

Dec. 19, 1944.

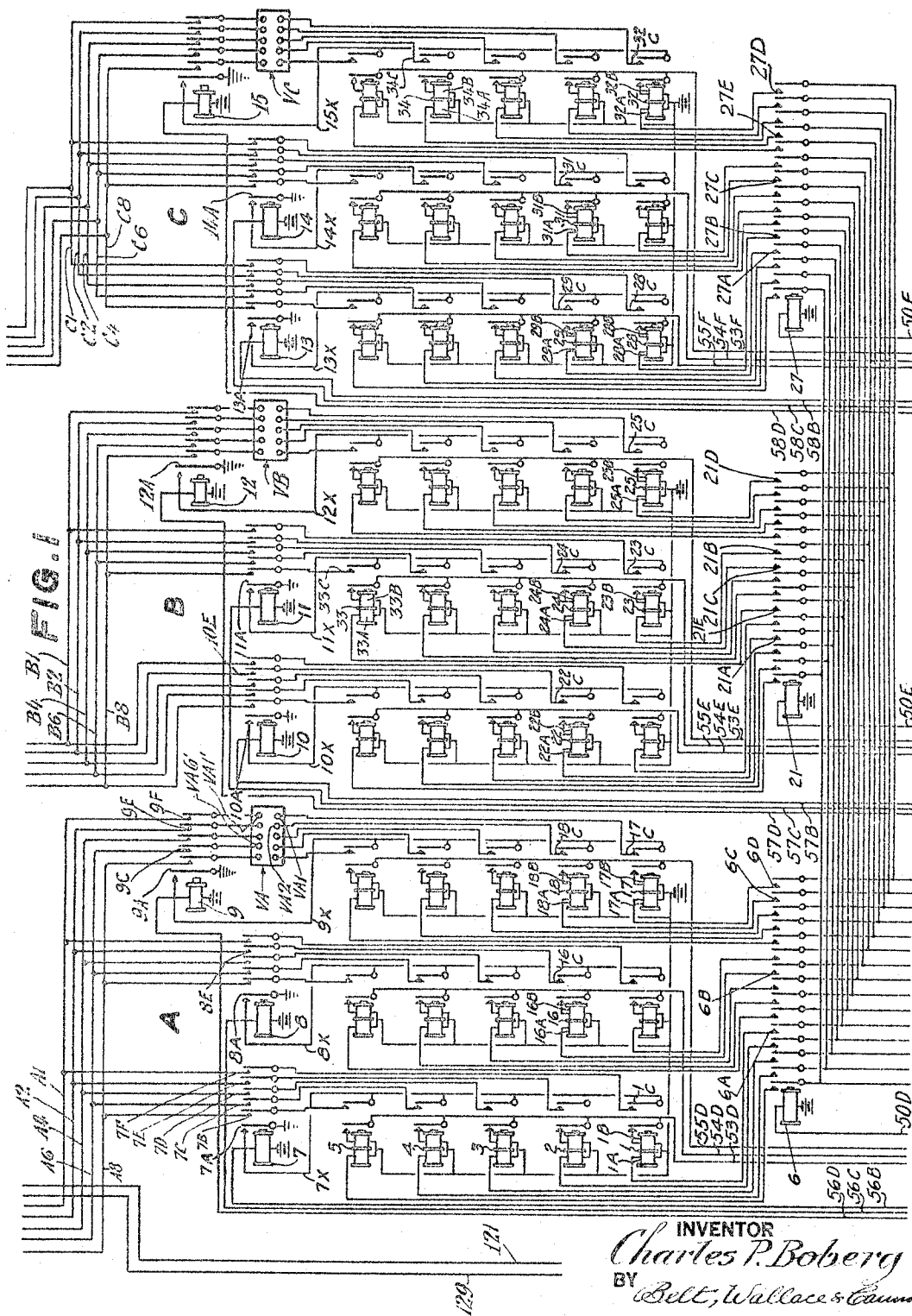
C. P. BOBERG

2,365,381

CALCULATING AND PRINTING MACHINE

Filed Nov. 27, 1939

10 Sheets-Sheet 1



Dec. 19, 1944.

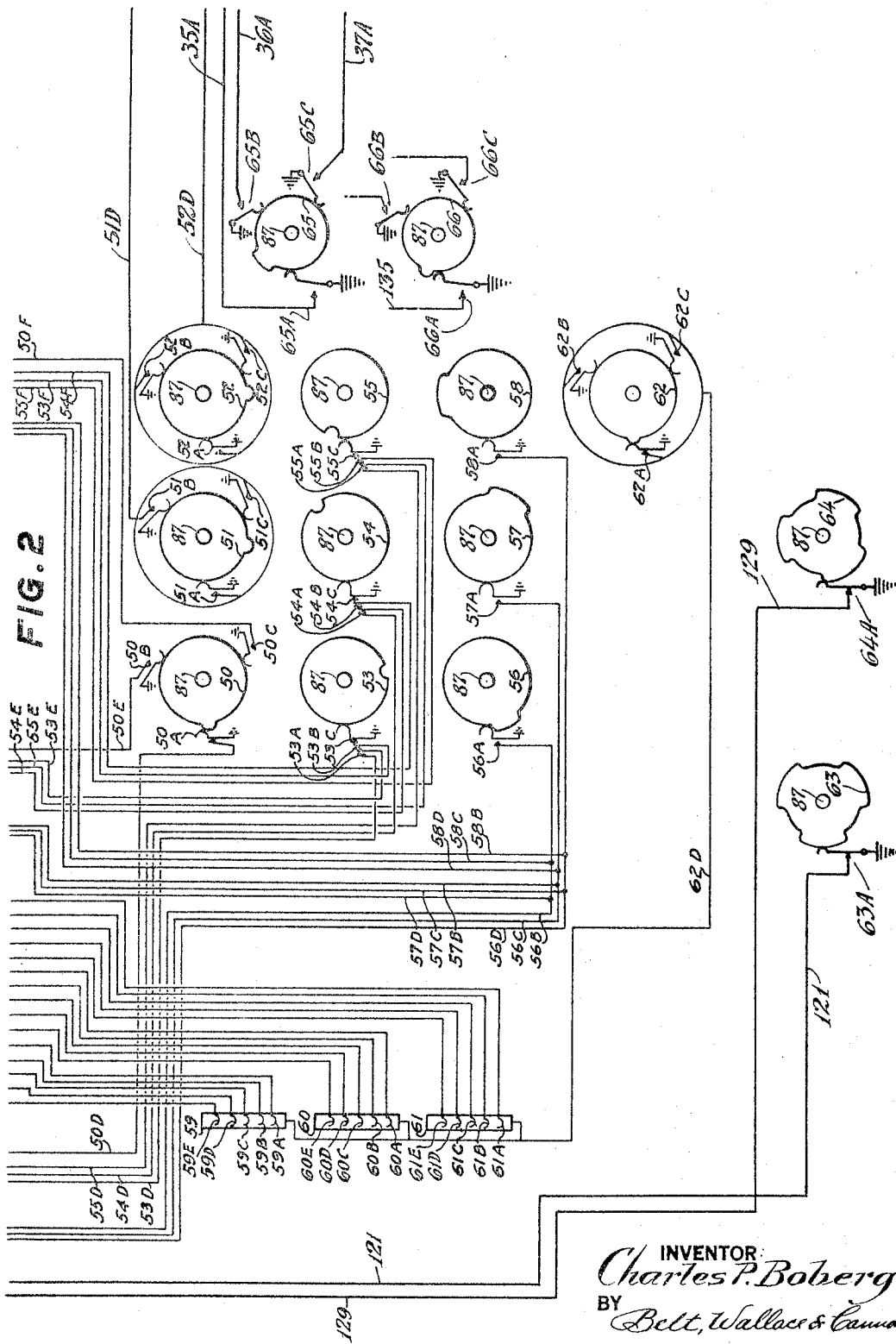
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CALCULATING AND PRINTING MACHINE

Filed Nov. 27, 1939

10 Sheets-Sheet 2



Dec. 19, 1944.

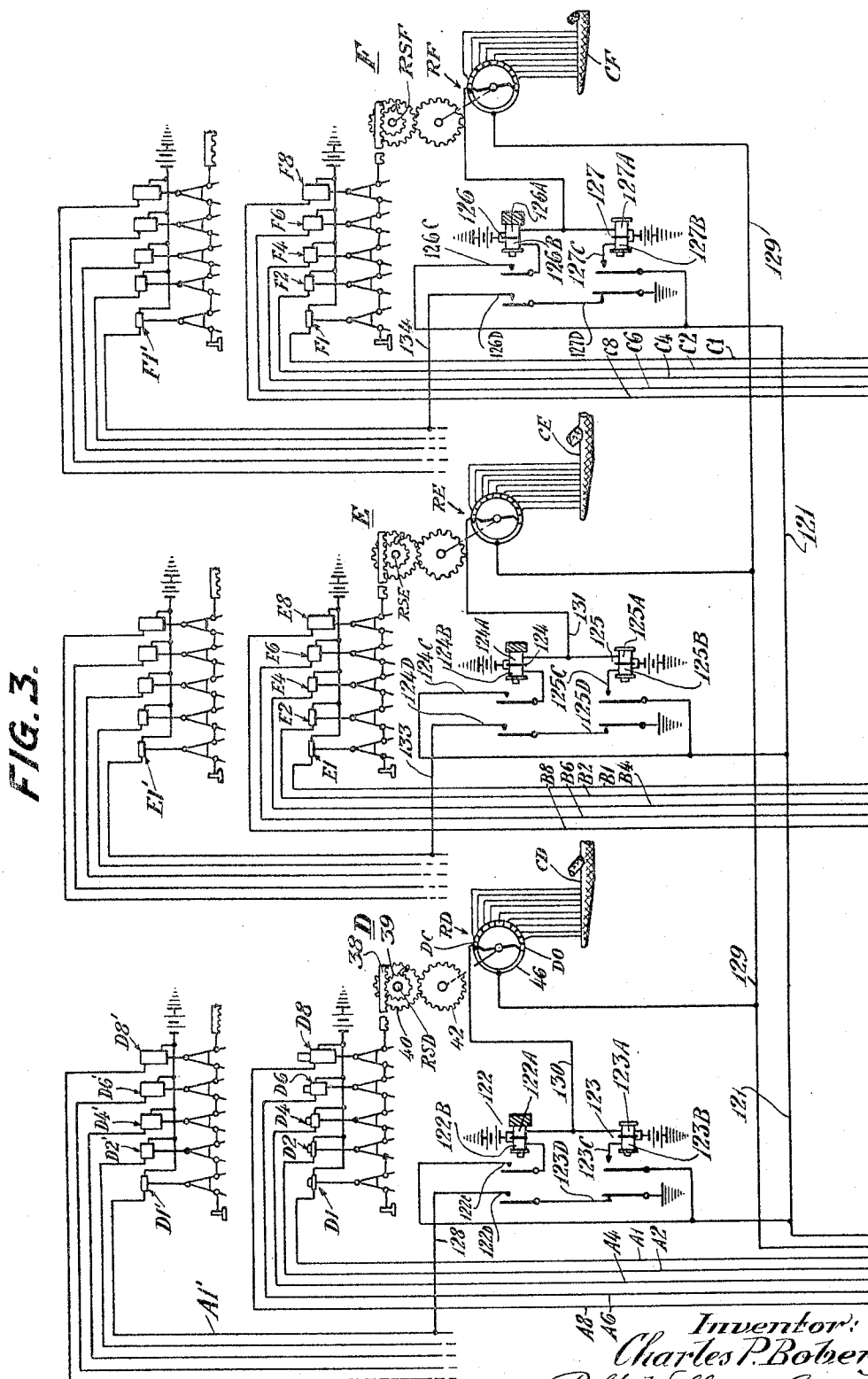
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CALCULATING AND PRINTING MACHINE

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10 Sheets-Sheet 3



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CALCULATING AND PRINTING MACHINE

Filed Nov. 27, 1939

10 Sheets-Sheet 4

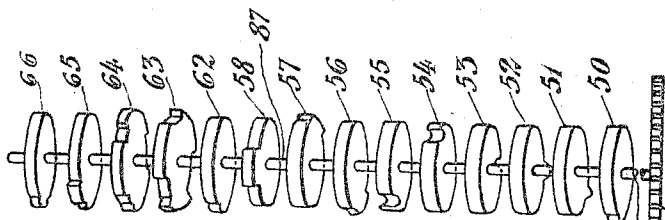


FIG. 5

FIG. 7

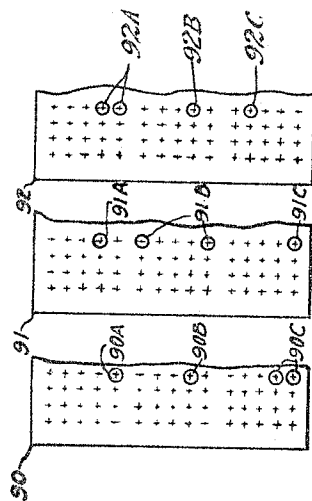


FIG. 4

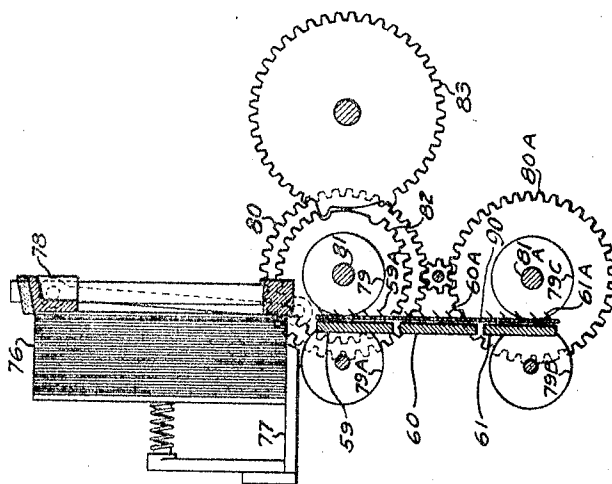


FIG. 7A.

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

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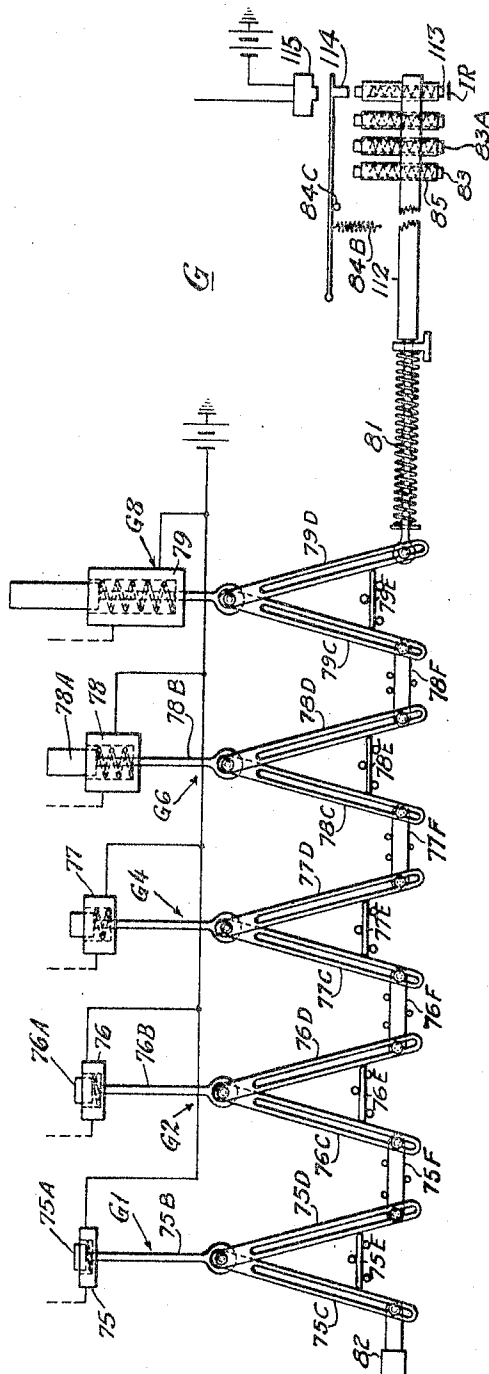
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CALCULATING AND PRINTING MACHINE

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10 Sheets-Sheet 5

65-144



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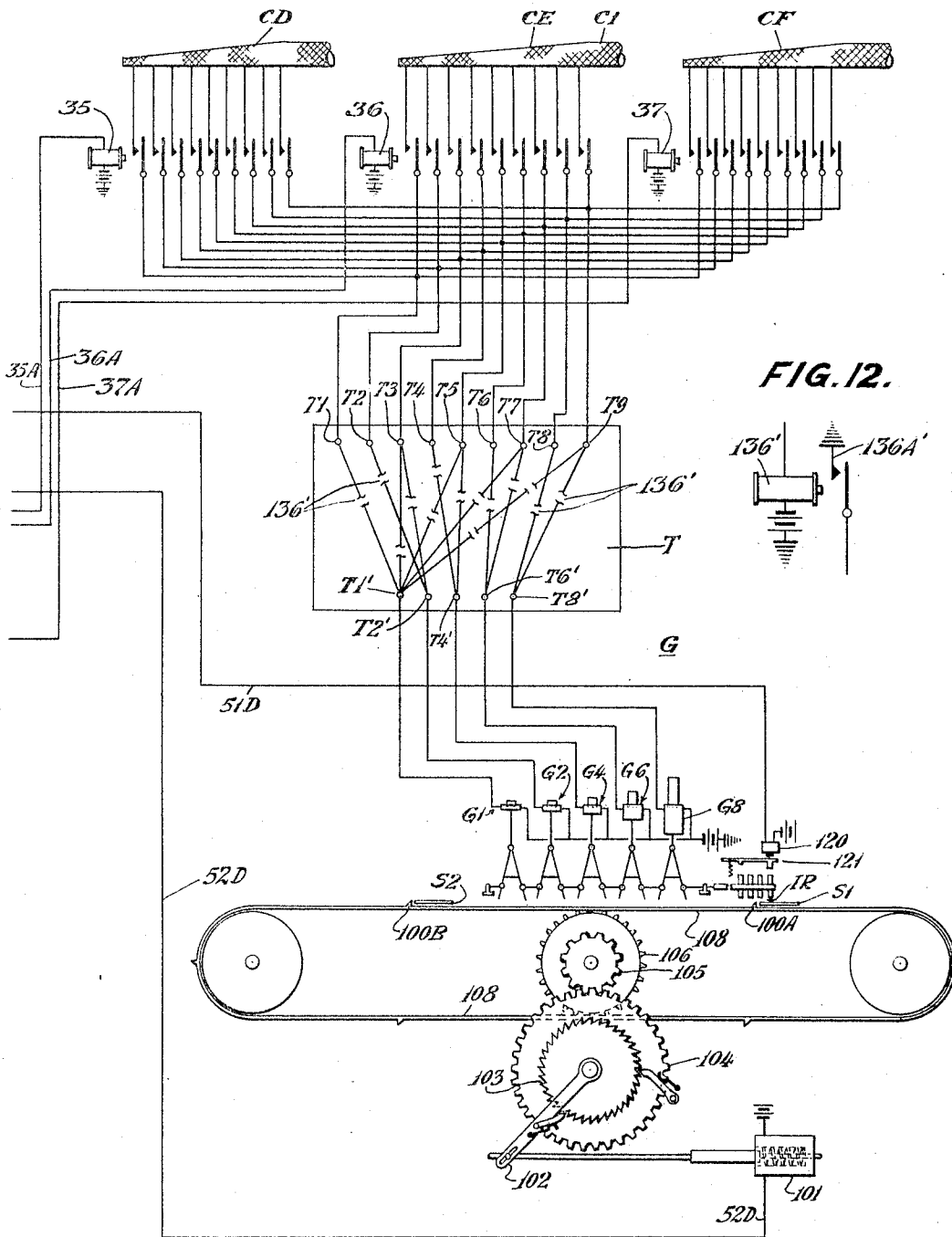
2,365,381

CALCULATING AND PRINTING MACHINE

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FIG. 8.



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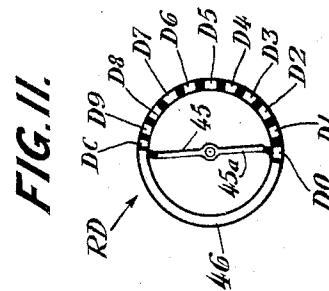
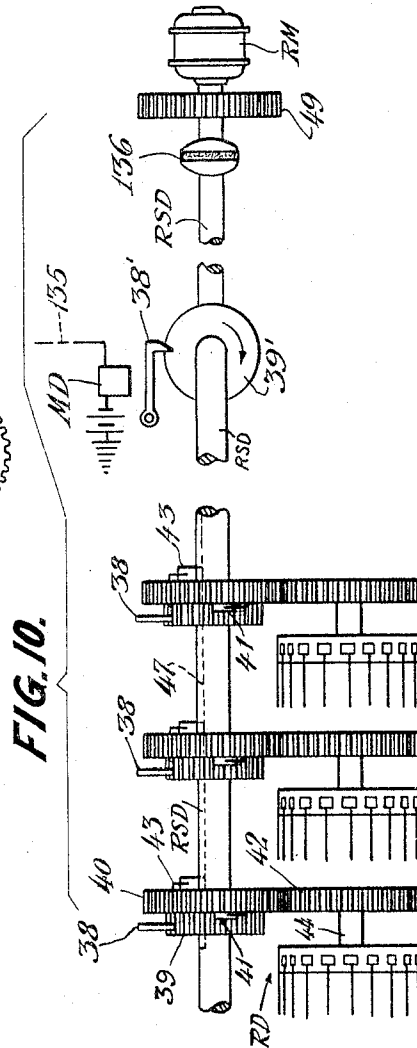
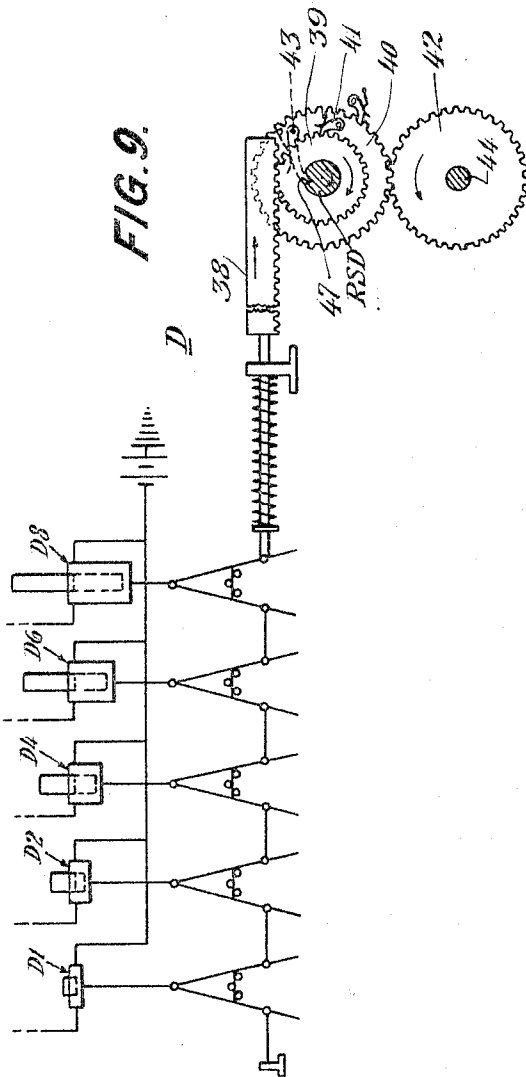
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CALCULATING AND PRINTING MACHINE

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10 Sheets-Sheet 7



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CALCULATING AND PRINTING MACHINE

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FIG. 13.

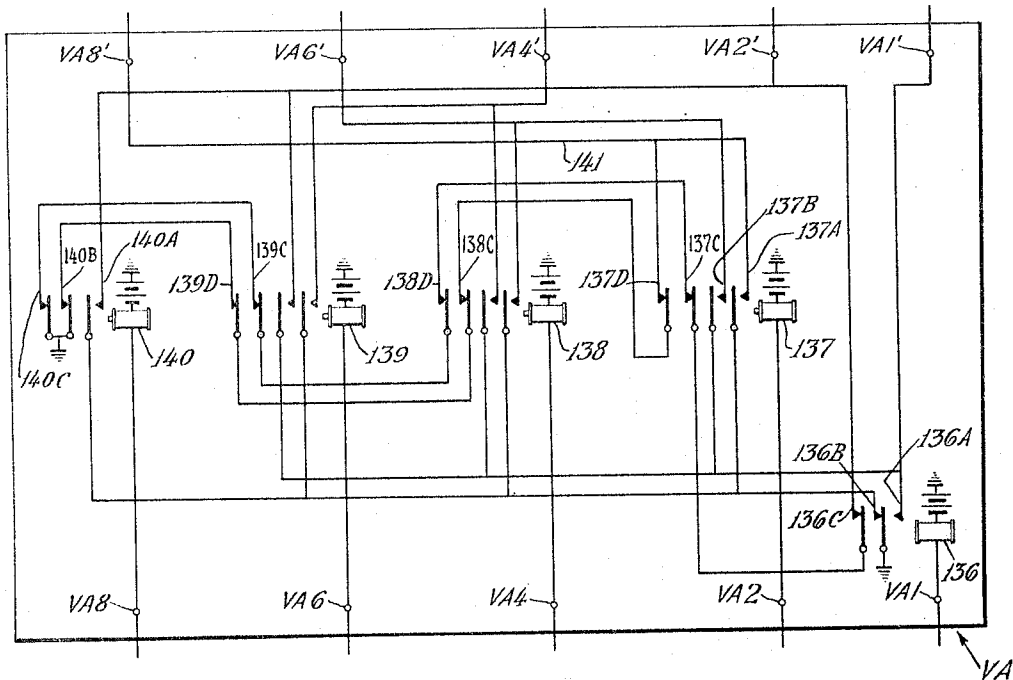
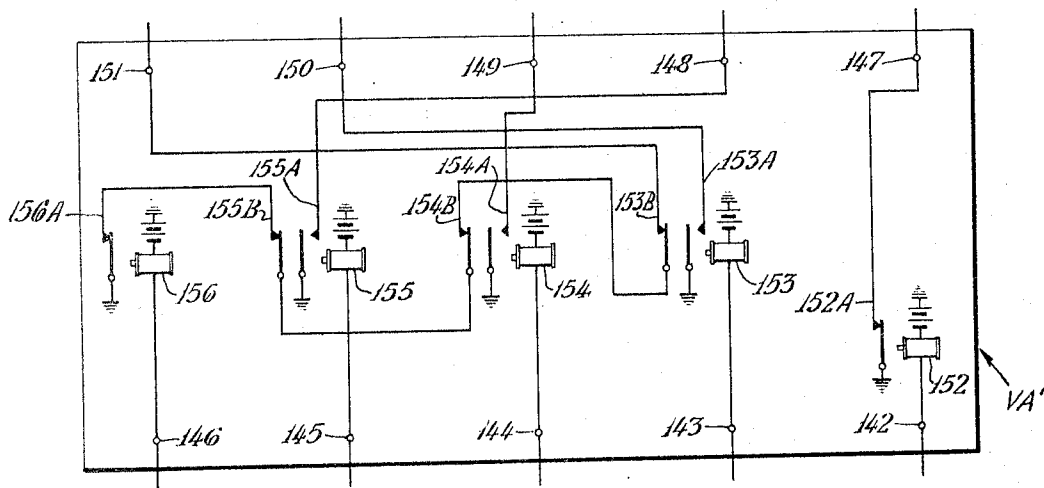


FIG. 14.



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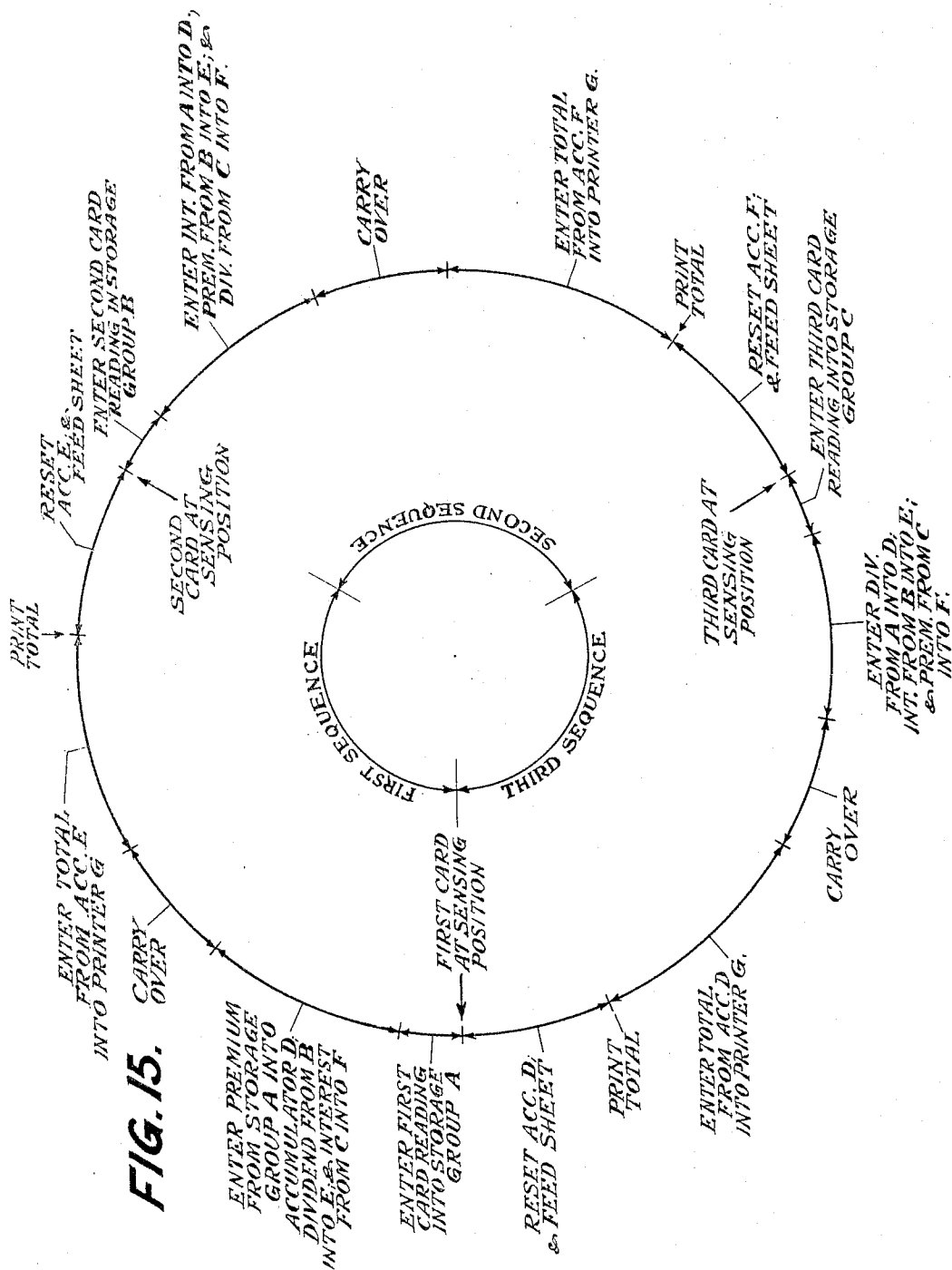
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CALCULATING AND PRINTING MACHINE

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10 Sheets-Sheet 9



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CALCULATING AND PRINTING MACHINE

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10 Sheets-Sheet 10

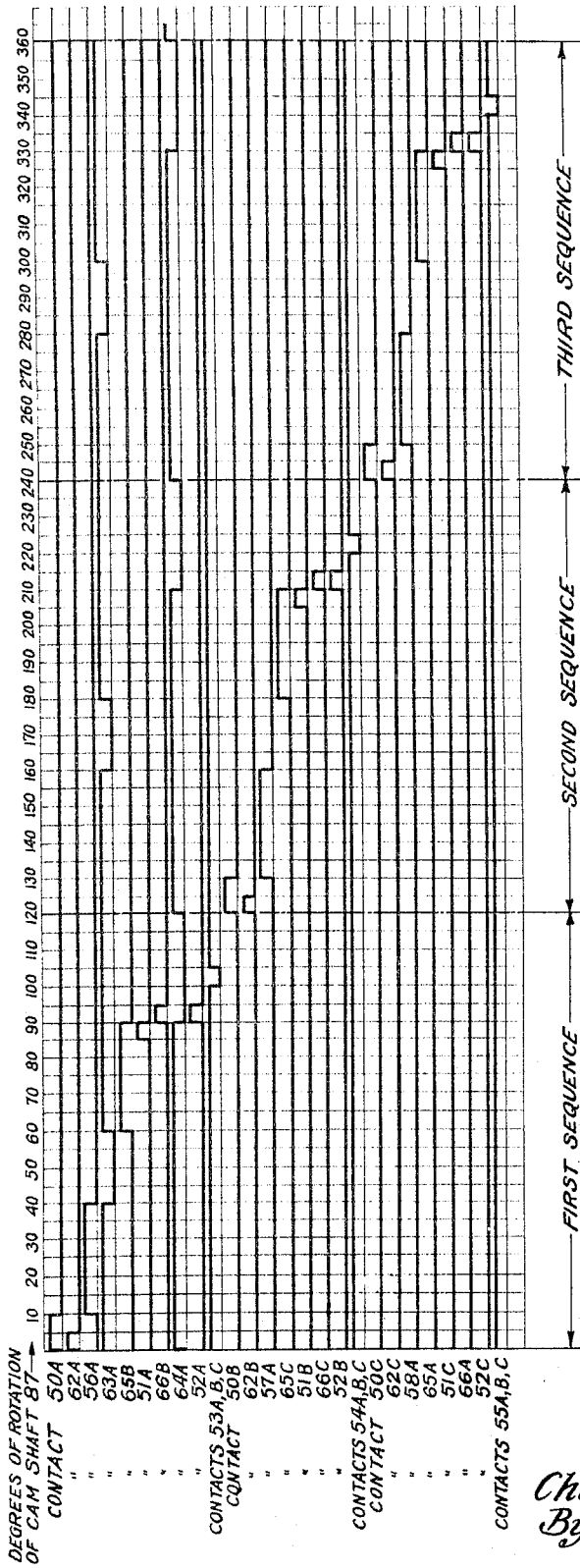


FIG. 16.

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UNITED STATES PATENT OFFICE

2,365,381

CALCULATING AND PRINTING MACHINE

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Application November 27, 1939, Serial No. 306,408
In Great Britain December 5, 1938

9 Claims. (Cl. 235—61.6)

This invention relates to calculating and printing machines and more particularly to machines into which groups of numerical items are entered and in which computations entailing the separate items in each group are performed.

The salient object of this invention is to enter numerical items group by group into a calculating or like machine and to effect independent computations or like operations, each based upon a particular group of items, in such a manner that a result of such a computation is produced concurrently with the entry of each group of items into the machine.

The present invention is an improvement on the invention disclosed in United States Letters Patent No. 2,077,965 in which storage and control devices are utilized for effecting the direct printing of data. According to the present invention such storage and control devices are utilized along with accumulators into which additive and subtractive entries are made, and printing means are provided for printing the results of such entries into said accumulators, but it will be understood that the aforesaid storage and control devices might be used with calculating means other than the aforesaid accumulators within the ambit of the present invention.

It has been known heretofore to derive numerical data from a record card or the like and to hold such data in storage until such time as it will be used to govern machine operations. For example, in calculating or other machines in which subtractive entries are effected into registers by the method of complemental addition, the item to be subtractively entered has been derived from the card and entered in an inverting device where it has been temporarily retained and then read out as a complement of the original item to the registering apparatus designed to receive it.

It has been further proposed, in machines of the character to which this invention pertains, to utilize record cards bearing representations of numerical data in code. 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 single-hole representation was employed. Because of the fact that utilization of code representations permits a large amount of data to be represented in a card of a given size it is possible, in place of employing a plurality of cards to record various items relating, for example, to a particular customer's account, to incorporate representations of such items in a single card. Such use of code representations has been resorted to in construc-

tions wherein data derived from a record card is entered in suitable storage apparatus to be subsequently released through the medium of translating devices to control the operation of registers, readouts, recording means or the like.

A disadvantage in such prior constructions as included in tabulating and calculating machines is that the storage means provided therein has been operative to store data from only one card at a time, and such storage means had to be completely cleared before the data from the next card could be introduced. This entailed suspending the card feeding operations so long as the storage means retained any part of the record entered therein. A further disadvantage has been that all parts of the stored intelligence were simultaneously released to the registering or other apparatus.

In view of these and other disadvantages, it is an object of the present invention to enable a tabulating, accounting, or like machine to rapidly and continuously store the data derived from record cards or the like advanced serially through the machine and to store data from successive cards in respective ones of a plurality of groups of storage devices.

Another object is to release different portions of the stored data or intelligence at selected times to accumulators or other amount manifesting devices.

Further objects are to store numerical data derived from sequentially fed cards or the like in groups of storage devices of which a particular group is selectively allocated to alternate or otherwise sequence successive cards or the like; to store different portions of the intelligence derived from each card in respective sets of storage devices within the group; to release numerical data stored in the several sets within the groups of storage devices at selected times so that the different sets within each group are rendered effective at different times with respect to each other, but so that selected sets among the several groups are simultaneously rendered effective; and to enable each group of storage devices to retain at least a portion of a sensed intelligence while the devices in another group are being set in accordance with the sensed intelligence from a subsequent card.

More specifically, it is an object to adapt a tabulating or accounting machine for use with record cards of such character that each card bears representations, preferably in code, of numerical items to be accumulated together; to enable concurrent transfer of a plurality of items

from one card to respective sets of storage devices within a storage group; to release a stored item from the first of such storage sets and enter same in an accumulator associated with the first storage group; to transfer a plurality of other items from a second card to respective sets of storage devices in a second storage group; to concurrently release a stored item from the second set in the first storage group and enter same in the first accumulator, and a stored item from the first set in the second storage group and enter same in a second accumulator; to transfer a plurality of items from a third card to respective sets of storage devices in a third storage group; to concurrently release stored items from the third set in the first storage group, the second set in the second storage group, and the first set in the third storage group, and enter same in the first, second and third accumulators, respectively; to thereupon read out the total of the three items entered in the first accumulator to a printing means for printing said total on a sheet; and to thereafter proceed in such a manner that a result is read out from an accumulator and printed on a record sheet for each record card advanced through the machine, this being accomplished without suspending card feeding operations to permit accumulation of items.

The illustrated embodiment of the invention is capable of use in connection with the preparation of insurance premium notices. A perforated record card is prepared for each policyholder of an insurance company. Such card comprises a record, preferably in code, of the amount of the premium on a policy, the interest, if any, due on a loan on the policy made by the company to the policyholder, and the value of the dividend, if any, issued by the company to the policyholder. The items of the premium and the interest, if any, are added together, and the dividend item, if any, is subtracted therefrom to yield the total amount to be billed to the policyholder. In the course of operation of the machine the record cards for the various policyholders are passed successively through a sensing or card reading station. Upon sensing the first card, the machine stores whatever items of premium, interest and dividend that are derived therefrom and shortly thereafter enters the premium amount in an accumulator. Upon the sensing of the second card the machine stores whatever items that are derived therefrom and an additive entry of the interest item, if any, previously derived from the first card is effected into the first accumulator, and the premium from the second card is entered in a second accumulator. Upon the sensing of the third card the machine stores whatever items that are derived therefrom and a subtractive entry of the dividend item, if any, previously derived from the first card is effected, by the method of complementary addition, into the first accumulator. The interest item, if any, previously derived from the second card is entered in the second accumulator, and the premium from the third card is entered in a third accumulator. The result standing in the first accumulator is then read out and printed on a premium notice or the like intended for the first policyholder. The first accumulator and storage group will have been cleared by the time the fourth card is in sensing position, so that the items derived from this card are entered in the first storage group and accumulator as were the items of the first card. The reading of the fifth card is stored in

the second storage group and the items thereof entered in the second accumulator; and so on. Commencing with the third card sensing operation, a total of the items of the premium and of the interest and dividend, if any, derived from the card which was sensed two card sensing operations previously will be printed in accompaniment with the advance of each successive card through sensing position.

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 schematic view of the storage relays; Fig. 2 is a schematic view of the control cams and the electrical connections for same;

Fig. 3 is a schematic view of portions of the entry-effecting means for the accumulators;

Fig. 4 is a vertical sectional view of the card-feeding mechanism;

Fig. 5 is a plan view of the card-feeding mechanism and control cams;

Fig. 6 is an elevation of a portion of the printing means;

Fig. 7 comprises fragmentary elevational views of typical record cards employed in the machine;

Fig. 7A is a chart of the code under which numerical datum is represented in the record cards employed in this invention;

Fig. 8 is a partially schematic view of an encoding device; printing means; and sheet feeding mechanism;

Fig. 9 is an elevational view of a portion of an accumulator;

Fig. 10 is a partially diagrammatic front elevation of an accumulator, showing the resetting means for same;

Fig. 11 is a detail diagrammatic view of an accumulator readout;

Fig. 12 is a schematic view of a one-way circuit device employed in the encoding device show in Fig. 8;

Fig. 13 is a schematic view of an inverting device for obtaining complements with respect to the digit 10 of digits represented in code;

Fig. 14 is a schematic view of an inverting device for obtaining complements with respect to the digit 9 of digits represented in code; and

Figs. 15 and 16 are timing charts of the machine.

GENERAL DESCRIPTION

The invention disclosed herein is capable of use in a wide variety of machines and its adaptation to the particular form of machine described herein is merely illustrative. In the particular embodiment of the invention chosen for purposes of description, use is made of perforated record cards bearing representations, preferably in code, of items pertaining to insurance policies or the like. A separate record card is prepared by the insurance company for each policyholder, and the several items to be represented on each record card are allocated to respective fields of the card. Thus in one field of the card the premium due on

a policy is represented, in another field the interest, if any, due on a loan made under the policy is represented, and in still another field of the card the amount of the dividend, if any, issued by the company to the policyholder is represented. The load interest is to be added to the amount of the premium and the amount of the dividend is to be subtracted from this sum to obtain the amount due from the policyholder.

Various machine functions are performed under control of cams which are mounted on a common cam shaft synchronized with the card feeding mechanism. In each complete cycle of rotation of said cam shaft and the cams mounted thereon, there are three distinct sequences of operations, each such sequence being characterized by the feeding of a card to a sensing station in the machine.

In the first sequence of operations the first card is initially in sensing position. As can be seen from the timing chart, Fig. 15, the reading derived from this first card, which reading comprises the items of premium, interest and dividend, it entered into a group of storage devices comprising, for instance, relays included in a storage group A. Thereafter the premium amount derived from the first card and stored in group A is entered into an accumulator D. At the same time, if there has been a dividend amount stored in another storage group B from a previously sensed card, this dividend amount is entered into an accumulator E. Also if there has been an interest amount stored in still another storage group C from another previously sensed card, said interest amount is entered into a third accumulator F. Following these entries into the accumulators D, E and F from the storage groups A, B and C, respectively, there is an interval in which carry-over operations, if any, take place. Following this the amount, if any, standing on the accumulator E is transferred to a printer G for this accumulator will now display the result of such entries that have been made thereto of premium, interest and dividend derived from a previously sensed card. Such result is printed on a sheet and the accumulator E is restored to zero condition.

Thus the first sequence of operations comes to an end with the premium amount derived from the first card having been entered into an accumulator D. The other operations which have been described are idle if there were no previous cards sensed by the machine.

At the start of the second sequence of operations, the second card is at sensing position and the premium and the interest and dividend, if any or either, represented thereon are or is entered in a storage group B. Thereafter the premium amount this stored in group B is entered into the accumulator E, which has been restored by this time. Also the interest, if any, from the first card is entered from the storage group A into accumulator D and the dividend amount, if any, stored in storage group C is entered into the accumulator F. Carry-over operations, if required, follow and if there is a total standing on the accumulator F as the result of a card having been sensed previously to the first card, this total is entered into the printer G and the result or total is printed onto a sheet.

Thus the premium and interest derived from the first card and stored in group A will have been entered in the accumulator D and the premium from the second card will have been entered in the accumulator E. If there had been no

card sensed previously to the first card, the total printing operation effected under control of the accumulator F would have been idle.

At the start of the third sequence of operations, the third card is in sensing position and the premium and the interest and dividend, if any or either, derived from this card are or is stored in a storage group C. Subsequent to this the premium from the third card is entered from storage group C into the accumulator F, which has been reset by this time. Also the dividend, if any, derived from the first card and stored in group A is entered subtractively (by complemental addition) in accumulator D, and the interest, if any, derived from the second card is entered from storage group B into accumulator E. Necessary carry-over operations ensue. The accumulator D now registers the result of such entry of items of premium, interest and dividend, derived from the first card, as have been made thereto. This result is entered into the printer G and is printed onto a premium notice or like sheet which is thereafter discharged from the machine. The accumulator D is reset to zero condition preparatory to receiving entries from the fourth card, and a new sheet is advanced to printing position.

Accumulator E now registers the premium amount or sum of the premium and the interest amount, if any, derived from the second card and accumulator F registers the premium amount derived from the third card. The storage devices in group A are cleared and conditioned to receive new entries by the time the fourth card is advanced to sensing position.

At the initiation of the fourth sequence of operations, or the first sequence in the second cycle of rotation of the aforesaid cam shaft, the reading derived from the fourth card is stored in group A and the dividend amount, if any, which was derived from the second card in the second sequence of operations is now entered from the storage group B into the accumulator E. After incidental carries, if any, have been entered, the accumulator E registers the premium amount, or the sum of the premium and interest, if any, or the difference between the premium and the dividend, if any, or the result of entries of the premium and the interest and dividend amounts, if any, dependent upon what amounts were derived from the second card. This result is then entered in the printer G and is printed onto a premium notice pertaining to the corresponding policyholder.

Thus it will be seen that in each and every sequence, commencing with the third sequence, there will be printed on a premium notice whatever result accrues from entering a premium amount and/or interest and dividend amounts, if any, that are derived from a particular card.

DESCRIPTION OF THE APPARATUS

Storage relays—Fig. 1

The storage relays are divided into groups A, B and C, each such group being arranged to be set up under control of a particular card. Each group in turn comprises three sets of relays, each of these sets being composed of a number of banks of five relays each, such as the relays 1, 2, 3, 4 and 5, there being five relays per bank inasmuch as the record cards, Fig. 7, are perforated in accordance with a five-unit code in the present instance. In Fig. 1 only one bank of five relays is shown in each set within the various groups but it will be understood that other banks will be arranged in

an identical fashion to those shown, the various banks of relays within each set respectively pertaining to the digits in the various denominations of the numerical items represented on a record card.

Thus in group A, the storage relays 1, 2, 3, 4 and 5 in the first set pertain to the units denomination of the premium amount represented on the first record card to be fed to a sensing station in a machine. A similar bank of five relays is provided in the first set in group A in each higher denomination of the premium amount represented on the first card. The second set in group A, which set includes the storage relay 16, pertains to the interest amount, if any, represented on the first card. The third set including the relays 17 and 18 pertains to the dividend amount, if any, on the first card.

In group B the first set of storage relays, including the relays as 22, pertains to the premium amount on the second card fed to sensing position in the machine. The second set, including the storage relays as 23, pertains to the interest amount, if any, represented on the second card, and the third set including the relay 25 pertains to the dividend amount, if any, on the second card.

In storage group C the relays in the first set, including the relay 28, relate to the premium amount represented on the third card fed to sensing position in the machine. The second set including the relay 31, relates to the interest amount, if any, on the third card. The third set including the relay 32 corresponds to the dividend amount, if any, on the third card.

It will be understood that not every card fed to sensing position in the present machine, which is adapted for insurance work, will bear representations of interest and dividend amounts for not every policyholder will have made a loan on his policy and it may be that no dividend is due, which condition, it will be understood, may arise for a wide variety of reasons. However, each card will customarily bear representations of a premium amount. In any event, where there are no representations in a particular field on a card then no storage relays in the set pertaining to such field are set up with the result that no operations, such as those hereinafter described, are effected under control of such relays. However, because it will facilitate description of this invention, hereinafter each card will be assumed to have representations in all fields thereon unless otherwise indicated.

Transfer relays 6, 21 and 27 are respectively provided for the storage relay groups A, B and C. The movable leaves of the contacts of these transfer relays are connected in multiple to corresponding card sensing fingers 59A to 59E, inclusive, 60A to 60E, inclusive, and 61A to 61E, inclusive, Fig. 2, that respectively cooperate with contact bars as 59, 60 and 61. These sensing fingers are adapted to be selectively grounded from the contact bars through perforations as 90A, 90B and 90C in a record card as 90, Fig. 7.

Assuming that the transfer relay 6, Fig. 1, has been energized, it will close its several contacts and complete circuits, from ground at those sensing fingers which are in contact with their respective bars, to the left-hand or energizing windings of the corresponding storage relays in group A. Thus when the sensing finger 59A is grounded from the bar 59 through a card perforation as 90A, it is effective through the contact 6A of transfer relay 6 to energize the winding 1A of the

lowermost storage relay 1 in the corresponding bank in the first set of storage relays, group A. This storage relay thereupon energizes to close its contacts and through its winding 1B it establishes a holding circuit through conductor 53D, Figs. 1 and 2, to ground at a cam contact 53A. Likewise every other storage relay which has been energized in group A will establish a similar holding circuit for itself. The relays in the first set, such as relay 1, lock up through the grounded conductor 53D and cam contact 53A. The storage relays as 16 in the second set lock up through conductor 54D and the grounded cam contact 54A. The relays in the third set such as the relays 17 lock up through conductor 55D and cam contact 55. After the storage relays have so been locked up the card as 90, Fig. 7, may be fed away from sensing position, after ground has been removed from the contact bars 59, 60 and 61 to prevent improper grounding as the perforations pass the sensing fingers. The storage relays in group A which have been so locked up under control of the card 90 will retain their settings until released at a subsequent time in the operation of the machine, as described in detail hereinafter.

Transfer relays 21 and 27 function in the same manner as the transfer relay 6 for their respective storage groups B and C. Relay 21 effects transfer of the data derived from the second card 91, Fig. 7 to the storage relays in group B and causes said relays to be selected and energized in accordance with said data. In the same manner as the storage relays in group A were set up under control of the card 90, transfer relay 27 when energized enables the storage relays in group C to be selected and energized in accordance with the data on the third card 92, Fig. 7. It will be understood that cards as 90, 91 and 92 are advanced successively to sensing position above the contact bars 59, 60 and 61 in the course of operation of the machine and the readings thereon are successively transferred to the storage relays in the groups A, B and C.

The shift relays 7 to 15, inclusive, are allocated to respective sets of storage relays in the several groups. For example, the shift relay 7 is allocated to the first set (premium amount) in group A. When this relay is energized, it closes its several contacts including the contact 7A to thereby extend ground to the contacts as 1C of the storage relays as 1 in the first set in group A. If any of these storage relays are energized at this time ground will continue through the contacts as 1C and corresponding contacts of the shift relay 7 to corresponding ones of the conductors A1, A2, A4, A6 and A8 for purpose of controlling the actions of certain permutation devices described hereinafter.

Shift relay 8 is adapted to close circuit from contacts as 16C of the energized storage relays as 16 in the second set of group A (interest amount) to corresponding ones of the conductors A1, A2, A4, A6 and A8.

Shift relay 9 establishes circuits from ground through the closed contacts as 17C of the storage relays as 17 in the third set of group A (premium amount) to the conductors A1, A2, A4, A6 and A8 through the intermediary of an inverting device generally designated VA. The device VA, as will be explained hereinafter, is adapted to set up a complement, in code, of the digit represented in code by the settings of the storage relays in the third set of group A. The utility of this arrangement will appear hereinafter.

Shift relays 10, 11 and 12 interconnect the con-

tacts as 22C, 24C and 25C of the storage relays as 22, 24 and 25 in the first, second and third sets, respectively, of group B with conductors B1, B2, B4, B6 and B8 for a purpose to be described. Relay 12 acts through the intermediary of an inverting device VB for converting the setting of the storage relays in the third set (dividend amount) into its complement. Shift relays 13, 14 and 15 operate to interconnect contacts of the selected storage relays in group C with conductors C1, C2, C3, C4 and C5.

It will be understood that in the present machine the shift relays in any one group are not operated simultaneously at any time in the operation of the machine. However, shift relays in different groups may be operated at the same time. For example, relays 7, 12 and 14 may be operated together; likewise relays 8, 10 and 15; or 9, 11 and 13 as will be explained.

Control cams—Figs. 2 and 5

The cams 50 to 58 and 62 to 66, inclusive, are mounted on a common shaft 87 and are all operated in synchronism with the feeding of record cards through the machine. The particular arrangement is such that the cam shaft 87 makes one complete rotation for every three cards successively passed through the machine. Each cycle of rotation of the cam shaft 87 and the cams mounted thereon is divided into three distinct sequences as will be explained.

Cam 62 is provided with three contacts 62A, 62B and 62C spaced at equal distances about its periphery and with a lobe for successively closing said contacts. Each contact, when closed, extends ground through a conductor 62D to the contact bars as 59, 60 and 61 at the card sensing station in the machine. Contact 62A closes when the first card has been fed to sensing position. Contact 62B closes when a second card has reached sensing position, and contact 62C closes when a third card has reached sensing position, and thereupon this order of closing of the contacts recommences if the cam shaft 87 continues rotation as it does in normal operation of the machine.

Cam 50 is provided with a lobe for successively closing the equally spaced contacts 50A, 50B and 50C thereabout. Contact 50A is closed when the first card is in sensing position and extends ground through a conductor 50D to the winding of transfer relay 6 for energizing said relay. Similarly, contact 50B closes and thereby effects energization of transfer relay 21 when the second card is in sensing position and contact 50C closes and thereby effects energization of transfer relay 27 when a third card is in sensing position, and thereupon this order of closing of the contacts recommences as explained with reference to contacts 62A, 62B and 62C.

Cams 56, 57 and 58 control the operation of the shift relays 7 to 15, inclusive, Fig. 1. Cam 56 closes its contact 56A during the first sequence in the cycle and thereupon impresses ground on the conductors 56B, 57D and 58C which respectively lead to the windings of the shift relays 7, 12 and 14. Cam 57 closes its contact 57A during the second sequence in the cycle and through conductors 56C, 57B and 58D extends ground to the windings of the shift relays 8, 10 and 15. Cam 58 closes its contact 58A during the third sequence in the cycle and through conductors 56D, 57C and 58B extends ground to the windings of shift relays 9, 11 and 13.

Cams 53, 54 and 55 control the holding circuits

for the storage relays in the various groups. Cam 53 momentarily opens its contacts 53A, 53B and 53C toward the close of the first sequence in the cycle to remove ground from the conductors 53D, 53E and 53F which form part of the holding circuits for the storage relays in the first set in group A, the third set in group B, and the second set in group C. Cam 54 momentarily opens its contacts 54A, 54B and 54C toward the close of the second sequence in the cycle to remove ground from the holding circuits including the conductors 54D, 54E and 54F for the second set of storage relays in group A, the first set in group B, and the third set in group C. Cam 55 opens its contacts 55A, 55B and 55C toward the close of the third sequence in the cycle to break the holding circuits including the conductors 55D, 55E and 55F for the storage relays in the third set in group A, the second set in group B, and the first set in group C.

Cams 51 and 52 control the printing and sheet feeding operations of the machine. Cam 65 controls the sequential operation of the shift relays 35, 36, and 37, Fig. 8, for interconnecting the readouts of the accumulators D, E, and F, Fig. 3, with the entry-effecting means for the printer G, Fig. 8. Cam 66 controls the resetting of the accumulators. Cams 63 and 64 are instrumental in controlling carry-over entry effecting operations in the accumulators D, E and F. Cam 64 also controls the application of ground to the accumulator readouts as RD, Fig. 3, for reading amounts from the accumulators.

Card feeding mechanism—Figs. 4 and 5

The motor 84, Fig. 5, drives the cam shaft 87 through gears 85 and 86 and also, through gears 83 and 82, drives the card feeding mechanism. Gear 82 is fast on a shaft 81 which also carries gears 80 and a feed roll 79, said feed roll cooperating with another feed roll 79A to advance a card fed into the bite therebetween. The stack of record cards 76 is supported on edge on a horizontal plate 77 and the cards are yieldably urged into engagement with a card picker 78 that is connected by links to the gears 80 and which functions to withdraw the foremost card from the stack 76 and feed it into the bite between the feed rolls 79 and 79A each time the gears 80 make a revolution.

Gear 82 on the feed roll shaft 81 is not driven continuously because both gears 82 and 83 are mutilated and there will be an interval in which the gear 82 is at rest, this occurring when the card has reached sensing position between the contact bars 59, 60 and 61 and the cooperating sensing brushes as 59A, 60A and 61A, Figs. 4 and 2. Thus the card feed rolls and card picker 78 are idle while the card is being sensed. Thereafter the rotation of the gear 82 is resumed and the card is advanced from sensing position by the roll 79 and also by the roll 79C which is driven by the gear 80 through the medium of an idler pinion and the gear 80A. The card picker 78 is restored to its upper position, shown in Fig. 4, when rotation of shaft 82 is resumed and thereafter descends to feed a new card to sensing position.

Printing and encoding means and sheet feeding mechanism—Figs. 6 and 8

The printing means G shown in Fig. 6 is illustrative of an arrangement that can be conveniently utilized in the preferred embodiment of the invention. Such printing means comprises a

series of type bars as 112, carrying type members as 83 and 83A contained in individual type holders as 85. Each type bar 112 is selectively positioned by a group of permutation members generally designated G1, G2, G4, G6 and G8. The several permutation members together constitute a permutation movement. Thus, for example, the member G1 includes a solenoid 75 having a plunger 75A and a rod 75B attached to said plunger. Slide bars 75C and 75D are pivotally connected at one end to the rod 75B and are separated at their other ends by a spacing bar 75E disposed therebetween intermediate said ends. The slide bar 75C acts against a stationary stop 82 while the slide bar 75D exerts a camming action on a push bar 75F whenever the plunger rod 75B is actuated upon energization of the solenoid 75. Member G2 includes a solenoid 76, a plunger 76A and connected rod 76B, slide bars 76C and 76D, spacing bar 76E and push bar 76F. Slide bar 76C acts against the push bar 75F of the member G1 and the slide bar 76D acts upon the push bar 76F. Members G4, G6 and G8 are arranged similarly to the members G2 and G1 with respect to each other. The slide bar 79D of the member G8 directly effects the positioning of the type bar 112.

A coil spring 81 tends to urge the type bar 112 to the left as viewed in Fig. 6 so that the zero type character 113 will be disposed in printing position above the inking ribbon IR and directly beneath a hammer 114. Magnet 115, when energized, draws the hammer 114 upwardly against the action of a spring 84B but when magnet 115 is deenergized the hammer 114 is quickly restored toward its normal position by the spring 84B and in so doing the hammer arm strikes a pin 84C located intermediate the spring 84B and the hammer head which causes the hammer 114 to snap sharply downwardly to so strike the type member disposed therebelow that an impression is made, through the ribbon IR, onto a sheet disposed in printing position.

Permutation member G1, when operated, moves the type bar 112 one step to the right as viewed in Fig. 6 to dispose the second type member, which carries the character "1," in printing position. Member G2 functions to move the type bar 112 through two positions to thereby dispose the type character "2" in printing position. Member G4, when actuated, moves the type bar 112 through four positions. Member G6 is effective to move the type bar through six positions. Member G8 will advance the bar 112 through eight positions when operated. Through the action of these permutation members, singly or in combinations, the type bar may be moved into a number of different positions. Inasmuch as the printer G is to be used for printing numerical items onto a sheet, there are ten type characters bearing the digits 0 and 1 to 9 mounted in the type bar 112. Members G1, G2, G4, G6 and G8, when operated singly, respectively position the type characters 1, 2, 4, 6 and 8, respectively in printing position. Members G1 and G2 when operated together dispose the digit 3 in printing position. Members G1 and G4 operating together set up the digit 5. Members G1 and G6 together set up the digit 7, and members G1 and G8 together enter the digit 9. The permutation members of the printer G are thus operated in accordance with the code shown in Fig. 7A which code is also employed in recording digital values in the record cards as 90, Fig. 7.

For a reason which will appear hereinafter, it

is necessary in the course of operation of the machine to convert digital entries to be effected into the printer G, from ordinary notation into the code shown in Fig. 7A. For this purpose encoding devices as T, Fig. 8, are employed, of which there is one for each order of the printer G. The terminals T1 to T9, inclusive, of each such device T are connected to digit-representing conductors pertaining to the digits 1 to 9, respectively. The terminals T1', T2', T4', T6' and T8' are respectively connected to the magnets of the permutation members G1, G2, G4, G6 and G8. The terminals T1 to T9 and the terminals T1', T2', T4', T6' and T8' are interconnected in such a manner that when ground is applied on a digit-representing conductor connected to a terminal as, for example, T3, circuit is continued to terminals as T1' and T2' and thence to the magnets of the permutation members as G1 and G2. Thus in the present example, the conventional representation of the digit 3 has been converted into the code representation of the digit. In order to prevent harmful feedbacks through the interconnected circuits of the encoding device T, a number of one-way current devices 136', Fig. 12, are provided in the respective circuits. In the present instance each such one-way current device comprises a relay 136', the winding of which is connected to a terminal as T1. The contact 136A' of this relay when closed upon energization thereof extends ground to a terminal as T1'. However, if ground is not present on the terminal as T1, the relay as 136' is not energized and therefore the grounding of a terminal as T1' has no effect. for ground cannot be extended from the terminal as T1' to the terminal as T1 when the contact 136A' of the relay 136' is open.

The sheet feeding apparatus comprises an endless conveyor 108 carrying a number of spaced projections as 100A and 100B that are adapted to engage sheets as S1 and S2 for advancing the same toward and away from printing position when the conveyor 108 is set in motion. Pin wheels 106 are provided for advancing the conveyor 108, each pin wheel 106 being attached to a gear 105 which meshes, in turn, with another gear 104. A ratchet wheel 103 is fast to the gear 104 and is operated by a ratchet arm 102 connected through a pin and slot arrangement to the plunger of a solenoid 101. Thus whenever the solenoid 101 is energized to move its plunger to the right, as viewed in Fig. 8, the ratchet arm 102 drives the ratchet wheel 103 and gear 104, and hence the gear 105 and pin wheel 106 to thereby advance the conveyor belt 108 to thereby discharge the sheet formerly at printing position and advance a new sheet thereto. When solenoid 101 is deenergized, it releases the ratchet arm 102 without effect other than to restore it to normal position.

Accumulators—Figs. 3, 9, 10, 11

The accumulators D, E and F, Fig. 3, are identical in construction and therefore but one of such accumulators, the accumulator D, is described in detail. Thus, each accumulator as D includes a set of permutation members, generally designated D1, D2, D4, D6 and D8 for the units order, D1', D2', D4', D6' and D8' for the tens order, and so on. The permutation members in each set thereof are respectively connected electrically to conductors as A1, A2, A4, A6 and A8. Figs. 3 and 1, which are included in the circuits controlled by the shift relays as 7, and these permutation members and associated shift circuit

means together constitute an entry-effecting means similar to that for the printer G, Fig. 6. However, in place of type bars as 112 the permutation means of the accumulator D are equipped with rack bars 38 that mesh with gears 39 on a shaft RSD (this being the reset shaft for the accumulator D and the operation of which is described subsequently). As viewed in Fig. 10, there is a series of rack bars as 38 that respectively pertain to the units, tens, hundreds, and so on, orders of the accumulators. Each gear as 39 is rotatably mounted on the shaft RSD in proximity to another gear 40 likewise rotatably mounted on the shaft RSD. A pawl 41, pivotally connected to one face of the gear 40, is yieldingly urged into engagement with the teeth of the gear 39 by suitable means such as a leaf spring. When gear 39 is driven clockwise, as viewed in Fig. 9, by the rack bar 38, it is effective through the pawl 41 to drive the gear 40. When rack bar 38 is restored to normal position, however, and the gear 39 is rotated counterclockwise, the teeth of the gear 39 move idly past the pawl 41, suitable detents being provided to prevent reverse movement of the gears as 40.

Gears as 40 mesh with gears as 42 fast on shafts as 44. When the gear 40 is driven by the entry-effecting means including the permutation members at D1, D2, and so on, it drives the gear 42 and shaft 44 to thereby position the brushes 45 and 45A of a readout RD, Figs. 3, 10 and 11. The readout RD comprises an approximately semi-circular conducting segment 46 and a number of smaller contact segments D0, D1, D2 and so on, respectively pertaining to the digits 0 and 1 to 9, inclusive, these digit representing segments being separated from each other by suitable insulation. Brushes as 45 and 45A are diametrically opposite each other and are adapted to be so positioned that one of the brushes is in contact with a digit-representing segment in accordance with the value of the digit set up in the readout. Brushes 45 and 45A are electrically connected so that whenever contact segment 46 is grounded, by means to be described hereinafter, ground will be extended through the selected digit-representing segment to one of a number of connected digit-representing conductors leading from these contact segments into a cable CD.

The segment D0 representative of the digit 0 is not connected to a digit-representing conductor in the illustrated form of the invention but if occasion arises where provision must be made for actually entering a zero, said segment D0 can be wired up accordingly. The contact segments D1 to D9, inclusive, are wired up as aforesaid. A special contact segment DC is located intermediate the segment D9 and the position on the readout RD which would correspond to the digital value 10. The segment DC is thus contacted by a brush as 45 whenever said brush is passing from the position corresponding to the digit 9 to that indicative of 10 or 0. The segment DC may thus be employed for indicating the need for a carry-over into the next higher order of the accumulator in the course of an entry into the readout RD. It will be understood that readouts similar to RD are provided for the tens and higher orders of the accumulator D as well as for the units order.

All entries of items into the accumulators D, E and F are in an additive sense; and where a subtractive entry of an item as a dividend amount is to be made, such entry is effected by the method of complemental addition, the precise manner in

which this is accomplished being explained in detail hereinafter. Therefore, the means for effecting carry-overs in the accumulators need only be operative to effect additive carries. Suitable carry-over apparatus for this purpose is provided for effecting transfers of carries from one order to another in each of the accumulators. Thus, for effecting carries from the units to tens orders in accumulator D, a pair of carry-over relays 122 and 123 is provided. A like pair of relays is provided for effecting carries from tens to hundreds orders. If the accumulator has capacity for four orders, a pair of carry-over relays as 122 and 123 is provided to effect carries from hundreds to thousands orders, and it will therefore be apparent that a pair of carry-over relays is provided to effect carries from each order to the next higher order within the capacity of the accumulator. Each pair of carry-over relays as 122 and 123, when operated in a manner to be described, controls the entry of a digital value of 1 into the readout in the higher of the two orders to which the particular pair of carry-over relays is allocated.

Such carries as are required to be made into the readouts of the accumulator D are entered following each entry of an item as premium, interest, or dividend into this accumulator. If, in the course of such an entry into the accumulator, the need arises for making a carry from one order into the next higher order, the corresponding pair of carry-over relays is conditioned for subsequent operation, such subsequent operation of the carry-over relays occurring after the entry of the item which is to be accumulated is completed, at which time each pair of carry-over relays that was previously conditioned for operation is operated to release the carry stored therein and enter same in the appropriate readout. All carry-over entries which result from the direct entry of the digits of one item to digits in corresponding orders of the amount previously manifested by the accumulator are entered concurrently at a predetermined time in the operation of the machine after entry of the item to be accumulated has been effected.

However, long carries, such as result when a readout which previously registered the digit 9 receives a carry of 1 from the next lower order and must therefore effect a carry of 1 to the next higher order, are entered subsequent to the direct carry entries, and long carries in successive orders are entered successively. Thus, for example, assume that each of the tens and hundreds order readouts registers the digit 9 following the entry of an item into the accumulator D, and that a direct carry entry of 1 is thereupon effected from units to tens order. The tens readout is thereby adjusted from the position representative of the digit 9 to its zero position, and as a result of this a long carry is thereupon effected from the tens order into the hundreds order readout, so that the latter is now advanced from the position representative of the digit 9 to its zero position, and a long carry is thereupon effected from the hundreds order into the thousands order.

Each of the carry-over relays as 122 or 123 is double wound, and in addition to this, the relay as 122 in each pair is slow to release so that a time delay is interposed in the interval between initiation of its deenergization and the opening of its contacts 122C and 122D. To condition a pair of carry-over relays as 122 and 123 for subsequently operating to effect entry of a carry, these relays are energized simultaneously and are main-

tained energized until such time as they are to be rendered effective to enter the carry digit. Such energization of the relay 123 causes it to open its contact 123D and deprive the contact 122D of relay 122 of ground, so that closure of contact 122D upon energization of relay 122 is without effect. To initiate carry-over operations relays as 122 and 123 are deenergized, and relay 123 promptly releases and closes its contact 123D; but relay 122, being slow to release, holds its contact 122D closed for a predetermined time after deenergization of this relay is initiated, and such sequential release of the carry-over relays in a pair as 122 and 123 is effective to enter the required carry into the next higher order, as will be explained presently.

Windings 122A and 123A of the relays 122 and 123 are connected by a common conductor 130 to the carry-over segment DC of the readout RD, Figs. 3 and 11, and when this segment is momentarily grounded, as the brush as 45 passes from digital positions 9 to 0 in the course of an entry into the readout RD, the windings 122A and 123A are momentarily energized and the relays thereupon actuate their several contacts. Relay 123 closes its contact 123C and establishes a holding circuit for itself through the winding 123B, contact 123C and a conductor 121, Figs. 3, 1 and 2, leading to the contact 63A of control cam 63 which will be closed at the time relay 123 is to be energized. Likewise, relay 122 establishes a holding circuit through its winding 122B, contact 122C, conductor 121 and cam contact 63A. When relay 122 energizes, its contact 122D closes, but without effect, inasmuch as this contact must derive ground through the contact 123D of relay 123, which latter contact will be open at the time relay 122 energizes.

After the respective entries into the several readouts of the accumulator D have been effected, the control cam 63, Fig. 2, opens its contact 63A and frees the conductor 121 of ground whereupon ground is removed from the windings 122B and 123B of the carry-over relays 122 and 123. The windings 122A and 123A of these relays are not energized at the time windings 122B and 123B are so freed of ground for the brushes as 45 of the readouts as RD never come to rest in engagement with the carry-over contact segments as DC. When winding 123B is freed of ground, as just described, relay 123 promptly deenergizes and closes its contact 123D. However, when winding 122B is freed of ground in the manner just described contact 122D of relay 122 remains closed since the relay 122 is a slow-to-release relay. Thus ground is momentarily extended from contact 123D of relay 123 to contact 122D of relay 122 and thence through a conductor 128 to the conductor A1' leading to the magnet of the permutation member D1' in the tens order of the accumulator D. Member D1' is thereupon actuated to enter a digital value of 1 into the tens readout. Likewise any direct carry-over entries which are required into higher orders of the accumulator D are effected concurrently with entry of the carry into the tens order and under control of carry-over relays similar to the relays 122 and 123.

When slow-to-release relays 122 release, their contacts as 122D open but by the time this occurs the permutation members as D1' will have had time to operate to enter the required carries. Opening of contacts as 122D of the relays as 122 removes ground from the conductors as 128 and A1' leading to the magnets of the permutation

members as D1' in the next higher orders and thereby deenergizes the magnets of said members to allow restoration thereof.

In the event the tens order readout had registered the digit 9 prior to entry of the carry digit thereinto a long carry would then be effected into the hundreds order. Conductor 121 which forms part of the holding circuits for the carry-over relays as 122 and 123 is not grounded during the carry-entering operations inasmuch as contact 63A of cam 63 which supplies ground to the conductor 121 is opened to initiate the carry-entering operation, as aforesaid, and remains open throughout the interval when carries are being effected. Therefore, although the carry-over relays as 122 and 123 in the tens order are momentarily energized as the readout brush 45 passes over the carry segment DC in the course of such carry entries into the tens readout, they immediately start to deenergize as the readout brush 45 moves from contact with the carry segment D. C. The relay as 123 promptly releases but the relay as 122 affords a time delay sufficient to enable a carry to be entered into the hundreds order in the same manner in which the carry into the tens order was effected under control of the slow relay 122 in the units order when the relay 123 in the units order was released.

The accumulators E and F, identical in construction to the accumulator D, as has been stated, are provided with readouts as RE and RF for each order thereof. Carry-over relays as 124 and 125 are provided for the accumulator E and carry-over relays as 126 and 127 are provided for the accumulator F, these relays functioning in the same manner as the carry-over relays 122 and 123 for the accumulator D. The digital conductors leading from the readouts as RD of the accumulator D are included in a cable CD, those conductors leading from the readouts as RE of the accumulator E are included in a cable CE, and the digital conductors leading from the readouts as RF of the accumulator F are included in a cable CF. These cables reappear in Fig. 8 and the digital conductors contained therein are connected to corresponding contacts of shift relays 35 for the cable CD, 36 for the cable CE, and 37 for the cable CF.

The shift relays 35, 36 and 37 selectively interconnect the digital conductors leading from the readouts of the various accumulators D, E and F with the terminals T1 to T9, inclusive, of the encoding device T. Thus, shift relay 35, when energized, enables an entry to be effected from readouts as RD in the accumulator D into the printing means G through the medium of the encoding devices as T wherein the amount standing on the accumulator D in conventional notation is converted into code before being entered into the printer G. Shift relay 36, when energized, similarly enables an entry to be made from the accumulator E into the printer G and shift relay 37, when energized, also similarly enables an entry to be effected from the accumulator F into the printer G.

Each of the accumulators D, E and F is provided with a reset shaft such as RSD, RSE or RSF. Referring first to the accumulator D, the shaft RSD is provided with a longitudinal groove 47. The gears 40, rotatably mounted on the shaft RSD, are provided with pawls 43, Figs. 9 and 10, which are yieldably urged into engagement with the periphery of the shaft RSD. When the gears 40, and accumulator readouts

driven thereby, are in their normal or zero positions, the pawls 43 are in engagement with the groove 47 in the shaft RSD. As the gears 40 are rotated clockwise as viewed in Fig. 9, however, in the course of entries thereto, the pawls 43 are rotated away from positions in which they engage the groove 47. When the accumulator D is to be reset, the shaft RSD is driven clockwise as viewed in Fig. 9, through a complete rotation by means to be described presently and in the course of such rotation of the shaft RSD, the groove 47 will align with the pawls 43 which then seat therein and drive the gears 40 and accumulator readouts connected thereto back to their normal or zero positions. In the course of such restoration of the gears 40 and their respective readouts the pawls 41 ride idly over the teeth of the gears 39 so that the rack bars 38 will not be affected during the zero-setting operation.

Contact segments as 46 of readouts as RD are connected to ground through conductor 129, Figs. 3, 1 and 2, and contact 64A of cam 64 throughout the entry-effecting and carry-entering operations. However, the apparatus is so timed that during the resetting operation the cam 64 opens its contact 64A and frees the conductor 129 and contact segments as 46 of ground so that the carry-over relays as 122 and 123 will not be energized in the course of the resetting operation.

The reset shafts RSD, RSE and RSF of the accumulators D, E and F, respectively, are driven by a reset motor RM, Fig. 10. Each reset shaft as RSD is driven through the medium of a friction clutch 136 during resetting operations. The shaft RSD is provided with a cam 39' having a notch therein which cooperates with a latch 38' so that normally the reset shaft RSD is held against movement while the friction clutch 136 slips. A magnet MD is provided for momentarily withdrawing the latch 38' from engagement with the cam 39' when the accumulator D is to be reset and when the cam 39' is so released the shaft RSD is driven through the medium of the friction clutch 136 by the motor RM for one complete rotation and meanwhile the magnet MD is deenergized wherefore the latch 38' drops back into engagement with the periphery of cam 39' so that when the shaft RSD completes its cycle, the latch 38' drops back into the notch in the cam 39' and restrains the shaft against further movement.

The reset shafts as RSE and RSF of the accumulators E and F are driven by the motor RM through intermediate gears as 49. Each such shaft is provided with a friction clutch such as 136 and a latching arrangement as 38'—39' controlled by a reset magnet as MD. Each magnet as MD is connected by a conductor as 135 to one of the contacts as 66A of the control cam 66, Fig. 2. Thus cam contact 66A is connected to the reset magnet for the accumulator D, contact 66B is connected to the reset magnet for the accumulator E and contact 66C is connected to the reset magnet for the accumulator F. The control cam 66 is provided with a lobe for successively closing these contacts to thereby reset the accumulators D, E and F at the proper times.

Inverting devices—Figs. 13 and 14

As explained, hereinabove, certain of the entries into the accumulators D, E and F in the present machine are subtractive in nature. For example, the premium amount and interest stored in the first and second sets of relays, respectively, in the storage group A are entered into the accumulator

D additively, but the dividend amount stored in the third set of relays in group A is to be subtracted from the sum of the premium and interest amounts or from the premium amount where there is no interest charge. Preferably, the subtractive entry of the dividend is performed by the method of complemental addition; that is, the units digit is, in effect, subtracted from 10 and the difference is entered in the units readout, while the tens and higher order digits are each, in effect, subtracted from 9 and these differences then entered in the corresponding readouts.

Thus assume that the original amount standing on the accumulator D is 723 and the amount to be subtracted therefrom is 154. The complement of the digit 4 in the units order with respect to 10 is 6, that of the digit 5 in tens order with respect to 9 is 4, and that of the digit 1 in the hundreds order with respect to 9 is 8. Thus the complemental of 154 is 846, and this amount, when added to 723, will cause the accumulator to be set to display 569, the difference that is ascertained when 154 is subtracted from 723. The foregoing result is realized since the accumulator D has a capacity of only three orders and while the sum of 723 plus 846 is 1569, since there is no thousands order readout, the digit 1 in the thousands order of the result will not be registered, leaving only the amount 569 standing on the readouts of the accumulator. The result of 723 minus 154, or 569, is so obtained by resort to complemental addition.

If ordinary notation were employed in storing the entries to be made into the accumulator D, that is to say, if there were nine storage relays pertaining to the digit 1 to 9 in each bank of each set, it would be a relatively simple problem to convert such stored entry into its complement, for example, by means of a simple plugboard arrangement, before entering same into the accumulator D. However, the use of code requires that special inverting devices as VA and VA', Figs. 1, 13 and 14, be employed. The inverting device VA for the accumulator D converts the code representation of the units digits of the dividend amount into its code complement with respect to the quantity 10 before entering same into the units order readout RD of the accumulator D. The device VA is schematically represented in Fig. 13. Other inverting devices VA', Fig. 14, similar to the devices VA, are provided for the tens and higher orders of the accumulator D but these latter inverting devices function to convert the digits in the tens and higher orders of the dividend amount into their complements with respect to the digit 9.

Referring to Fig. 13, (ten-complement inverting device) the terminals VA1, VA2, VA4, VA6 and VA8 are respectively connected to contacts as 17C and 18C of the corresponding storage relays as 17 and 18 in the third set of the storage group A. The terminals VA1', VA2', VA4', VA6' and VA8' on the opposite side of the devices VA are respectively connected to corresponding contacts of the shift relay 9, and are respectively connected to conductors A1, A2, A4, A6 and A8 leading to the corresponding magnets of the permutation members D1, D2, D4, D6 and D8 in the units order of the accumulator D, when said shift relay 9 is energized. When certain of the terminals VA1, VA2, VA4, VA6 and VA8 have been selected in accordance with the value of a digit for which the complement is to be obtained, the device VA, through the medium of relays 138 to 140 included

therein, selects certain of the terminals VA1', VA2', VA4', VA6', and VA8' in accordance with the value of the complemental digit. For example, assuming that the storage relays 17 and 18 have been locked up to represent the digit 3, when shift relay 9 closes its contact 9A, it extends ground through the conductor 9X, and contacts 17C and 18C of the storage relays 17 and 18 to the terminals VA1 and VA2 to thereby indicate that the digit for which the complement is to be obtained is 3. In a manner to be explained presently, this results in the extension of ground to the terminals VA1' and VA6' on the opposite side of the device VA, and thence through corresponding contacts of the shift relay 9 to the conductors A1 and A6 leading to the magnets of permutation members D1 and D6 in the units order of the accumulator D, and this results in the entry of a digital value of 7 into the units readout RD. Hence the grounding of the terminals VA1 and VA2 of the device VA from the contacts 17C and 18C of the storage relays 17 and 18, this being representative of the digit 3 in the units order of the dividend amount, is effective to cause the digit 7, or the complement of 3 with respect to 10, to be entered in the readout RD when shift relay 9 is energized. Examples of the operation of the device VA are as follows:

When terminal VA1 alone is grounded to represent the digit 1, the relay 136 is energized. This relay closes its contact 136A and opens its contacts 136B and 136C. Closure of contact 136A extends ground to the terminal VA1' corresponding to the digit 1. The terminals VA2, VA4, VA6 and VA8 are respectively connected to the windings of the relays 137, 138, 139 and 140 included in the device VA, but inasmuch as these latter terminals are not grounded in the present instance, the relays 137 to 140 are deenergized at this time. Relay 140 extends ground from its contact 140B through the now closed contacts 139D of relay 139, 138C of relay 138, and 137D of relay 137 to a conductor 141 leading to the terminal VA8' representative of the digit 8. Thus when terminal VA1 alone is grounded, terminals VA1' and VA8' are both grounded, thereby signifying that the complement of the digit 1 with respect to 10 is 9.

When terminal VA2 alone is grounded to represent the digit 2, the relay 137 is energized. Contact 137A of this relay closes and extends ground from the now closed contact 136B of relay 136 for the conductor 141 and thence to the terminal VA8'. Opening of contacts 137C and 137D of relay 137 prevents ground from being extended from the contacts 140B and 140C of relay 140 to the contact 136C of relay 136 or to the conductor 141. Inasmuch as conductor 141 had already been grounded upon closure of contact 137A, however, opening of contact 137D is without effect in the present instance. Closure of contact 137B is without effect since contact 136A of relay 136 is now open. Therefore, when terminal VA2 alone is grounded, the terminal VA8' is the only terminal grounded on the other side thereof thereby indicating that the complement of the digit 2 with respect to 10 is 8.

When terminals VA1 and VA2 are both grounded to represent the digit 3, the relays 136 and 137 both energize. Contact 136A of relay 136 closes and grounds the terminal VA1', also extending ground through closed contact 137B of relay 137 to the terminal VA6'. Thus when terminals VA1 and VA2 are grounded, terminals VA1' and VA6' are both grounded thereby denot-

ing that the complement of the digit 3 with respect to 10 is 7. Grounding of the various terminals VA1, VA2, VA4, VA6 and VA8, either singly or in combination in accordance with the code shown in Fig. 7A results in the grounding of the terminals VA1', VA2', VA4', VA6', VA8' in accordance with the code representations of the complements with respect to 10 of the digits to be entered subtractively in the units order of the accumulator D. If a zero is to be entered, subtractively, none of the relays 136 to 140 are energized and ground is extended from contacts 140B and 140C of relay 140 through contacts 139D and 139C of relay 139, contacts 138C and 138D of relay 138 to contacts 137D and 137C of relay 137. Contact 137D extends ground to terminal VA8'. Contact 137C extends ground to contact 136C of relay 136 and thence to terminal VA2'. It will be apparent, therefore, that the complement of 0 with respect to 10 is 10 for, in complemental addition to effect subtraction, the effect of subtraction from 10 to obtain the complement is essential. Thus the extension of ground to terminals VA2' and VA8' is, in effect, the result of the subtraction of 0 from 10, for in this instance the complement amount is to be 10. When entry of such a complement amount is effected into the units readout RD of the accumulator D, a carry-over into the tens order will always result. Thus if the subtrahend is 150 and the minuend is 723, the quantity 150 will be converted into the quantity 840 plus a carry of one into the tens order. 840 added to 723 gives 563 (assuming there is no thousands order readout), plus a carry of one into the tens order equals 573, the latter being the difference between 723 and 150.

Inverting devices as VA' shown in Fig. 14 are utilized in effecting complemental entries into the tens and higher orders of the accumulator D. The terminals 142, 143, 144, 145 and 146, respectively, correspond to the terminals VA1, VA2, VA4, VA6 and VA8 of the inverting device VA in the units order while the terminals 147, 148, 149, 150 and 151, respectively, correspond to terminals VA1', VA2', VA4', VA6', VA8' of the device VA. An example of the operation of the device VA would be where the terminals 142 and 145 are grounded to represent the digit 7. This causes relays 152 and 155 to become energized. Relay 152 energizing opens its contact 152A and prevents ground from being applied on the terminal 147. Relay 155 closes its contact 155A to apply ground on the terminal 148 and opens its contact 155B to break the circuit commencing with ground at the contact 156A of the relay 156. Thus grounding of the terminals 142 and 145 to represent the digit 7 results in grounding of terminal 148 to represent the digit 2, which is the complement of 7 with respect to 9. If a zero is to be entered, none of the relays 152 to 156 is energized. Contact 152A of relay 152 grounds the terminal 147. Ground is likewise extended from contact 156A of relay 156 through contact 155B of relay 155, contact 154B of relay 154, and 153B of relay 153 to the terminal 151. Thus if none of the terminals 142 to 146 are grounded indicating 0, the terminals 147 and 151 are grounded to represent the digit 9, the complement of 0 with respect to 9.

When the dividend amount is zero, the inverter VA causes an entry of 10 to be effected into the lowest order of the accumulator, and the inverters VA' cause entries of 9 to be made in all higher orders. As a result of this, carries are successively effected from order to order so that,

in effect, a zero is entered in each order. Thus, if the minuend (or premium amount less loan interest) is 534, and the subtrahend (or dividend) is zero, the complemental addition of the latter to the former is as follows:

534
990—complement of 000, without carries
11 —carries
—
(1)534

The digit 1 in the parentheses is lost since it has been assumed, as aforesaid, that the accumulator has only a three-order capacity.

An inverting device VB identical to the device VA cooperates with the storage relays in the units order of the third set, group B, while inverting devices identical to the device VA' cooperate with the storage relays in the tens and higher orders of this set. Similarly, an inverting device VC identical to the device VA is provided for the storage relays in the units order of the third set, group C, and inverting devices identical to the device VA' cooperate with the storage relays in the higher orders in this set.

Record cards and code—Figs. 7 and 7A

Record cards 90, 91 and 92 such as may be conveniently employed in the machine of the present invention are shown in Fig. 7. Numerical items are represented on such cards by perforations as 90A, 90B and 90C in the card 90. Each item is represented in a separate field of the card and each such field is arranged to accommodate representations of digits under a five-unit code, the code employed in the present instance being illustrated in Fig. 7A.

The field on card 90 in which the perforation 90A is formed is allocated, in accordance with the arrangement of the present machine to the premium amount, this being an instance where the card is prepared to pertain to a policyholder of an insurance company, but obviously any other item could be so represented dependent upon the use to which the card is to be put. The card field in which the perforation 90B is located is utilized in the present instance for receiving representations of interest due on a loan advanced to the policyholder. The card field in which the perforations 90C are located is allocated to receive representations of the amount of the dividend due the policyholder. Perforations 90A, 90B and 90C are shown in the units orders of the respective items and it will be understood that additional perforations will ordinarily be provided in the tens and hundreds or higher orders as required. Considering only the units order digits represented in the card 90, it will be seen by reference to Fig. 7A that the premium amount (perforation 90A) is 1, the loan interest (perforation 90B) is 2 and the dividend (perforations 90C) is 3.

On card 91 the units digit of the premium (perforation 91A) is 2, that for the interest (perforation 91B) is 9, and that for the dividend (perforation 91C) is 1. Similarly, in card 92 the perforations 92A represent a units digit of 3 for the premium, perforation 92B indicates a units digit 2 for the interest and perforation 92C represents the units digit 6 in the dividend.

If any of the items is missing, for example, if there has been no loan advanced to the policyholder or if no dividend is being declared by the company, corresponding fields of the card are left blank. It will be understood that the particular five-unit code employed is merely indicative of a wide variety of codes in five units or otherwise

that may be employed to advantage and hence the machine of the present invention is not to be limited to the precise form of code chosen for illustration.

OPERATION OF THE MACHINE

In the following description of the operation of the machine it will be assumed that the cards 90, 91 and 92, Fig. 7, represent the records of three successive policyholders. Considering only the digits in the units orders on these cards, it will be noted that in card 90 there is a perforation 90A in the lowest index position in the upper field, a perforation 90B in the next to lowest index position in the middle field, and perforations 90C in the two lowest index positions in the bottom field. Thus for the units orders of the numerical quantities represented on the card 90, and in accordance with the code shown in Fig. 7A, there is a digit 1 for the premium, a digit 2 for the interest and a digit 3 for the dividend.

Similarly, in card 91 there are perforations 91A, 91B and 91C in the units orders of the numerical quantities representative of the digits 2 for the premium, 9 for the interest and 1 for the dividend. In card 92 there are perforations 92A, 92B and 92C in the units orders of the numerical quantities represented thereon, these perforations being indicative of the digit 3 for the premium, 2 for the interest and 6 for the dividend.

It will be understood that the digits in the tens, hundreds, and higher orders, if there be any, are represented on the cards as 90, 91 and 92 in the same manner as the aforesaid digits in the units orders of the various numerical quantities, the code shown in Fig. 7A being utilized throughout.

Before the start of machine operation a dummy sheet is placed at printing position in the printer G, Fig. 8. The next two sheets in succession to pass through the printer G are likewise dummy sheets. This is done for the reason that a sheet is printed by the printer G in each and every sequence of operation, but a complete total is not printed until the fourth sequence after the machine has been set in operation. The initial sequence of operation, described hereinafter under the heading "Initial card feeding operation," corresponds to what will be referred to hereinafter as the third sequence of the cycle, but inasmuch as many of the functions which are normally performed in the third sequence of each cycle are performed idly in the initial sequence of operation, only those functions which are actually effective in this initial sequence will be described. The second sequence after starting is described under the heading "First cycle—first sequence," and the third sequence after starting under the heading "First cycle—second sequence." The fourth sequence after starting is described under "First cycle—third sequence," and it is in this sequence that the first total is printed. Hence the first premium notice to be fed into printing position will in reality be the fourth sheet to be printed upon, and thereafter a premium notice is printed by the printer G in each and every printing operation.

Throughout the following description of machine operation, reference should be made to the timing charts, Figs. 15 and 16. Fig. 15 shows the relative timing of various machine functions during a complete cycle of the cam shaft 87, while Fig. 16 shows the times at which the various cam contacts, Fig. 2, are opened and closed to effect such functions. It will be understood, of course,

that while the operations of the various parts are represented on the timing charts in exact terms of degrees in the cycle of rotation of the cam shaft 87, the precise timing there shown need not be strictly adhered to, so long as the illustrated timed interrelation of the various devices is maintained, it only being important that they be timed to operate so as not to interfere with the respective operations of each other.

Initial card feeding operation

Card feed motor 84, Fig. 5, and the reset motor RM, Fig. 10, are set into operation. Rotation of the motor RM is without effect at the present time inasmuch as the reset shafts RSD, RSE and RSF, Figs. 3, 9 and 10, for the accumulators D, E and F are held against movement by the latches as 38 cooperating with the cams as 39 on these various reset shafts.

The motor 84, Fig. 5, through gears 85 and 86, drives the cam shaft 87 and the mutilated gear 82 is driven therefrom through the mutilated gear 83. Gears 80 attached to the gear 82 commence to rotate and in so doing move the card picker block 78 downwardly and the card 90 is thereby fed toward sensing position. While this is taking place, the control cams 50 to 58 and 62 to 66, inclusive, Figs. 5 and 2, are performing their respective functions, but such functions are idle in this instance. For example, the printer G, Fig. 8, is operated to make an impression upon the first dummy sheet at printing position. After this sheet has been printed, it is discharged and the second dummy sheet is fed to printing position.

Gear 83 and cam shaft 87 rotate continuously but the gear 82 is rotated only until the card 90 reaches sensing position above the bars 59, 60 and 61, at which time the gear 82, card picker 78, and feed rolls 79, 79A, 79B and 79C remain stationary for a short interval while the card 90 is being sensed.

During this initial card feeding operation (which, as has been explained hereinabove, corresponds to what will be referred to hereinafter as the third sequence of each machine cycle) the cam contact 62C, Fig. 2, momentarily closes and applies ground on the contact bars 59, 60 and 61, thereby causing the storage relays in group C, Fig. 1, to be energized. As a result, fictitious entries are effected in accumulator F during the initial card feeding operation and in the following two sequences. This causes an unwanted sum to be set up on the accumulator F, which amount is then printed on the third dummy sheet, as will be described subsequently under the heading "First cycle—second sequence."

First cycle—first sequence

The card 90 is now in sensing position. Contact 62A of the cam 62, Fig. 2, is closed to extend ground through the conductor 62D to the contact bars as 59, 60 and 61. Through card perforation 90A, Fig. 7, the sensing finger 59A is grounded from the bar 59; through perforation 90B the sensing finger 60B is grounded from the bar 60; and through perforations 90C, the sensing fingers 61A and 61B are grounded from the bar 61.

Contact 50A of cam 50 is also closed at this time to extend ground through conductor 50D, Figs. 2 and 1, to the winding of transfer relay G, which relay therefore energizes and closes its several contacts. Through the now closed relay contacts 6A, 6B, 6D and 6C, the grounded sensing

fingers 59A, 60B, 61A and 61B, respectively, are effective to energize the left-hand windings as 1A of the storage relays 1, 16, 17 and 18 in the storage group A. These storage relays thereupon close their contacts and establish holding circuits through their right-hand windings as 1B, conductors 53D, 54D and 55D, Figs. 1 and 2, and contacts 53A of cam 53, 54A of cam 54 and 55A of cam 55, all of these cam contacts being closed at the present time. Hence the storage relays 1, 16, 17 and 18 remain locked up through their windings as 1B subsequent to the removal of ground from the contact bars 59, 60 and 61.

The rotation of the driven gear 82, Fig. 4, is now resumed, and the card 90 starts to move away from sensing position. Meanwhile, the contact 62A of the cam 62, Fig. 2, will have opened to thereby deprive the conductor 62D and the bars 59, 60 and 61 of ground. The contact 50A of cam 50 likewise opens to thereby deenergize the transfer relay G. Contact 56A of cam 56 closes and applies ground on the conductors 56B, 57D and 58C, respectively connected to the windings of the shift relays 7, 12 and 14, Fig. 1, and these shift relays thereupon close their contacts. Closure of contact 7A of relay 7 extends ground through conductor 7X to the closed contact 1C of the storage relay 1 in the first set of storage relays, group A. Ground continues through contacts 1C of relay 1 and 7F of relay 7 to the conductor A1 leading to the winding of the magnet for the permutation member D1 in the units orders of the accumulator D. As the member D1 is thus actuated, it advances its rack 38, Fig. 9 through one digital position, thereby advancing the ratchet gear 39 and the gears 40 and 42 through one digital position. Thus the brushes of the readout RD in the units order of the accumulator D are positioned to represent the digit 1.

Similarly, the permutation members as D1', D2', D3', D4' and D5' of the tens and higher orders in the accumulator D are actuated in accordance with the set-up of the storage relays in the corresponding denominations of the first set in group A.

When shift relay 12 closes its contact 12A, it grounds the normally open contacts as 25C of the storage relays as 25 in the third set of storage relays in group B but this is without effect other than to enter the 10-complement of 0, or 10, in the units order of accumulator E and the 9-complement of 0, or 9, in all other orders, inasmuch as none of the storage relays in group B are energized at the present time, and after a carry-over operation, the readouts of accumulator E all register zero again. Likewise, shift relay 14 closes its contact 14A but this is without effect inasmuch as none of the storage relays in group C are energized at the present time.

Cam contact 56A, Fig. 2, opens after the entry of the premium amount from the card 90 has been effected into the accumulator D, Fig. 3, thus releasing the shift relay 7 and permitting the permutation members as D1 to be restored. The readouts as RD of the accumulator D are not affected by such restoration of the permutation members inasmuch as the gears as 39, Fig. 9, driven by the rack bars as 38 are now rotating counter-clockwise and are therefore unable to drive the gears as 40 by means of the pawls as 41.

Contact 65B of the cam 65 closes to energize the shift relay 36, Fig. 8, associated with the readouts of the accumulator E, Fig. 3, but this is without effect as the present time inasmuch as no significant entry has been effected as yet into

the accumulator E. Therefore, none of the permutation members of the printer G are actuated. Contact 51A of cam 51 closes and grounds the common conductor 51D, Figs. 2 and 8, which leads to the magnets as 120 which operate the hammers as 121 of the printer G. Cam contact 51A opens shortly thereafter to deenergize the magnets as 120 and release the hammers as 121. This has the effect of printing all zeros on the second dummy sheet now in printing position. Cam contact 65B opens to release the shift relay 36. Contact 66B of cam 66 closes momentarily to enable the reset shaft RSE of the accumulator E to reset the readouts as RE of this accumulator but this operation is idle.

Cam 52 momentarily closes its contact 52A and thereby actuates the sheet feed solenoid 101, Fig. 8, for feeding the second dummy sheet away from printing position and advancing the third dummy sheet into such position. Contacts 53A, 53B and 53C of the cam 53 are open momentarily toward the end of the first sequence. Opening of contact 53A frees conductor 53D of ground and thereby breaks the holding circuit to the windings as 1B of the storage relays as 1 in the first set, group A. Relay 1 is thereupon released. Opening of cam contacts 53B and 53C is without effect in the present instance.

First cycle—second sequence

As an incident to the initiation of the second sequence of the first cycle the card 91, Fig. 7, is advanced to sensing position above the bars 59, 60 and 61, Fig. 2, and is then momentarily arrested in this position. Cam 62 closes its contact 62B to momentarily ground the conductor 62D and the bars 59, 60 and 61. Cam 50 closes its contact 50B and thereby energizes the transfer relay 21. Sensing fingers 59B, 60E, 60A and 61A are grounded through the card perforations 91A, 91B and 91C, and through contacts 21A, 21E, 21B and 21D of relay 21 they extend ground to the windings as 22A of the storage relays 22, 33, 23 and 25. These storage relays thereupon energize and lock up through their windings as 22B, conductors 54E, 55E and 53E and cam contacts 54B, 55B and 53B, closed at this time. Cam 50 opens its contact 50B to deenergize the transfer relay 21 after the various storage relays in group B have thus been selected and locked up, and cam 62 opens its contact 62B to deprive the bars 59, 60, and 61 of ground. The card 91 thereupon starts to move away from sensing position.

Cam 57 closes its contact 57A and grounds conductors 56C, 57B and 58D, Figs. 2 and 1, to thereby energize the shift relays 8, 10 and 15. As shift relay 8 closes its contact 8A, it extends ground through the contact 16C of the locked up storage relay 16 in the second set, group A, and relay contact 8E to the conductor A2 leading to the magnet of the permutation member D2 in the units order of the accumulator D. The member D2 thereupon actuates the units rack 30 and advances the ratchet gear 39, gears 40 and 42 and the brushes of the readout RD in the units order through two digital positions. Similarly, the permutation members in the tens and higher orders of the accumulator D adjust their respective readouts in accordance with the amount of the loan interest on the first policy.

The storage relay 22 of the first set, group B, extends ground from contact 10A of shift relay 10 through its contact 22C and relay contact 10E to the magnet of the permutation member E2 in

the units order of the accumulator E to thereby advance the brushes of the readout RE through two digital positions in accordance with the units digit of the premium amount represented on card 91. Likewise, the digits in the tens and higher orders of this premium amount are entered in the respective readouts of the accumulator E.

Shift relay 15 in energizing, grounds the normally open contacts as 32C of the storage relays as 32 in the third set, group C, but this is without effect at the present time inasmuch as none of the relays in group C have been energized. As in the case of the accumulator E during the first sequence, the complement of zero is entered into the accumulator F during the present sequence, but this merely causes the readouts to be reset to zero.

After the necessary entries have been effected into the several accumulators in this sequence of operations, the cam 57 opens its contact 57A and thereby releases the shift relays 8, 10 and 15 and permits restoration of the permutation members in the several accumulators. The brushes of the readout RD now stand at 3, which is the sum of the digit 1 for the premium and the digit 2 for the loan interest represented in the units order on the first card 90, Fig. 7. The brushes of the readout RE stand at 2 in accordance with the value of the digit in the units order of the premium amount represented on the second card 91. Readout RF is still at zero. Readouts in the higher orders of the accumulators D, E and F will have been likewise positioned under control of the storage groups A, B and C.

Cam 63 opens its contact 63A at the completion of the just described entry-effecting operations and thereby removes ground from the conductor 121, Figs. 2, 1 and 3, for effecting any carry-over operations that are required. Cam contact 63A again closes.

Cam 65 closes its contact 65C and thereby energizes the shift relay 37 associated with the readouts as RF of the accumulator F but this is without effect on the permutation members of the printer G inasmuch as the brushes of the readouts as RF all stand at zero. Also, the cam 51 momentarily closes the contact 51B to thereby operate the magnets 120 and hammers 121 at the printing station but this is without effect other than to print on the third dummy sheet now in printing position the unwanted sum standing on the accumulator F.

Cam 52 momentarily closes its contact 52B to thereby actuate the solenoid 101, Fig. 8, for feeding the third dummy sheet away from printing position and advancing the first premium notice or like sheet into printing position. Cam 66 closes contact 66C for energizing the reset magnet of the accumulator F and sending the reset shaft RSF of this accumulator through a complete rotation, thereby clearing the accumulator F.

Cam 54 momentarily opens the contacts 54A, 54B and 54C to thereby remove ground from the conductors 54D, 54E, 54F and break the holding circuits for the storage relays in the second set of group A, the first set in group B and the third set in group C. Thus in group A the relay 16 and in group B the relay 22 are released. There is no effect insofar as the relays in group C are concerned, inasmuch as no entry has been made as yet into this storage group. Thus the first and second sets of relays in group A have now been released, as well as the first set in group B.

First cycle—third sequence

Card 92, Fig. 7, is fed to sensing position as an incident to the initiation of the third sequence of the first cycle. Cam 62 closes its contact 62C to ground the conductor 62D and the contact bars 59, 60 and 61. Contact 50C of cam 50 closes and energizes the transfer relay 27. Through perforations 92A, 92B and 92C in the card 92, ground is extended to the sensing fingers 59A, 59B, 60B and 61D and thence to contacts 27A, 27B, 27C and 27E of relay 27, and the windings as 28A of the storage relays 28, 29, 31 and 34 in group C. These relays energize and lock up through their windings as 28B, conductors 55F, 54F, 53F and cam contacts 55C, 54C and 53C, which are closed and grounded at this time. Cam 62 opens its contact 62C and deprives its contact bars 59, 60 and 61 of ground and the card 92 is fed away from sensing position. Cam 50 opens its contact 50C to release the transfer relay 27.

Cam 58 closes its contact 58A and thereby energizes the shift relays 9, 11 and 13, respectively corresponding to the third set of storage relays in group A, the second set in group B and the first set in group C. Shift relay 9 closes contact 9A and grounds the closed contacts 17C and 18C of the storage relays 17 and 18. Ground is extended through these contacts to the terminals VA1 and VA2 of the inverting device VA, Figs. 1 and 13. As previously explained, under the heading "Inverting devices," this is effective through now closed contacts 9F and 9C of relay 9 connected to the terminals VA1' and VA2' of device VA to ground the conductors A1 and A6 leading to the magnets of the permutation members D1 and D6 in the units order of the accumulator D. It will be noted that the perforations 90C, Fig. 7, in the dividend field of card 90, units order are representative of the digit 3 according to the code of Fig. 7A. Inasmuch as dividend entries are always subtractive it is necessary to obtain the complement of the units order digit thereof with respect to 10 and then add this to the amount standing on the units order readout of the accumulator in order that the subtractive entry will be properly effected in so far as the units order is concerned. In the tens and higher orders, however, the complements of the digits comprising the dividend amount must be obtained with respect to the digit 9 so that entries into the permutation members as D1', D2', and so on, in the tens and higher orders of the accumulator D, must be made through the medium of an inverting device VA' such as is shown in Fig. 14, this device functioning to obtain complements with respect to the digit 9.

Inasmuch as the permutation members D1 and D6 in the units order of the accumulator D have been actuated, the digit 7 will be entered in the readout RD. Since the digit registered in this readout was 3 before such entry of 7 was effected, the brushes of the readout will now be moved forwardly to their zero positions. In so doing, the brushes momentarily extend ground from the contact segment 46 to the contact segment DC located between the 9 and 0 positions of the readout. Thus the carryover relays 122 and 123 are energized through their windings 122A and 123A, and these relays thereupon lock up through their windings 122B, 123B, contacts 122C and 123C, conductor 121, Figs. 3, 1 and 2 and the contact 63A of the cam 63, which contact is closed at this time.

As shift relay 11 energizes, it extends ground through contacts 23C and 33C of the storage relays 23 and 33 in the second set, group B, and corresponding conductors B1 and B8 to the magnets of the permutation members E1 and E8 in the units order of the accumulator E. Entries are similarly effected into the tens and higher orders of this accumulator under control of corresponding storage relays in the second set, group B. The amount previously standing on the units readout RE was 2. As the permutation members E1 and E8 are actuated, a digital value of 9 is added so that the brushes of the readout RE are moved through their zero positions and thence to positions indicative of the digit 1, inasmuch as the sum of 2 and 9 is 11. In the course of such entry the carry-over relays 124 and 125 for the units order of the accumulator E are energized through their windings 124A and 125A as the readout brushes pass from 9 to 0, and these relays thereupon lock up through their windings 124B and 125B, contacts 124C and 125C and conductor 121 to the contact 63A of the cam 63, Fig. 2.

As shift relay 13 in group C closes, it extends ground from the contacts 28C and 29C of the storage relays 28 and 29 in the first set to the windings of the magnets F1 and F2 in the units order of the accumulator F. Similarly, entries are also effected into the tens and higher orders of this accumulator under control of corresponding storage relays in the first set, group C. Inasmuch as this is the first item to be entered in the accumulator F, no carry-overs are required and the readout RF is adjusted to a position representative of the digit 3 in accordance with the value of the units order digit in the premium amount represented on the card 92, Fig. 7.

Cam 58 opens its contact 58A and releases the shift relays 9, 11 and 13. The various permutation members in the accumulator D, E and F are now restored to their normal conditions. Cam 63 now opens its contact 63A to thereby remove ground from conductor 121. Holding circuits to the windings of the various carry-over relays are thus broken.

Carry-over relay 123, Fig. 3, in the units order of the accumulator D immediately deenergizes but the slow-to-release relay 122 still maintains its contacts closed. Contact 123D of relay 123, in closing, extends ground through contact 122D of relay 122 and conductor 128 to the conductor A1' leading to the magnet of the permutation member D1' in the tens order of the accumulator D. Member D1' is thereupon actuated to effect a carry entry of 1 into the tens order readout. Contact 122D of relay 122 thereupon opens and releases the permutation member D1'.

In the event a 9 had been standing on the tens order readout prior to the entry of this carry, another carry would be required into the hundreds order readout. In such a contingency the carry-over relays corresponding to the relays 122 and 123 in the tens order would have been energized momentarily as the tens readout brush passed from 9 to 0 and would then have started to deenergize without having established any stick circuits for themselves inasmuch as the contact 63A of cam 63 is now open, and hence a carry of 1 would have been instantly made into the hundreds order in the same manner that the carry into the tens order was effected. Cam 63 again closes its contact 63A after all carries have been entered in the accumulator D.

When cam contact 63A was opened, the carry-

over relays as 125 of the accumulator E were de-energized and through the still closed contacts as 124D of the slow-to-release relays as 124 caused ground to be extended to the magnets of the permutation members as E1' in the next higher orders of the accumulator to thereby effect carries. As has been mentioned hereinabove, no carries are required to be entered in any of the readouts of the accumulator F at this time. The readout RD in the units order of the accumulator D now registers 0, this being the units component of the sum of the digits 1 and 2 in the units orders of the premium and interest amounts, respectively, minus the digit 3 in the units order of the dividend represented on the card 90, Fig. 7. Readout RE in the units order of the accumulator E registers 1, this being the units component of the sum of the digits 2 and 9 in the units orders of premium and interest amounts, respectively, represented on the card 91, Fig. 7. Readout RF in the units order of the accumulator F registers 3, this being the digit in the units order of the premium amount represented on the card 92. Readouts in the higher orders of the accumulators D, E and F will have been positioned in a manner similar to that for the units readouts thereof.

Cam 65 closes its contact 65A to thereby energize the shift relay 35, Fig. 8. Inasmuch as the readout RD is at zero, none of the digital conductors leading into the cable CD from this readout will be grounded. However, there may be digital conductors leading into this cable from the readouts in the other orders of this accumulator which are now grounded, the source of ground being derived from the now closed contact 64A of the cam 64, Fig. 2 and the conductor 129 connected to the contact segments as 46 of the readouts as RD. Therefore, when shift relay 35 closes its several contacts, it extends ground from such of the digit-representing conductors leading from the cable CD as are grounded, to corresponding terminals of the encoding devices as T which devices function to convert ordinary notation into code as has been explained above. Inasmuch as the units order digit is 0, none of the terminals T1 to T9 of the encoding device T in the units order will be grounded and hence ground is not extended from any of the opposite terminals T1', T2', T4', T6' or T8' thereof to the units order magnets of the permutation members in the printer G. However, permutation members in the other orders may be selectively positioned at this time under control of the corresponding readouts of the amount manifesting device or accumulator D, through the medium of encoding devices as T in these orders. When this has been done, the cam 51, Fig. 2, closes its contact 51C to momentarily energize the printing magnets as 120 and then release same to allow the hammers 121 to print the total of the three items of premium, interest and dividend on the first premium notice S1. It will be recalled that this is in reality the fourth printing operation of the printer G after initiation of machine operation, there having been an idle printing operation in the initial card feeding operation and in each of the first and second sequences of the first cycle.

After the impression-making operation has been performed, cam 65 opens its contact 65A and releases the shift relay 35, to permit the printing means G to be restored. Cams 52 and 66 momentarily close their contacts 52C and 66A, respectively. Closure of cam contact 52C momentarily energizes the sheet feed solenoid 101

and the first premium notice S1 is thereupon discharged from printing position and the second notice S2 is fed into printing position. Closure of cam contact 66A momentarily grounds the conductor 135, Figs. 2 and 10, to enable the reset magnet MD for the accumulator D to withdraw the latch 38' from the cam 39' and permit the reset motor RM, through the friction clutch 136, to drive the reset shaft RSD of the accumulator D through a complete rotation. In the course of such rotation of the shaft RSD, the pawls 43 on the gears 40 in the various orders of the accumulator are engaged by the groove 47 in the shaft RSD and the gears 40 are thus returned to their home positions. Such zeroizing of the gears 40 resets the brushes of the various readouts of the accumulator D to zero but does not affect the ratchet gears 39 and racks 38 of the entry-effecting permutation units therefor, inasmuch as the pawls 41 ride idly over the teeth of the gears 39 while the gears 40 are being reset.

While the zero-setting operation for the accumulator D is in progress, the cam 64, Fig. 2, maintains its contact 64A open so that ground is not available on the conductor 129, Figs. 2, 1 and 3. Hence the contact segments 46 of the readouts as RD will not be grounded and false carry-overs will thus be prevented as the readout brushes pass from positions representative of the digit 9 to their home or zero positions.

Cam 55 momentarily opens its contacts 55A, 55B, and 55C toward the close of the third sequence and thereby releases the locked-up storage relays as 17 and 18 in the third set, group A; 23 and 33 in the second set, group B; and 28 and 29 in the first set, group C. All the storage relays in group A will now have been released.

Second cycle—first sequence

The fourth card is now fed to sensing position and the items of premium, interest and dividend derived therefrom are stored in the relays in the first, second and third sets, respectively, of storage group A. Accumulator D is now clear so that in this sequence of operations the item of premium derived from the fourth card may be entered in this accumulator. Also the storage relay 25 in the third set, group B, corresponding to the units digit 1 in the dividend amount represented on the card 91, Fig. 7, functions through the medium of the inverting device VB to effect a complemental entry of 9 into the units order of the accumulator E, thereby bringing the brushes of the readout RE in the units order thereof to zero, this readout having been previously set to the value 1. The inverting devices in the tens and higher orders of the third set in group B effect entries of complemental values of the digits therein taken with respect to the digit 9, and thus the amount set up on the readouts of the accumulator E will comprise the sum of the items of premium, interest and dividend without carry-over. Contact 63 then opens its contact 63A to initiate carry-entering operations as described hereinabove under the heading "First cycle—third sequence," so that the accumulator E now registers the true sum of the three items of premium, interest, and dividend represented on the card 91, Fig. 7.

Also, in this sequence of operation the storage relay 31 in the second set of group C controls the entry of the digital value 2 into the units order readout RD of the accumulator F and similar entries will be effected into the readouts in the tens and higher orders in accordance with

the interest amount represented on the card 92, Fig. 7, and the necessary carry-over operations incident thereto will be performed so that the amount manifesting device or accumulator F now registers the sum of the items of premium and interest derived from the card 92, Fig. 7.

At the proper time the cam 65 closes its contact 65B and energizes the shift relay 36 for transferring the amounts standing on the read-outs of the accumulator E to the encoding devices as T and thence to the permutation members of the printer G, and subsequently this amount is printed upon the second premium notice S2 so that said notice now bears the total of the items derived from the card 91, Fig. 7. After such printing has been effected, the sheet S2 is discharged and a third premium notice advanced to printing position. Accumulator E is reset as cam 66 closes contact 66B, in a manner similar to that in which accumulator D was reset in the third sequence of the first cycle of operations so that accumulator E is now ready to receive entries from the fifth card.

Second cycle—second sequence

The fifth record card is advanced to sensing position and the intelligence derived therefrom is stored in the relays of storage group B. In this sequence of operations the interest amount derived from the fourth card is entered in the accumulator D, the premium from the fifth card is entered in the accumulator E, and a complementary entry of the dividend derived from the third card 92, Fig. 7, is entered in the accumulator F. Carry-over operations incident to these entries are effected. Accumulator F now registers the sum of the items of premium, interest, and dividend derived from the card 92. At the proper time this amount is transferred to the printer G through the medium of shift relay 37, Fig. 8, and the encoding devices as T, and is printed onto the third premium notice. The sheet feed mechanism is then operated to discharge the third notice and feed a fourth notice to printing position. Accumulator F is reset.

Second cycle—third sequence

In this sequence of operations the sixth record card is fed through sensing position and the intelligence derived therefrom is stored in the relays in storage group C. Also in this sequence of operations there is a complementary entry of the dividend derived from the fourth card into accumulator D, an entry of the interest amount derived from the fifth card into the accumulator E, and an entry of the premium from the sixth card into the accumulator F, under the control of storage relays in the third set, group A; second set, group B; and first set, group C, respectively. Incidental carry-overs are effected and the accumulator D now registers the sum of the premium, interest and dividend that were represented on the fourth card. This amount is transferred to the printer G via the shift relay 35, Fig. 8, and the encoding devices as T, and is printed upon the sixth premium notice that has been fed to printing position.

Subsequent machine operation

It will be seen from the foregoing description of operation that commencing with the third sequence of the first cycle of operations, a premium notice will be printed in each and every sequence, which is to say, that there will be three premium notices printed for each rotation of the cam shaft

87, Fig. 5. Thus it will be seen that by arranging the storage devices in groups as A, B and C and by dividing these groups into sets respectively allocated to the items represented on the record cards, the machine may operate continuously to feed record cards and print totals of premium, interest and dividend amounts on record sheets, such as premium notices, without any delay being required for the computation of these sums. This has a distinct advantage over prior machines of the character to which this invention pertains in that card feeding operations of the machine need not be interrupted to provide for the accumulation of items derived from the same record card.

After the last card has been fed away from the sensing station, the machine goes through two more sequential operations culminating in the printing of the total of the items derived from the last card on the last premium notice. During these sequences the contact bars as 59, 60 and 61, Fig. 2, are grounded for the sensing operations which take place as usual. This results in fictitious entries being effected into certain of the accumulators. The resulting totals standing on these accumulators may be printed on dummy sheets following the last premium notice, or if the operation of the machine is interrupted immediately after the printing of the last premium notice, then the unwanted totals may be printed on dummy sheets preceding the next run of premium notices, as explained hereinabove, this procedure being employed merely to prevent the making of undesirable offset impressions on the conveyor tape 108. Thus, the accumulators are cleared prior to the entry therein of any real numbers derived from record cards.

It is recognized that if the card feed is interrupted in the midst of the run due to jamming or some such cause, the operation of the machine should be suspended to prevent misplacement of the sheets relative to the cards and the making of unwanted entries into the accumulators. This can conveniently be accomplished by arranging a conventional card detecting means to control, say, the supply of current to the motor 84, Fig. 5, as well as ground for the cam contacts, Fig. 2, in dependence upon the continuous feeding of cards through the machine, and in this way if a card should fail to reach sensing position at the appropriate time, the operation of the machine is suspended until the proper card has been manually positioned at the sensing station. Such a safety means is a common feature in machines of the character to which this invention pertains and is merely ancillary to the present invention. To prevent premature interruption of the machine operation at the end of a run of cards, blank cards may be provided at the end of the run to keep the safety means from operating until the last notice has been printed.

While I have shown and described a selected embodiment of my 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 scope of the following claims.

I claim:

1. In a calculating machine including a plurality of accumulators each operable to compute the algebraic sum of a plurality of amounts, the combination of a plurality of groups of settable storage devices, each of said groups of storage devices being allocated to a separate one of said

accumulators, the devices in each group operating when set to store the respective amounts entering into the addition to be performed by the corresponding accumulator, setting means common to all of said storage groups and operable when connected to the storage devices of a group to concurrently set the same in arrangements of numerical significance, means for operatively connecting said setting means to the storage devices group by group in cyclic succession to enable said setting means to set the devices in each storage group in accordance with the amounts entering into the addition to be performed by the respective accumulator, and cyclically operable means for successively connecting the devices in each storage group in operative relation to the corresponding accumulator for controlling the additions to be performed by said accumulator and operating to connect certain of the devices in one group to the corresponding accumulator upon setting of the devices in such group by said setting means and connecting other of the devices in said one group to the corresponding accumulator upon setting of the devices in other of the groups, whereby at least some of the devices in each group function to control their addition after the common setting means has been transferred into controlling relation to another group of said devices.

2. In a progressive record-controlled calculating machine including record sensing means effective in each sensing operation thereof to analyze a record having data representations representing a plurality of amounts, a plurality of storage units adapted to be controlled by said sensing means, transfer means for placing said sensing means in controlling relation to said storage units in a predetermined rotation and for entering in each of the respective ones of said storage units the plurality of amounts represented on the records successively sensed by said sensing means, a plurality of accumulators respectively related to said storage units and each adapted to be controlled by its respective storage unit to compute the algebraic total of the amounts derived from a record and stored in such unit, and entry-effecting means operable to place said accumulators in controlled relation to their storage units and operable to enter successively into each accumulator the plurality of amounts represented on the related record in such a manner that an amount derived from a record and entered in each storage unit under control of said sensing means is entered in its accumulator after said transfer means has placed the sensing means in controlling relation to another storage group for entering therein the plurality of amounts derived from a succeeding record.

3. In a machine for performing calculations under the control of a series of control cards each of which bears representations of a plurality of amounts entering into a to be performed calculation, the combination of sensing means including a sensing station, feeding means operable in a succession of feeding periods to feed such cards in sequence to said sensing station, a plurality of storage units each having storage devices for storing the amounts derived from a control card, cyclically operated means operable to place said sensing means in controlling relation to said storage units in a predetermined succession as successive control cards are fed to sensing station, a plurality of accumulators one for each of said storage units, and means operatively connecting the storage devices of

each storage unit to a related accumulator and operable to successively transfer the amounts stored in the storage devices of a storage unit to the related accumulator during a succession of feeding periods including the period in which a subsequent card is placed in controlling relation to another of said storage units.

4. In a machine for performing a series of independent computations each based on representations of a plurality of amounts carried by each of a series of control cards, the combination of card feeding means operable to feed such cards in succession, sensing means including a sensing station to which cards are fed in succession by said feeding means, a plurality of storage units each having a plurality of storage devices one for storing each of the amounts represented on a control card, cyclically operated means operable to place such storage units in controlled relation to said sensing means in a predetermined cycle of succession, a plurality of accumulators one for each of said storage units, entry-effecting means operatively connected to each of said accumulators and controlled by a corresponding one of said storage units, and cyclically operated means operable to place such accumulators and their respective entry-effecting means in controlled relation to the storage devices in said storage units in a predetermined cycle of succession such that each entry-effecting means is placed successively under control of the several storage devices in the corresponding storage unit for successively entering in its accumulator the amounts derived from a card and which have been stored therein, each accumulator being rendered responsive to the final storage device in its corresponding storage unit for receiving the final one of the amounts stored in such unit subsequent to the time when another storage unit has been placed in controlled relation to said sensing means by the first-named cyclically operated means for receiving the amounts represented on a succeeding card.

5. In a machine for producing successive records of the results of a series of computations each based on representations of a plurality of amounts carried by each of a series of control cards, the combination of card feeding means operable to feed such cards in succession, sensing means including a sensing station to which cards are fed in succession by said feeding means, a plurality of storage units each having a plurality of storage devices one for storing each of the amounts represented on a control card, cyclically operated means operable to place such storage units in controlled relation to said sensing means in a predetermined cycle of succession for storing representations of amounts derived from respective cards in the series, computing means comprising a plurality of accumulators each allocated to a separate storage unit, data transfer and entry-effecting devices interposed between said storage devices and said accumulators and operating in a predetermined sequence to successively enter the amounts stored in each of said storage units into its respective accumulator, recording means, governing means for placing said recording means in controlled relation to said accumulators in a predetermined rotation, means for feeding sheets consecutively to said recording means, and means for operating said recording means to record on each sheet the result of a computation performed by one accumulator during the period in which the ac-

cumulator next to control said recording means is receiving entries from its storage unit.

6. In a record card-controlled machine of the character described having a sensing station and means for feeding to said station a series of cards each bearing representations of a plurality of amounts entering into a to be performed computation, card sensing means, a plurality of groups of storage devices, each of such devices being settable under control of said sensing means to store a representation of an amount derived from a card, holding means for causing said devices when set to retain their respective settings, selective transfer means operative to place said storage devices group by group in predetermined rotation under the control of said sensing means in timed relation with the feeding of cards, each of said groups being conditioned to receive entries of amounts only when selected cards of the series separated by a predetermined number of intervening cards are sensed, a plurality of accumulators and associated entry-effecting means each being solely allocated and responsive to a respective one of said storage groups, second transfer members one for each storage device in the several groups thereof and each operable when the devices of its group have been set in accordance with the amounts derived from a card to connect its device to the entry-effecting means of the accumulator allocated to the particular group in which such device is included, means for timing the operation of said members to successively connect the several devices of each group to the entry-effecting means of the corresponding accumulator and operating in such timed relation to the feeding of cards that at least some of the amounts derived from one card are entered in an accumulator during the time that a subsequent card is being advanced and sensed by the machine and all of such amounts are entered prior to the time such storage group is again placed under control of said sensing means, and means effective upon said holding means as the amounts are read out from any of said groups to render the devices from which such amounts are read out incapable of further retaining their settings, thereby restoring such devices to their normal unset condition in preparation for a subsequent sensing and storing operation.

7. In a calculating machine adapted to be operated under control of record cards or the like each bearing representations of a plurality of numerical amounts, means for advancing a series of such cards successively through a single sensing station in the machine, sensing means for reading the data represented on the cards successively presented at the sensing station, a plurality of accumulators, a plurality of groups of storage devices, each group being operatively interposed between said sensing means and a respective one of said accumulators, means for transferring the data derived from successive record cards by said sensing means to respective ones of said storage groups in predetermined succession, and means under control of the storage groups for successively entering into each accumulator the amounts stored in the related storage group whereby a cross-addition of the amounts derived from each card is obtained, said last-named means being so constituted and arranged that certain amounts are substantially concurrently read out from the several storage groups and entered in the respective accumu-

tors, and said last named means being operable to so read out the amounts from the several storage groups so that the cross-addition operations in the different accumulators are at all times in different stages of completion.

8. In a machine for ascertaining the results of a series of computations each based on representations of a plurality of amounts recorded on each of a series of record cards, the combination of a sensing means having a sensing position, card feeding means for advancing cards in succession to said sensing position, a plurality of storage units each having storage devices for individually storing a plurality of amounts, means effective to place said storage units in controlled relation to said sensing means in a predetermined sequence whereby each storage unit receives a plurality of amounts from the different respective cards as such cards are successively sensed by said sensing means, a plurality of accumulators each operatively related to a respective storage unit, entry-effecting means for said accumulators, transfer means operatively interposed between said storage units and the entry-effecting means of the respective accumulators, and cyclically operated means controlling the operation of said entry-effecting means to successively enter in each accumulator the various amounts stored in the related storage unit, said cyclically operated means also being effective to cause certain of the amounts stored in different ones of the storage units to be concurrently entered in the respective accumulators, and said last named means being operable to so read out the amounts from the several storage groups that the cross-addition operations in the different accumulators are at all times in different stages of completion.

9. In a record card-controlled machine through which record cards each bearing combinational code representations of two numerical amounts are successively fed, card reading means for deriving the amounts represented in code from each card as it is advanced into position to be read, first and second storage units each settable to store coded amounts, transfer means operating in timed relation with the feeding of cards to place said storage units in rotation under the control of said reading means for enabling said first storage unit to be set in accordance with the amounts derived from a card and said second storage unit to be set in accordance with the amounts derived from a succeeding card, a first accumulator, entry-effecting means for said first accumulator controllable by coded indications, transfer means for associating said first storage unit and said first accumulator and operable to successively enter in such accumulator the amounts stored in said first storage unit, a second accumulator, entry-effecting means for said second accumulator controllable by coded indications, transfer means for associating said second storage unit and said second accumulator and operable to successively enter in such accumulator the coded amounts stored in said second storage unit whereby each accumulator is enabled to obtain a cross-addition of the amounts derived from a related card, and means timing the operation of the entry-effecting means of said accumulators to cause the respective periods in which the cross-adding operations are performed by said accumulators to be partially overlapped.