of the relay 100 being brought about in the same manner as was explained hereinabove in connection with the timing charts shown in Figs. 26 and 29. Hence, there is an indication of an 000 condition, and when the contact 100N of the shift relay 100 closes, ground is extended from the contact 102A

of relay 102 through the conductors 468, 470 and 224 to the winding of the sequence control relay 144, Fig. 8, causing this relay to be shunted out of circuit at point 920 and deenergized at point 921 so that the sequence relay 129 is released at point 922. The contact 129G of relay 129 opens to remove ground from the conductor 129H and thereupon the shift relay 100 is released at point 923. The clutch magnets 171, 172 and 173 of the last reading printer, Fig. 9, and the clutch magnets 185, 186 and 187 of the consumption quantity printer were energized at points 575 to 580, respectively, in the manner previously described in connection with Figs. 26 and 29, but when the sequence relay 129 is deenergized at point 922 it releases the relay 149 at point 924 and thereby releases the aforesaid clutch magnets at points 925 to 930, respectively. Inasmuch as there were no storage relays locked up in the last reading group, none of the code magnets of the selectors 189-U, 189-T and 189-H, Fig. 9, are energized and, therefore, the selector shafts remain stationary in the present instance.

When the shift relay 100 deenergizes at point 923, Fig. 35, it opens its contact 100N and removes ground from the conductors 469 and 470, Figs. 7 and 8, thereby enabling the control relay 144 to energize at point 931, whereupon the sequence relay 130 is released at point 639 to initiate the operation of entering the previous meter reading. This operation is conducted in substantially the same manner as was explained in connection with Figs. 27 and 30, and, therefore, reference may be had to such description for a more detailed explanation.

In the course of entering the previous meter reading of 416, the carry-over contact closing wheels 157B, 158B and 159B, Fig. 9, of the consumption quantity accumulator, are first driven backwardly from their zero positions to positions representative of the digit 9, which latter positions they attain at the point 669, Fig. 35. In such movement these wheels momentarily close the carry-over contacts 157G, 158G and 159G. Closure of the contacts 158G and 159G energizes the sequence relays 132 and 136, Fig. 8, at points 932 and 933, respectively, thereby indicating that subtractive carry-overs must be made from the units to the tens, and tens to hundreds orders, respectively. Closure of the carry-over contact 157G is without effect since in the present structure the capacity of the consumption quantity accumulator is limited to three orders and hence no carry need be made into the thousands order. The sequence relays 132 and 134, in energizing, close their contacts as 132D and energize their mates, relays 133 and 135, at points 934 and 935, respectively. Contact 132A of relay 132, in closing, establishes a holding circuit for this relay through the conductor 437 and contact 131F of sequence relay 131 so that the energized condition of the control relay 144 does not affect the relay 132 so long as the relay 131 remains energized. Similarly, the contact 134A of sequence relay 134 closes a circuit from ground at the contacts 131F and 133F of the sequence relays 131 and 133, respectively, to one of the windings of the relay 134 to maintain this relay energized until after the sequence relay 133 has been released.

After the digit 6 of the previous meter reading has been entered into the consumption quantity accumulator, at point 674, Fig. 35, the slow-to-release relay 221 releases at point 679 and initiates the deenergization of the slow-to-re-

lease relay 222 at point 680. This is followed by the deenergization of the sequence control relay 144 at point 682 and the release of the sequence relay 131 at point 683. Thereupon the locked up storage relays in the previous reading group are released, as well as the clutch magnets 182 to 187, inclusive, and other parts as described hereinabove. The selectors are restored, the last stop arm (202-T in this instance) attaining its zero position at the point 719. The type wheels 157, 158 and 159 of the consumption quantity printer at this point register the digits 6, 9 and 4, respectively, at the printing line, this being the difference between 000 (or 1000) and 416 without carry-over.

Shortly prior to this, the slow-to-release relay 222 releases at point 720 and energizes the control relay 144 at point 722. Sequence relay 132 thereupon releases at point 723 and closes its contacts 132B and 132C. Closure of the contact 132B extends ground through the contact 133B of sequence relay 133 and the conductor 133K, Figs. 8 and 9, to the winding of the clutch magnet 186 in the tens order of the consumption quantity accumulator, and hence this magnet is energized at point 728. Contact 132C of sequence relay 132 closes and applies ground on the contact 133J of sequence relay 133 and thence ground is extended through conductors 428 and 429, Figs. 8 and 9, to the winding of the reversing magnet 186-T, so that this magnet energizes at point 729.

Contact 132C of relay 132 also extends ground through contact 133C of relay 133 and the conductor 133H, Figs. 8 and 9, to the winding of the code magnet T-1, energizing this magnet at point 727 and concurrently energizing the relay 216 at point 731. The selector shaft 188-T is, therefore, advanced through one digital position until the point 730 is attained, as described previously under the heading "Carry-over in consumption quantity subtraction," and in the course of such advancing movement the relays 221 and 222 are energized at points 732 and 733, respectively. Relay 221 deenergizes at point 734 and effects the deenergization of the sequence control relay 144 at point 737. This causes the sequence relay 133 to be released at point 738 whereupon the clutch magnet 186, the reversing magnet 196-T, and the code magnet T-1 are deenergized at the points 739, 740 and 741, respectively. The resetting of the selector shaft 188-T commences at point 741 and is completed at point 744.

At point 745' the slow-to-release relay 222, which commenced to deenergize at point 735, is released and sequence control relay 144 thereupon energizes at point 747' to deenergize the sequence relay 134 at point 936. Sequence relay 137 being still energized at this time, the conductor 135K is grounded to energize the winding of the clutch magnet 185, Fig. 9, in the hundreds order of the consumption quantity accumulator, at point 937. Ground is likewise extended through conductors 438' and 428 to the winding of the reversing magnet 196-T, and this magnet energizes at point 938. Ground is also applied on conductor 135H leading to the winding of the code magnet H-1, Fig. 9, so that this magnet and the relay 216 are energized at points 939 and 940, respectively. The selector shaft 188-H thereupon advances through one digital position and is arrested at the point 941, by which time the carry digit of 1 will have been entered into the hundreds order of the consumption quantity accumulator.

Pulsing contact 218-H is momentarily closed in

the course of entering the carry digit and energizes the slow-to-release relay 221 at point 942 whereupon the slow-to-release relay 222 is energized at point 943. Relay 221 thereafter deenergizes at point 944 to initiate deenergization of the relay 222 at point 945. Contact 221B of relay 221 closes and grounds out the winding of the control relay 144, Fig. 8, causing this relay to deenergize at point 946 and release the sequence relay 135 at point 947. Relay 135 opens its several contacts and removes ground from the windings of the clutch magnet 185, reversing magnet 186-H, code magnet H-1 and relay 216, Fig. 9, these parts being then released at the points 948 to 951, respectively. The selector shaft 188-H returns to its zero position at the point 952. Slow-to-release relay 222 deenergizes at point 745 and enables the control relay 144 to energize at point 747. The sequence relay 136 is thereupon released at point 748 to initiate the money charge entering operation as described hereinabove in connection with Figs. 28 and 31.

Thus the type wheels 157, 158 and 159 of the consumption quantity printer are adjusted to correctly register the amount 584 at the printing line, this being the difference between 1000 and 416. Hence, it will be understood that the machine is able to properly perform consumption quantity computing operations in any case where the previous meter reading is apparently greater than the last meter reading (so long as the actual values of the two readings do not differ by more than 999) as well as in cases where the opposite is true, or where the two meter readings are equal in value.

OPERATION WITH CARD INACTIVE

Where a card C, Fig. 1 is to be rendered inactive, the perforation 15A may be omitted or, alternatively, this perforation, if present, may be covered by a suitable adhesive strip 16 or the like. When the card C is fed through the sensing station, the position on the card normally occupied by the perforation 15A will come into alignment with the sensing brush 44. At this time the lobe 51 on the cam 48 is engaging the rider 53 to engage this rider with the contact 54. Inasmuch as brush 44 is withheld from contact with the grounded bar 43, due to absence of the perforation 15A, ground cannot be extended at this time through conductor 56, cam contact 54, or conductor 57 to the winding 58A of relay 58 and this relay therefore does not energize. Contact 58J of relay 58, therefore, cannot impress battery upon the selecting switch 65 and therefore none of the transfer brushes 70A, 70B or 70C, Fig. 6, will be potentialized. Therefore, none of the brushes on the drum D which are brought into contact with the strips 68A, 68B or 68C will be able to derive potential from the brushes 70A, 70B or 70C. Thus, battery cannot be impressed upon the windings as 84A of any of the storage relays as 84 and therefore the perforations in the meter reading fields of the card C are not effective to cause energization of the storage relays.

The special perforations as 15B, 15C and 15D aligned with the sensing brush 44, Fig. 1, are likewise ineffective, for although these perforations cause ground to be extended through sensing brush 44, conductor 56 and cam contact 55 to the contact 58H of relay 58, this relay is not energized and therefore the contact 58H is open. Hence the brush 82 on the drum D, Fig. 6, is unable to extend ground through the conductive

strips 80 and 79 and brushes cooperating therewith to any of the coded contact relays, Fig. 7, in the sets including the relays 110 and 121, so that there will be no actuation of any of the counter magnets as 120 for counting meters by types, and no selection of a totalizer according to customer's classification.

Contact 58F of relay 58 remains closed throughout the entire card feed cycle, inasmuch as relay 58 was not energized. Thus, although the opening of cam contact 50B at the close of the card feed cycle removes ground from conductor 64 connected to conductor 63, ground will nevertheless be supplied to conductor 63 through relay contact 58F from the closed starting switch 62. Thus the card feed clutch magnet 31, Fig. 3, remains energized to maintain clutch 27 engaged, and the card feeding operation continues uninterruptedly unless and until a card as C having an active perforation as 15A has passed through sensing position whereupon further card feeding operations are suspended while the machine goes through its regular operation as described hereinabove.

SUMMARY

It will be manifest from the foregoing description that I have provided a machine which, in the illustrated embodiment, is primarily useful in public utility billing. Such usage only requires that representations of a past month's or previous meter reading and of a present month's or last meter reading need be afforded and through the intermediary of devices provided in the machine such meter readings are subtracted one from the other and then through the intermediary of other devices, the product tables, the consumption quantity, ascertained by the aforesaid subtraction, is, in effect, multiplied according to a sliding rate scale and the resulting ascertained amount is entered in means from which such amount may be printed, the two meter readings and the difference therebetween or the consumption quantity also being entered in suitable means from which impressions may be made therefrom. The aforesaid printing means are arranged in such positions that impressions are made therefrom at proper positions on a public utility bill or the like and certain of the mechanisms, in this instance the mechanism from which the ascertained amount is printed, are so arranged that impressions will be made on both the main body and the stub usually included in a public utility bill. In connection with this latter, it will be understood from what has been described hereinabove that additional printing means could be provided for printing on additional stubs that might be included in the bill. Moreover, means could be provided for printing data which, in accordance with the herein illustrated embodiment of the invention is only printed on the main body, also on a stub or stubs included in the bill.

One of the important advantages of the present invention is that the representations of meter readings or other data may be afforded in a code in such a way that but very small space need be provided to accommodate such representations and this enables a far greater number of representations to be accommodated on a card of given size than has heretofore been possible. The foregoing entails dividing the card into zones, each containing a plurality of fields, and providing mechanism under control of which only a selected zone or zones, or a field or fields, may be rendered

operative, and in the illustrated form of the machine this arrangement is afforded by switch 65, Fig. 1, for selecting the zones, and the selecting device including the pointer 42, Fig. 145, for selecting the fields.

Furthermore, by my invention I am enabled to rapidly feed a card or the like, bearing representations of data that are to control machine operations, through a sensing station in the machine, and then, by storing in the machine representations pertaining to data so derived, I am enabled to carry out operations, based on such data or the representations thereof, in a sequential manner in the machine. It will be appreciated that the storage devices are so arranged that data or representations thereof included therein may be utilized or not depending upon the nature thereof, which obviously contributes to flexibility of a machine to which this invention pertains.

Inasmuch as my invention entails the use of permutation devices, in the present instance in the form of code disc selectors, I am enabled to rapidly and accurately effect whatever entries are required in the course of machine operation into registers, accumulators or the like and by reason of the inclusion of such devices in the machine I am enabled to avoid duplication of parts for, first of all, the permutation devices are utilized, in accordance with my invention, to selectively effect entries into a plurality of registers, accumulators and the like and, moreover, duplication of parts is further avoided by reason of the fact that I am enabled to selectively use such devices to effect operations that would ordinarily require the provision of other means for bringing about the functioning thereof.

Additionally, I have provided other entry effecting means which are of such a nature that entries may be made through the medium thereof into registers, accumulators or the like in a rapid and accurate manner and such devices entail the additional advantage of being positive in operation. Furthermore, such devices are of economical construction and are simple in operation and they afford a high degree of flexibility which is, of course, a desirable attribute in machines of this character.

It will be understood that while I have described the present invention with particular relation to a public utility billing machine, it will be susceptible of a wide variety of other uses, and while such other uses may entail some rearrangement of the parts herein illustrated, they will nevertheless include the essential features of my invention that I have herein illustrated and described. Furthermore, while in most instances I have shown the apparatus in such form that it may accommodate numbers of three digital orders, it will be understood that the mere elimination of certain operative parts would permit the handling of numbers of fewer digital orders, and, moreover, by the duplication of herein fully illustrated and described parts, accommodation could readily be afforded for numbers of more than three digital orders. It will be understood that if accommodation is to be afforded for more than three numerical orders this might well entail affording additional apparatus in the mechanism controlling the sequence of operations in order to care for such instances as carry-overs from the hundreds order to the thousands order, and in this connection it should be noted that the utilization of means in the mechanism controlling the sequence of operations for effecting

carry-over operations is an expeditious and economical way of taking care of such carry-overs.

Thus, while I have illustrated and described a selected embodiment of this invention it is to be understood that this is capable of variation and modification and I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. In a calculating machine, a plurality of registers, entering means for each of said registers, shafts cooperating with said entering means to effect differential operation of said registers, entry control means for effecting differential operation of said shafts, sequence control means for controlling entries into said registers, operating means for said sequence control means, and means including members rotatable with said shafts for delaying the operation of said operating means until said shafts come to rest at the end of an entry operation thereof.

2. An entry-effecting means comprising an actuating shaft, a plurality of digit representing wheels rotatably mounted on said shaft and each pertaining to a different digital order, said wheels being selectively positionable in digit representing positions, an electrically operated clutch for each of said wheels each operable to clutch its associated wheel to said shaft, a control circuit for each of said clutches, each of said control circuits including a plurality of parallel branch leads, switch means operatively associated with each of said wheels and operable to connect said parallel branch leads in the associated control circuit in predetermined sequence as its wheel is rotated, primary switch means in said branch leads for selectively conditioning said branch leads for completion of an electrical circuit, a supplemental control circuit for each of said clutches, and means including elements on each wheel for maintaining the supplemental control circuit for the associated clutch closed during the advancing of the wheel from one digit representing position to another to thereby insure positioning of the wheel in the desired digit representing position.

3. In an entry-effecting means, the combination of an actuating shaft, means for rotating said shaft through a one-revolution cycle, a digit representing wheel rotatably mounted on said shaft, said wheel being selectively positionable in digit representing positions, a clutch for connecting said wheel to said shaft for rotation thereby, an electrically operated actuator for said clutch, and a control circuit for said actuator including a plurality of parallel branch leads each of which includes two switches in series, one of the switches in each of the branch leads constituting a conditioning switch, and the other of said switches constituting control switches, means associated with said wheel operable to govern the open and closed relation of said control switches in accordance with the rotative position of said wheel, a supplemental control circuit for said actuator, and means including elements on said wheel for maintaining the supplemental control circuit during the advancing of the wheel from one digit representing position to another to thereby insure positioning of the wheel in the desired digit representing position.

4. In an entry-effecting means, the combination of a driving shaft operable to rotate through one revolution in one operating cycle, a digit representing wheel rotatably mounted on said shaft

and having a plurality of positions one corresponding to each of the digits to be represented, a clutch for connecting said wheel to said shaft, an electrically operated actuator for controlling said clutch, rotary switch means actuated by said wheel and having a different switch element for each of said positions of said wheel, parallel conditioning circuits respectively connected to said switch elements to govern said actuator in accordance with the rotative position of said switching means, individual conditioning switches in each of said parallel conditioning circuits for selectively potentializing the same, circuit means for initially operating said actuator, a supplemental control circuit for said actuator, and means including elements on said wheel for maintaining the supplemental control circuit closed during the advancing of the wheel from one digit representing position to another to thereby insure positioning of the wheel in the desired digit representing position.

5. In an entry-effecting means, the combination of an actuating shaft, means for rotating said shaft through a one-revolution cycle, an entry-effecting wheel rotatably mounted on said shaft, a clutch for connecting said wheel to said shaft for rotation thereby, an electrically operated actuator for said clutch, and a control circuit for said actuator including a plurality of parallel branch leads each of which includes two switches in series, one of the switches in each of the branch leads constituting a conditioning switch, and the other of said switches constituting control switches, means associated with said wheel operable to govern the open and closed relation of said control switches in accordance with the rotative position of said wheel, a supplemental control circuit for said actuator, and means including elements on said wheel for maintaining the supplemental control circuit closed during the advancing of the wheel from one digit representing position to another to thereby insure positioning of the wheel in the desired digit representing position.

6. In a public utility billing machine through which record cards are sequentially fed, each such card bearing coded representations of a present meter reading and each bearing coded record data representative of a previous meter reading, means for sequentially feeding said record data cards through the machine, storage means, means for simultaneously sensing coded record data representative of both the present and previous meter readings from each of said cards without interrupting the movement of the card through the machine, means under the control of said sensing means for simultaneously entering coded record data representative of both the present and previous meter readings in said storage means, a register for receiving the present meter reading, a register for receiving the previous meter reading, and into which the present meter reading is entered upon operation of the third register in one direction and into which the previous meter reading entered upon operation of the third register in the other direction whereby upon completion of such operations the third register displays a consumption quantity, common driving means for said registers, means controlling the connection between said driving means and said registers and operable to connect the register for the present meter reading and said third register to the driving means in one operation of the driving means and to con-

nect the register for the previous meter reading and said third register to said driving means in a succeeding operation of said driving means, permutation means for determining the operation of said driving means and the registers connected thereto, means for first controlling said permutation means under control of the storage means in which the present meter reading is entered and for thereafter controlling said permutation means under control of the storage means in which the previous meter reading is entered, and means for operating the driving means in one direction when the permutation means are under control of the storage means for the present meter reading and in the other direction when the permutation means are under control of the storage means for the previous meter reading.

7. In a machine of the character described including accumulators, a plurality of devices effective when conditioned to control predetermined functions in the course of a cycle of operation of the machine, control means operative each time a function is to be effected and adapted to render said devices effective one after the other in a predetermined sequence, means for conditioning predetermined of said devices for operation in each cycle of operation of the machine whereby said control means may be effective to bring about the functions controlled by such conditioned devices in a selected sequence including repeated entries in said accumulators, and means rendered effective in the course of an entry in an accumulator requiring a carry-over which entry is controlled by one of the devices conditioned in each cycle of operation for selectively conditioning other of said devices for operation whereby when such devices are conditioned for operation said control means will be effective through such other device to cause a carry-over to be introduced in the sequence that is effected when only those devices which are conditioned in each cycle of operation of the machine are conditioned for operation.

8. In a machine of the character described, a plurality of pairs of relays each effective when energized to control a predetermined function in the course of a cycle of operation of the machine, a control relay operative each time a function is to be effected and adapted to control deenergization of the relays of said pairs in a predetermined sequence, means for energizing predetermined of said pairs of relays at the initiation of each cycle of operation of the machine whereby the control relay may be effective to bring about the functions controlled by such energized relays in a selected sequence, and means adapted to be rendered effective in the course of the performance of certain of the functions controlled by the pairs of relays that are energized in each cycle of operation of the machine for energizing other of said pairs of relays whereby when such relays are energized said control relay will be effective to cause the functions to be performed in a sequence different from the selected sequence that is effected when only those pairs of relays that are energized in each cycle of operation are energized.

9. In a machine operable according to data representations borne by a record within selected of a plurality of zones and within selected of a plurality of fields in the respective of the zones, sensing means for sensing data representations in adjacent fields of the zones and including first and second groups of sensing elements, means for moving a record past said sensing means,

means for adjusting said sensing means to locate the same in positions such that said groups of sensing elements sense data representations in selected adjacent pairs of fields in all of said zones, means operable to render said sensing means effective in respect to a selected one of said zones and to render the same ineffective in respect to the other zones of the record, storage means allocated to one group of sensing elements, storage means allocated to the other group of sensing elements, and means operatively associating said sensing means with said storage means to enter data sensed by one group of sensing elements into the storage means allocated to such group and to enter data sensed by the other group of sensing elements into the storage means allocated to said other group, said entries being made in the same storage means from any of the selected fields in any of the selected zones.

10. In a calculating machine, a plurality of sets of registers each comprising a plurality of registering wheels respectively devoted to different denominational orders, driving means including a plurality of driving members one for each denominational order of said registers, means connecting each register wheel for a particular order to the driving member for the order to which the particular wheel pertains, control means for controlling the connection of said register wheels to said driving members whereby said register wheels may be selectively operated upon operation of said driving members, a plurality of permutation devices each devoted to a denominational order and each operative to determine the differential actuation of the register wheel actuatable thereby, means for connecting each of said permutation devices to the driving member devoted to the same denominational order as that to which the particular permutation device is devoted, means for operating each of said permutation devices in a given direction, reversing means in the connections between the permutation devices and the driving members, means controlling the operation of said reversing means whereby the driving members may be selectively driven in opposite directions upon operation of the permutation devices, sequence means controlling the operation of the means connecting the register wheels to the driving members and the reversing means and effective to cause permutation devices to drive predetermined of said register wheels in a given direction in one operation of said permutation devices and also effective to drive selected of said predetermined register wheels and other predetermined register wheels in the opposite direction in the succeeding operation of the permutation devices, and means controlled by said sequence means for restoring said register wheels to zero intermediate each such two succeeding operations of said permutation devices.

11. In a printing calculating machine, a plurality of sets of registers each comprising a plurality of register wheels respectively devoted to different denominational orders and each register wheel having type characters thereon for printing the digital amounts represented thereon, the wheels in each register in close relation one to the other to thereby enable the digits respectively printed therefrom to be printed in conventional closely-spaced relation, driving means including a plurality of driving members one for each denominational order of said registers, means connecting each register wheel for a particular order to the driving member for the order to which the

particular wheel pertains, and each such connecting means including an element mounted on the driving member and geared to said wheel, and a clutch for connecting said driving member and said element, control means for individually controlling the respective clutches of said connecting means whereby said register wheels may be selectively operated upon operation of said driving members, a plurality of permutation devices each devoted to a denominational order and each operative to determine the differential actuation of the register wheel actuatable thereby, means for connecting each of said permutation devices to the driving member devoted to the same denominational order as that to which the particular permutation device is devoted, means for operating each of said permutation devices in a given direction, reversing means in the connections between the permutation devices and the driving members, means controlling the operation of said reversing means whereby the driving members may be selectively driven in opposite directions upon operation of the permutation devices, sequence means controlling the operation of the clutches connecting the register wheels to the driving members and the reversing means and effective to cause permutation devices to drive predetermined of said register wheels in a given direction in one operation of said permutation devices and also effective to drive selected of said predetermined register wheels and other predetermined register wheels in the opposite direction in the succeeding operation of the permutation devices, and means controlled by said sequence means for restoring said register wheels to zero intermediate each such two succeeding operations of said permutation devices.

12. In a calculating machine, a plurality of registers each comprising denominational elements, a plurality of groups of permutation members, each of said groups of permutation members having a denominational significance, sequence control means, value representing means controlled by said sequence control means for setting up the permutation members in each of said groups in permutations representative of values to be entered in said registers, means under the control of said permutation members for entering said values in said registers, said means comprising a common driving member for corresponding denominational elements of each of said registers and unidirectional driving means controlled by said permutation members for transmitting differential values to said common members, and means under control of the sequence control means for causing the denominational elements of at least one of said registers to be operated in a given direction during one operation of the unidirectional driving means and to cause the denominational elements of said one register to be operated in a direction opposite to said given direction during another operation of the unidirectional driving means.

13. A calculating machine as claimed in claim 12 wherein means under control of said unidirectional driving means are provided to delay operation of the sequence control means until a differential entry operation into the elements of a register has been completed.

14. A calculating machine as claimed in claim 12 wherein circuit pulsating means are actuated by the unidirectional driving means and wherein said pulsating means control delay instrumentalities which prevent operation of the sequence control means until a differential entry operation

into the elements of a register has been completed.

15. In a calculating machine, a plurality of registers each comprising denominational elements, a plurality of groups of permutation members, each of said groups of permutation members having a denominational significance, sequence control means, value representing means controlled by said sequence control means for setting up the permutation members in each of said groups in permutations representative of values to be entered in said registers, means under the control of said permutation members for entering said values in said registers, said means comprising a common shaft for corresponding denominational elements of each of said registers and clutch means for each denominational element and unidirectional driving shafts controlled by said permutation members for transmitting differential values to said common members, and means including reversing devices intermediate said common and driving shafts under control of the sequence control means for causing the denominational elements of at least one of said registers to be operated in a given direction during one operation of the unidirectional driving shafts and to cause the denominational elements of said one register to be operated in a direction opposite to said given direction during another operation of the unidirectional driving shafts.

16. A record controlled computing machine, sensing means arranged for sensing coded numerical data from representations thereof on a record during relative movement of the record and said sensing means, storage means set in code according to the data sensed from said record, sequence control means, a register, entry effecting means comprising reversing means and permutation devices directly controlled from said storage means, and means controlled by said sequence control means for causing said entry effecting means to perform an additive entry of a portion of said numerical data from said storage means into said register at one time and for causing a subtractive entry through said reversing means of another portion of the numerical data from said storage means into said register whereby the difference between said portions of said numerical data is represented on said register after said two entry operations.

17. A record controlled computing machine, sensing means arranged for sensing coded numerical data and control data from a record during relative movement of the record and said sensing means, storage means settable according to the coded data sensed from said record, a plurality of registers, means operable under control of the said storage means for translating and additively entering a portion of the numerical data in one of said registers and subsequently translating and subtractively entering another portion of said numerical data in said one of the registers to cause said register to represent the difference between said entered por-

tions, a value computing table based on fixed factors and controlled by said register in accordance with the difference represented thereon to yield representations of values based on said factors and difference, means for energizing said table, means operable under control of said control data sensing means to select a further register, means controlled by the energized value computing table for entering a computed value in said register, and sequence control means operable to control the sequence and operating times of said entering operations.

18. In a calculating machine, a driving shaft, a plurality of item entry receiving elements on said shaft, one for each denominational order, a second operable shaft, totalizer wheels freely mounted on the second shaft, one for each denominational order, driving means intermediate each item entry receiving element and the totalizer wheel for the corresponding denominational order and comprising means freely rotatable on the second shaft, a clutch for coupling each item entry element and the drive therefrom to the driving shaft, a second clutch for coupling the corresponding means freely rotatable on the second shaft with the totalizer wheel, whereby simultaneous entry is effected in an item entry wheel and its corresponding totalizer wheel when said clutches are operated simultaneously, and a further clutch for each totalizer wheel for coupling such wheel to the second shaft to effect carry-overs, said last clutch being operated after the second clutch is released whereby carry-over entries do not disturb the setting of the totalizer wheel.

19. In a calculating machine as claimed in claim 18 wherein the first named clutch of each item entry receiving element is differentially controlled by a switching structure comprising a plurality of switch terminals selectively potentialized in accordance with the item to be entered, a rotary switching element mounted on said item entry receiving element for cooperation with said terminals, means for engaging the last named clutch when the item entry receiving element is in zero position to initiate an entry operation, means for disengaging said clutch as said rotary switching element is rotated to the potentialized one of said terminals, and a supplemental control circuit for said clutch controlled by a further switching device operable with the item entry receiving element for maintaining said clutch engaged until a differential entry into the receiving element is completed.

20. In a machine as claimed in claim 8 wherein one of the predetermined functions controlled by said pairs of relays that are energized in each cycle of operation of the machine comprises entry in an accumulator and wherein said accumulator comprises instrumentalities effective when a carry-over is required to energize a pair of said other relays whereby such pair of relays introduces a sequence step in the course of which a carry-over is effected into said accumulator.

CLYDE SMITH.