

Oct. 19, 1943.

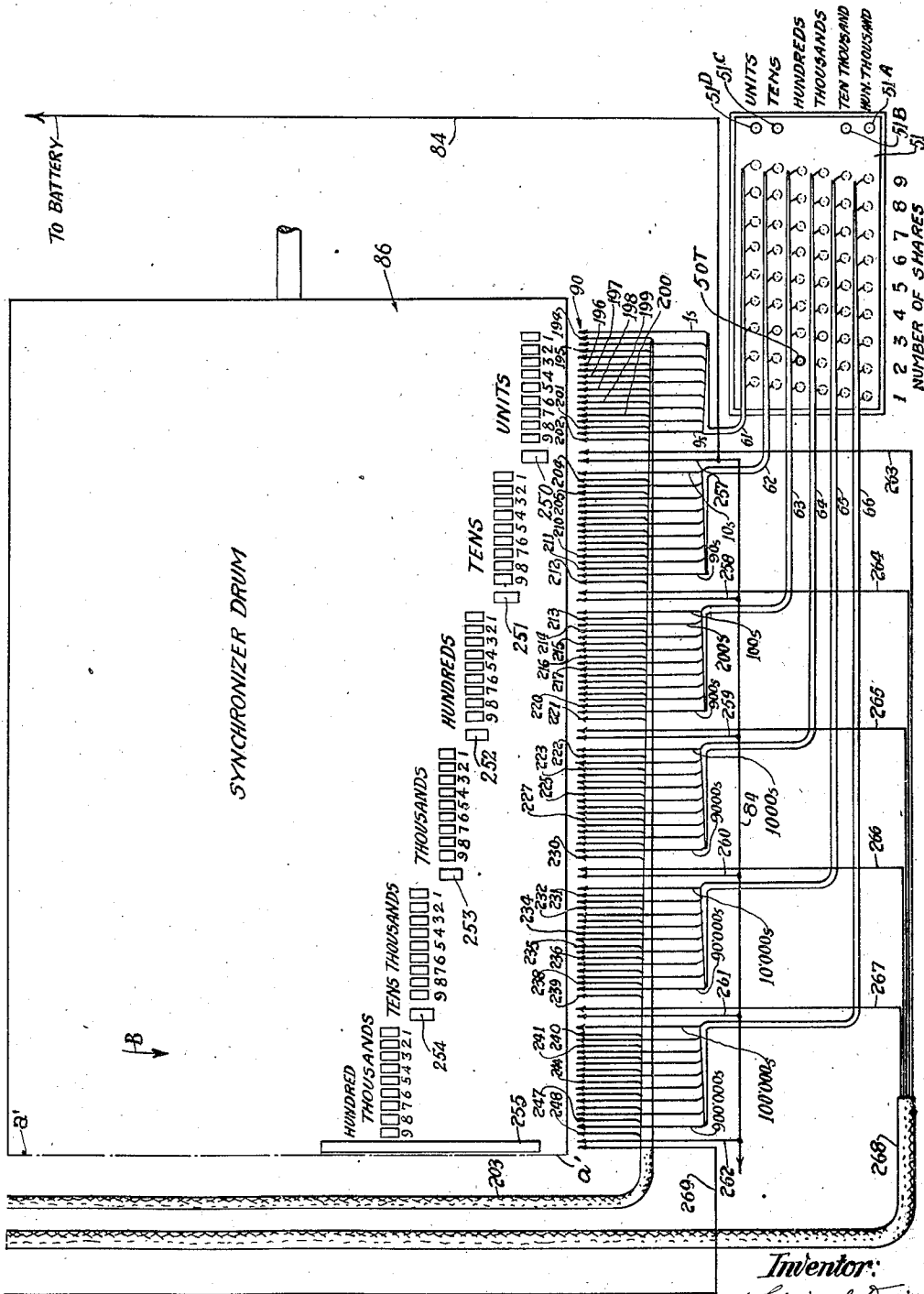
A. E. DAVIES

2,332,304

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45 Sheets-Sheet 1



Inventor:

Albert Edward Davies

By: Belt and Wallace

Attorneys.

Oct. 19, 1943.

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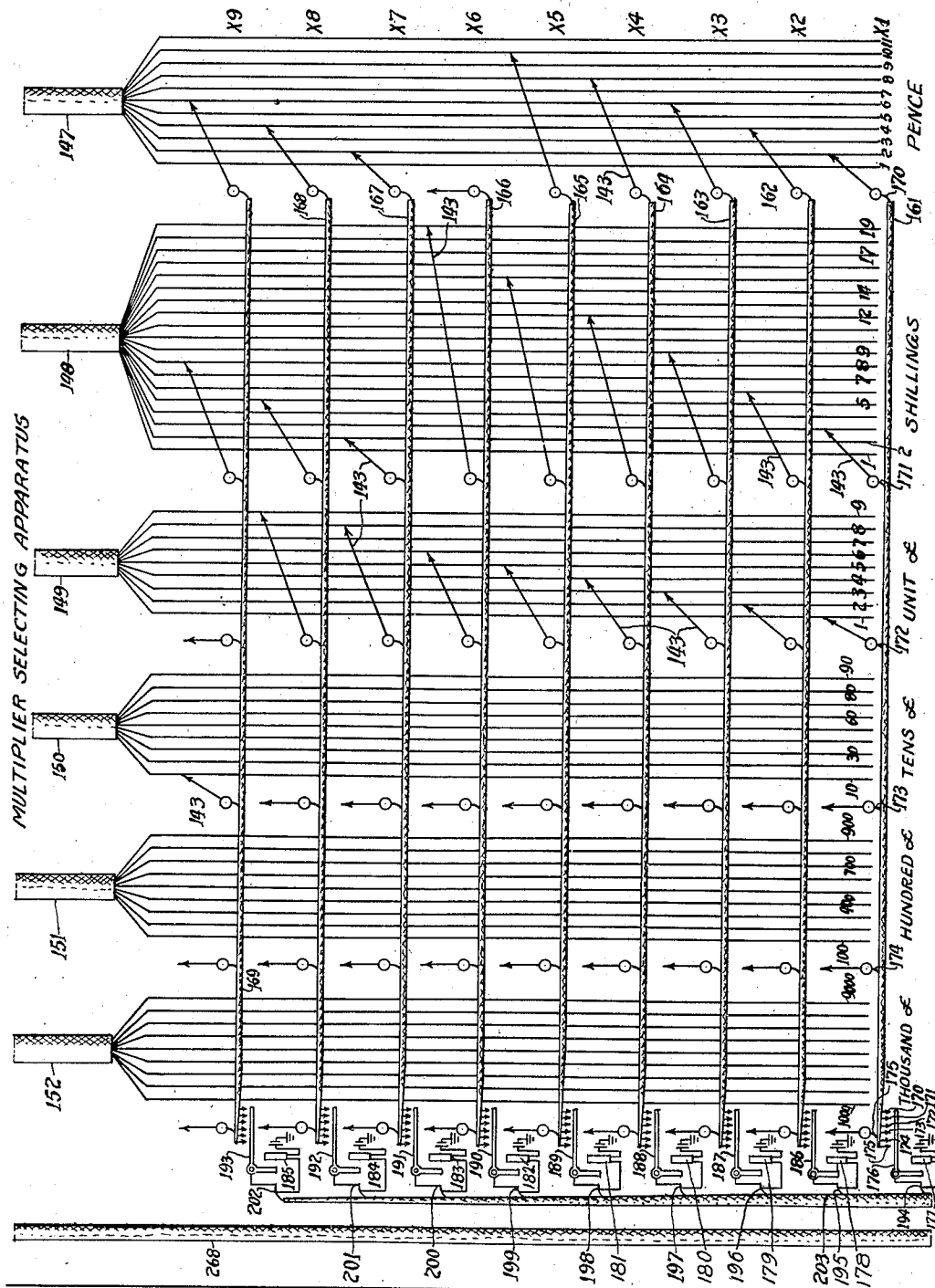


Fig. 1a

Inventor:
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Oct. 19, 1943.

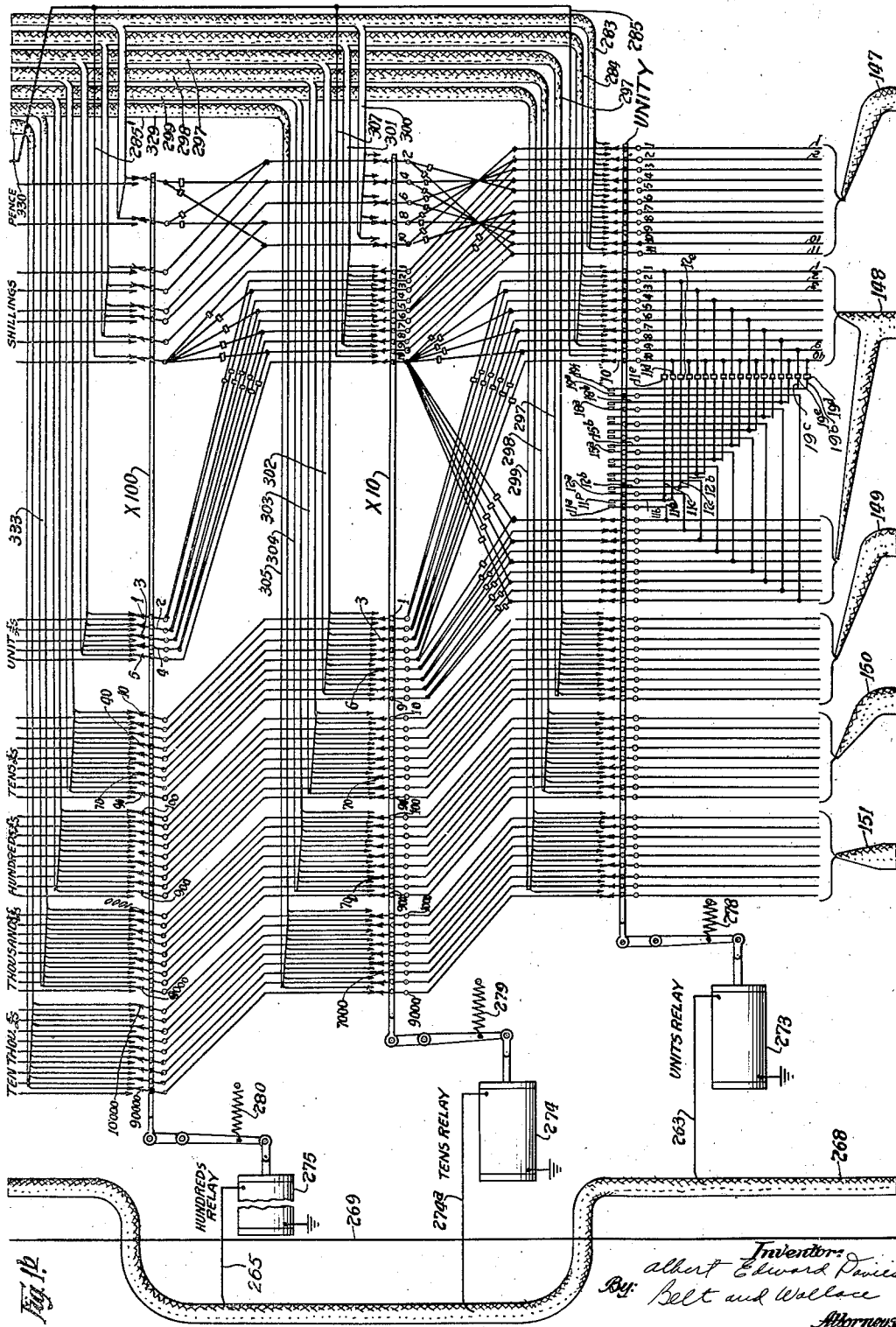
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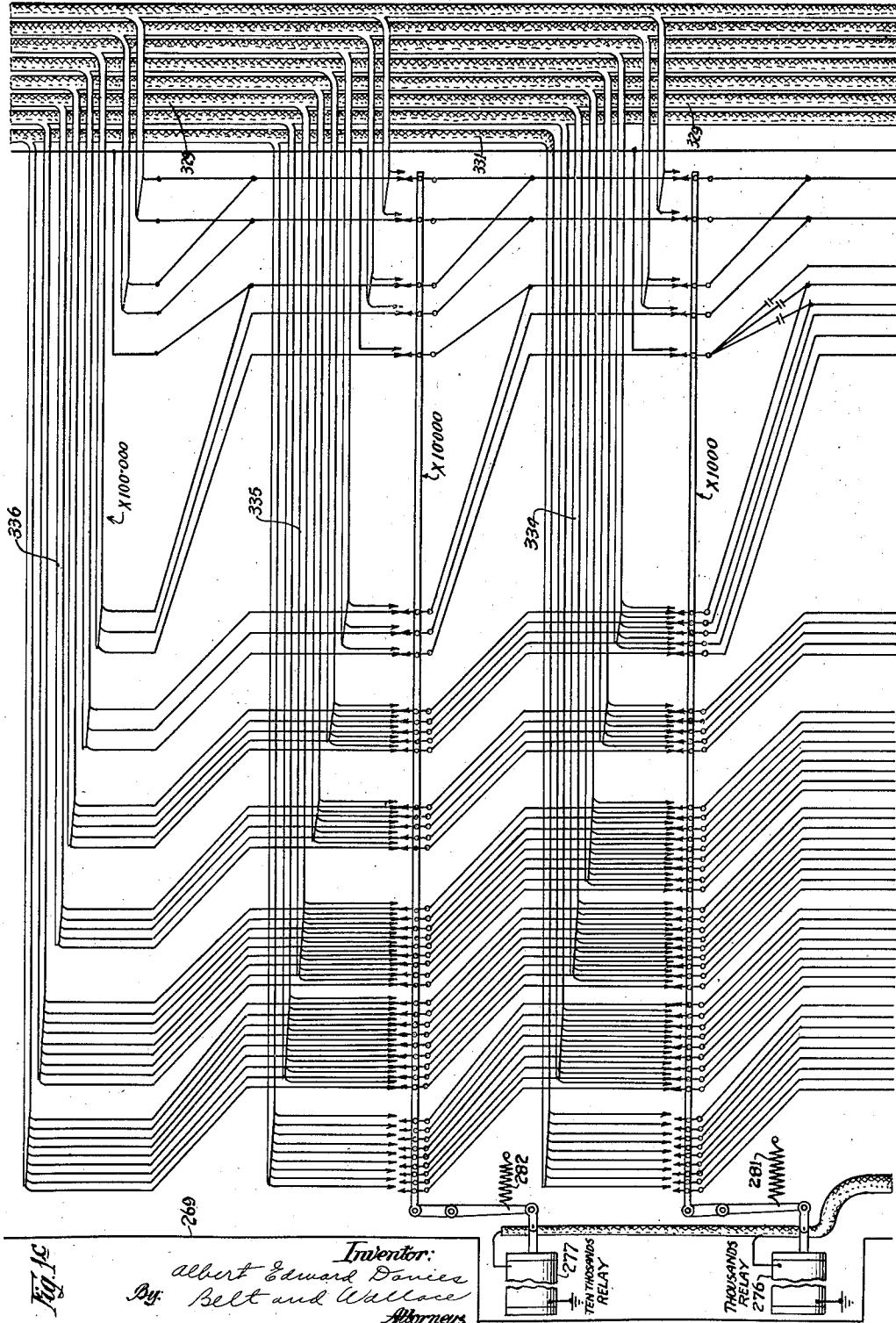
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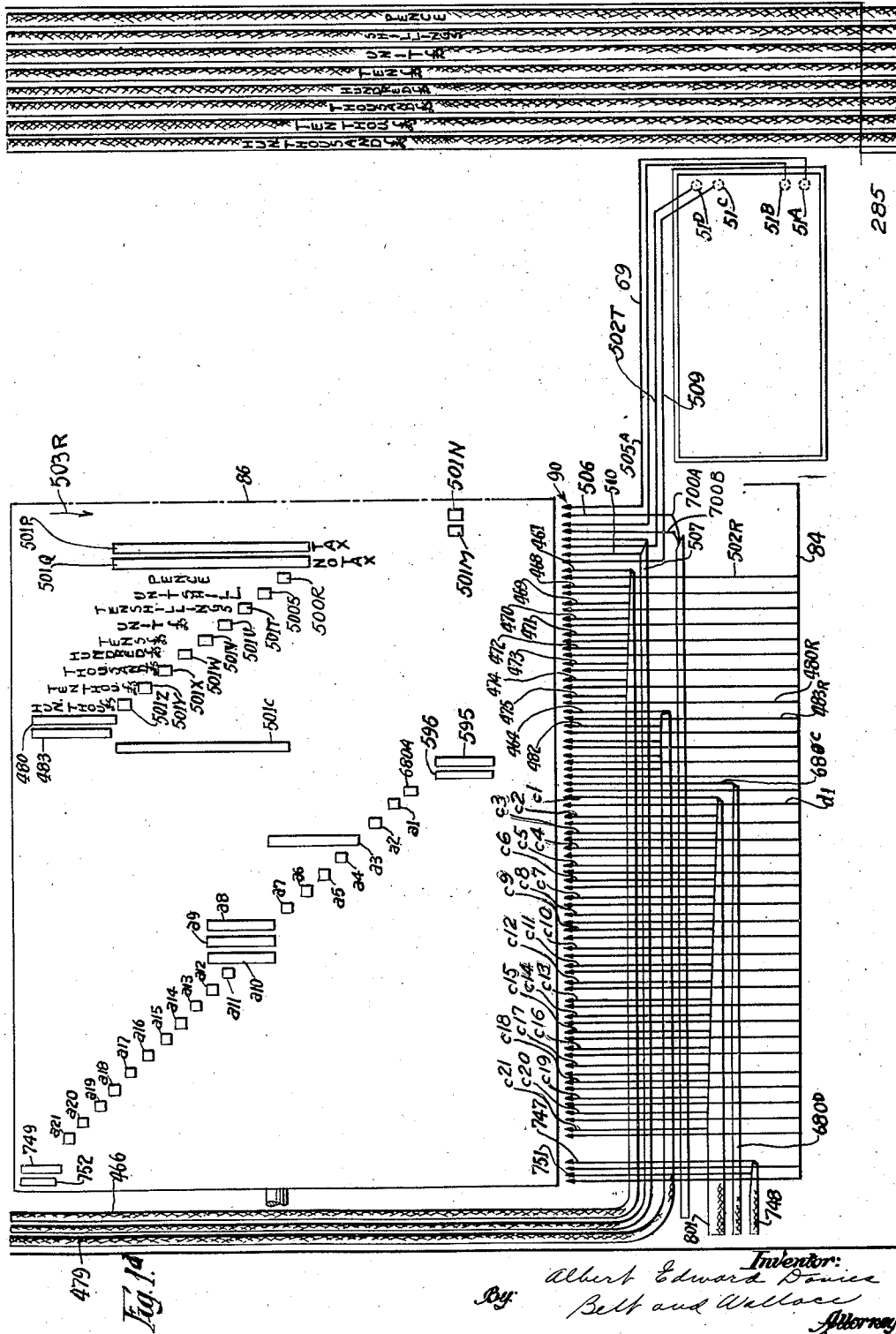
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Oct. 19, 1943.

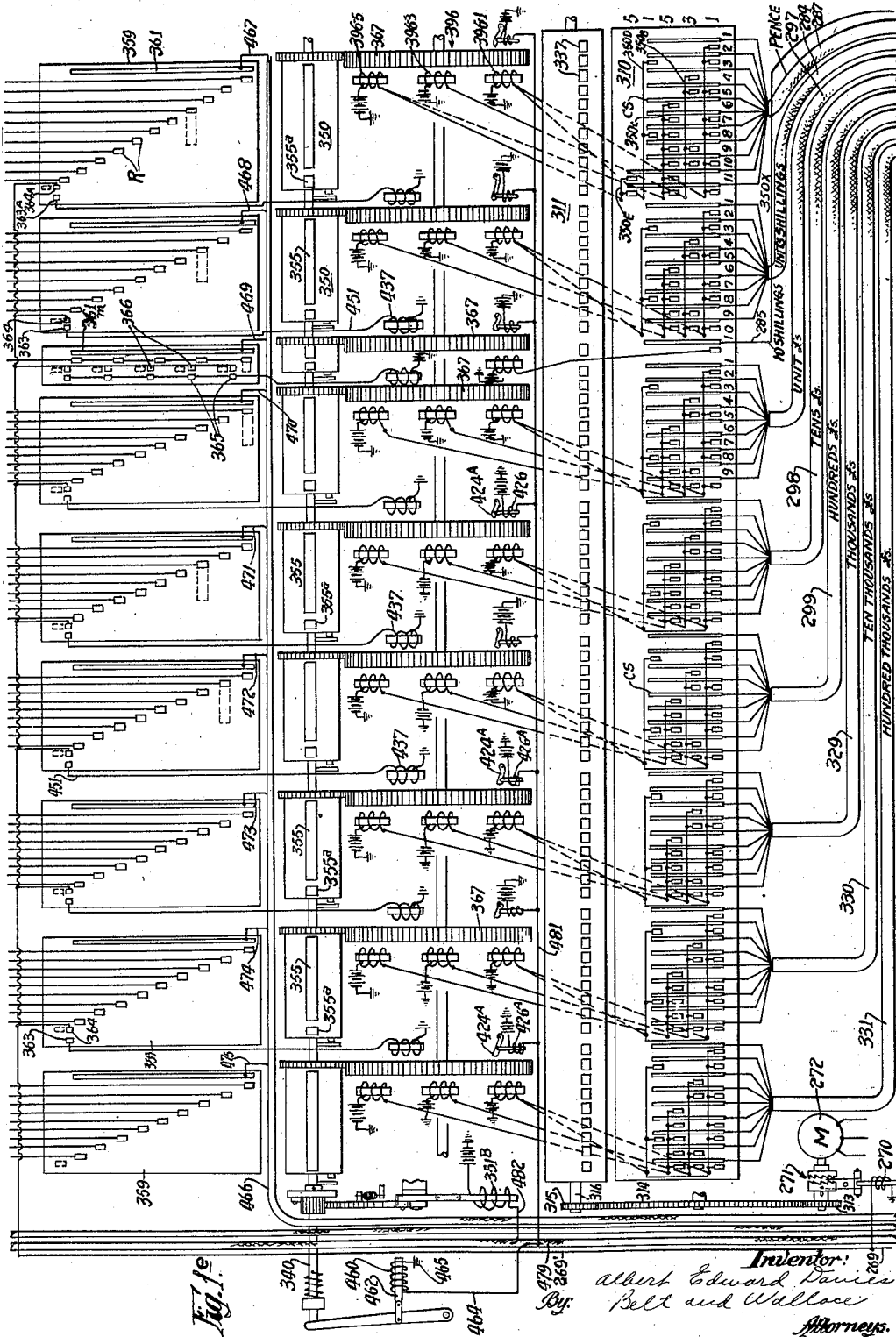
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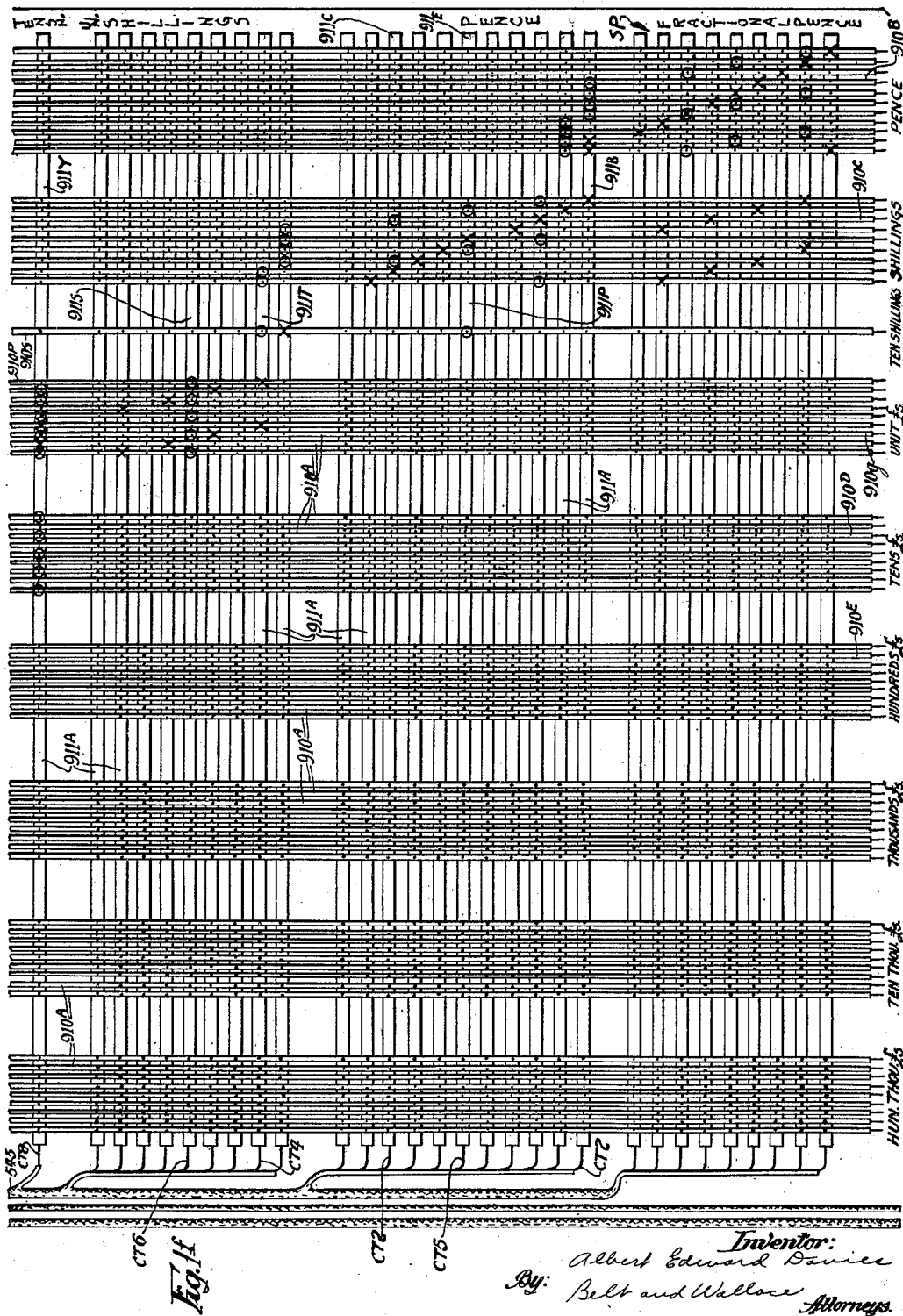
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Inventor:
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By: Belt and Wallace Attorneys.

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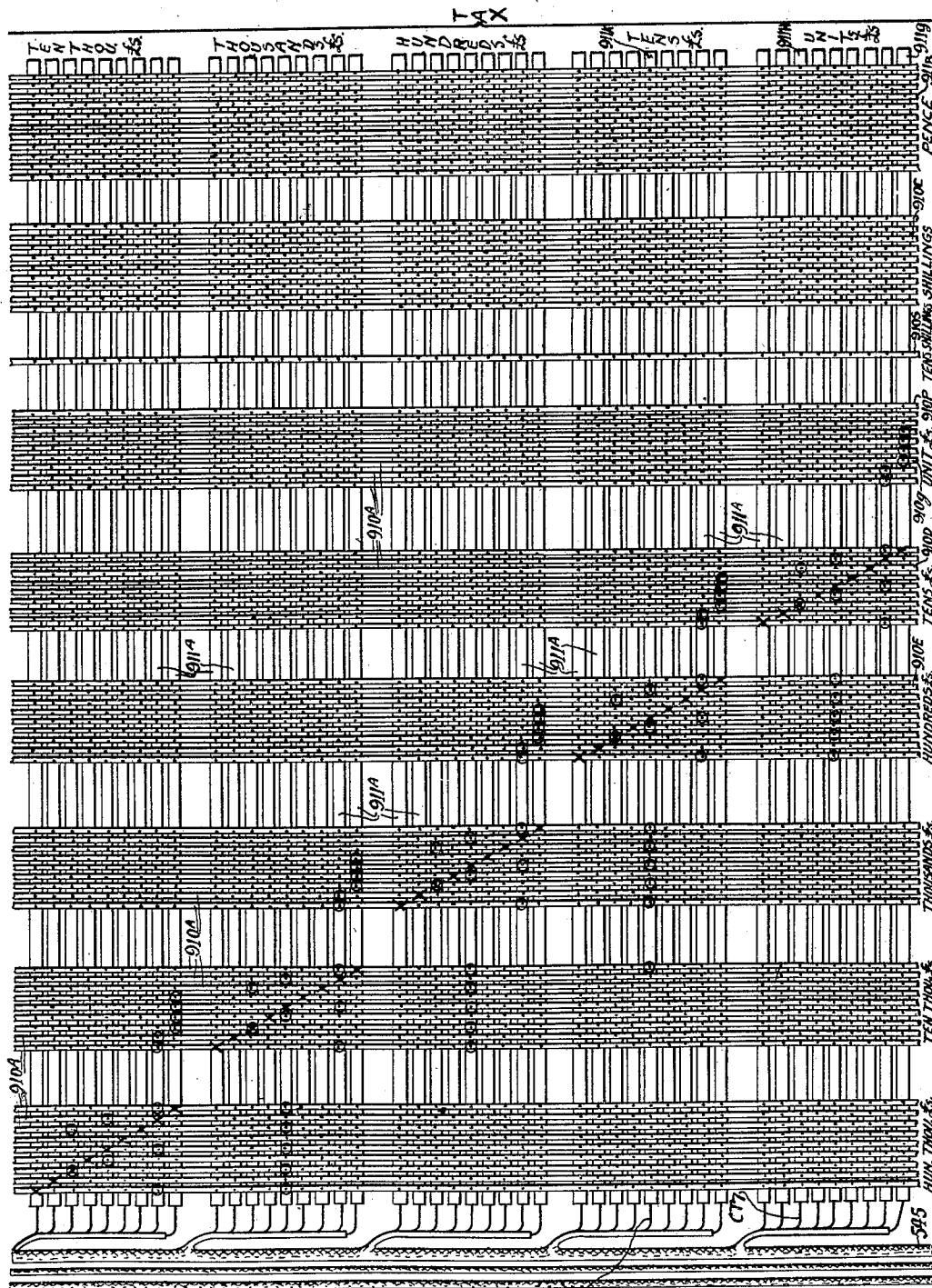


Fig. 19

Inventor:
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By: *Belt and Wallace Attorneys*

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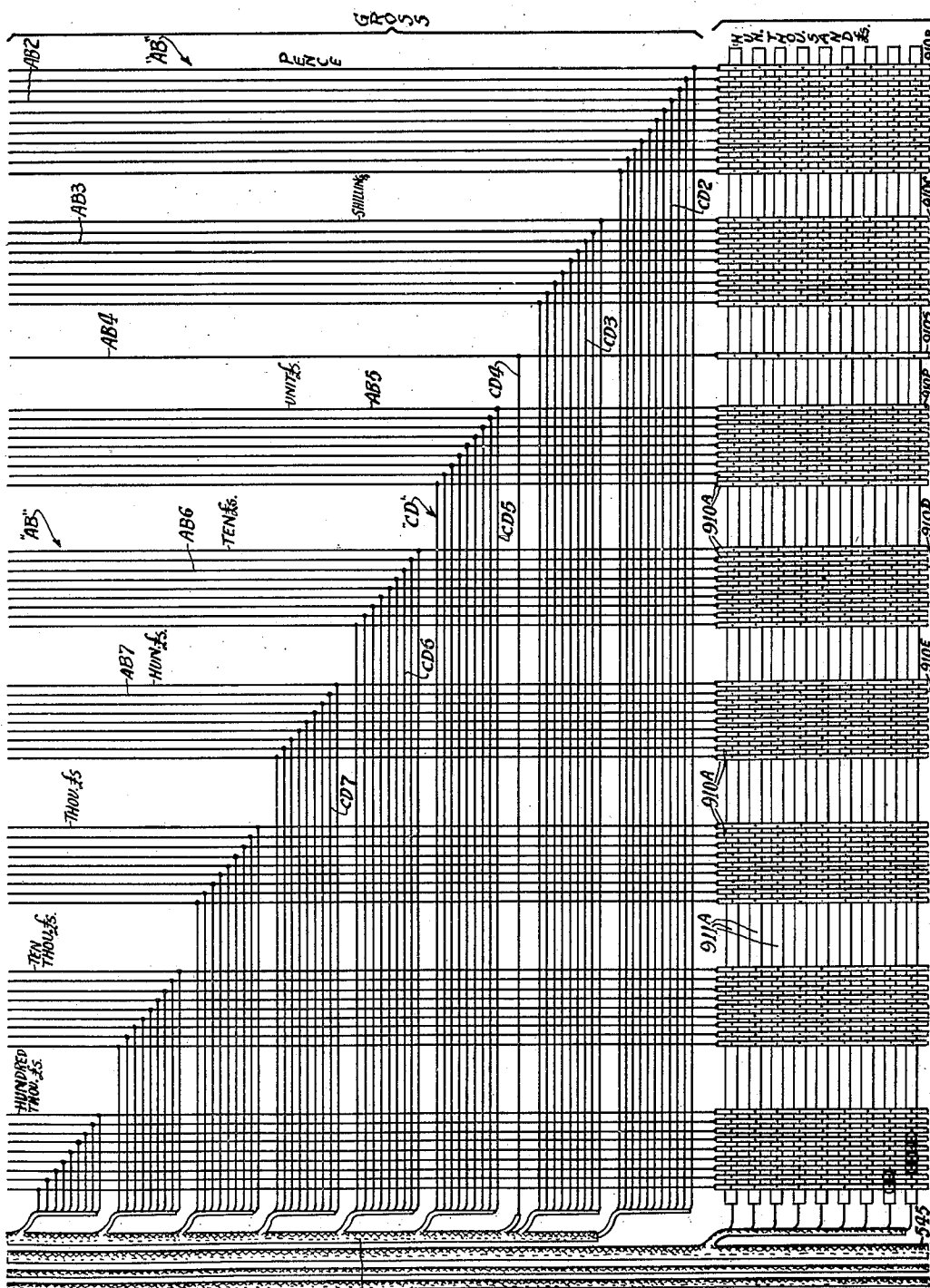


Fig. 11

547

Inventor:
Albert Edward Davies
By: Bell and Wallace Attorneys

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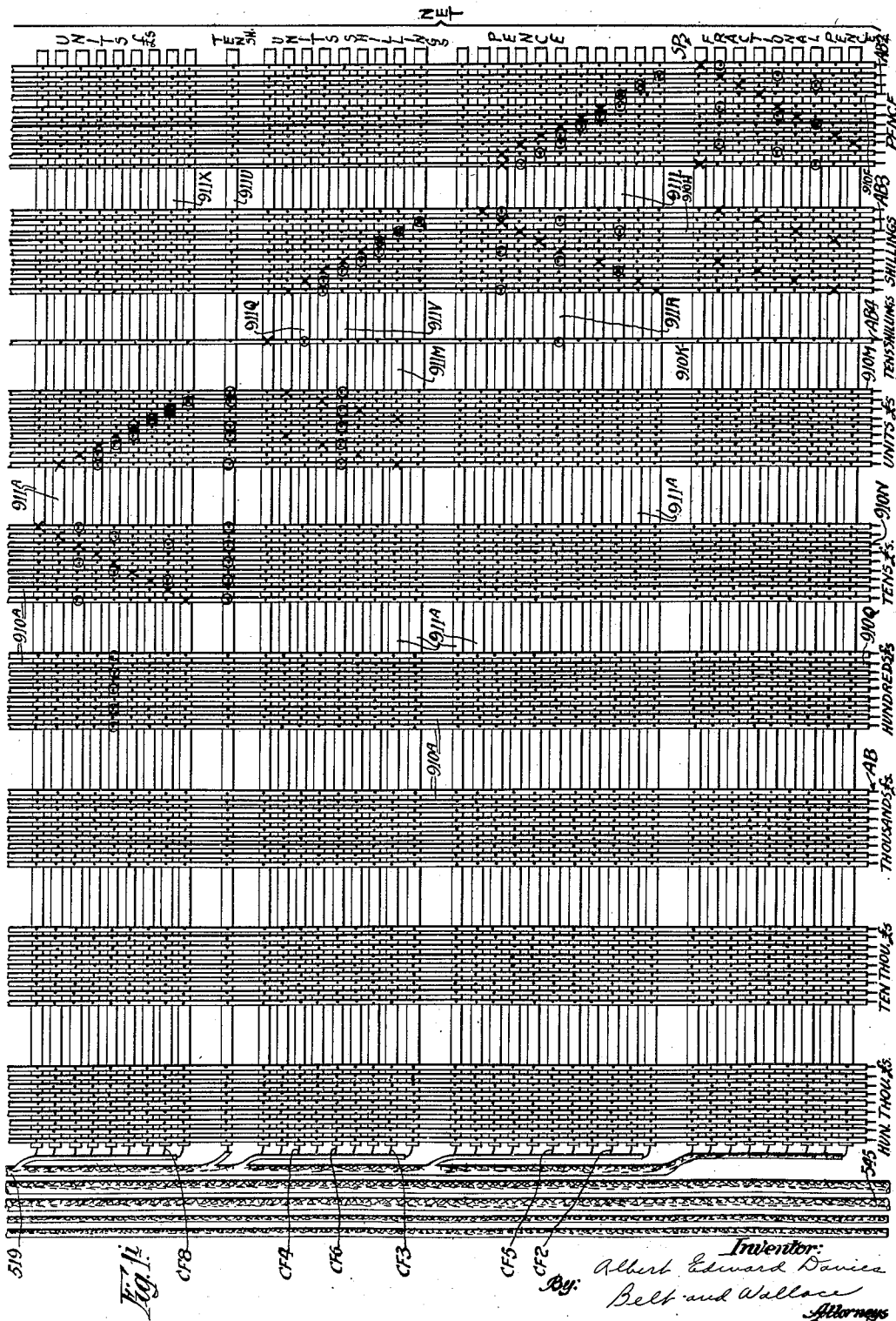
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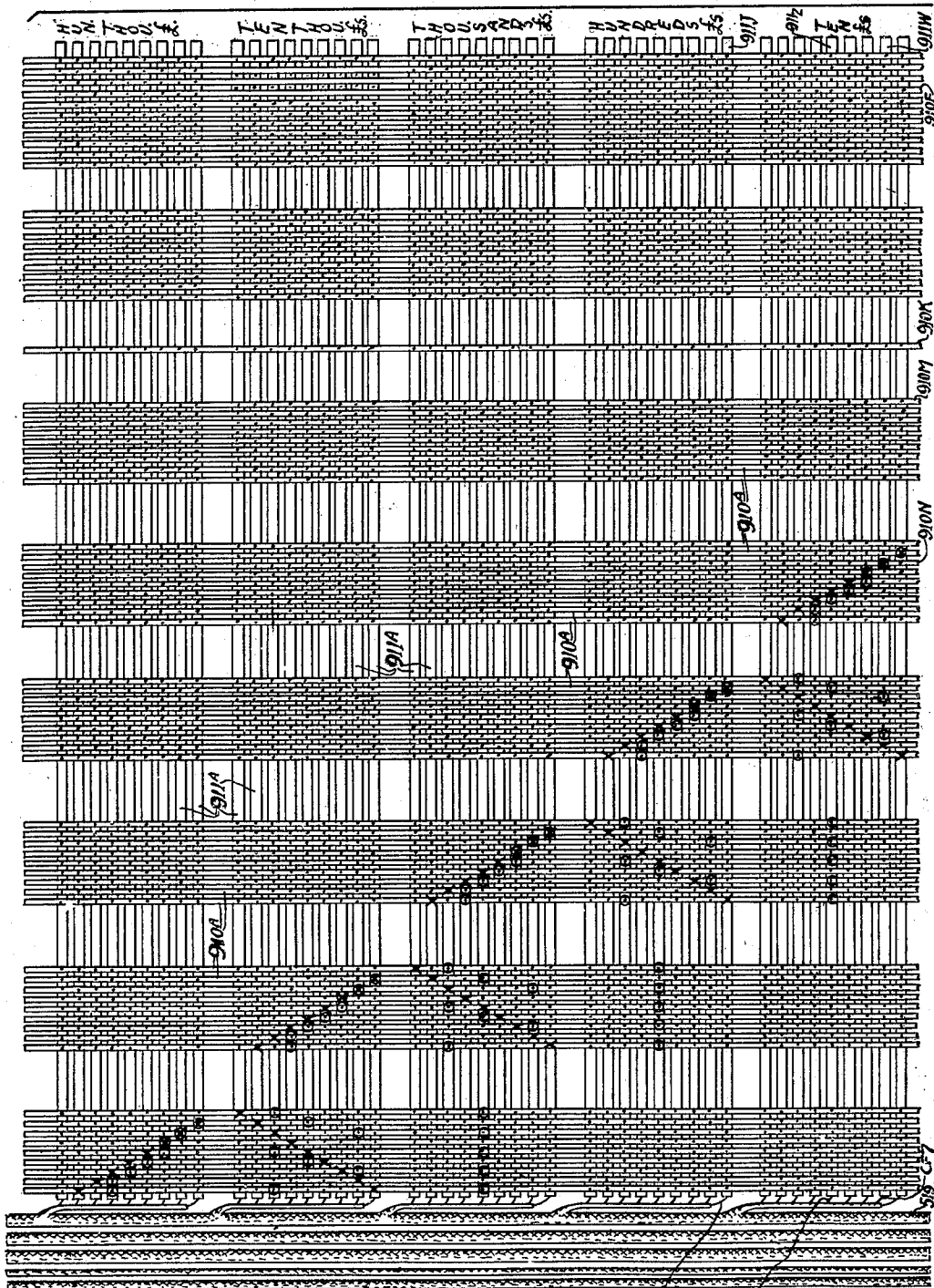


Fig. 12

Inventor:
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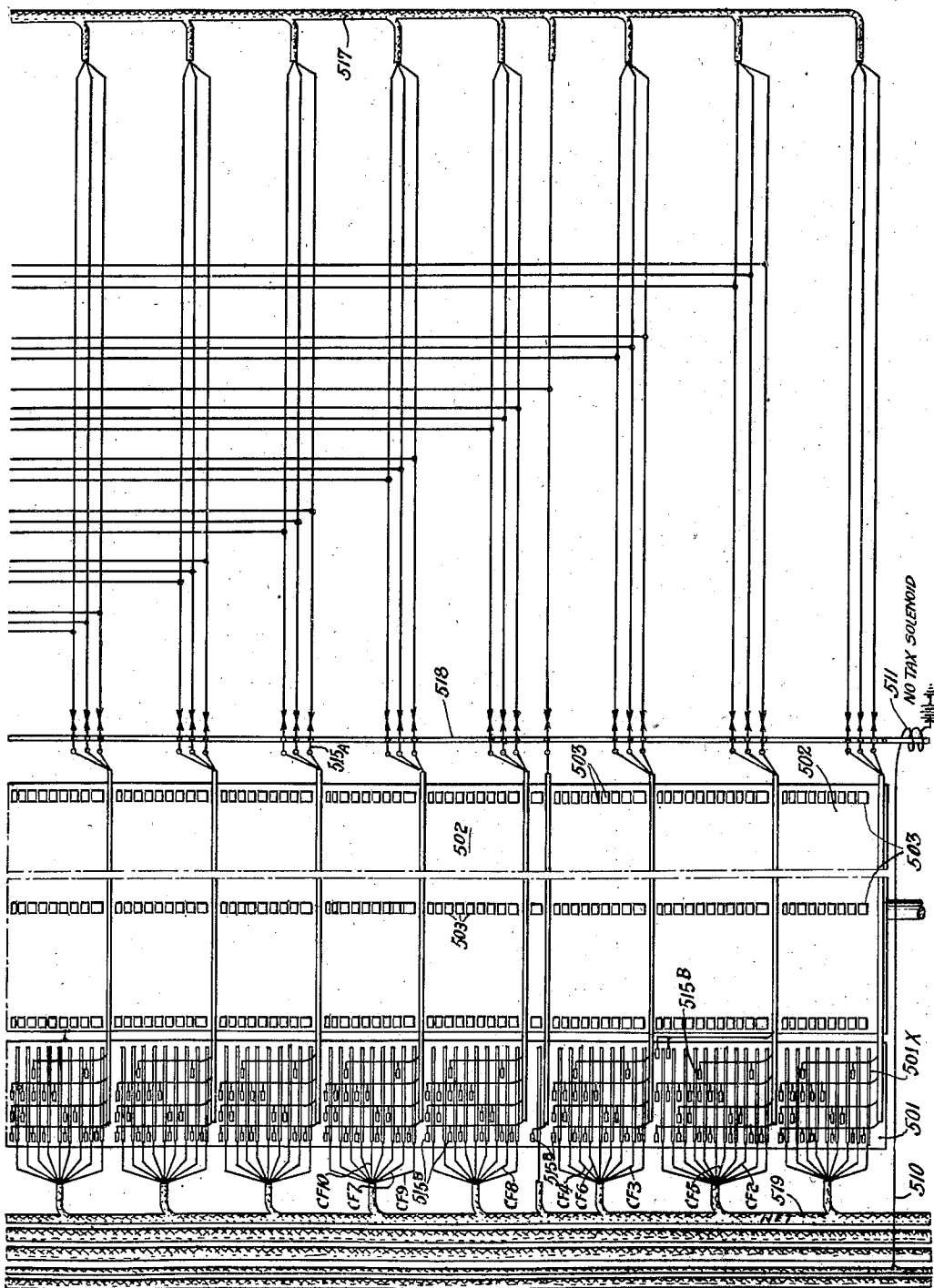


Fig. 12

Inventor:
Albert Edward Davies
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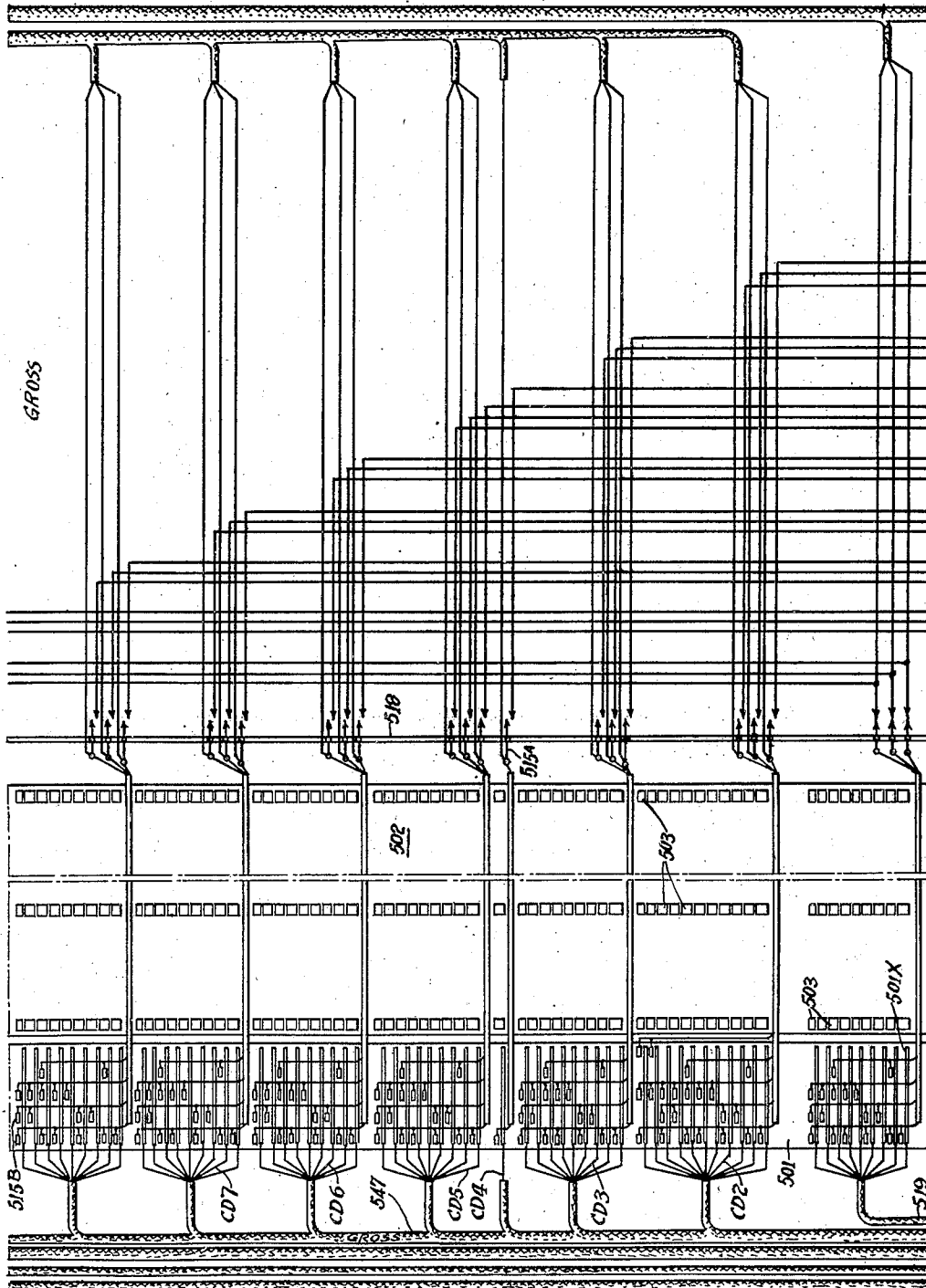


Fig. 13

Inventor:
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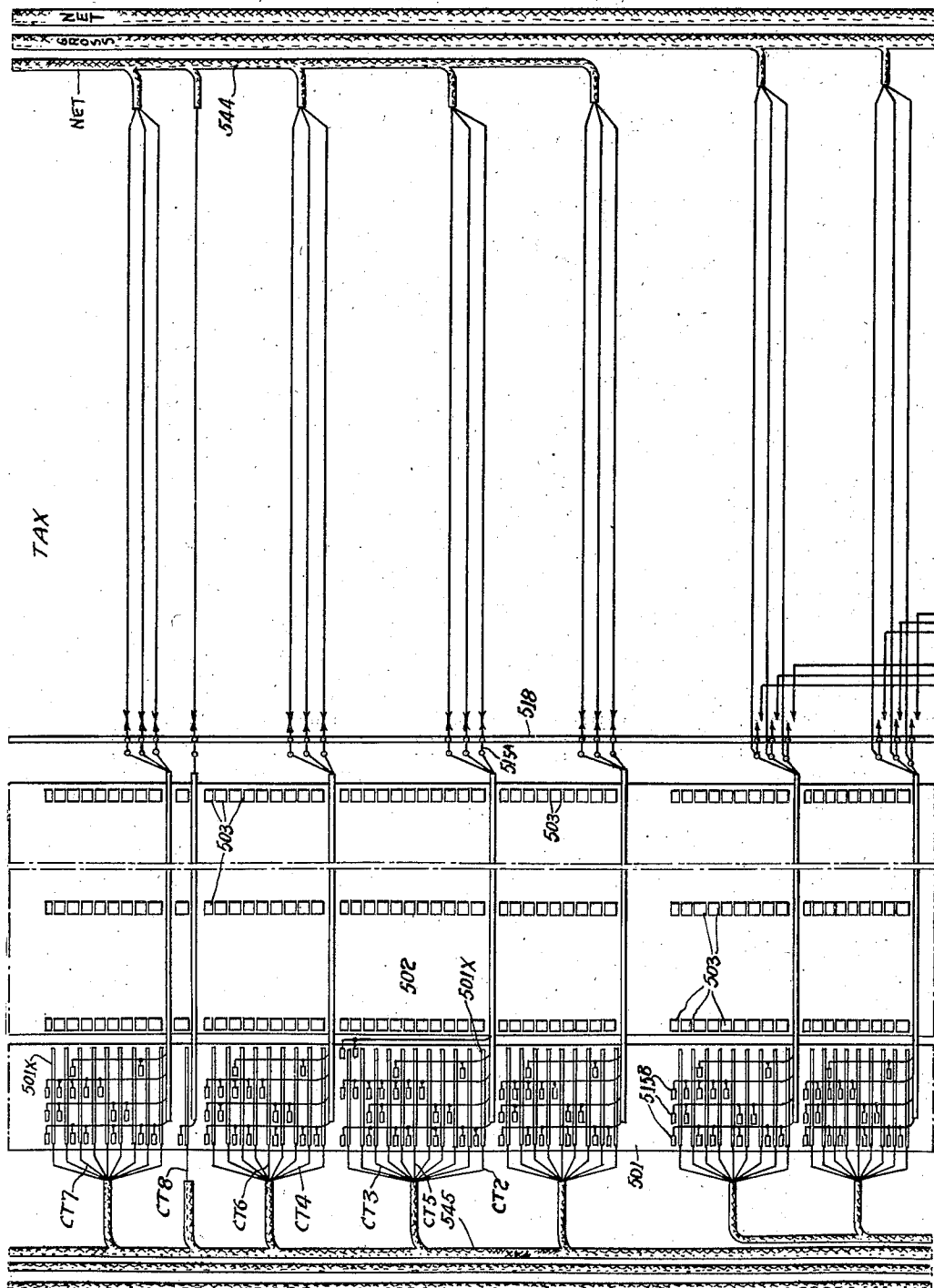


Fig. 14

Inventor:
Albert Edward Davies
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Oct. 19, 1943.

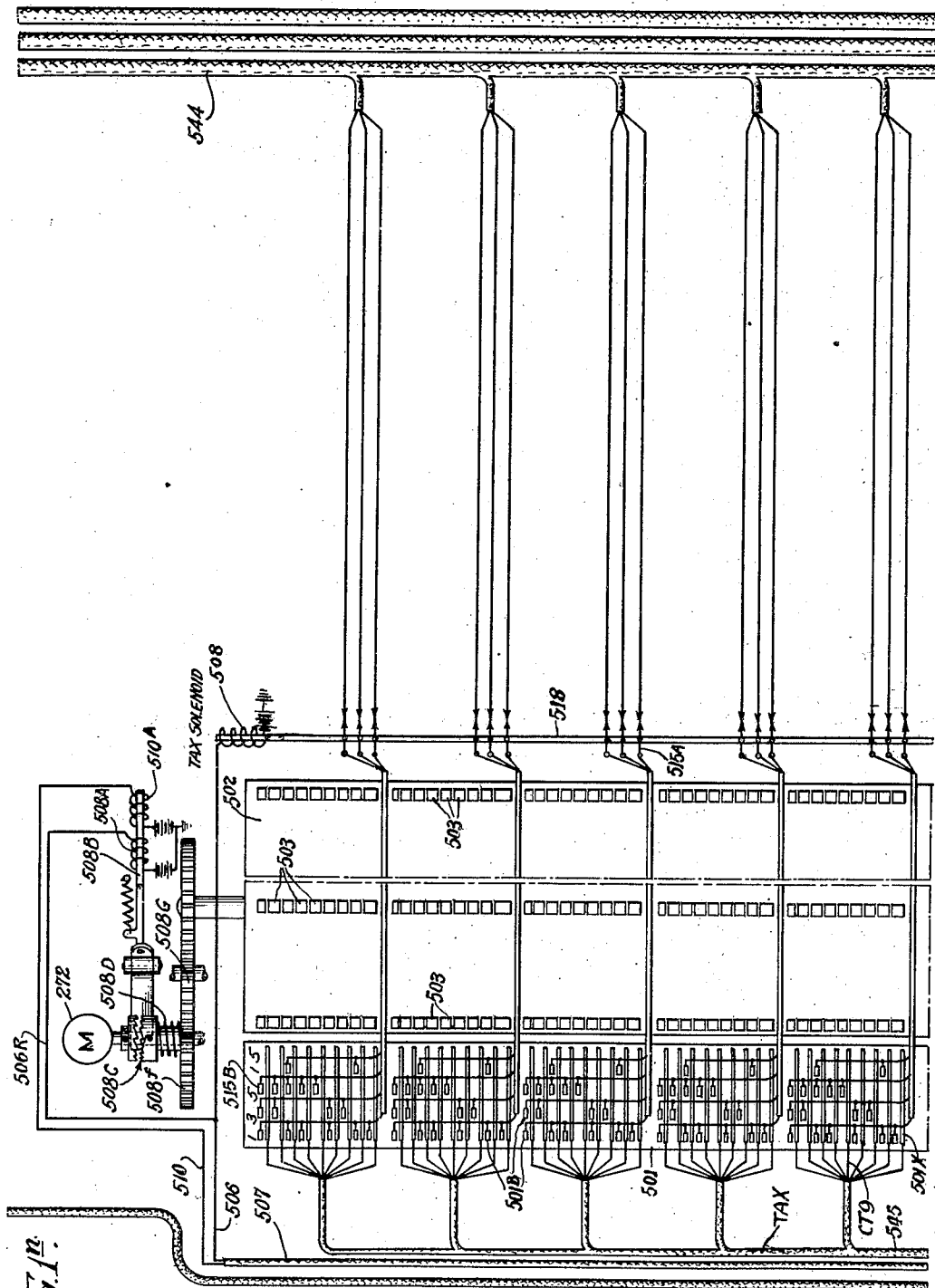
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Inventor:
Albert Edward Davis
By: Belt and Wallace *Attorneys*

Oct. 19, 1943.

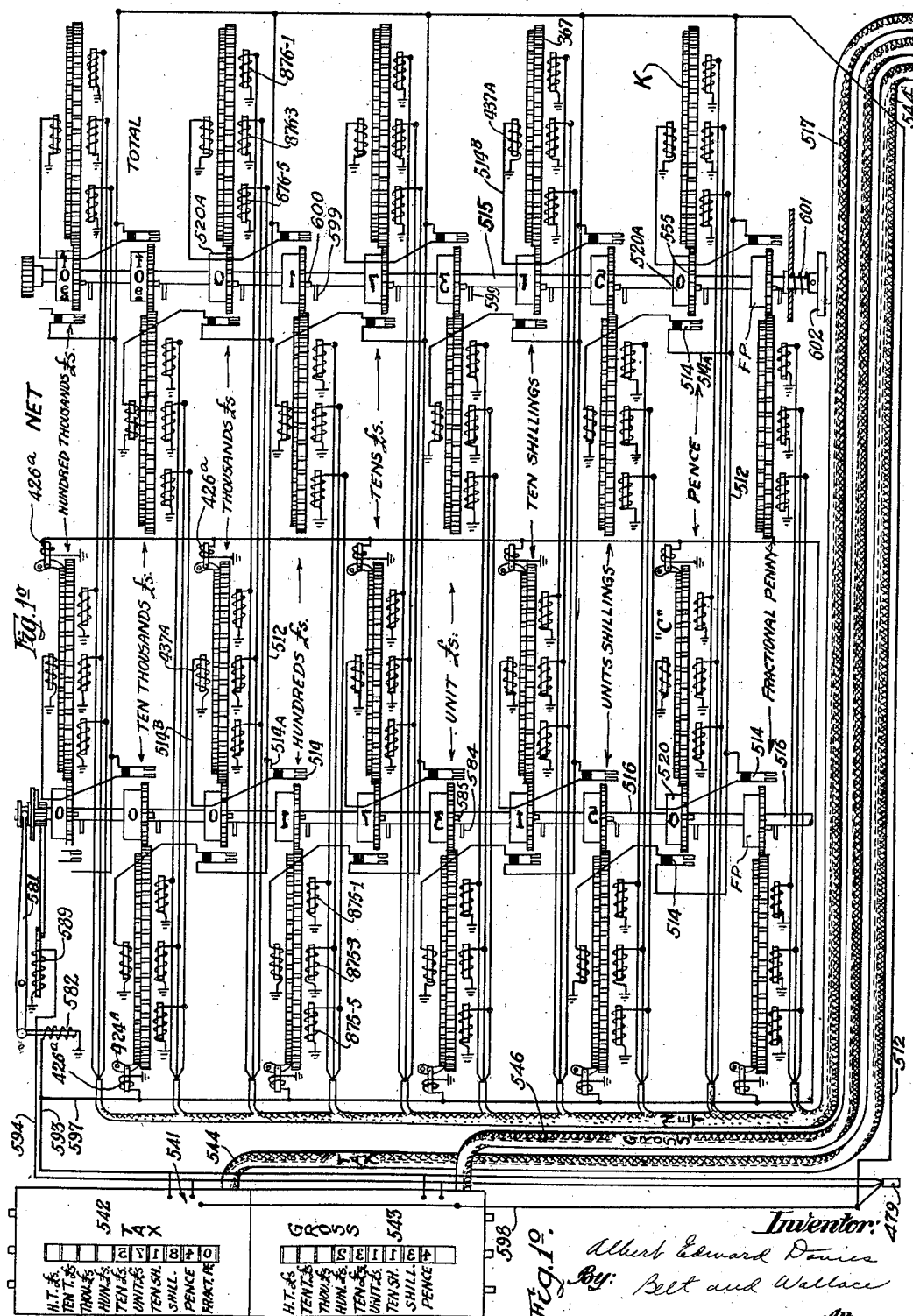
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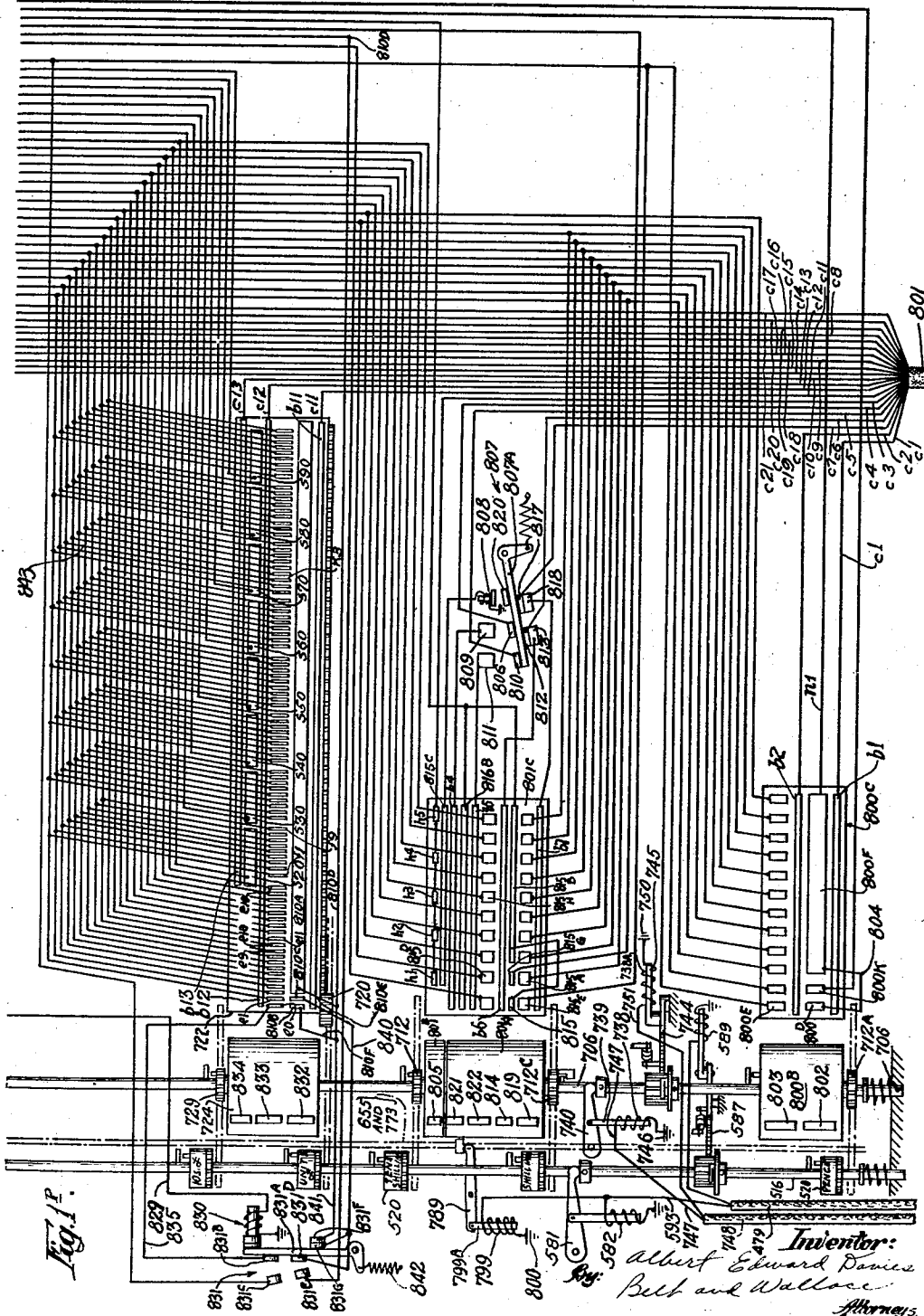
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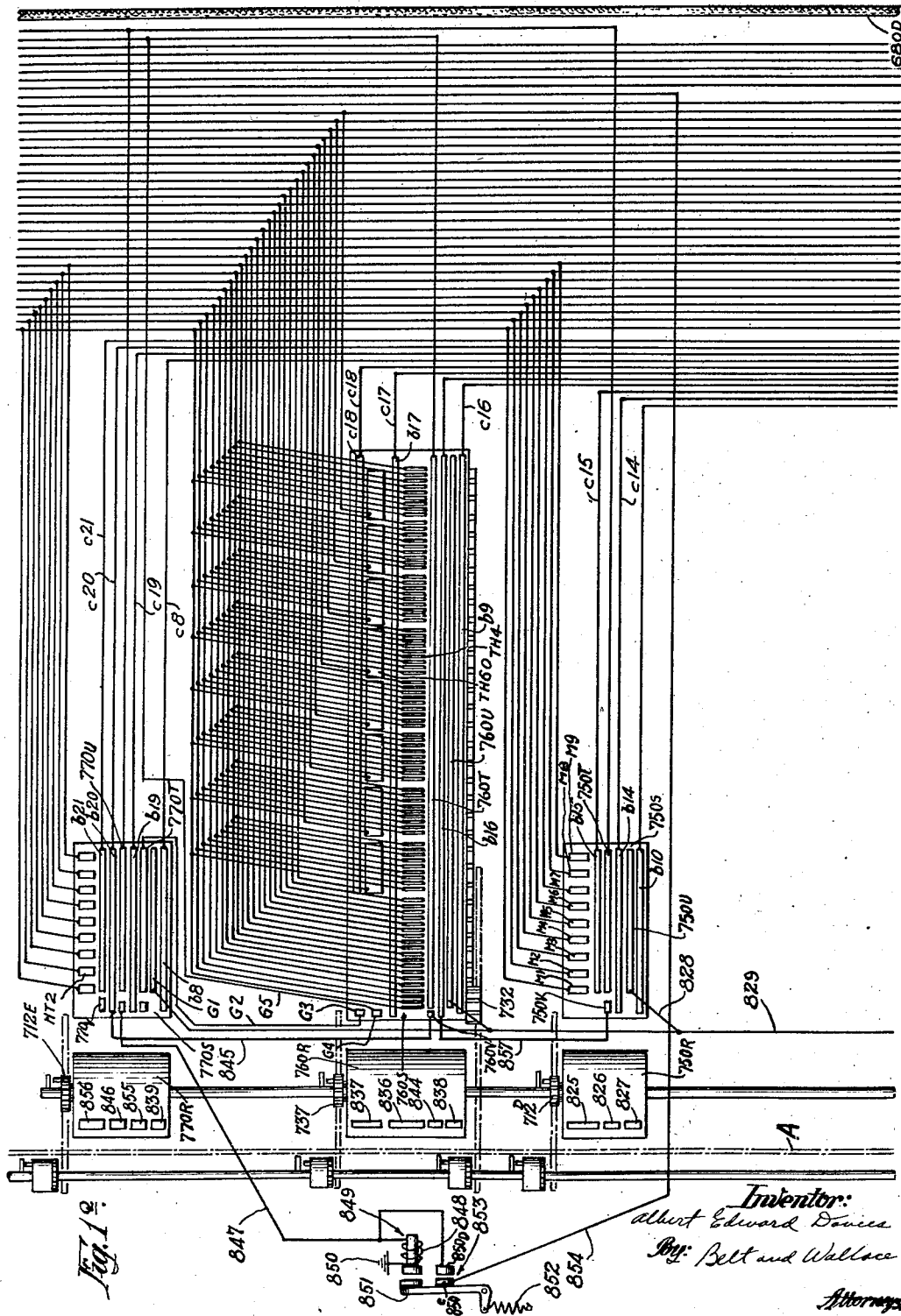
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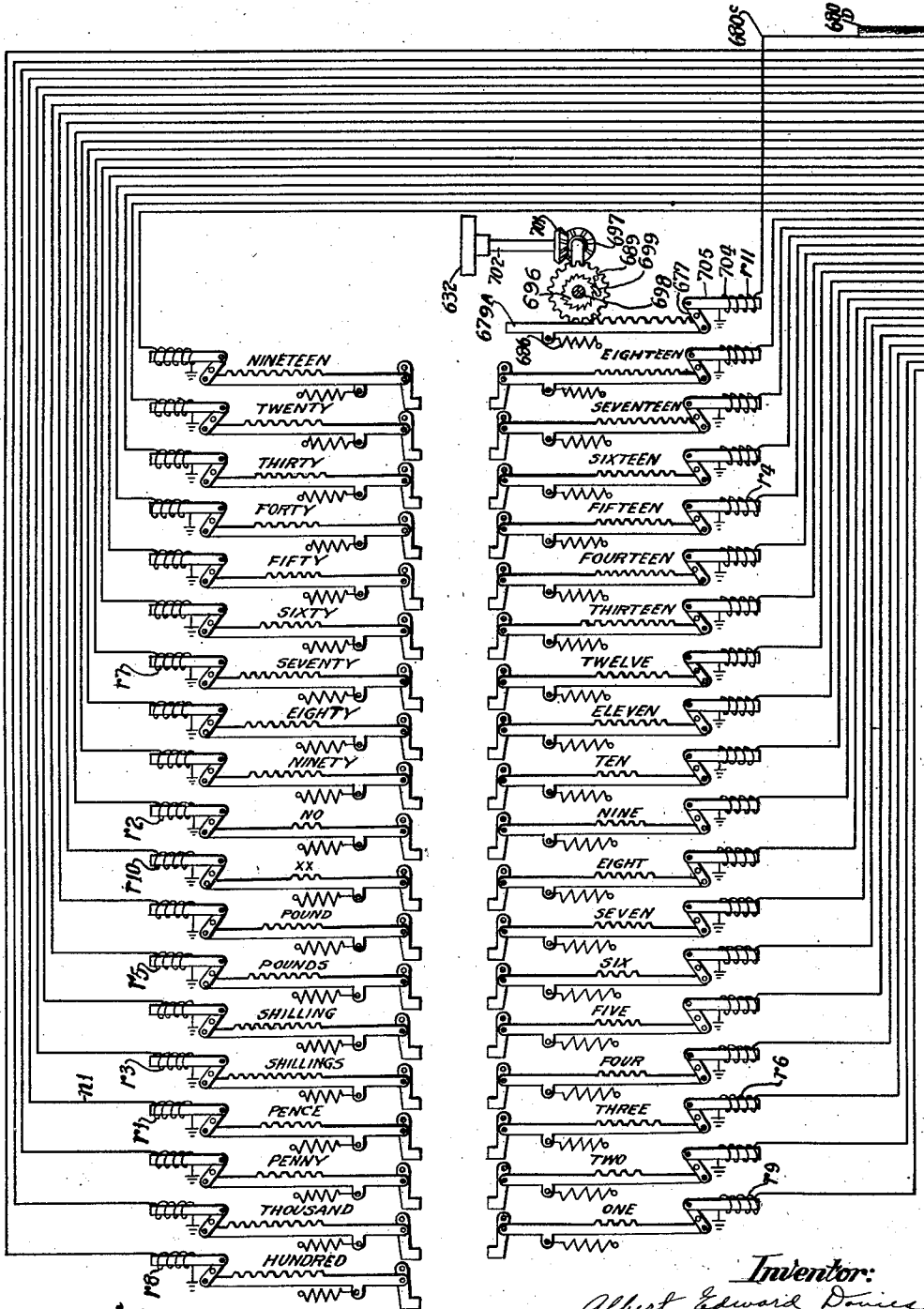


Fig. 17.

Inventor:

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By: Belt and Wallace

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Oct. 19, 1943.

A. E. DAVIES

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Fig. 2.

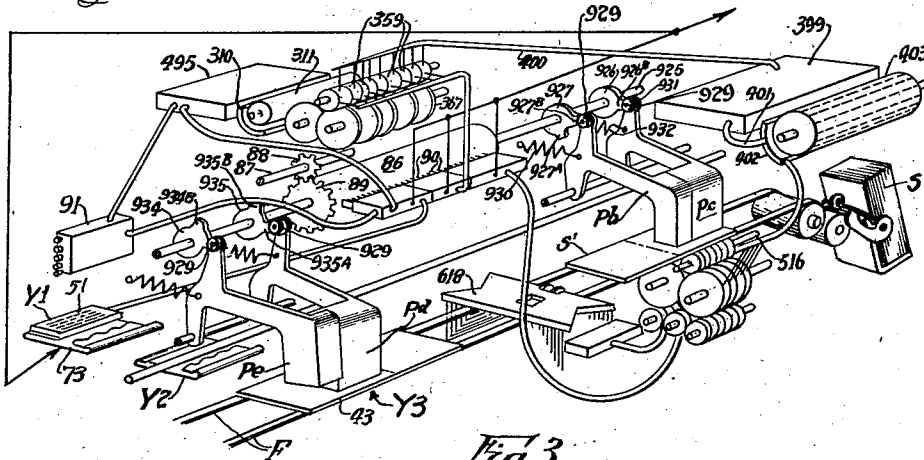


Fig. 3.

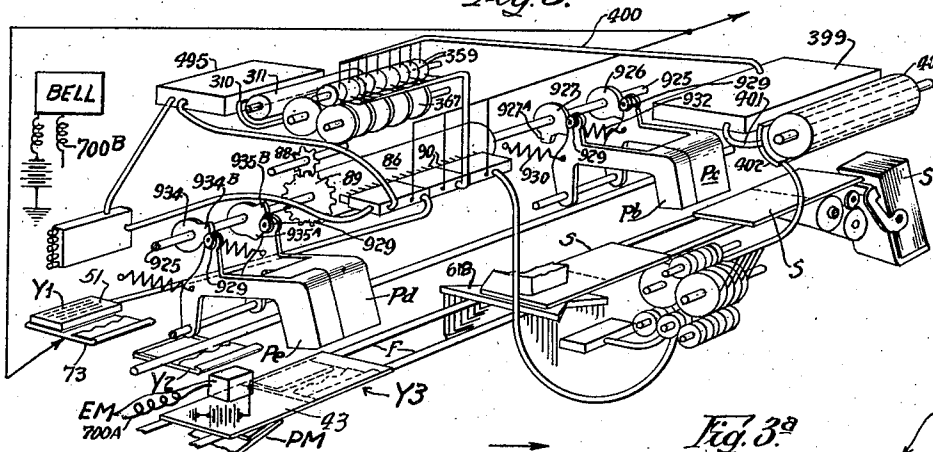


Fig. 3a

NAME JOHN K. DOE 111 MAIN COURT CHICAGO, ILL.					3x PAY TO JOHN K. DOE 111 MAIN COURT CHICAGO, ILL.	
ACCOUNT NO.	REG. HOLDINGS	GROSS DIVIDEND	TAX	NET DIVIDEND	ONE HUNDRED SEVENTY THREE POUNDS FIFTEEN SHILLINGS NO PENCE 173.15.0	
4675	200	231.13.4	57.18.4	173.15.0	T2 T1	

Inventor:
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By: Belt and Wallace
Attorneys.

Oct. 19, 1943.

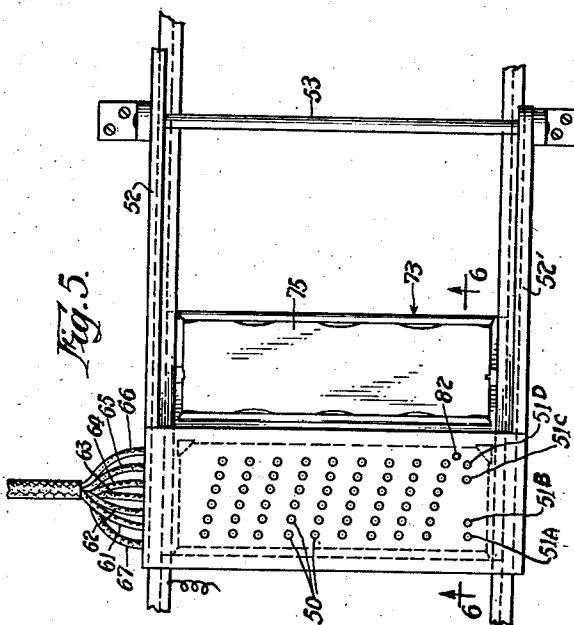
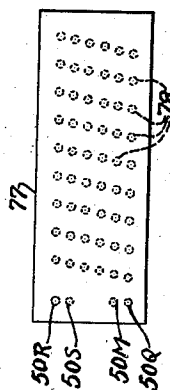
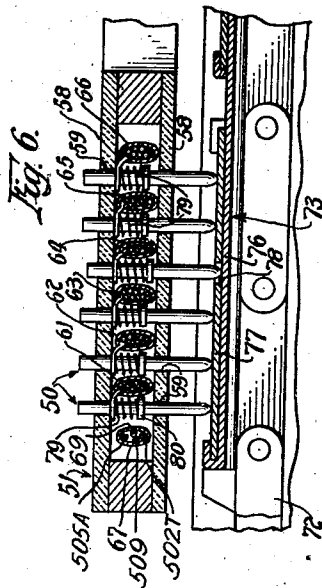
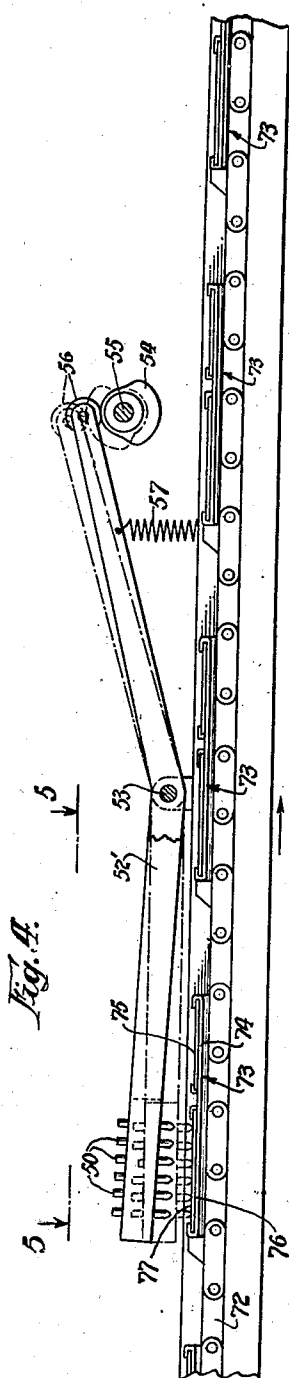
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Inventor:
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Oct. 19, 1943.

A. E. DAVIES

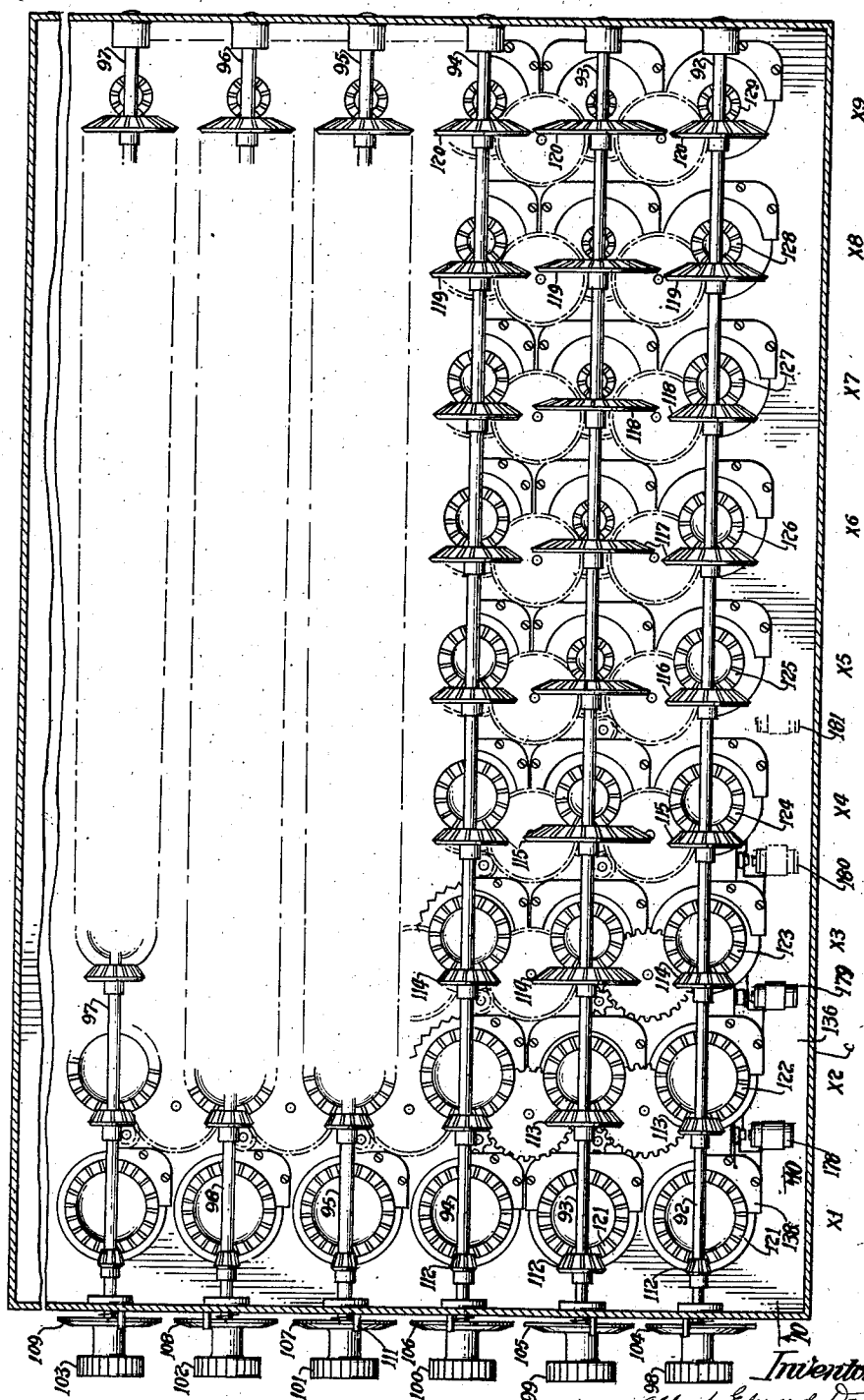
2,332,304

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Fig. 7



Inventor:
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Oct. 19, 1943.

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Fig. 8.

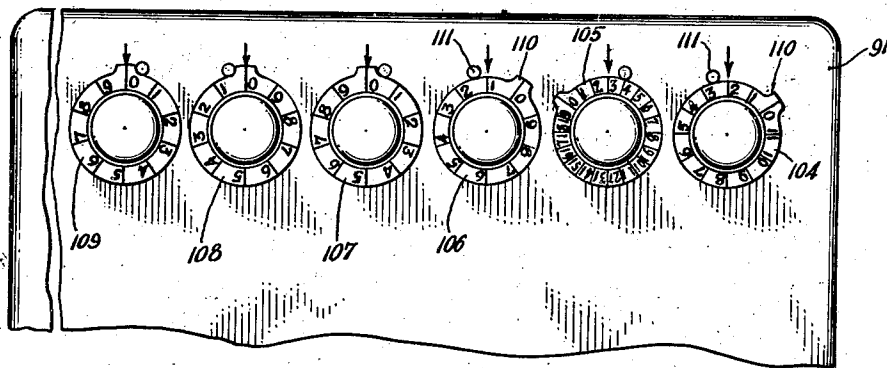


Fig. 9.

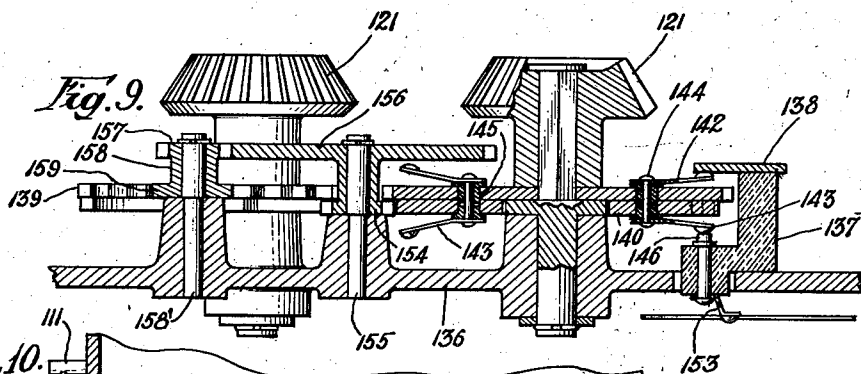


Fig. 10.

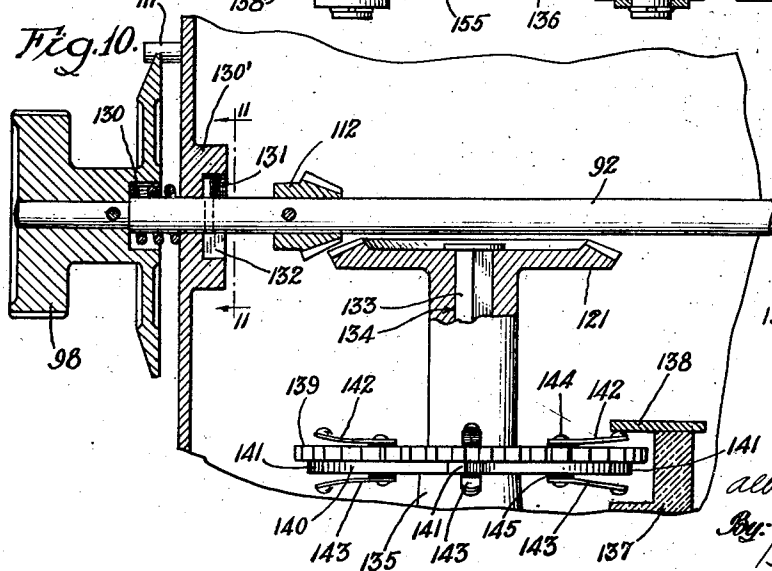
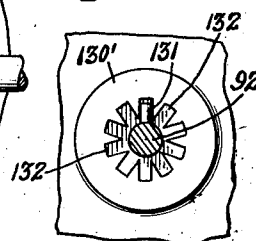


Fig. 11.



Inventor:

Albert Edward Davies

By: Belt and Wallace

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Oct. 19, 1943.

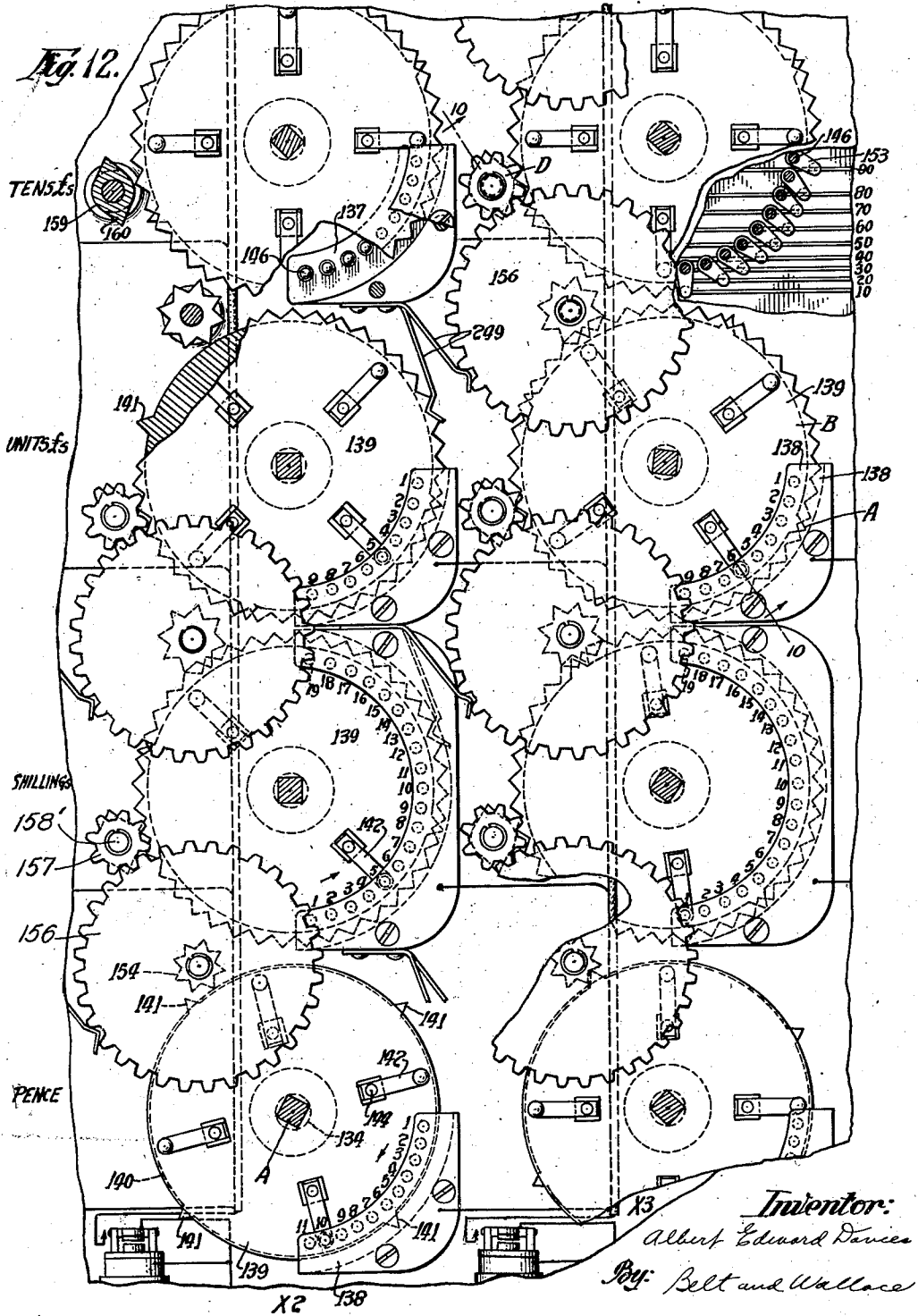
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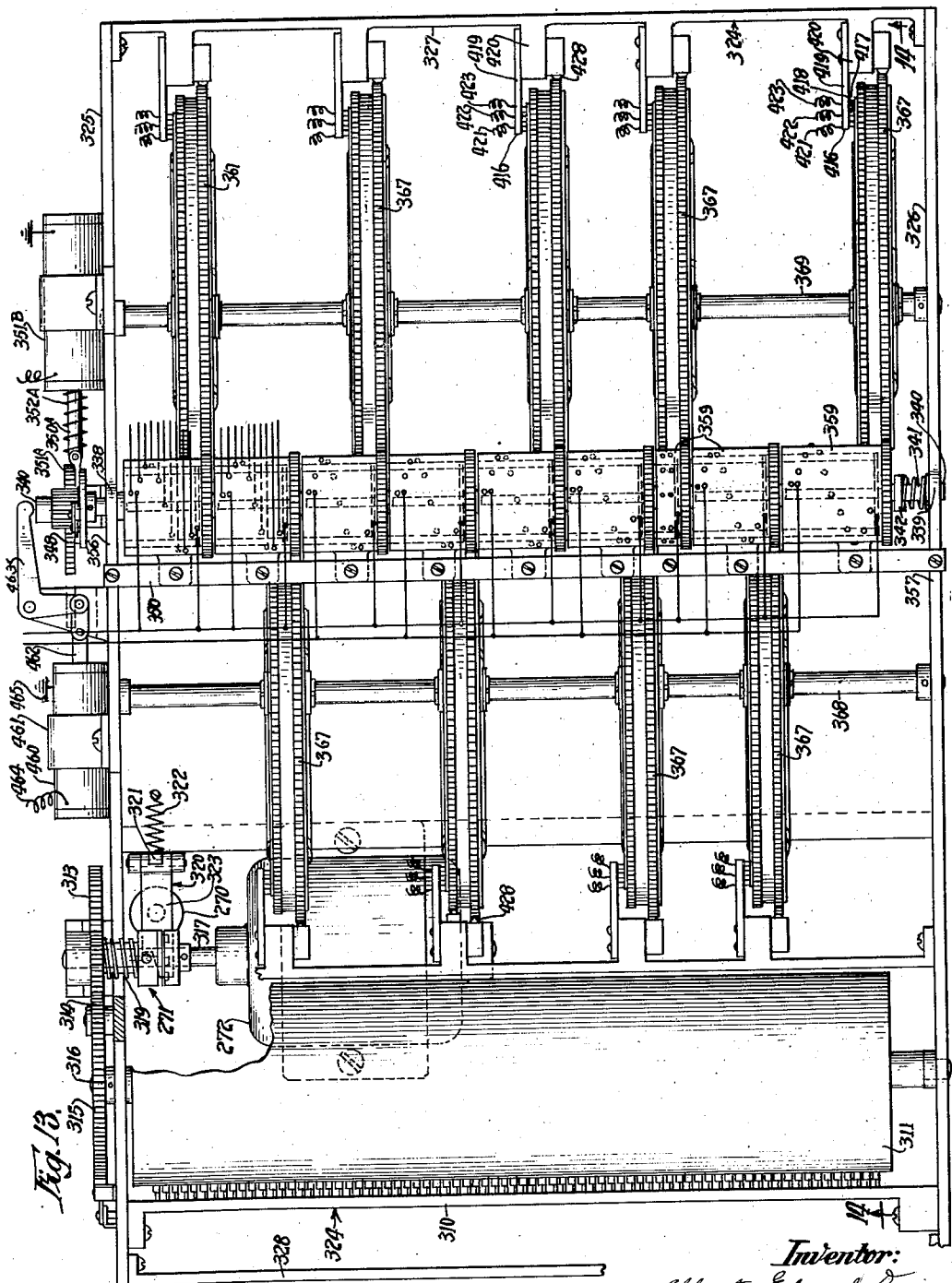
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Inventor:
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By: Belt and Wallace
Attorneys

Oct. 19, 1943.

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Fig. 18.

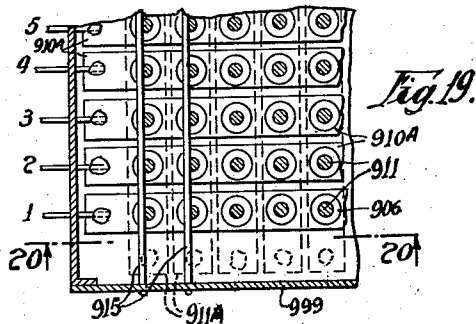
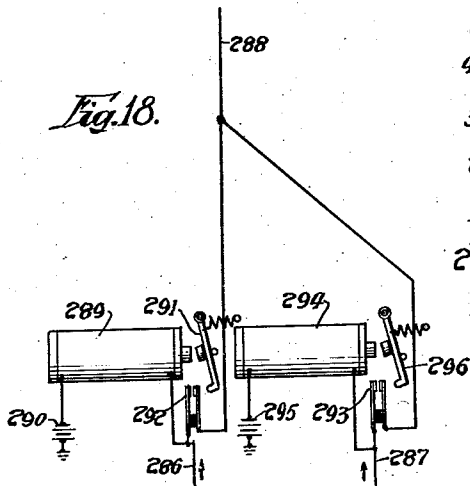


Fig. 19.

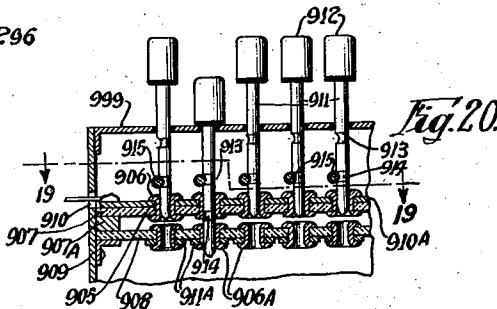


Fig. 20.

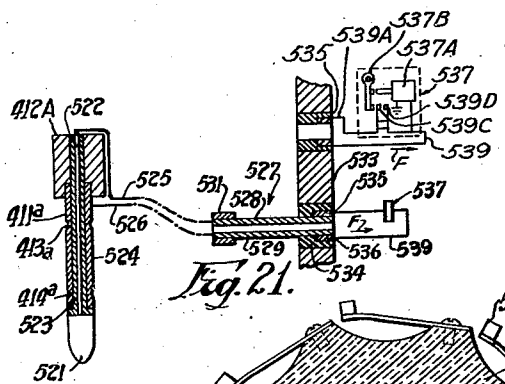


Fig. 21.

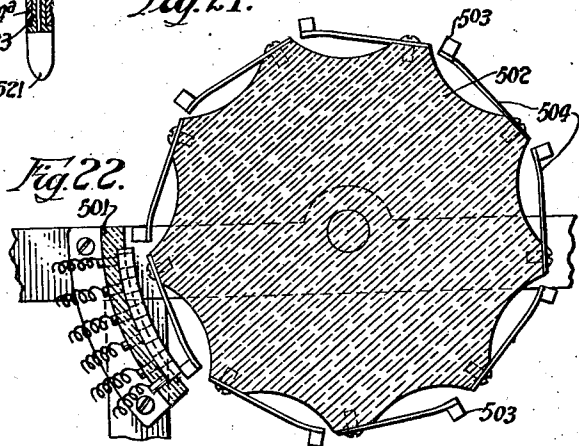


Fig. 22.

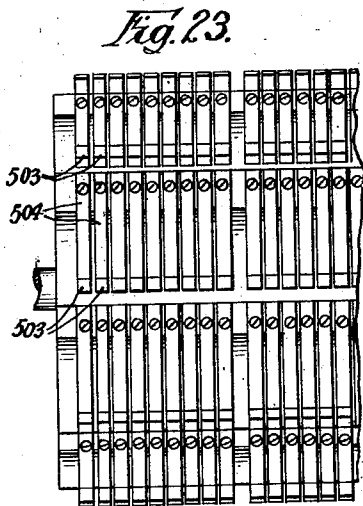
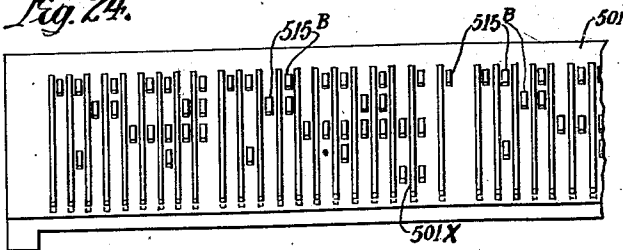


Fig. 23.

Fig. 24.



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Oct. 19, 1943.

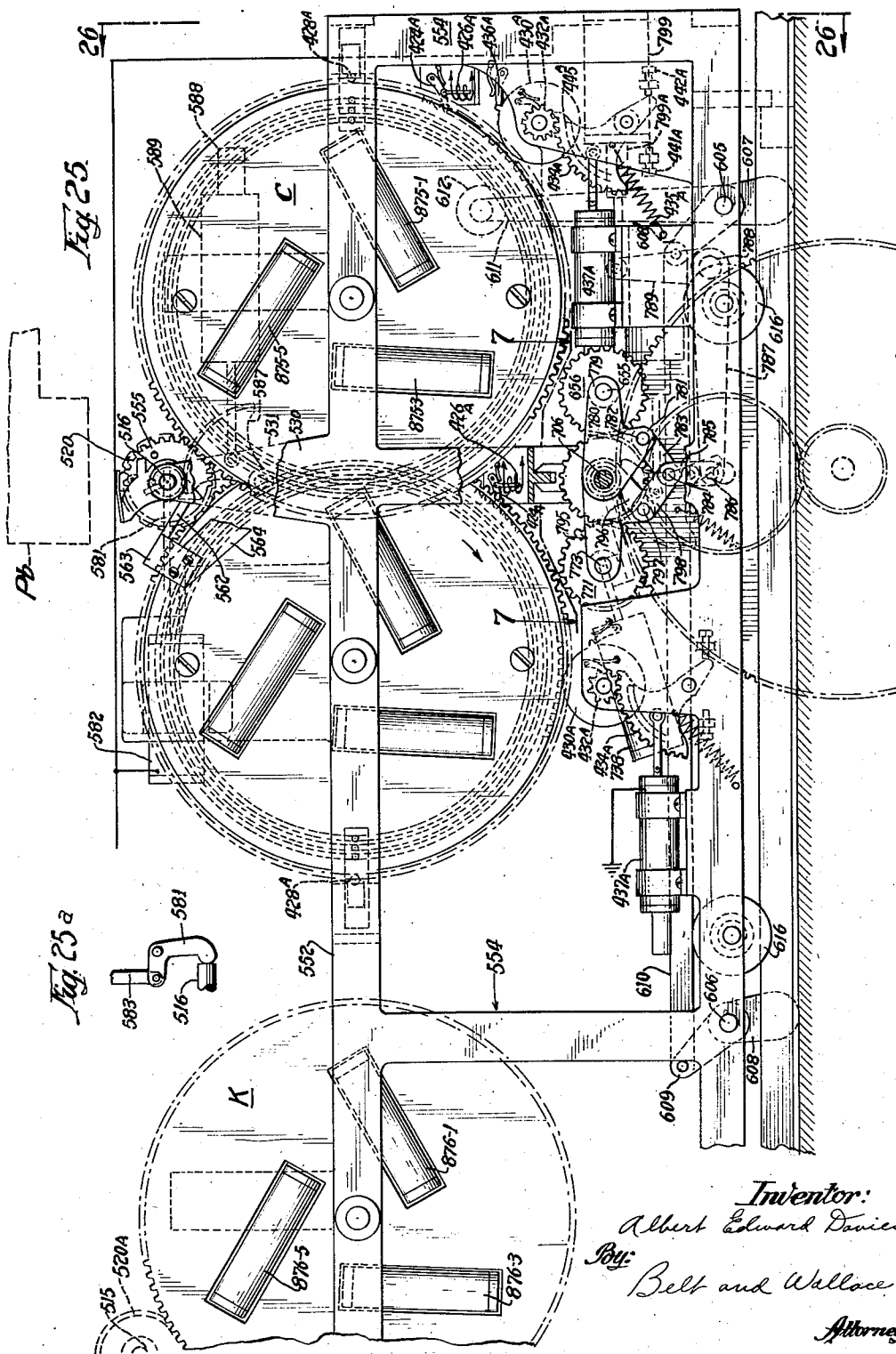
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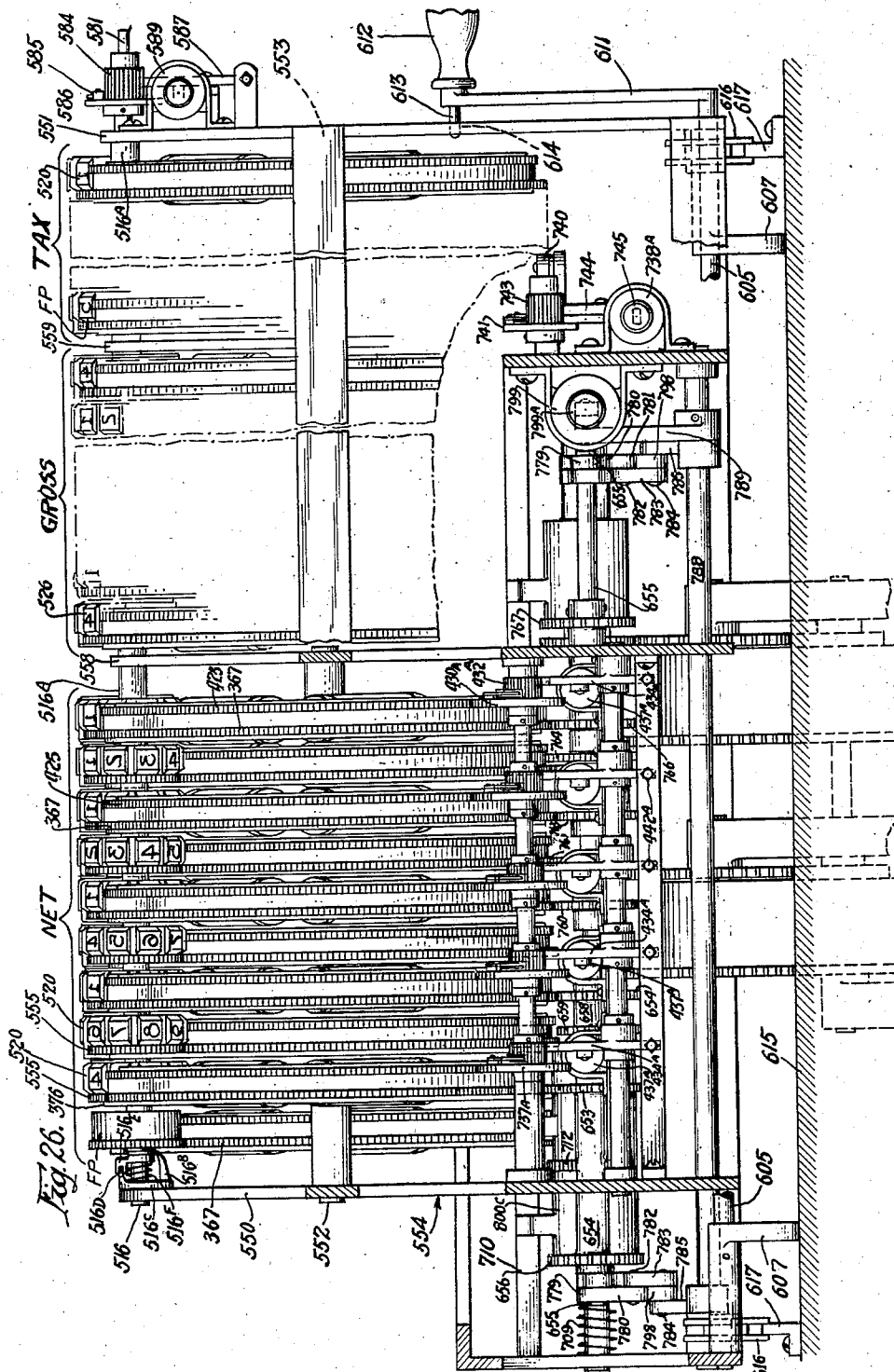
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Inventor: Albert Edward Davies By Belt and Wallace

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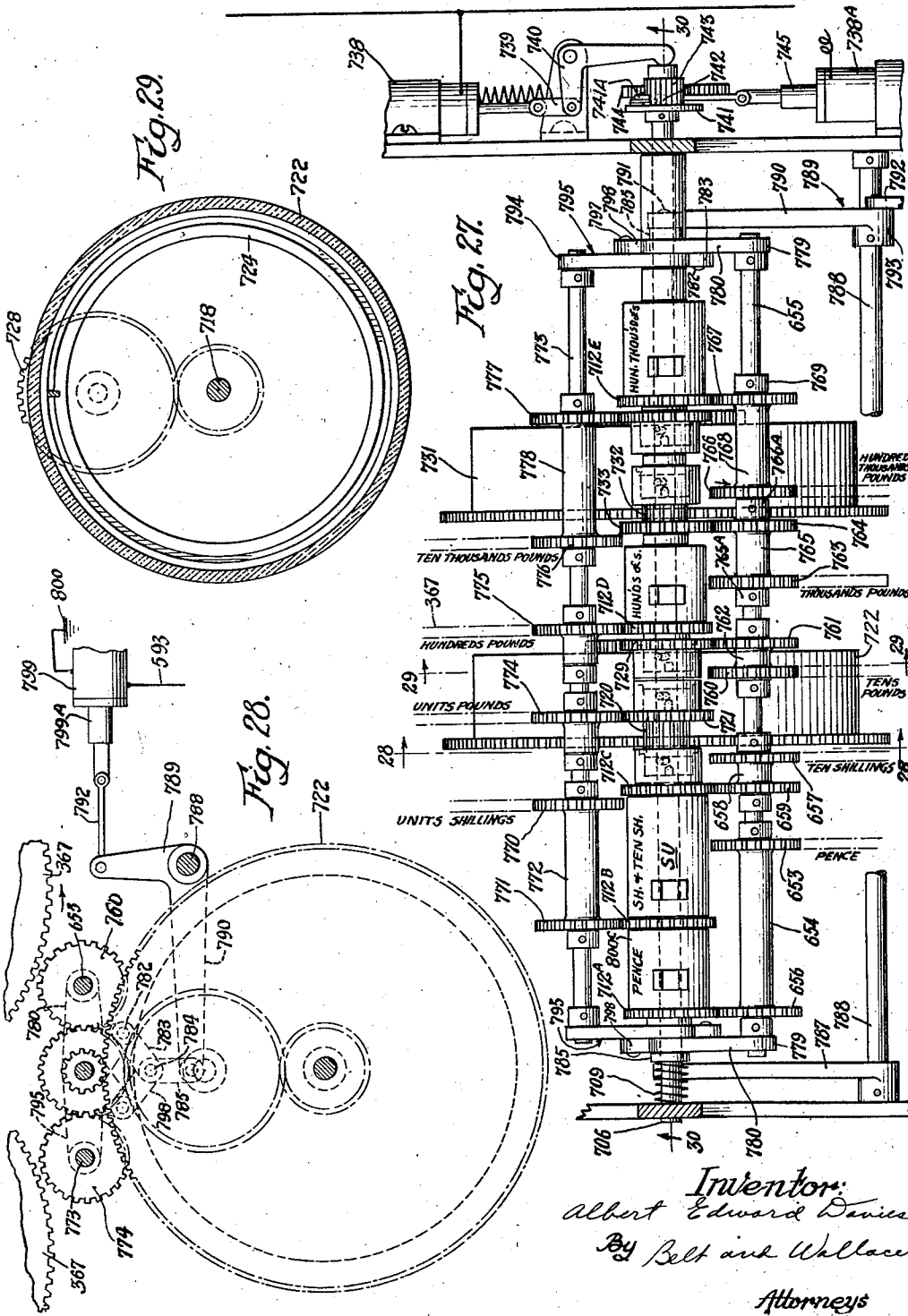
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Inventor:
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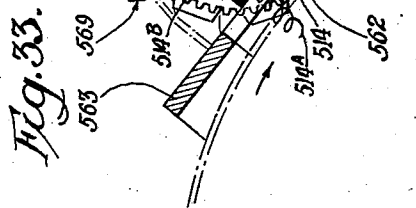
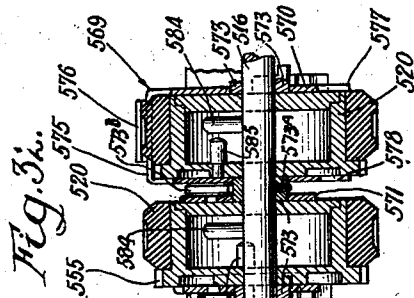
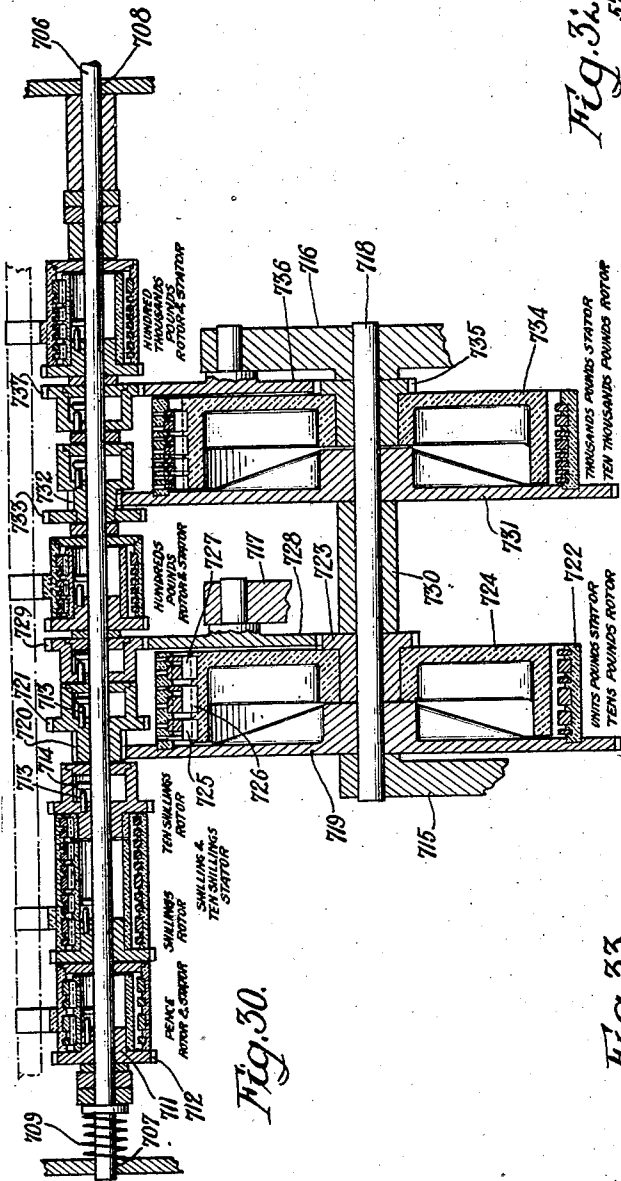
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Inventor
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Oct. 19, 1943.

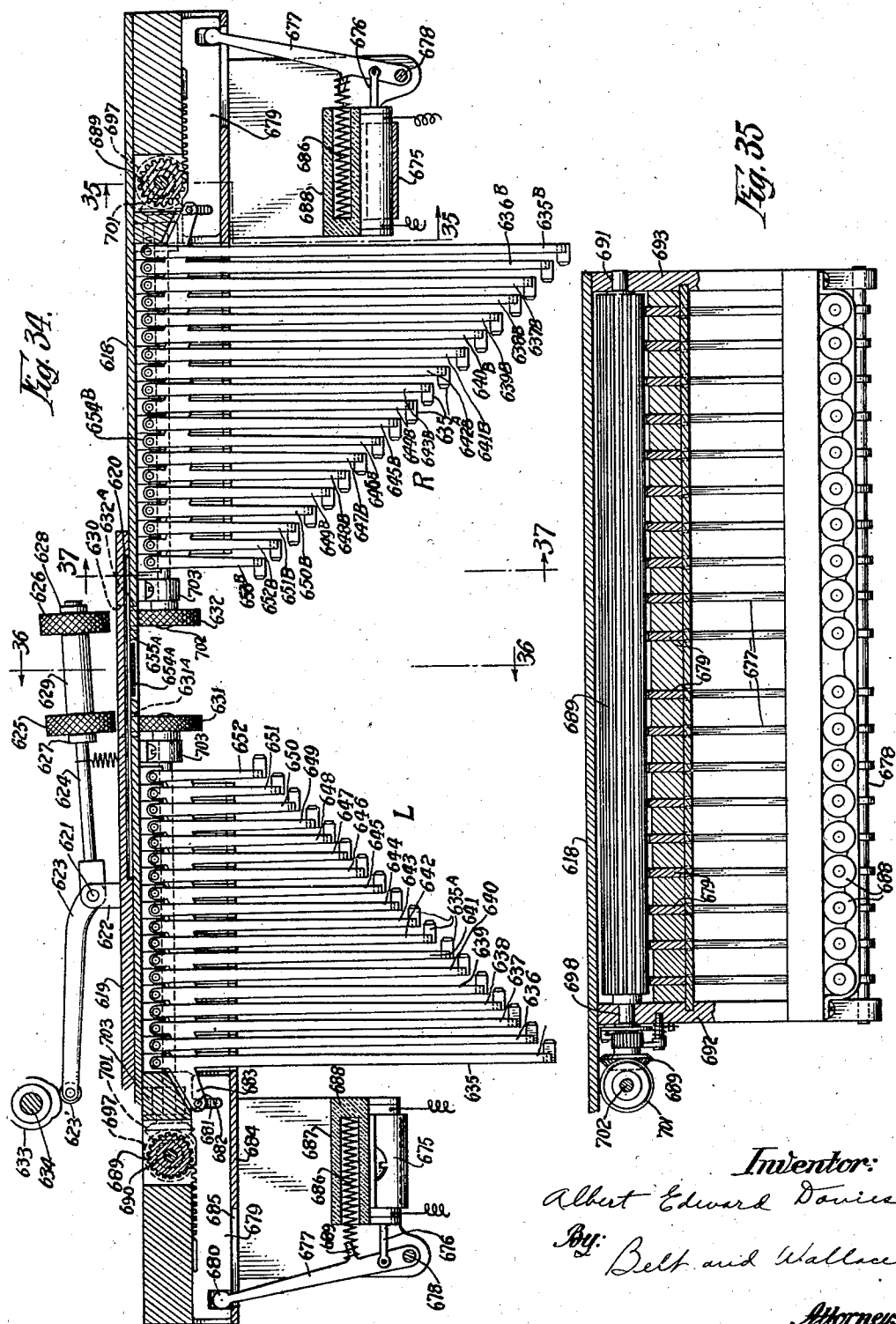
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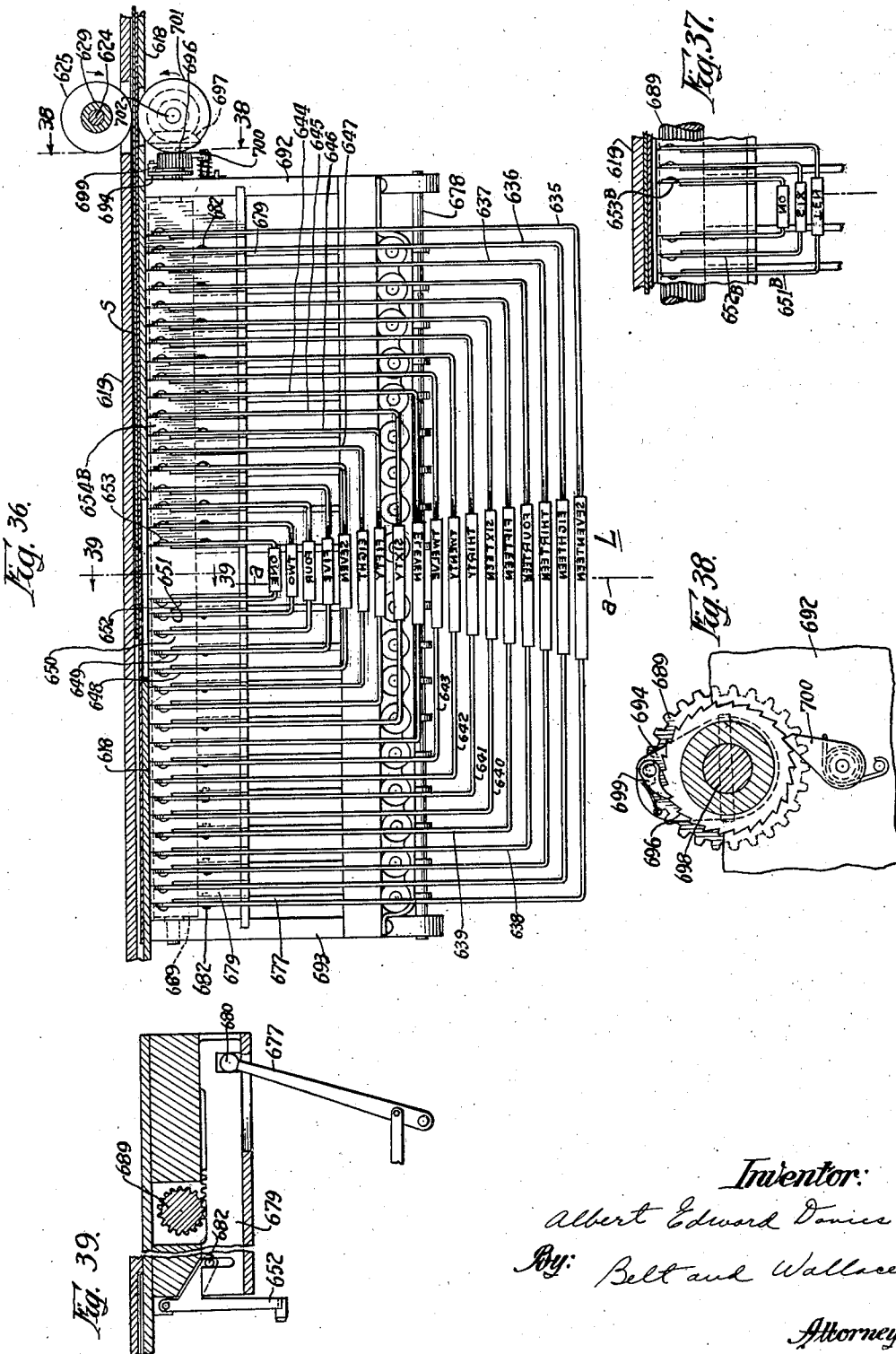
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Inventor:
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Oct. 19, 1943.

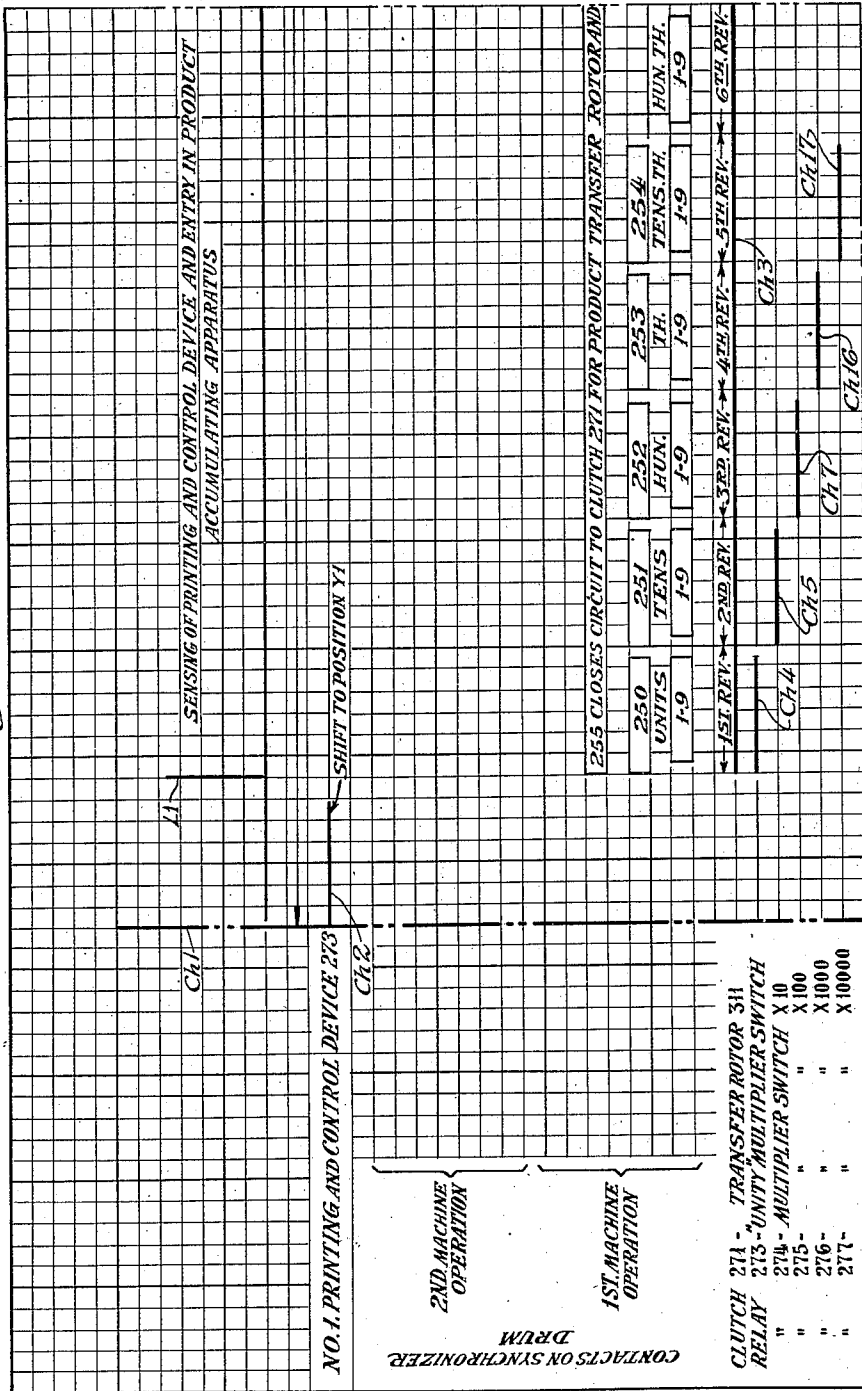
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Inventor:
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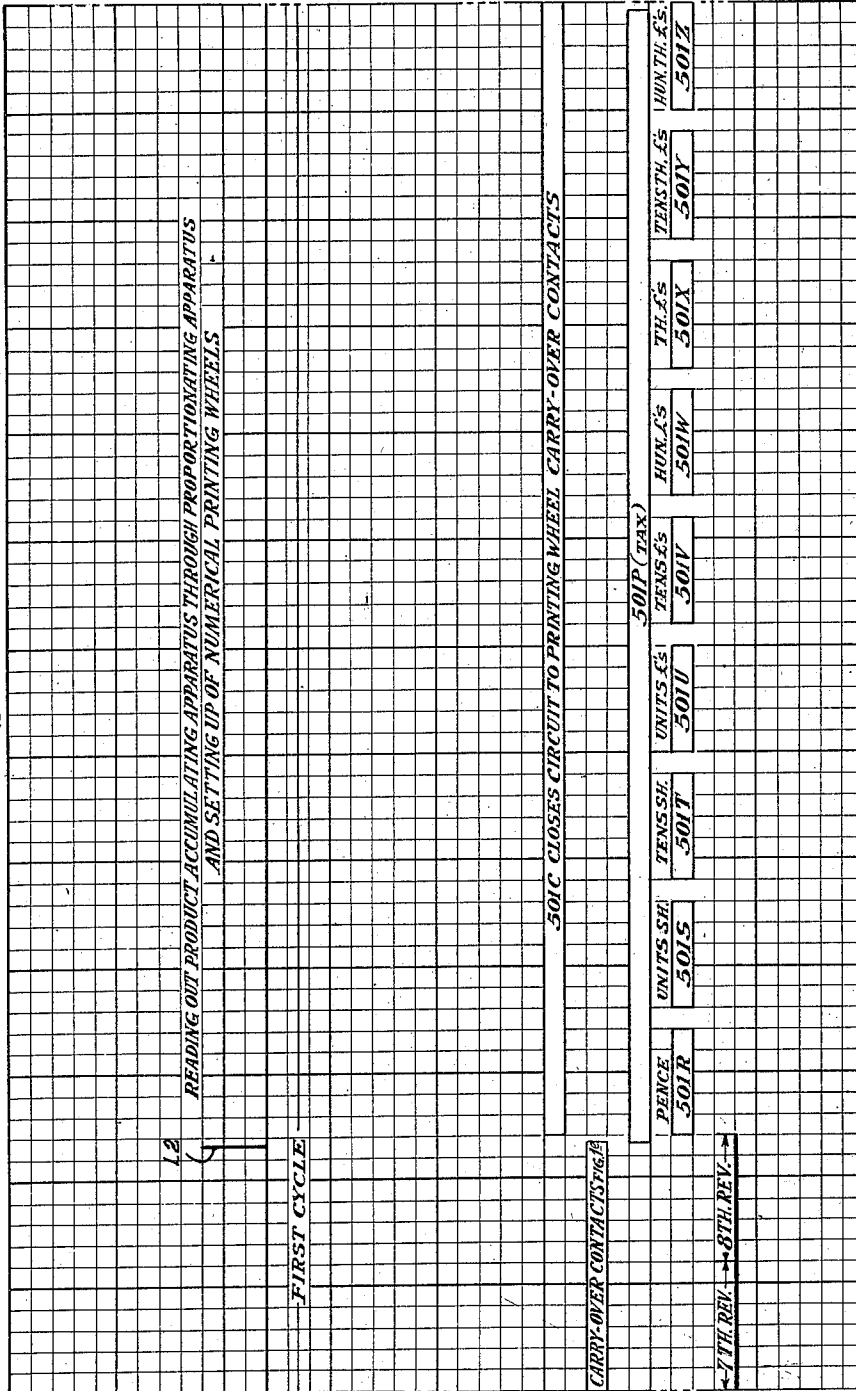
2,332,304

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Fig. 44.



Inventor:
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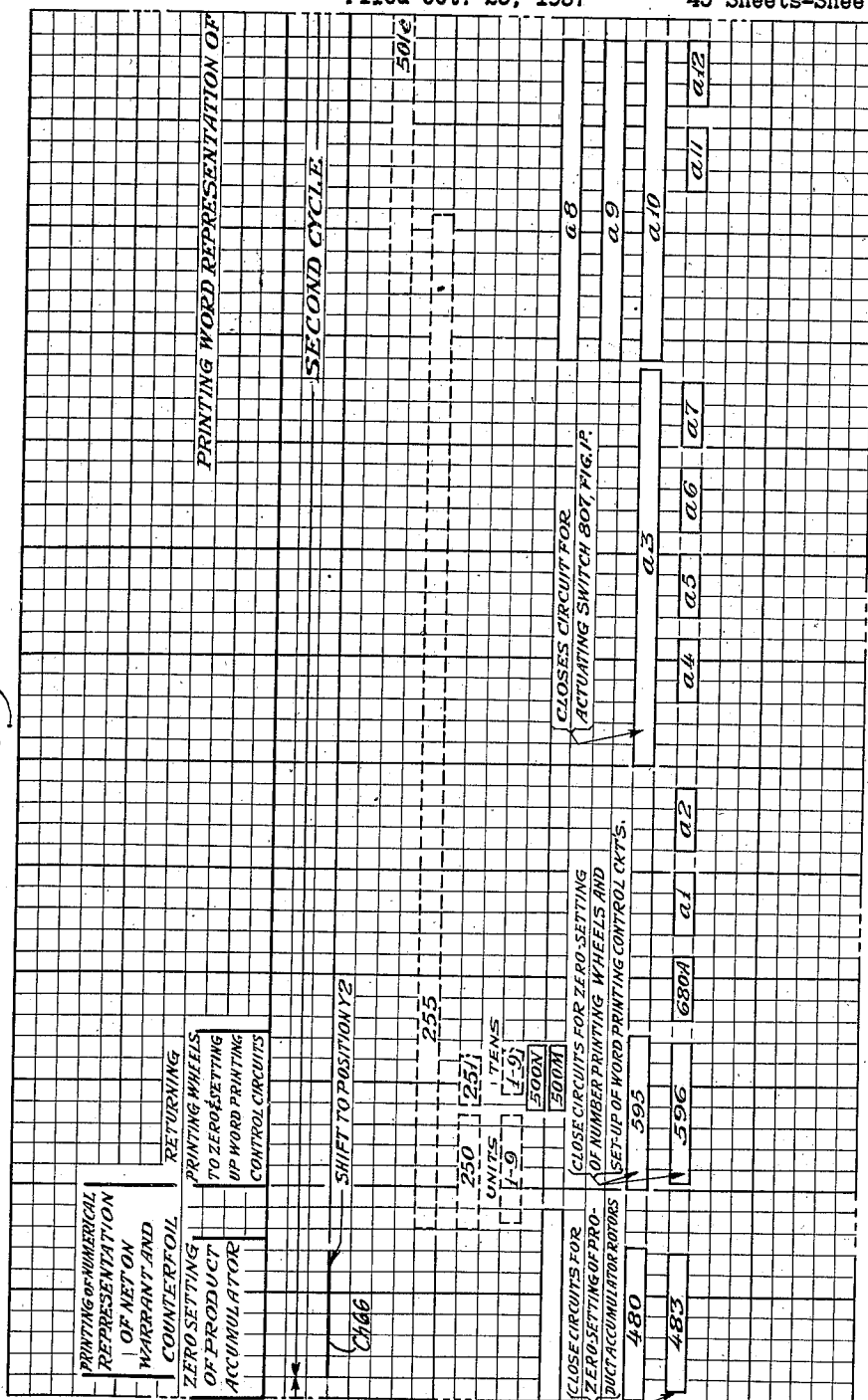


Fig. 42.

Inventor:
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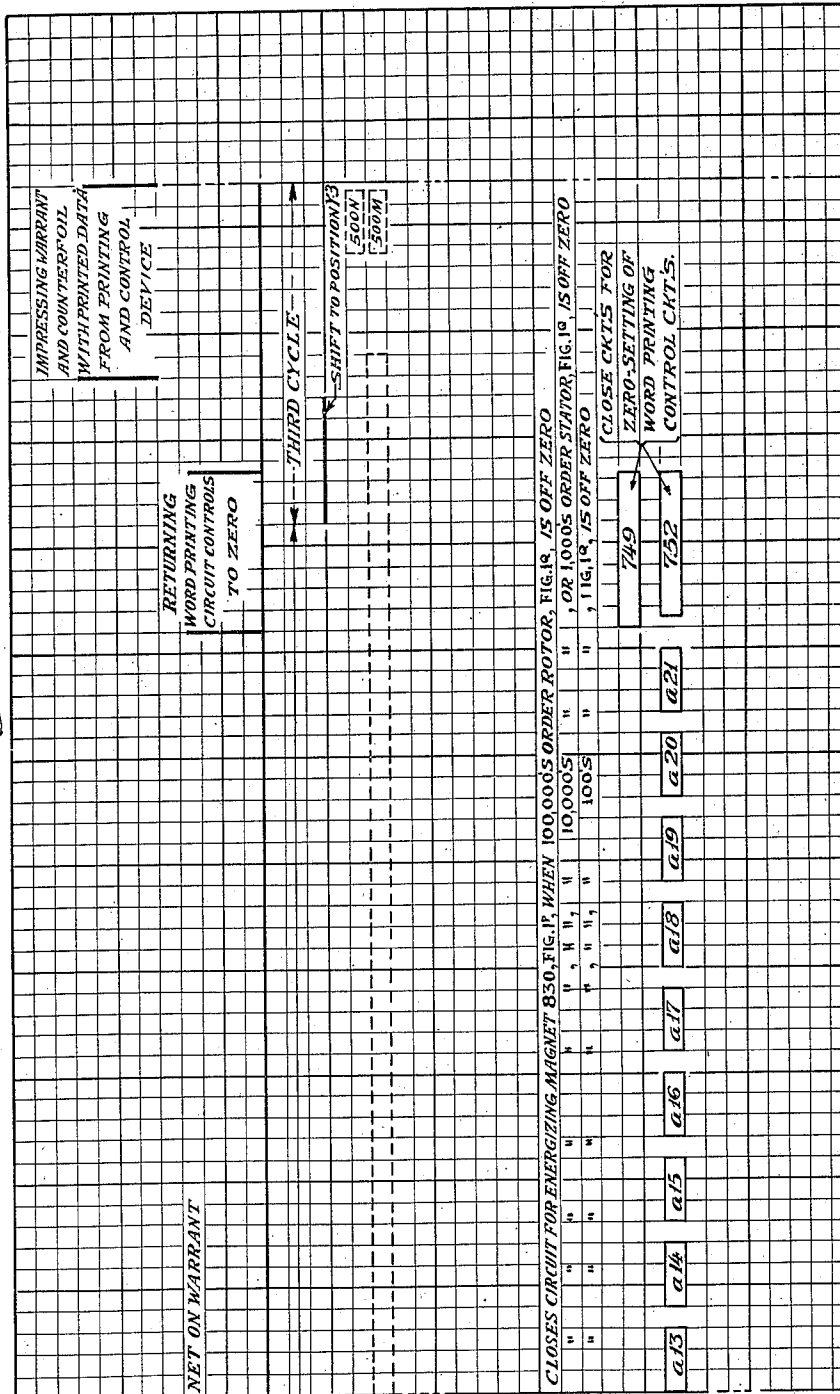
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Fig. 43.



Inventor:
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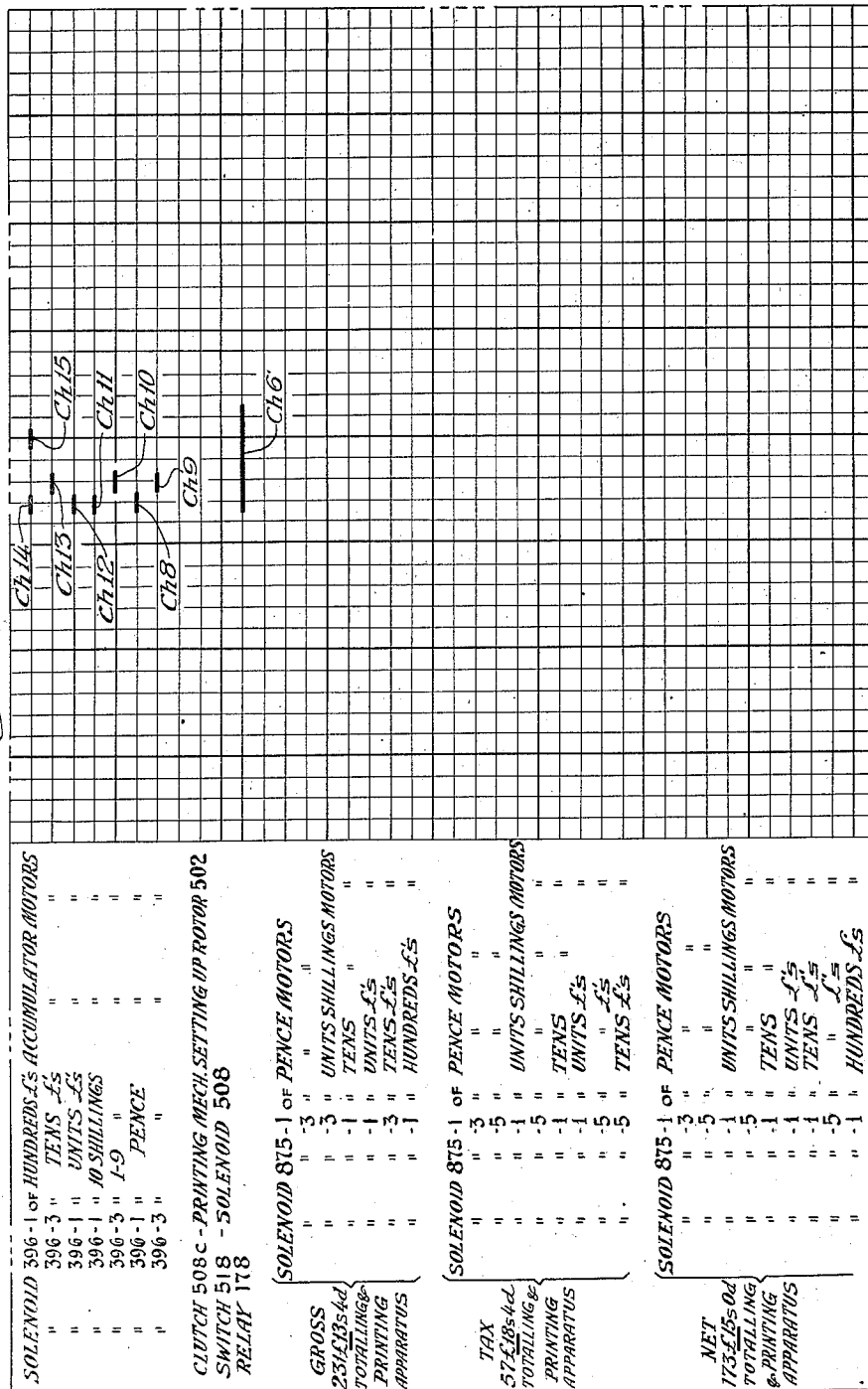
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Fig. 44.



Inventor:
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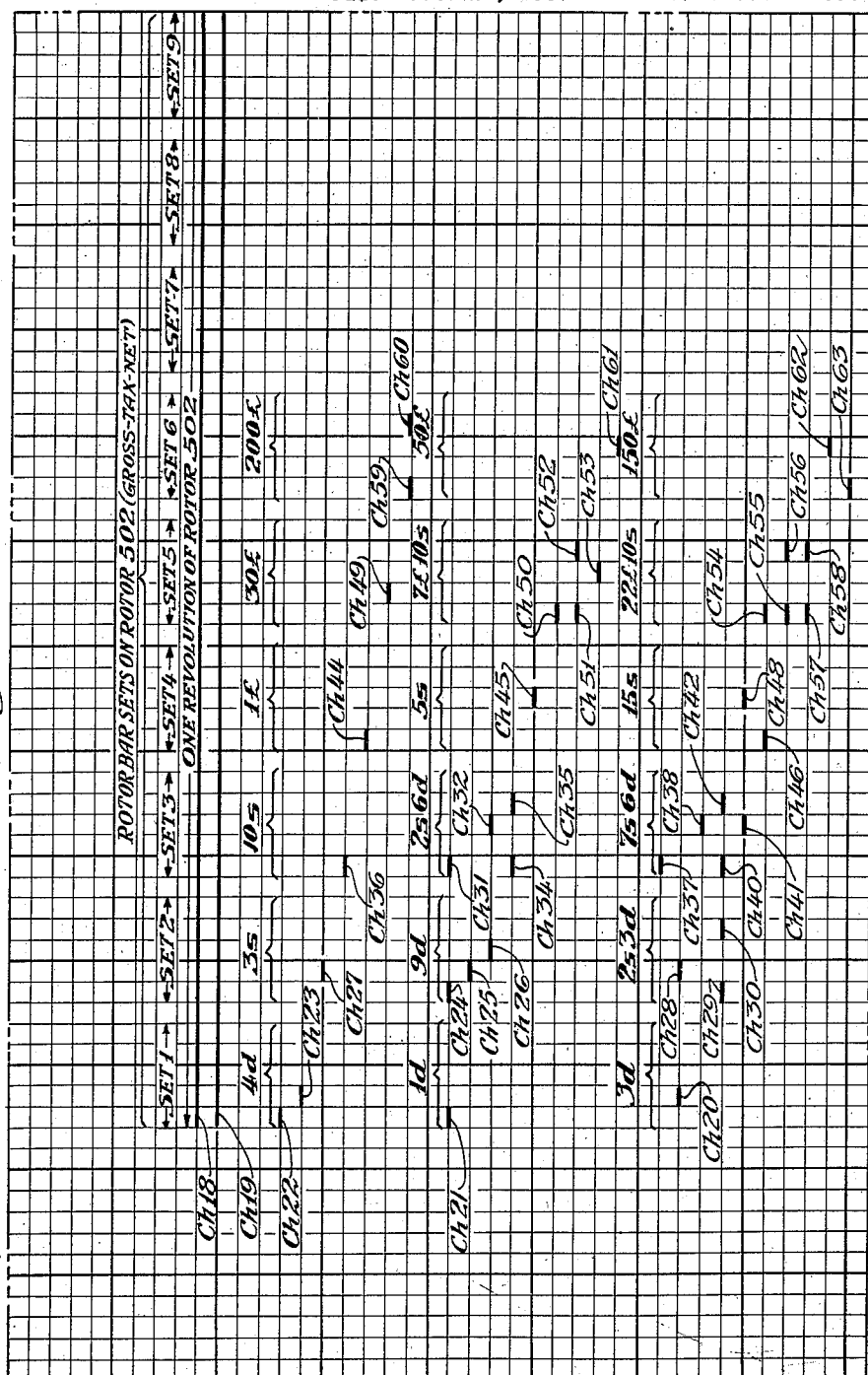


Fig. 45.

Inventor:
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Oct. 19, 1943.

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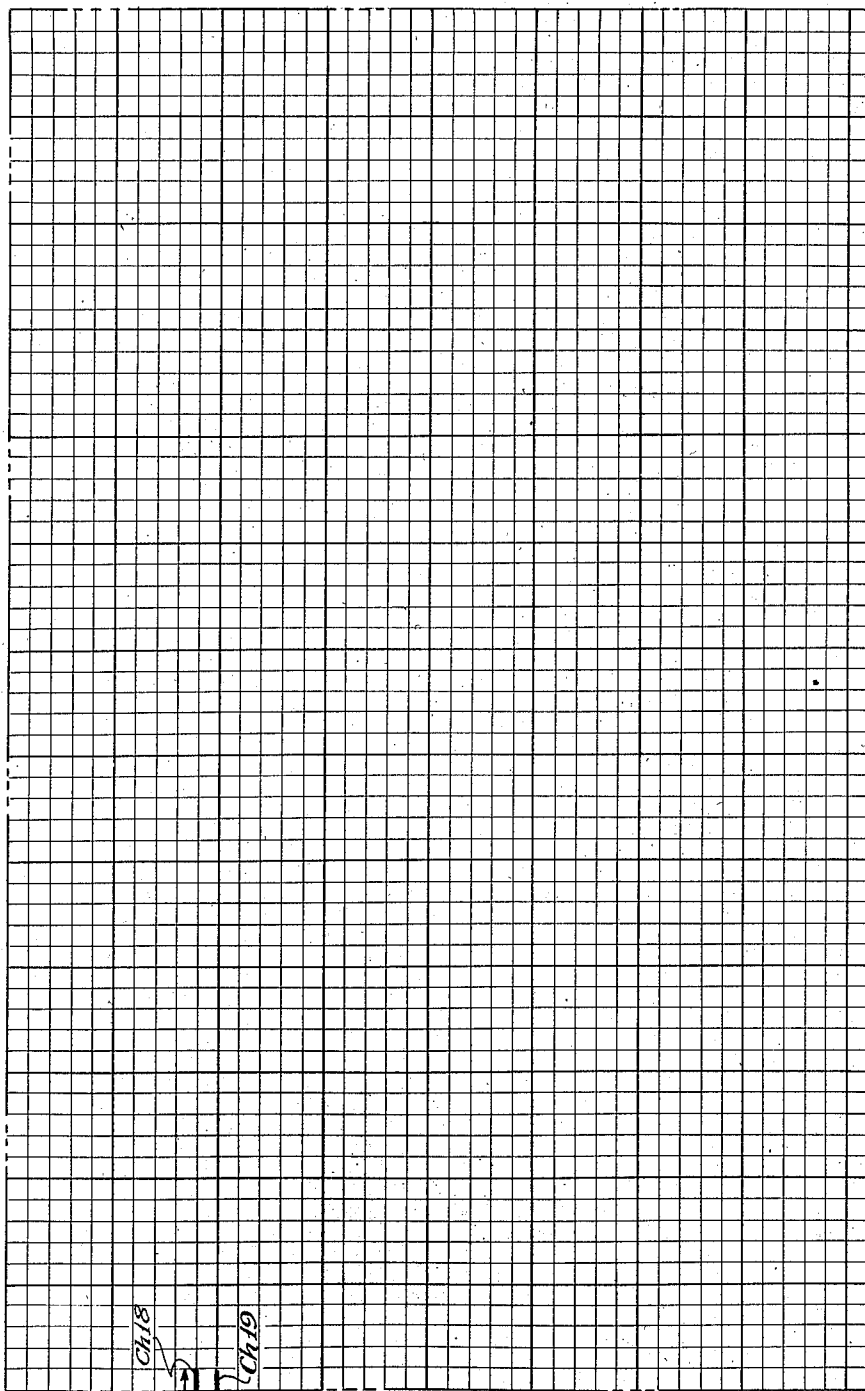
2,332,304

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Fig. 40.



Inventor:
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By Wallace and Cannon
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Oct. 19, 1943.

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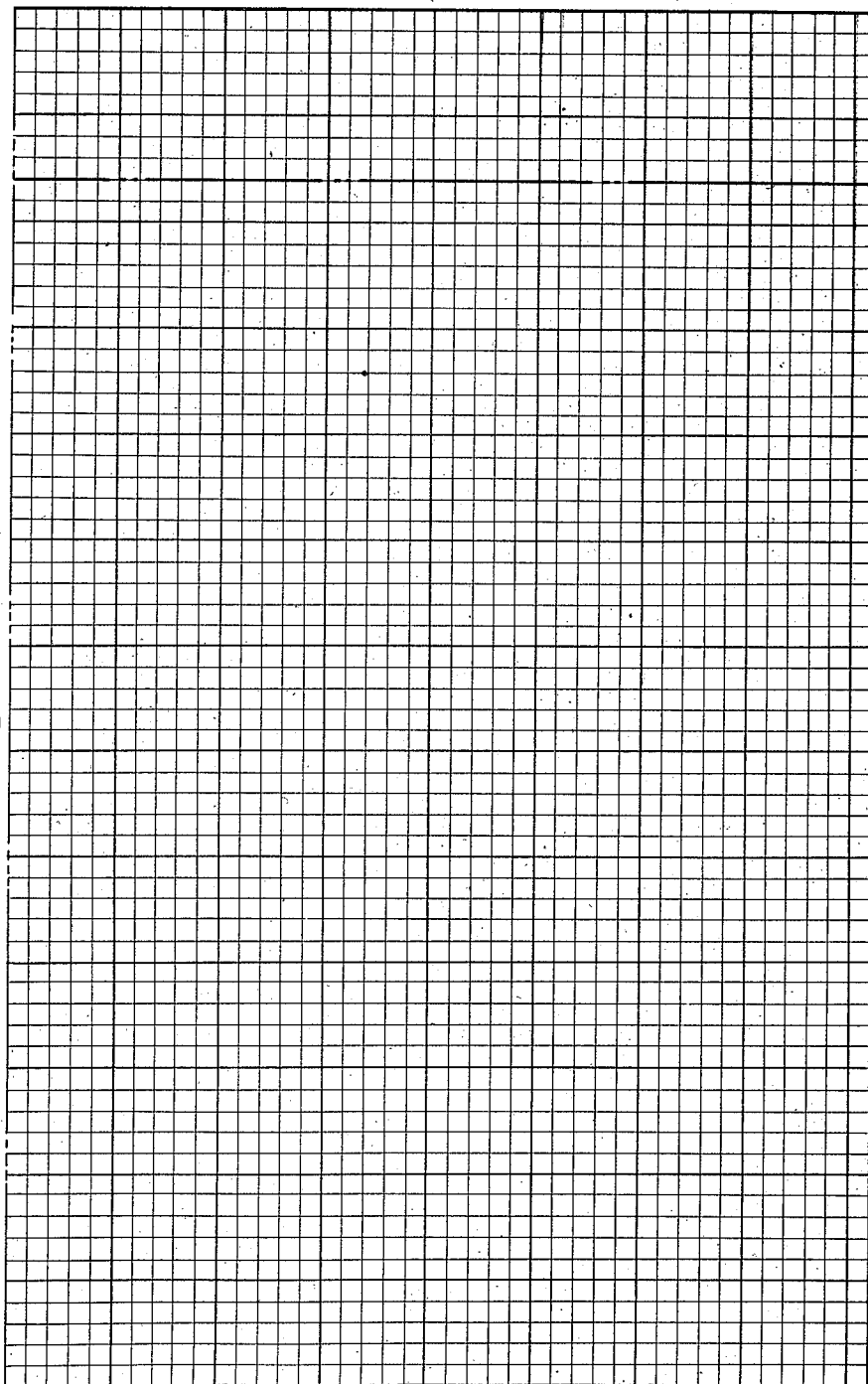
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Fig. 47.



Inventor:
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Oct. 19, 1943.

A. E. DAVIES

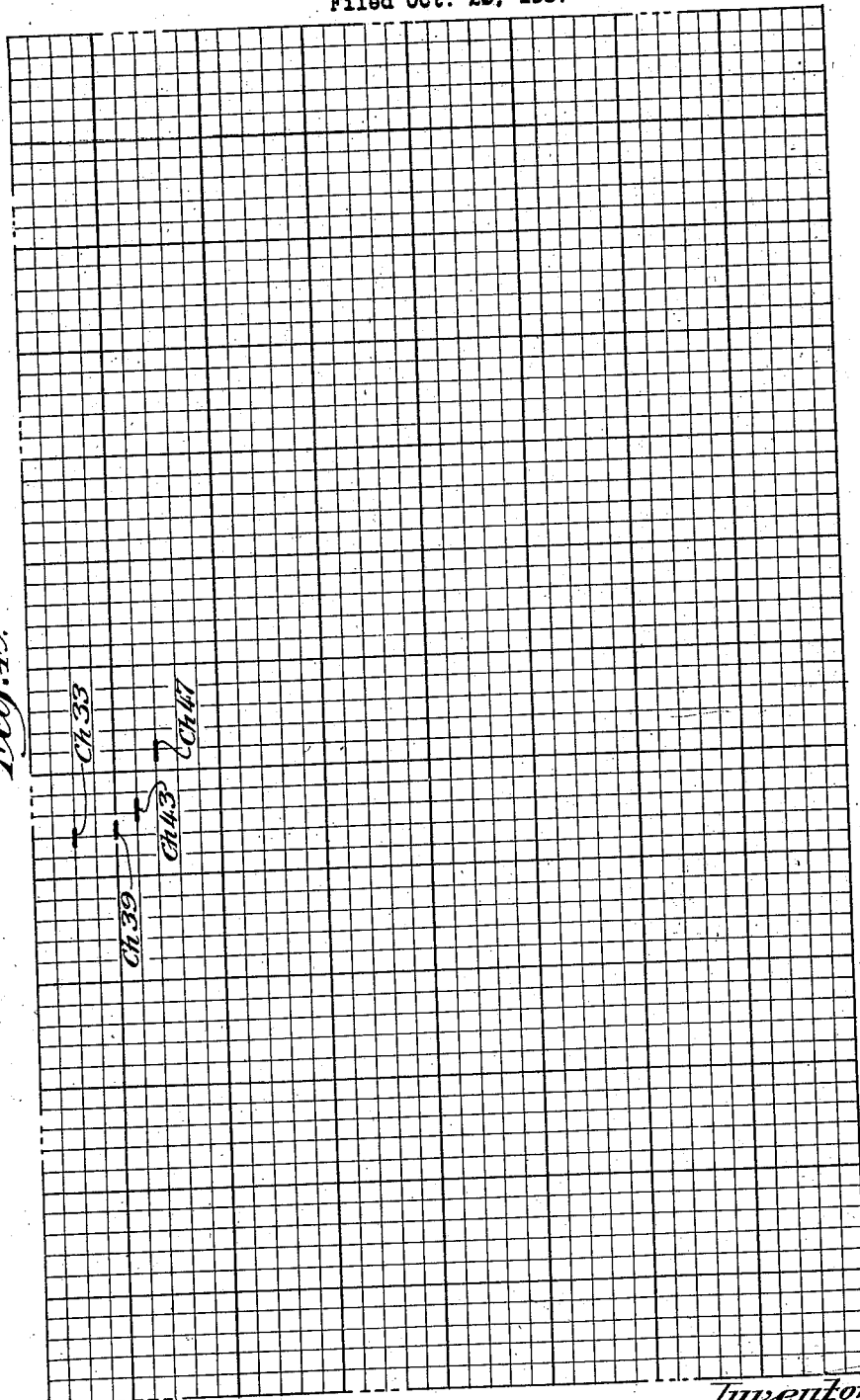
2,332,304

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Fig. 49.



Inventor:
Albert Edward Davies.
By Wallace and Cannon
Attorneys.

Oct. 19, 1943.

A. E. DAVIES

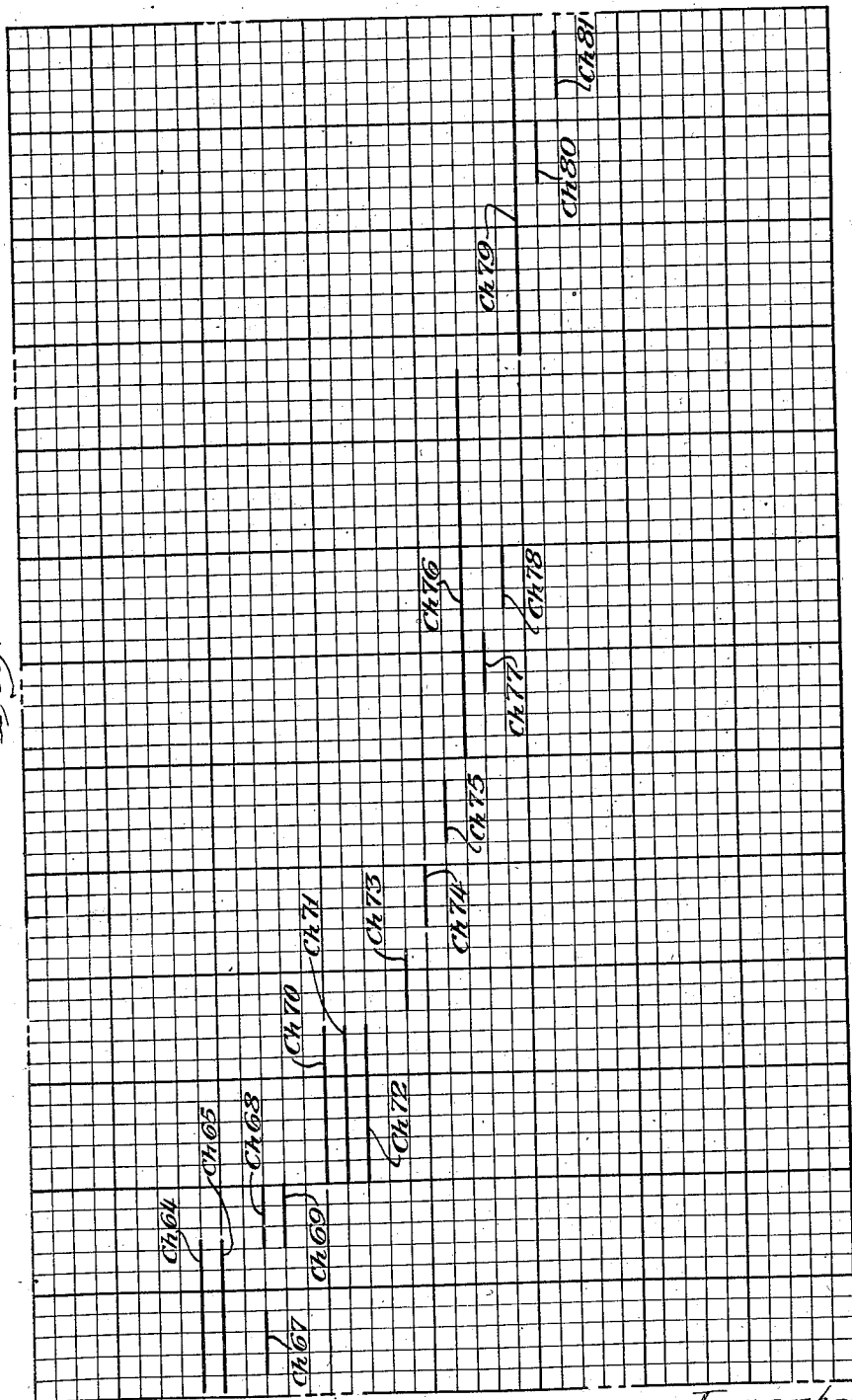
2,332,304

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Fig. 50.



Inventor:
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Oct. 19, 1943.

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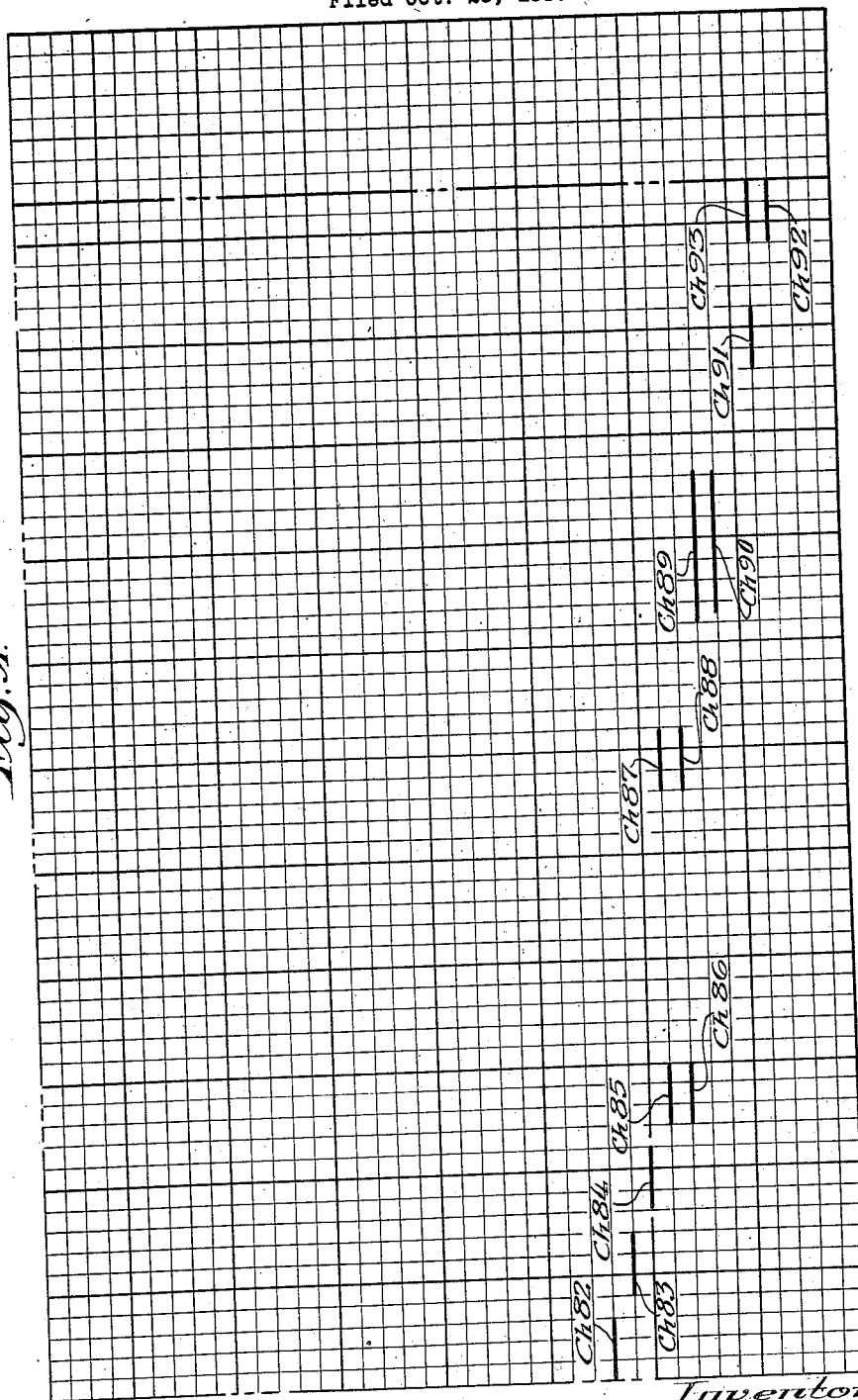
2,332,304

PRINTING AND CALCULATING MACHINE

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Fig. 51.



Inventor:
Albert Edward Davies
By Wallace and Cannon
Attorneys

UNITED STATES PATENT OFFICE

2,332,304

PRINTING AND CALCULATING MACHINE

Albert Edward Davies, Hornchurch, England, assignor to Addressograph-Multigraph Corporation, Wilmington, Del., a corporation of Delaware

Application October 23, 1937, Serial No. 170,698
In Great Britain October 27, 1936

20 Claims. (Cl. 235—61.6)

This invention relates to printing and calculating machines of the kind capable of producing both identifications and numerical accounting data on business instruments and the like and also to devices and appurtenances adapted for use in such machines.

Heretofore it has been proposed to print business instruments, such as warrants, checks, receipts, counterfoils and the like, by the use of machines wherein the identifications, such as names and addresses are printed on the checks or the like and to subsequently, in another machine, print the numerical accounting data on such business instruments, and both card-controlled and key-operated machines have been used for this latter purpose. However, when the identifications are printed on the business instruments in a machine separate and apart from the machine in which the numerical data are printed on the instruments, it is essential that extreme care and caution be exercised in order to insure that the numerical accounting data are printed on the instrument bearing the identification to which the data pertain, and inasmuch as this is done manually errors have been frequently encountered.

It has also been proposed to pass through a single machine both a device from or under control of which an identification could be printed and another and separate device from or under control of which the numerical accounting data could be printed, and a pair of such devices are employed in such machines to make impressions on the same sheet but this entails carefully checking the paired device one against the other to insure that they relate to the same subject matter and in event the two devices do not correspond it is necessary to interrupt the operation of the machine, which obviously materially reduces the production of the machine which remains idle while the reason for machine stoppage is ascertained and the error, if any, corrected.

It has also been known in the art to directly print both identifications and numerical accounting data directly from the devices bearing type characters from which such information could be directly produced, but inasmuch as the numerical accounting data frequently varies and any change in such devices upon variation of the numerical accounting data requires that one such device be discarded and another created in its place, this system has not been entirely satisfactory. Moreover in such instances it has not been possible to automatically accumulate totals or to otherwise calculate with respect to the nu-

merical accounting data, which is another reason why such an arrangement, as last discussed, has not been always satisfactory.

In the present invention it is proposed to print both an identification and numerical accounting data on a sheet from and under control of the same device which is passed through a machine wherein the identification is printed directly from the device and wherein the numerical accounting data is printed indirectly under control of control means provided on the device and so to do constitutes the primary object of this invention. Objects ancillary to the foregoing are to embody the means from which the identification is printed and the means under control of which the numerical accounting data is printed in a single device for each instrument or each group of related instruments to be printed, and also to provide a device wherein both the means from which the identification is directly printed and the means from and under control of which numerical accounting data are printed so that these means may be readily and inexpensively replaced upon variations or changes in either the identification or numerical accounting data.

One specific use to which the present invention may be put is the preparation of instruments, such as warrants and counterfoils employed to distribute dividends declared by corporations and the like, and when the machine is put to such usage it is desirable to incorporate the identifications, such as the name and address of each stockholder and the number of shares owned by the stockholder, on a single device and to print the name and address directly from the device and to so arrange the part of the device pertaining to the number of shares owned by the stockholder that, from or under control of this part of the device, the monetary value of the declared dividend in direct proportion to the number of shares owned by the stockholder may be printed on one of the instruments employed to distribute the dividend, and in many instances it is also desirable to accumulate a total of the amounts printed on various instruments and so to do constitutes a still further important object of this invention.

It will be appreciated, however, that where the number of shares owned by a stockholder are provided on a device this alone will not be sufficient to produce the monetary value of the part of the declared dividend for each respective stockholder, and in order to determine such monetary value it is necessary to, in effect, multiply the number of shares of stock owned by the

respective stockholder by the amount of the dividend rate. Hence another object of this invention is to determine and print a monetary value, such as a dividend, by multiplying a number constituting a multiplicand, such as the number of shares of stock owned by the stockholder of a corporation, by a multiplier, such as a dividend rate.

In machines such as have been constructed heretofore, where a multiplicand, such as the number of shares of stock owned by a stockholder of a corporation, is to be multiplied by a multiplier, such as the rate of the dividend declared by a corporation, various methods of multiplication have been used, among which have been over and over addition and what has come to be known in the art as partial product multiplication. However, such methods of multiplication entail the performance of certain operative functions and due to inherent features in the machine errors have been found to occur almost in direct proportion to the number of operative functions entailed in making the multiplications. Hence a still further important object of this invention is to, in effect, multiply a multiplicand, such as the number of shares of stock owned by a stockholder, by a multiplier, such as the rate of a dividend declared by a corporation, in such a manner that a minimum number of operative functions need be performed by the machine to determine the product, and an object ancillary to the foregoing is to incorporate in the machine all of the possible products that may be ascertained within the capacity of the machine and to then, under control of one of the factors of a multiplying operation, select the proper one of the products.

While it has been proposed heretofore to incorporate pre-computed products in a machine and to select the proper product under control of what amounts to the multiplicand of a multiplying operation, such arrangements have usually been limited to a single multiplier or to the selection of the sum of a plurality of multiplications, and it will therefore be appreciated that when any change in the multiplier was made it was necessary to revise the machine. Therefore still another important object of this invention is to enable the use of any multiplier within the capacity of the machine in an arrangement wherein pre-computed products are selected under what amounts to the multiplicand of a multiplying operation, and ancillary objects are to enable selection of any multiplier within the capacity of the machine and to enable such selection to be effected manually when so desired.

Not all monetary systems follow the decimal system as does the dollars and cents system employed in the United States and certain other countries, as, for example, in the United Kingdom and many Dominions of the British Empire, the pounds, shillings, pence monetary system is used which, unlike the decimal system, is not uniform. For example, in the system employed in the United Kingdom, there are twelve pence in a shilling and twenty shillings in a pound, but pounds follow the decimal system. Thus it will be seen that in such a monetary system there are what may be called three variations, which is to say, the number of pence in a shilling, the number of shillings in a pound, and lastly the decimal system for pounds. Hence, still another object of this invention is to provide an arrangement wherein multiplication may be performed under a system such as the pounds,

shillings and pence monetary system, and an object ancillary to the foregoing is to utilize pre-computed products in such circumstances.

It has been stated heretofore that it is often desirable to not only print upon the business instruments, such as warrants or checks, the amount of money to be paid pursuant to each of such instruments, but also to accumulate the total of the amounts printed on a plurality of such instruments since this enables the operations of the machine to be checked. The total amount of money intended to be paid out on a plurality of such instruments may be ascertained in a variety of ways, independent of the machine in which checks or the like are printed, such as under the accounting system controlling payment of the dividend. By checking such an ascertained amount against a sum accumulated in the machine it may be determined whether or not the machine is accurately performing its intended functions, and a further object of this invention is to accumulate such totals in a machine wherein amounts are printed on a plurality of instruments.

In the operation of machines wherein data, such as numerical accounting data, are derived from control means, such as punched cards or the like, frequently a plurality of mechanisms are provided through which the derived data or amounts determined therefrom successively pass and frequently the derived data will be entirely passed out of one mechanism and into another mechanism subsequent to which the first mechanism stands idle during the operation of the second mechanism. This may occur through a large plurality of mechanisms, wherefore the operating speed of the machine is materially impaired. Hence a still further object of this invention is to insure high productive capacity of the machine by causing more than one of the various mechanisms in the machine to function simultaneously, and an object ancillary to the foregoing is to enable derived data or amounts determined therefrom to be stored within the machine so that they can be used when and as required in the sequence of operations performed in the machine. An object supplementary to this is to immediately clear the mechanism from which stored data has been transferred so as to enable this mechanism to begin a new operation with respect to additional data. A still further object related to the foregoing is the provision of mechanism for the storage of derived data or amounts based thereon and operable in such a way that such data or amounts may be subsequently transferred to more than one mechanism, if so desired. An object related to this is to so construct and arrange the various mechanisms and instrumentalities to which this invention pertains that derived data or amounts based thereon may be directly passed into certain of the mechanisms or instrumentalities or may be indirectly passed thereto from devices wherein said data or amounts are first stored.

Still further objects are to ascertain numerical values related to or based upon another numerical value or values, as for example, to ascertain the amount of tax to be paid upon a dividend and the net amount payable when the tax is deducted from the gross amount or dividend, to so set up electrical paths that function, when circuit is closed through certain of them corresponding to a numerical amount, to select a circuit or circuits which relate to a numerical value or values constituting a function of such numerical amount pursuant to which circuit was closed; to afford

a plurality of potential paths for electric circuits and to select predetermined of such paths to thereby potentially establish circuits representative of numerical values and to selectively close circuit through the potentially established circuits and thereby select numerical values; and to provide a plurality of conductor groups of which the conductors are of notational significance, and a plurality of common conductors of notational significance selectively connectable with the conductors in each of said plurality of groups according to a schedule wherefore electrification of any of said common conductors will simultaneously cause electrification of conductors in said groups so the electrified conductors in each group will represent an independent predetermined amount based upon the notational significance of the electrified common conductor.

Still further objects are the provision of numerical entry receiving means wherein receiving devices respectively for each order comprise motors energizable singly or in predetermined combinations to effect digital entries for their respective orders; entry receiving means of the aforesaid character wherein a carry may be effected into any order simultaneously with a normal numerical entry into such order; and the provision of a device for energizing the motors of said entry receiving means in combinations conjugate of amounts to be entered therein.

Further important objects of this invention are the provision of a novel selectively settable apparatus instrumental in the selection of products based upon a factor predetermined by the setting of such apparatus and upon a variable factor represented by card perforations or the like and operable under control of electrical circuits of numerical significance energized order by order through such perforations; and the provision of an accumulator or amount manifesting device controlled by the energized of such circuits to express such products.

Other and further objects will be apparent from the following description and the appended claims.

The machine of the present invention as described in the following detail description is arranged for use under the pounds, shillings, pence monetary system and is employed to print business instruments such as dividend warrants or checks and receipts or counterfoils. The instruments may have the constantly reoccurring matter printed thereon prior to introduction thereof into the machine or they may be cut from a continuous web and have the constantly reoccurring matter printed thereon along with the identification or address matter in a machine such as that disclosed in Patent No. 2,041,183 patented May 19, 1936, and the numerical accounting data printing devices of this invention would, in such an instance, also operate on the sheets as they passed through the machine. In the present machine, however, pre-printed business instruments are employed.

The variable information which is printed on the instruments in the present invention is derived from what are called printing and control devices which may be of the kind shown in the patent to Walter T. Gollwitzer, No. 2,132,412, patented October 11, 1938, but, instead of the control means being afforded by alined openings provided in the control card and carrier of the device as is disclosed in the aforesaid Gollwitzer application, the control means in the present instance are merely perforations in the control card

so that when, as explained hereinafter, sensing fingers pass through these perforations they contact the metallic frame of the printing and control device to complete electrical circuits in which such frame is included.

In the present machine the printing and control devices are sequentially fed first into association with a sensing head wherein the sensing fingers cooperate with the control means on the printing and control devices to ascertain in each cycle of operation, the number of shares of stock of a corporation owned by the stockholder in the corporation whose name and address is embossed in the metallic printing plate provided on the carrier of each of the printing and control devices. The number of shares of stock owned by the stockholder is represented by perforations provided in the control card and the numerical value thus ascertained constitutes the multiplicand of a computing operation that is effected in the machine.

The sensing fingers are electrically connected to a multiplier apparatus provided in the machine and in the present instance this multiplier apparatus is of the pre-computed product selecting type, which is to say, when the sensing fingers pass through certain perforations in the control card of the printing and control device and are electrified according to the number of shares of stock owned by a particular stockholder, circuit is closed to the multiplier apparatus and the product is thereupon selected.

In so far as the numerical accounting data are concerned, the machine is under control of a synchronizer drum which regulates and sequences the operations of the machine. Thus, when sensing fingers are electrified as above described and the synchronizer drum is in operation, the multiplying operations or product selections are sequentially effected progressively up through the orders of the multiplicand under control of the synchronizer drum and, when the synchronizer drum has passed beyond the highest order in which a sensing finger is electrified, the product of the number of shares owned by a stockholder times the dividend rate will have been ascertained and entered in a product accumulating device which will be set up pursuant to the magnitude of the product.

The present machine is also so arranged that not only is the gross amount of the dividend ascertained, which is to say, the product of the number of shares of stock times the dividend rate, but it is also arranged to compute the tax on the dividend in accordance with a manually set-up rate and to also determine the net amount of the dividend, which is to say, the amount payable to the stockholder after the amount of the tax has been deducted.

Hence, after the product or gross dividend has been ascertained by setting up the product accumulator, the synchronizer drum next sequentially closes circuits to the manually set-up means for ascertaining the tax and also to the means which determine the net amount of the dividend and when these circuits are electrified the gross amount of the dividend, the amount of the tax, and the net amount of the dividend are read out into printing mechanisms which are set up pursuant to these amounts ready for impression on the instruments being printed in the machine.

After the gross dividend, the amount of tax and the net dividend have been read out, the product accumulator and associated devices are cleared and by this time a new printing and con-

trol device will have moved into association with the sensing fingers which thereupon ascertain another multiplicand and, as the next product selection is being effected under control of the new or next device, the previously ascertained gross dividend, amount of tax and net dividend are printed.

The printing means into which the gross dividend, amount of tax and net dividend are transferred in the read-out just described are arranged to print the numerical data in figures or numerals and after they have been set up and an impression has been made therefrom they are reset to zero to be ready to receive the gross dividend, amount of tax and net dividend pertaining to the printing and control device succeeding the one under control of which these amounts were ascertained and as the means from which the net amount of the dividend is printed return to zero another printing means is set up therefrom to print the net amount of the dividend in words and after, in the course of operation of the machine, the net amount of the dividend in words has been printed on the instrument, this printing means is returned to zero.

After the numerical data have been so printed on the instrument it passes to means wherein an impression is directly made from the printing and control device and in this operation the name and address or the like of the stockholder is printed and the operation of the machine is so timed that the name and address is printed from the same device as that under control of which the numerical data were printed on the instrument.

The present machine is adapted to print two instruments of which one is a dividend warrant or check and the other of which is a tax receipt or counterfoil and these are joined during passage thereof through the machine. The operations are such that the numeral printing means for the amounts of gross, tax and net print on the counterfoil while only the net amount numeral printing means and the word printing means make impressions on the warrant.

The operation that has been described thus far may for the sake of convenience be referred to as a tax operation for, as has been explained, in addition to ascertaining a gross dividend, the amount of tax payable on the gross dividend and the net dividend payable after deduction of the amount of tax are ascertained.

There are however circumstances where the machine will so operate that no tax is ascertained and in such an instance a switching arrangement in the machine is operated and in a no tax operation this switching arrangement renders inoperative the devices from which the amount of tax would normally be printed and also establishes circuits such that the gross amount of the dividend is not only entered on the wheels which normally print this amount but it is also entered on the type wheels which would normally print the net amount of the dividend in numerals. Therefore, since the means which prints the amount in words is set up under control of the means which print the net, it follows that in a no tax operation the word printing mechanism is set up to print the gross amount of the dividend in words.

There is still another special condition for which the machine makes provision and this pertains to what is known as a bankers warrant. The custom has been established that, where a number of stockholders in a corporation have made the same bank their collecting agent, a

plurality of warrants or checks, one for each of such stockholders, is not sent to the bank, but only one check or warrant is sent which calls for the total amount of dividend that is to be paid to all of the customers of the bank.

In such operation of the machine all of the printing and control devices pertaining to customers who have made a particular bank their collecting agent are arranged in a group and these devices are passed through the machine in the usual way but in this instance the machine so operates that the warrant or check portion of the sheets passed through the machine are not so printed as to be instruments pursuant to which sums of money would be paid. The counterfoils or receipts are printed in the usual way and when the last printing device of such a group of printing devices passes into the machine a signal is operated and, when this signal operates, the operator causes the machine to so operate that the total amount of money that is to be paid, which will have been ascertained during the course of operation of the machine under control of the particular group of printing devices, will be printed on what is called a bankers warrant or check and the name and the like of the bank is printed on this particular warrant so as to make it payable to the bank.

The manner in which the machine is operated to effect the foregoing operations and the instrumentalities which enter into this operation are explained in the following detailed description.

The preferred form of my invention is illustrated in the accompanying drawings wherein

Figs. 1 to 1r, inclusive, are diagrammatic views which, when joined, show the complete electrical hook-up of a machine constructed in accordance with the present invention, the respective views being as follows:

Fig. 1 is a fragmentary developed view of the synchronizer drum and parts associated therewith used to time the operations of the machine, the group of sensing fingers for reading data from a perforated card also being shown in this view;

Fig. 1a is a view showing the circuits of the multiplier selecting apparatus;

Figs. 1b and 1c are views showing the product selecting circuits;

Fig. 1d is another fragmentary developed view of the synchronizer drum, the other fragment of which is shown in Fig. 1;

Fig. 1e is a view of the product accumulating mechanism;

Figs. 1f to 1j are views showing a manually settable proportionating grid;

Figs. 1k to 1n are views of a transferring mechanism employed in the machine;

Fig. 1o is a view of registers employed in the machine;

Figs. 1p to 1r are views of the printing mechanism which prints in words amounts computed in the machine, and electrical circuits used therewith;

Figs. 2 and 3 are schematic views showing the principal operating parts of the machine in different stages of operation;

Fig. 3a is a view showing a typical business instrument printed in the machine;

Fig. 4 is a side view of the means which feed the printing devices through the machine and wherein detector means that cooperate with the printing devices are also shown;

Fig. 5 is a fragmentary view taken substantially on the line 5-5 on Fig. 4;

Fig. 6 is a fragmentary view taken substantially on the line 6—6 on Fig. 5;

Fig. 6a is a plan view of one of the record cards that are carried by the printing devices;

Fig. 7 is a plan view of the multiplier selecting apparatus, the top of the casing therefor having been cut away;

Fig. 8 is a fragmentary front elevational view of the multiplier selecting apparatus;

Fig. 9 is a fragmentary vertical sectional view taken through a section of the mechanism shown in Fig. 7 and taken substantially on the line 9—9 on Fig. 12;

Fig. 10 is a fragmentary sectional view taken substantially on the line 10—10 on Fig. 7;

Fig. 11 is a view taken substantially on the line 11—11 on Fig. 10;

Fig. 12 is a fragmentary plan view of parts of the mechanism shown in Fig. 7 and wherein certain parts are broken away;

Fig. 13 is a plan view of the product accumulating mechanism shown schematically in Fig. 1e;

Fig. 14 is a sectional view taken substantially on the line 14—14 on Fig. 13;

Fig. 14a is a fragmentary view taken on the line 14a—14a on Fig. 14;

Fig. 15 is a vertical sectional view taken substantially on the line 15—15 of Fig. 14 and showing a longitudinal section through the product accumulating mechanism;

Fig. 16 is a transverse sectional view taken substantially on the line 16—16 on Fig. 15;

Fig. 17 is a diametrical sectional view taken substantially on the line 17—17 on Fig. 14;

Fig. 18 is a schematic view illustrating certain circuit interrupters used in the machine;

Fig. 19 is a fragmentary sectional plan view taken substantially on the line 19—19 on Fig. 20 and showing a corner of the proportionating apparatus;

Fig. 20 is a view taken substantially on the line 20—20 on Fig. 19;

Fig. 21 is a view of a plug and jack device used for insertion in the bus bar apparatus shown in Figs. 19 and 20;

Fig. 22 is a transverse sectional view through a multiple contact rotor used in the machine;

Fig. 23 is a fragmentary side elevation of the rotor shown in Fig. 22;

Fig. 24 is an end section of a stator used with the rotor shown in Figs. 22 and 23, the rotor and stator shown in Figs. 22 to 24 being that shown in Figs. 1k to 1n of the wiring diagram;

Fig. 25 is a side view of the printing and adding apparatus shown schematically in Fig. 1o of the wiring diagram;

Fig. 25a is a fragmentary detail of a shaft shifting device employed in the machine;

Fig. 26 is a view taken substantially on the line 26—26 on Fig. 25;

Fig. 27 is a view taken substantially on the line 27—27 on Fig. 25;

Fig. 28 is a sectional view taken substantially on the line 28—28 on Fig. 27;

Fig. 29 is a transverse sectional view taken substantially on the line 29—29 on Fig. 27;

Fig. 30 is a sectional view taken substantially on the line 30—30 on Fig. 27;

Fig. 31 is a fragmentary perspective view of two numeral printing wheels and illustrating guards therefor;

Figs. 32 and 33 are views taken respectively substantially on the lines 32—32 and 33—33 on Fig. 31;

Fig. 34 is a side view of the word printing mechanism;

Fig. 35 is a sectional view taken substantially on the line 35—35 on Fig. 34;

Fig. 36 is a sectional view taken substantially on the line 36—36 on Fig. 34;

Fig. 37 is a fragmentary sectional view taken substantially on the line 37—37 on Fig. 34;

Fig. 38 is a sectional view taken substantially on the line 38—38 on Fig. 36;

Fig. 39 is a fragmentary sectional view taken substantially on the line 39—39 on Fig. 36; and

Figs. 40 to 51 constitute a timing chart of a typical operation of the machine; Figs. 40 to 43, when placed end to end from left to right in the order named, forming the upper section of said chart; Figs. 44 to 47, when placed end to end from left to right in the order named and respectively below Figs. 40—43, forming the central section of said chart; and Figs. 48—51, when placed end to end in the order named and respectively below Figs. 44 to 47, forming the lower portion of said chart.

The present machine prints both identifications, such as names and addresses, and numerical data on sheets passed therethrough. All of the material so printed on each sheet is derived from the same printing and control device. In the following description the manner in which the numerical data are derived and computations based thereon are made and the resulting data are printed is first described and then the manner in which the identifications are printed is briefly described.

The printing and control devices may be similar to those shown and described in the patent to Walter T. Gollwitzer, No. 2,132,412, patented October 11, 1938, and will be described in some detail presently. These devices are stacked in a magazine in the machine from which they are withdrawn one at a time to be fed through the machine in step-by-step manner and are collected in a galley after passing from the position they occupy while the identifications are printed therefrom. Suitable means for effecting such operation are shown in U. S. Patent 1,982,374, patented November 27, 1934.

A printing and control device 73 suitable for use in the present machine is best illustrated in Figs. 4 to 6. Each device 73 includes a metallic frame 74 carrying an embossed printing plate 75 and a control card 77 of insulating material. The card 77 has a number of areas 78, Fig. 6a, in which perforations may be provided to represent numerical values. These areas on the card are spaced similarly to the sensing fingers provided in the machine and adapted for cooperation with the printing and control devices. The printing and control devices are, in the course of operation of the machine positioned below the sensing fingers 50, Fig. 6, so that if a card should be perforated at one or more areas the sensing finger or fingers registering therewith will make electrical contact through the perforation or perforations with the metallic frame 74 of the printing and control device which frames are electrically grounded when the devices are associated with the sensing fingers.

The sensing fingers 50 to which reference has been made are shown particularly in Figs. 1, 2, 3, 4, 5, and 6. These fingers are encased within a box 51, Figs. 4 and 6, mounted at the free ends of levers 52 and 52'. The levers 52 and 52' are pivotally supported upon a pin 53 and are periodically rocked about such pin by a cam 54 mounted on a shaft 55. The cam 54 acts on a roller 56 at the end of an extension of the lever

52 and this arm 52 thus receives movement to lower the sensing fingers 50 into sensing position, this lowering movement being effected against the action of a spring 57 that constantly urges the lever 52 in a clockwise direction, as viewed in Fig. 4, this spring retracting the sensing fingers, under control of cam 54 at the end of the sensing operation. The cam 54 is driven from the motor 272, Fig. 14, in timed relation with other operative parts of the machine.

Plates 58 of insulating material form the upper and lower sides of the box 51 and each has rows of apertures 59 which are arranged in axially aligned pairs for receiving the sensing fingers 50, as shown in Fig. 6. The fingers 50 are arranged in six rows (see Fig. 1) which rows are respectively for the units, tens, hundreds, thousands, ten thousands and hundred thousands orders of the multiplicand of a multiplying operation to be described. There are nine fingers in each row for the significant digits 1 to 9. Hereinafter the first of the fingers in the units row or order will be referred to as the number "1" finger of the units order, the second finger in the row as the number "2" finger of the units order and so on. Likewise in the other orders, such as the hundred thousands order, the finger opposite the numeral 1 appearing beside the box 51 in Fig. 1 will be referred to as the number "1" finger in the hundred thousands order while the fingers opposite the numerals 8 and 9, for example, will be referred to, respectively, as the number "8" and number "9" fingers of the hundred thousands order.

In Figs. 5 and 6, the sensing fingers 50 are shown connected individually with conductors which lead to other parts of the apparatus through cables 61 to 66, which cables are respectively for conductors connected to the fingers in the units, tens, hundreds, and so on orders. Cable 61, for example, contains nine conductors which are individually connected with the nine sensing fingers in the units order, while cable 62 contains nine conductors which are similarly connected with the fingers in the tens order, and so on.

The box 51 also contains four additional sensing fingers, 51A, 51B, 51C and 51D, which are used for purposes other than sensing digital representations in the record card. It will be understood that a greater or less number of such special sensing fingers might be provided, and also that these fingers might be put to a variety of uses, this latter being dependent upon the nature of the work to which the calculating devices of the machines are put.

Conductors respectively lead from the four special or control sensing fingers into a cable 67 shown in Figs. 5 and 6. Thus conductor 505A, Figs. 6 and 1d, leads from the finger 51A, conductor 69 leads from finger 51B, conductor 509 leads from finger 51C, while conductor 502T leads from finger 51D. All of the fingers 50 and the special fingers are constantly urged downwardly by springs 79 which bear between the upper plate 58 of the box 51 and a collar 80 upon each of said fingers.

Energization of the sensing fingers 50 is under control of a synchronizer drum 86 that is shown in Figs. 1 and 1d and which is driven from the shaft 87, Fig. 2, through the gears 88 and 89, said shaft 87 being constantly driven by the motor 272 when the machine is in operation. The synchronizer drum 86 is adapted to cooperate with pairs of contacts or brushes 90, Fig. 1, in

such a way that circuit through these brushes is closed by contact strips provided on the periphery of the drum, as is explained more fully hereinafter. Certain of the brushes 90 when bridged by their associated contact strips on the drum 86, at intervals during rotation of the drum, close circuit to the sensing fingers 50. Thus, under control of the synchronizer drum, the sensing fingers 50 are energized only during a predetermined time in a cycle of operation of the machine, and since other operations of the machine are also under control of certain of the brushes 90 and contact strips on the drum, it will be seen that the time at which the sensing fingers are electrified is properly tied in with other operations in a cycle of operation of the machine. The exact timing of the electrification of these fingers, and the timing of the entire machine is hereinafter described with reference to the timing chart shown in Figs. 40 to 51.

In the present instance the perforations provided in the control card 77 are representative of the number of shares of stock owned by the stockholders of a corporation, and as the machine is set up in the present instance, when this number is ascertained by cooperation of the sensing fingers with the perforations in the control card on the printing and control device associated with the fingers, it is representative of a multiplicand. In the operation of the machine the number of shares of stock owned by a stockholder (or the multiplicand) is to be multiplied by the dividend rate (or multiplier). This dividend rate or multiplier is adapted to be set up in an apparatus which is in circuit with certain of the brushes 90, and which apparatus will now be described.

Multiplier selecting apparatus

The mechanical construction of the multiplier selecting apparatus will now be described. It is to be understood, in this connection, that in the description of the electrical circuits which are embodied in this apparatus, and which circuits will be described hereinafter, it will be shown that conductors lead from the multiplicand, which is to say, the sensing fingers 50, to the multiplier selecting apparatus, and from this apparatus to the product accumulating apparatus.

It will be sufficient for the present, however, to explain that the orders of the multiplicand are successively potentialized, first the units order, then the tens order, and so, on, under control of synchronizing means comprising the synchronizer drum 86 and the associated contacts or brushes 90.

In addition to the foregoing it may be stated generally that the multiplier selecting apparatus includes units which are arranged in rows and each of such rows pertains to a significant digit so that when a significant digit in an order of the multiplicand is potentialized during the successive potentialization of the orders of the multiplicand, the set-up of the units in the row on the multiplier selecting apparatus that pertains to the same digit will be potentialized. The arrangement of such units in rows and the manner in which they are set up, as well as the purpose for which they are set up, will now be explained.

The manually settable portion of the multiplier apparatus is shown in Figs. 7 to 12, inclusive, and is mounted within a casing 91. Six shafts 92 to 97 are slidably and rotatably journaled in suitable bearings provided in the end walls of this casing. Knobs 98 to 103 are respectively fast to

the left ends, as viewed in Fig. 7, of the shafts 92 to 97, and these knobs include dials 104 to 109, as shown in elevation in Fig. 8 and in section in Fig. 10. The knobs and shafts are so arranged that they are limited to a single rotation and to this end stop pins as 111 are provided on the casing 91 in association with each dial, and each dial has a lug as 110 thereon that engages the stop pin at each end of the potential rotative movement of the shafts.

As is shown in Fig. 8, the knobs are graduated and numerical values are ascribed to the graduations whereby numbered dials or scales are provided. The scale or numerals on the dial 104 reads from "0" to "11" while the scale on dial 105 reads from "0" to "19," and the scales on the remaining dials read from "0" to "9." The reason for this is that since the present machine utilizes the pounds, shillings, pence monetary system in the multiplier, the multiplier must be arranged to accommodate the units of this system. Thus the dial 104 and its associated shaft 92 are for setting up pence in the multiplier or dividend rate and since there are twelve pence in a shilling, the scale on this dial provides for setting this shaft so as to represent any number of pence less than twelve. The dial 105 and its associated shaft 93 are for setting up shillings in the multiplier and since there are twenty shillings in a pound, the scale on this dial provides for setting up any number of shillings less than twenty. The remaining dials 106 to 109 and their associated shafts 94 to 97 are for setting up pounds in the units, tens, hundreds and thousands orders, respectively, from right to left in Fig. 8, and since there can be but nine pounds set up in any one order, the scales on these dials read from "0" to "9." This arrangement will accommodate a maximum multiplier of nine thousand nine hundred ninety-nine pounds, nineteen shillings and eleven pence.

When it is desired to set up a multiplier in the multiplier apparatus, a knob as 98, Figs. 7 and 10, is grasped which pertains to the order of the multiplier to be set up, the knob 98 being grasped for pence, the knob 99 for shillings, the knob 100 for units pounds, and so forth. Such a knob is pressed inwardly whereupon it may be rotated, and it is rotated until the graduation for the digit in the scale thereon corresponding to the digit in the unit or order of the multiplier to be set up registers with the associated index mark provided on the casing 91 and thereupon the knob is axially returned to its initial position which results in this order of the multiplier apparatus being set to the proper value in the order of the multiplier to which it pertains.

The shafts as 92 are adapted to be held in any position in which they are set and to this end a boss 130', Figs. 10 and 11, is provided about the bearing in the front wall of the casing in which the shaft is journaled. A plurality of pockets as 132 are provided in uniformly spaced relation in the inwardly disposed face of the boss 130'. The number of such pockets in any particular boss corresponds to the number of graduations on the dial mounted on the associated shaft, and these pockets are spaced correspondingly to the graduations. A pin as 131 is fast in each shaft in such a position that it will be disposed in the pocket as 132 for the "0" position of the shaft when the "0" graduation on the associated dial registers with the index mark on the casing 91. Thus when this pin is moved out of this pocket, upon axial movement of the shaft on which it is

mounted, and the dial is rotated to bring a particular numeral thereon into alignment with the index mark associated with the dial, which index mark is disposed at the "0" position, the pin as 131 will be aligned with the pocket as 132 positioned correspondingly with the numeral associated with the index mark.

In order to retain the shafts as 92 in their normal positions, as shown in Fig. 10, a spring as 130 extends between the front wall of the casing 91 and the inner end of a pocket provided in the knob, and this spring holds the pin as 131 in the pocket as 132 with which said pin is aligned until manual pressure is applied on the knob and the shaft is forced to the right, as viewed in Fig. 10.

According to the present invention, where pre-computed products are selected under control of the multiplicand pursuant to the setting of the multiplier, each part of the multiplier selecting apparatus pertaining to an order of the multiplier is equipped with as many settable devices as there can be significant digits represented in any order of the multiplicand, which is to say, each shaft as 92 includes nine settable devices each of which devices in the present instance comprises a pair of bevel gears. Thus on the shaft 92 there are nine bevel gears 112 to 120, Fig. 7, which are fast to the shaft in spaced apart relation, and these gears are respectively adapted to mesh with cooperating bevel gears 121 to 129 that are mounted on vertically extending spindles, which will be explained more fully presently. When the knob 98 and shaft 92 are moved to the right, as viewed in Fig. 10, the bevel gears 112 to 120 each respectively mesh with their cooperating gears 121 to 129, but when the pin 131 is seated in a pocket 132 under the influence of the spring 130, the bevel gears 112 to 120 are all demeshed from their respective cooperating gears 121 to 129.

Each of the bevel gear sets in the vertical row thereof at the left-hand end of Fig. 7 pertain to a digit "1" in the multiplicand while those in the second row from the left pertain to a digit "2" in the multiplicand and so on, whereby those in the vertical row at the right-hand end of Fig. 7 pertain to a digit "9" in the multiplicand. For convenience these vertical rows of gears have been designated X1, X2, X3 and so on to X9. The cooperation between these respective bevel gear sets and their associated parts and the digits in the multiplicand is more fully explained in connection with the wiring diagram to which reference will be made presently, the present description pertaining solely to the mechanical arrangement of this portion of the apparatus.

Each of the gears as 121, Figs. 9 and 10, is non-rotatively mounted on a squared section as 133 on a vertical spindle as 134, which is journaled in a bearing as 135 in the bottom wall of the casing 91. Hence when the gears as 112 are respectively meshed with the gears as 121 and the shaft as 92 is rotated, the spindles as 134 are rotated in an amount corresponding to the amount of rotation of the gear as 121.

A gear as 139 is mounted on each spindle as 134 above the bearing as 135, a cam 140 also being mounted on the spindle and being interposed between the top of the bearing and the gear. Referring first to the shaft 92 for the pence group of multiplier selecting devices, four bushings as 145 extend through both the gear 139 and the cam 140 at ninety degree intervals to insulatingly support pins 144. These pins 144 serve to secure contacts as 142 and 143 to the bushings 145, the con-

tacts as 142 being at the upper ends of the bushings and the contact as 143 being at the lower ends of the bushings.

A block 137 of insulating material is mounted on the lower wall of the casing 91 adjacent each bearing 135, as is shown in Fig. 9, and is shouldered at its upper end and on its inwardly disposed face, as shown in Figs. 9 and 10. As shown in plan in Fig. 12, the inwardly disposed face of the block 137 is segmental which is also the shape of the seat defined by shouldering of the block 137. In the pence order of the multiplier, eleven contacts as 146 extend through the block 137 from the shouldered seat to the lower end thereof in uniformly spaced part relation. When shaft 92 and the spindles as 134 are rotated, the pairs of contacts 142 and 143 pass over the contacts as 146, and when rotation of the shaft 92 away from "0" position is interrupted and the pin 131 is seated in a pocket 132, one of the contacts 143 will be resting upon a pin 146 depending upon the setting of the shaft 92 and at this same time the contact 142 will be engaging the contact plate 138 provided at the top of the insulating block 137. A similar arrangement is provided in association with the vertical spindles 134 in the shillings order of the multiplier, but in this instance nineteen contacts as 146 are provided in each block 137. Furthermore, a similar arrangement is provided with each of the spindles 134 in each of the pounds orders of the multiplier but here nine contacts as 146 are provided in each block as 137.

When reference is made herein to manually setting up the multiplier, what is ultimately meant is that various contacts as 143 are selectively engaged with contacts as 146, and which contact 143 is engaged with a particular contact 146 depends upon the numerical value of the multiplier. The contacts 143 are selectively moved into association with respective contacts 146 by rotation of a shaft as 92.

It will be recalled that the dials on the shafts as 92 have scales thereon so that it can be determined by means of these scales how much rotation is imparted to each of the shafts as 92 for it is the amount of rotation that is imparted to a shaft as 92 which determines the selective positioning of the contacts 143 with respect to the contacts 146. Thus it is essential that a definite relation be maintained between the numerals on the scales and the contacts as 143, which means that a definite relation must be maintained between the gears as 121 and the gears as 112. This is assured by the seating of the pins as 131 in the pockets as 132 and when a shaft as 92 has been rotated in a predetermined amount, the gears as 121 will also have been rotated and contacts 143 will have been positioned. Hence in order to insure that the gears 112 do not get out of step with the gears 121, the length of the pockets 132 is such that the pins as 131 do not disengage therefrom until the gears as 112 are completely meshed with gears as 121.

As will be explained presently, there is a condition where the contacts 143 are moved into association with selected contacts 146 other than by rotating the shaft as 92 with which they are associated, but in this instance as well as in the instance where the contacts 143 are rotated upon motivation of the shaft 92 with which they are associated, a definite relationship is still maintained, which is to say, that the means which move the contacts as 143, other than the shaft

92 with which they are associated, move these contacts in either direction in an equal amount. Thus it may be stated that there is a definite relationship always maintained between the numerals on the dials as 104 and the various contacts as 143.

The gears 112 to 120 increase in diameter in the order named while the gears 121 to 129 decrease in diameter in the order named. When the shaft 92, for example, is shifted to the right, Fig. 7, by pressing upon the knob 98, thereby causing the gears 112 to 120 to mesh with their respective cooperating gears 121 to 129, and when the knob 98 is then rotated to cause rotation of the shaft 92, the gears 112 to 120 will cause the gears 121 to 129 to rotate in different amounts depending upon the ratio therebetween.

Thus the ratio between the gears 112 and 121 is such that the gear 121 will be rotated an amount, during rotation of the shaft 92 and dial 104 to advance the dial a single scale division from "0" to "1," sufficient to cause a contact 143 associated with the gear 121 to engage a contact 146 representative of one penny. Hence it may be said that movement of the shaft 92 one scale division from "0" to "1" causes the devices associated with the gear 121 to be set to one penny. To continue, the ratio between the gear 113 and the gear 122 is such that when the shaft 92 is rotated in the amount just described a contact 143 associated with the gear 122 will be set to engage a contact 146 representative of two pence. This arrangement progresses on through the gear set 114 and 123, and so on to the gear set 120 and 129, and in so far as this latter gear set is concerned the ratio therebetween is such that when the shaft 92 is moved in the amount of one scale division from "0" to "1" a contact 143 associated with the gear 129 is engaged with a contact 146 representative of nine pence.

If the shaft 92 had been rotated in the amount of three scale divisions from "0" to "3" the result would have been in view of the ratio between the respective gears 112 to 120 and 121 to 129 to have set a contact 143 associated with the gear 121 in engagement with a contact 146 representative of three pence, a contact 143 associated with the gear 113 in engagement with a contact 146 representative of six pence, and a contact 143 associated with the gear 114 in engagement with a contact 146 representative of nine pence. In this latter circumstance however, when the shaft 92 is rotated from "0" to "3" on the dial 104, the ratio between the gears 115 and 124 would be such that twelve pence should have been set up by a contact 143 associated with gear 124. Twelve pence however are one shilling and in such a circumstance the arrangement of the mechanism is that instead of setting a contact 143 associated with the gear 124 in engagement with a contact 146 representative of twelve pence, that a transfer over into the shilling unit of the multiplier selecting apparatus is effected, and the manner in which such transfer is effected will be described presently.

It will be noted from the foregoing description that when the shaft 92 is moved one scale division as from "0" to "1" the gear set associated therewith in the row X1 is so operated that in contact-positioning effect there is a one to one ratio therebetween while in the row X2 the contact-positioning effect is of a ratio of two to one and so on through to the gear set 120 and 129 where the ratio is in effect nine to one. Or in

other words, when the shaft 92 is moved one scale division the gear 129 and its associated parts are moved in an amount which corresponds to nine scale divisions, which is to say, in other words, that a contact 143 associated with the gear 129 is moved into association with a contact 146 representative of nine pence. This same relationship follows through when the shaft 92 is moved in the amount of two scale divisions on the dial 104. Furthermore, the various gear sets associated with the shafts 93 to 97 operate similarly to the shaft 92 so that if, for example, the shaft 97 is moved the amount of one scale division from "0" to "1" the gear set thereon in the row X9 will move a contact 143 associated with the vertical shaft on which a gear of this gear set is mounted into engagement with a contact 146 representative of the digit "9" in the thousands order of pounds.

It has been stated hereinbefore that the functional relationship, that is, the contact-positioning or multiplier set-up relationship between the gear 112 and the gear 121, for example, is one to one although, of course, as may be seen by reference to Fig. 7, this is not the mathematical relationship between these gears. This relationship is obtained by providing, for example, in the pence group of the multiplier selecting apparatus first, four contacts as 143 in association with each gear as 121 and spacing these contacts at ninety degree intervals and, second, by definitely positioning and spacing the contacts 146 and, third, by so arranging the ratio between the gears as 112 and 121 that when the gear 121 rotates with the shaft 92 the contacts 143 will successively in an arithmetical progression engage the contacts 146. To illustrate, one of the contacts 143 and one of the contacts 146 are so positioned and the ratio between the gears 112 and 121 is such that when the shaft 92 is moved in the amount of one scale division on the dial 104 one of the contacts 143 engages the contact 146 representing the one penny and when the shaft 92 is rotated in the amount of two scale divisions another of the contacts 143 will engage a contact 146 representative of two pence.

In the pence group of the multiplier selecting apparatus four contacts as 143 are utilized as stated but in the shillings group only two contacts as 143 are utilized but here again the positioning of the contacts 143 and the contacts 146 and the ratio between the gears is such that, depending upon the amount of movement imparted to the shaft 93, one or the other of one of the contacts 143 associated with each vertical spindle will engage the proper one of the contacts 146, which is to say, a contact representative of the necessary numerical value as determined by the amount of movement imparted to the shaft 93 and the positioning of the gear set controlling the particular contact 143 along the length of this shaft.

In the various orders of the pounds group of the multiplier selecting apparatus, four contacts as 143 are associated with each gear set and again the positioning and spacing of the contacts 146 and the gear ratio is such that, depending upon the amount of shaft movement and the positioning of the particular gear set along the shaft, a contact 143 will engage the proper contact 146 for the numerical value to be represented.

As was explained above, there will be instances in which one of the shafts as 92 will be rotated in such an amount that certain of the gear sets thereon will be so advanced that it will be neces-

sary to effect a transfer over into the next higher group or order of the multiplier selecting apparatus as where the shaft 92 is rotated in the amount of three scale divisions which causes the contacts as 143 associated with the gear 124 to tend to assume a position representative of twelve pence which is the equivalent of one shilling and in this instance instead of setting up twelve pence a transfer is made over into the shillings unit in a manner which will now be explained.

Such transfer-overs are effected through the cam plates as 140. Referring now to Fig. 12 it is shown that four cam points 141 are provided on the cam plate 140 mounted on the vertical spindle designated in this view as A, which is the spindle on which the gear 122 in the pence group of the multiplier selecting apparatus is mounted. The cam points 141 are adapted for cooperation with the star wheel 154 provided on the hub of the gear 156 that is rotatably mounted on the pin 155 journaled in a bearing provided in the lower wall 136 of the casing 91. These cam points are so positioned on the periphery of the cam plate that whenever a contact 143 sweeps and moves beyond all eleven of the contacts 146 associated therewith, which means, for example, that more than eleven pence are to be set up in the pence group or, in other words, one shilling is to be transferred over, a cam point 141 cooperates with the star wheel 154 to impart rotative movement to the gear 156. This gear 156 meshes with a gear 157 formed on the sleeve 158 which is journaled on the pin 158' and, when a cam point 141 engages the star wheel 154 and rotates the gear 156, the gear 157 likewise rotates as does the gear 159 also formed on the sleeve 158. This gear 159 is shaped similarly to the gear 159 shown near the upper left-hand corner of Fig. 12 and as there illustrated the gear includes but two teeth 160 which are normally disengaged from the gear 139 with which they are adapted to cooperate. When, however, the gear 157 is rotated as just described, the gear 159 is rotated one hundred eighty degrees during which movement one of the teeth 160 thereon moves into mesh with the gear 139 and rotates this gear and its associated cam plate 140. The particular gear 159 that is rotated when the cam plate 140 associated with the gear 122 is rotated meshes with the gear 139 provided on the vertical spindle in the shillings group of the multiplier selecting apparatus in the row X2, in which row the aforesaid cam plate 140, that is mounted on the spindle A along with gear 122 is located, and the rotation imparted to the gear 159 so rotates this gear 139 that the cam plate 140 and its associated contacts as 143 are moved, and one of the two contacts 143 on this cam plate moves into position above the contact 146 representative of one shilling.

The cam plates 140 in the pence group and the cam plates in all orders of the pounds group of the multiplier selecting apparatus carry four contacts as 143 while the cam plates in the shillings group carry but two contacts as 143. Since the cam points as 141 are to be effective when a contact as 143 sweeps over and passes beyond the sets of contacts 146 with which it cooperates, it is necessary to provide as many cam points 141 on each cam plate as there are contacts 143 thereon to insure that each time a contact 143 sweeps over and passes beyond its associated contacts 146 a transfer over into the next higher order will be effected, such transfer-overs in all instances being effected in the same manner as

that in which the specific transfer-over described above was effected.

All gears as 139 are always out of mesh with gears 139 with which they cooperate except during a transfer-over operation. Hence any one of the shafts 92 to 97 may be pushed inwardly against the action of the spring 130 when it is desired to set up a multiplier, and rotation of this shaft will set up the multiplier including whatever transfer-overs there may be incident to the particular set-up. However, no more than one of the shafts 92 to 97 should be moved at one time for so to do might cause certain of the gears 139 to so mesh with the gears 139 with which they cooperate that proper setting up of the multiplier might be prevented even if jamming were avoided due to such inadvertent operation. Suitable means may be provided to prevent simultaneous operation of more than one of the shafts 92 to 97 at one time if so desired but for the sake of simplicity the illustration and description of such means are not here presented since such means in no way modify the calculating and printing operations the present machine is adapted to perform.

In the typical computation described herein the multiplier or dividend rate is one pound, three shillings and two pence and the manner in which this particular dividend rate is set up in the multiplier selecting apparatus will now be described.

When the multiplier of one pound, three shillings and two pence is to be set up any one of the shafts 92, 93 or 94 which will be entailed in setting up this multiplier will be first operated but herein setting up pence will first be described. To this end the shaft 92 is pushed inwardly against the action of the spring 130 and it is rotated until the graduation associated with the numeral "2" registers with the associated index mark whereupon the spring 130 is permitted to return this shaft to its normal position. In this operation a contact 143 associated with the gear 121 in the pence group engages a contact 146 representative of two pence, a contact 143 associated with the gear 122 engages a contact 146 representative of four pence, while in so far as the gear 123 is concerned a contact 146 representative of six pence is engaged, and a contact 146 representative of eight pence is engaged in so far as the gear 124 is concerned, while a contact 146 representative of ten pence is engaged in so far as the gear 125 is concerned. However, no contact 143 associated with the gear 126 in the pence group will be in engagement with a contact 146 since this gear 126 is set to represent twelve pence which is equivalent to one shilling. This means that a contact 143 associated with the gear 126 will sweep over and pass beyond the contacts 146 associated therewith and a cam point 141 will in this movement engage and rotate a star wheel 154 which in turn will rotate a gear 156, a gear 157 and a gear 159, and this gear 159 will rotate its associated gear 139. The associated gear 139 in this instance is the gear 139 which is arranged in the shillings group in the row X6 of the multiplier selecting apparatus and this gear 139 will be rotated sufficiently to cause a contact 143 thereon to engage a contact 146 associated therewith which is representative of one shilling.

A transfer-over identical with this will be effected from the unit of which the gear 127 is a part so that the device in the row X7 in the shillings group will be set to one shilling and a

contact 143 associated with the gear 127 in the pence group will at this time engage a contact representative of two pence. Similar transfer-overs are made in the rows X8 and X9 and additionally a contact 143 associated with the gear 128 in the pence group engages contact 146 representative of four pence while a contact 143 associated with the gear 129 in the pence group engages a contact 146 representative of six pence. It will be appreciated in those instances where there is a transfer-over, due to a contact 143 sweeping over and passing beyond the cooperating contacts 146, that it is the succeeding contact 143 which cooperates with the contacts 146 when pence are to be indicated in addition to the transfer-over.

Attention is also directed to the fact that when a shaft as 92 is rotated as just described, the gears such as 120 and 129 which are shown at the right-hand end of Fig. 7, cause the vertical spindle of the corresponding unit to rotate more rapidly than the gears such as 112 and 121, which are shown at the left-hand end of Fig. 7, cause the vertical spindle of this unit to rotate. It will therefore be appreciated that the actual order in point of time in which the aforesaid transfer-overs were effected was first in the row X9, then in the row X8, then in the row X7, and lastly in the row X6, and this will always be true irrespective of which shaft is moved, which is to say, that the transfer-overs will be progressively effected from right to left as viewed in Fig. 7.

After effecting set-up in the pence unit, as just described, the set-up is effected in the shillings unit and this is done by pushing the shaft 93 inwardly and rotating it sufficiently to bring the graduation associated with the numeral "3" on the dial 105 into register with the associated index mark. In so doing a contact 146 in the unit in the row X1 representative of three shillings is selected, a contact 146 in the unit in the row X2 representative of six shillings is selected, a contact 146 in the unit in the row X3 representative of nine shillings is selected, a contact 146 in the unit in the row X4 representative of twelve shillings is selected, and a contact in the unit in the row X5 representative of fifteen shillings is selected.

In setting up the pence one shilling was entered in the units in the shillings group in the rows X6, X7, X8 and X9. Hence, in this operation where the shillings group of the multiplier selecting apparatus is being set up for three shillings, the unit in the row X6 will be so arranged that a contact 143 therein will engage a contact 146 representative of nineteen shillings which is the sum of the one shilling already set up in this unit (X6) and the eighteen shillings that would be set up therein by reason of the rotation of the shaft 93 through three scale divisions from "0" to "3." Nineteen is the largest number of shillings that may be set up in the shillings group of the multiplier selecting apparatus. Hence, in so far as the unit in the row X7 is concerned, a transfer-over from the shillings group to the units order of pounds group is effected and as a result a contact 143 in the unit in the row X7 in the units order of pounds group will be set to engage a contact 146 representative of one pound. Were it not for the fact that the unit in the row X7 in the shillings group already had a contact 143 therein engaged with a contact 146 representative of one shilling, the present rotation of the shaft 93 would select this one shilling con-

tact 146, but inasmuch as the contact 143 was already in this position the present rotation of the shaft 93 caused it to be advanced to a contact 146 representative of two shillings. Thus, in so far as the row X7 is concerned, the set-up is twenty-one shillings plus one shilling or one pound, two shillings.

Similar transfer-overs and additive settings in the shillings unit are effected in the rows X8 and X9 in the present rotation of the shaft 93 with the result that in the row X8 a contact 146 in the unit in the units order of pounds group representative of one pound is selected as well as a contact 146 representative of five shillings in the shillings group. In so far as the row X9 is concerned, contacts representative of eight shillings and one pound are selected.

After the shillings have been so set up the shaft 94 is pushed inwardly and rotated one scale division which, in so far as this shaft is concerned, causes a contact 146 representative of one pound to be selected in the row X1, while in the row X2 a contact 146 representative of two pounds is selected, in the row X3 a contact 146 representative of three pounds is selected, in the row X4 a contact 146 representative of four pounds is selected, in the row X5 a contact 146 representative of five pounds is selected, and in the row X6 a contact 146 representative of six pounds is selected. In the rows X7, X8 and X9, so far as this shaft is concerned, contacts representative of one pound are already engaged so that in this rotation of the shaft 94 an additive operation takes place in the rows X7 and X8 so that contacts 146 in these rows respectively representative of eight pounds and nine pounds are selected. Such additive operation also takes place in the row X9 but since one pound is already set up therein and nine pounds more are to be added therein a transfer over into the tens order of pounds group of the multiplier selecting apparatus is entailed and hence a contact 146 representative of one pound in the tens order of the pounds group of the multiplier selecting apparatus is selected, but insofar as the unit in the units order of the pounds group is concerned no contact 143 engages a contact 146 since a zero is to be represented in this unit and lack of engagement of a contact 143 with an associated contact 146 is indicative of zero in all units.

It has been explained how the multiplier selecting apparatus is set up first in the pence unit, then in the shillings unit and then in the units order of the pounds unit, and the specific contacts 146 selected in the set-up of one pound, three shillings and two pence have been described. It is to be understood that precisely the same contacts 146 would have been selected eventually had the set-up first been made in the units order of pounds group, then in the shillings group, and lastly in the pence group. Furthermore, the same result would have been attained had any other order of selecting this multiplier or dividend rate been followed.

Even though the shafts 92 to 97 are pushed inwardly and rotated to cause the various units comprising the bevel gear sets associated therewith to be turned and even though the operation of one of such shafts may bring about transfer-overs in the units associated with higher of the shafts, the definite relationship between the numerical values ascribed to the graduations on the dials as 104 and the setting of the contacts 143 in the various units with respect to contacts 146

is always maintained and this is assured first of all because a pin as 131 on any one of the shafts cannot be unseated from the pocket 132 in which it is disposed unless and until the bevel gear sets as 112 and 121 are meshed. Furthermore, this is assured because the units of which gears as 121 are a part are held in any position into which they are moved either by operation of a shaft as 92 or in a transfer-over operation by dual spring detents 249, Fig. 12. The dual spring detents are mounted on the insulating blocks 137 and one arm of each of these dual spring detents cooperates with one of the gears 156 and another arm thereof cooperates with the teeth of the adjacent gear 139. Such dual spring detents cooperate with all of the gears 156 and 139 and therefore as stated effectively hold the units of which these gears are a part in the positions into which they are moved.

When it is desired to set up a different multiplier in the multiplier selecting apparatus, all that need be done is to rotate proper of the shafts 92 to 97 in the manner just described and this may be done by first returning all the shafts to zero or by moving the shafts from whatever position they may occupy into the position they are to occupy for the new multiplier. It should also be noted that when it is desired to return all of the shafts to their zero position, all that need be done is to rotate the shafts so that they will return to zero. When the shafts are rotated in a reverse direction to be returned to zero the above described transfer operations are effected in a reverse direction, which is to say, the cam points 141 engage the star wheels 154 and rotate these star wheels just as they did in effecting the transfer-overs but in this instance of course the star wheels are rotated in a direction opposite to that in which they were rotated when the transfer-overs were effected and the gears associated with the star wheels likewise rotate in a direction opposite to that in which they rotated when the transfer-overs were effected.

Electrical circuits of multiplier apparatus

It has been explained that conductors lead into the multiplier selecting apparatus from the sensing fingers 50, which ascertain the multiplicand, and that conductors lead out of the selecting apparatus to the product accumulator. The conductors leading out of the apparatus will now be described. Thus eleven conductors associated with the word "Pence," Fig. 1a, are arranged to extend parallel to the shaft 92 of the pence group within the casing 91. These eleven conductors to which reference has just been made are not shown in Figs. 7 to 12, inclusive, but by referring to Fig. 12 it will be seen that a group of conductors to which the reference characters 10, 20, 30 and on to 90 are applied are shown. These nine conductors correspond to the eleven conductors associated with pence but the particular conductors shown pertain to tens pounds. By referring to Fig. 12, it will be seen that clips 153 respectively connect the pins or contacts 146 to the aforesaid nine conductors and resort is had to this same arrangement to connect the contacts 146 pertaining to pence to the eleven pence conductors.

The eleven "Pence" conductors are respectively representative of the number of pence for which the pence group of the multiplier selecting apparatus may be set. The contacts 146 are respectively connected to these conductors, which is to say, the contact 146 pertaining to one penny

in the unit in the row XI of the pence group is connected to that one conductor of the eleven conductors which is representative of one penny as is every other contact 146 in the pence group representative of one penny in the rows X2 to X9, inclusive. Likewise the contacts 146 representative of two pence, three pence and so on are respectively connected to the conductors representative of two pence, three pence and so on. The eleven conductors to which reference has just been made are referred to hereinafter as the pence conductors.

Nineteen conductors are arranged in juxtaposition to the shaft 93 of the shillings group and these conductors are respectively representative of the number of shillings which units associated with the shaft 93 may be set to represent. The various contacts 146 of the units of the shillings group in the rows XI to X9, inclusive, and representative of one shilling, are connected to the conductor representative of one shilling, and the other contacts 146 representative of other numbers of shillings are respectively connected to the conductors respectively representative of other numbers of shillings. The conductors to which reference has just been made are shown in Fig. 1a in association with the word "Shillings" and are hereinafter referred to as the shilling conductors.

A set of nine conductors is associated with each of the shafts 94 to 97 of the various orders of pounds groups and the conductors of these sets are referred to hereinafter as units order pounds conductors, tens order pounds conductors, and so forth. The contacts 146 that may be selected by operation of the shafts 94 to 97 are also respectively connected to a conductor representative of the same number of pounds as the particular contact 146 just as were the contacts 146 in the pence and shillings groups.

The eleven pence conductors associated with the shaft 92 are passed into a cable 147, Fig. 1a, and the nineteen shilling conductors associated with shaft 93 are passed into a cable 148 while the set of nine conductors respectively associated with the shafts 94 to 97 are respectively passed into cables 149 to 152.

It has been explained that each of the contacts 143 has associated therewith a contact 142, and that the contacts 142 and 143 are electrically connected to each other. Each contact 142 rides under and engages a contact plate as 138, Figs. 10 and 12, at the time its associated contact 143 is in direct association with the contacts 146 with which it is to cooperate so that when a contact 143 is engaged with and selects a contact 146, circuit is potentially closed from the contact plate 138 to the selected contact 146.

Now referring to the conductors leading into the multiplier selecting apparatus from the multiplicand, which is to say, the sensing fingers 50, sets of six conductors 170 to 175, Fig. 1a, are respectively passed into cables 161 to 169 each of which cables respectively extends parallel to one of the rows XI to X9 within the casing 91. Each conductor 170 in each set for each row XI to X9 is passed out of the cable into which it is passed and is connected to the contact plate 138 in the pence group in the row to which the set of conductors pertains, and each conductor 171 in each set is connected to the contact plate 138 in the shillings group in the particular row and so on so that each conductor 175 is connected to the contact plate 138 for the thousands order of pounds. The sets of conductors 170 to 175 passed

into the cables 161 to 169, Fig. 1a, are passed out of these cables and are respectively connected to normally open contacts of relays 177 to 185, Figs. 1a, 7 and 12, said relays respectively being associated with the rows XI to X9. The effect of this arrangement is that circuit will not be closed to the contact plates as 138 unless a relay as 177 is energized, and this arrangement, as will be explained presently, prevents a feed-back. The relays as 177 are also mounted within the casing 91, as shown in Figs. 7 and 12. The manner in which circuit is selectively closed to the relays 177 to 185 is explained in connection with the description of operation under control of the synchronizer drum 86 and which appears hereinafter.

The synchronizer drum 86 is fragmentally illustrated in the developed view, Fig. 1, and by referring thereto it will be seen that groups of bridging contacts for respectively controlling the closing of circuit from the units, tens, hundreds and so forth orders of the multiplicand are mounted on the periphery of this drum in stepped relation in such a way that as the drum rotates, the bridging contacts associated with the word "Units" in Fig. 1 first come into operation, then those associated with the word "Tens" come into operation and so on until, lastly, those bridging contacts associated with the words "Hundred thousands" come into operation.

Each set of bridging contacts on the periphery of the drum 86 consists of a contact for each of the significant digits in an order of the multiplicand and a control contact as 250, and these contacts are adapted to close circuit between pairs of brushes or contacts 90 disposed along and spaced from the periphery of the drum 86, said brushes or contacts being disposed in a single horizontal plane. Thus since the groups of contacts are arranged in stepped relation on the periphery of the drum and as the drum rotates toward the brushes or pairs of contacts, the bridging contacts first for the units, then for the tens and so on successively come into association with the pairs of contacts, and in this way the multiplication or product selection in the device is caused to proceed through the various orders of the multiplicand in a step by step manner beginning first with units and progressing on upwardly through tens, hundreds and so forth.

Referring now to the bridging contacts associated with the word "Units" in Fig. 1 and particularly to the bridging contact for the digit "1," this contact is adapted to close circuit between a pair of brushes or contacts 90, from the right hand one of which brushes, Fig. 1, a conductor 15 leads to the sensing finger 50 in the sensing head for the digit "1" in the units order of the multiplicand while a conductor 194 leads through cable 203 from the left hand contact or brush of the pair to the relay 177, Fig. 1a. The bridging contact for the digit "2" associated with the word "Units" in Fig. 1 is adapted to close circuit between brushes 90 which are respectively connected to conductors, the right hand one of which conductors 2s leads to the sensing finger 50 for the digit "2" in the units order, and the left hand of which conductors 195 leads to the relay 178, Fig. 1a, through cable 203. This same arrangement is provided in association with each pair of the bridging contacts pertaining to the units order of the multiplicand, which is to say, a conductor leads from the right hand one of the brushes associated with a bridging contact in the "Units" group on the drum to a sensing finger

of the same digital value in the units order of the multiplicand and a conductor leads from the left hand of the brushes to the proper one of the relays 179 to 185, which relays are set to represent digits, which is to say, in effect, the relay 177 represents a digit "1," the relay 178 a digit "2" and so on to the relay 185, which represents a digit "9." The conductors 194 to 202 from the brushes 90 are not shown individually in Fig. 1 but are passed into a cable 203, Fig. 1, and are fanned out of this cable 203 in Fig. 1a to be respectively connected to the relays 177 to 185.

The foregoing detailed description of the bridging contacts associated with the word "Units" and their cooperating brushes 90 applies to the bridging contacts associated with the words "Tens," "Hundreds" and so forth but, of course, the conductors which lead from the brushes to sensing fingers respectively lead to sensing fingers in the tens, hundreds or other orders of the multiplicand. However, the right hand one of the brushes of a pair of brushes, to cooperate with a bridging contact representative of the digit "1," whether it be units, tens or hundreds, is connected to the conductor 194. Further the left hand conductor of each pair of brushes to cooperate with a bridging contact representative of the digit "2," whether it be in the units, tens or hundreds orders, is connected to the conductor 195. This same arrangement follows through the various orders and digital values so that each left hand brush adapted for cooperation with a contact for the digit "3" is connected to a conductor 196, for the digit "4" to conductor 197, for the digit "5" to a conductor 198, and so on to those for the digit "9" which are connected to a conductor 202.

To further explain, as shown in Fig. 1, the left hand brush of the pair of brushes to cooperate with the bridging contact for the digit "1" in tens order is connected to the conductor 194 by a tap 204 and similarly the left hand brush of the pair of brushes to cooperate with the bridging contact for the digit "2" of the tens order is connected to the conductor 195 by a tap 205, and this arrangement progresses on through for the various digits in the various orders.

The conductors 170 to 175 are shown in Fig. 1a connected to arrows 143 which are schematic representations of the contacts 143, Fig. 10. In reality, of course, these conductors are connected to plates 138, as has been previously explained, and contacts 142, 143 and 146 complete the connection to the notational conductors with which the heads of said arrows are associated, but it is believed this description will be facilitated if these conductors are shown as connected to the arrows in the wiring diagram.

These arrows, as shown in Fig. 1a, terminate in positions representative of the manner in which the multiplier selecting apparatus is set up, which has been previously described. Thus the arrow 143 in the pence unit and in the X1 row indicates the setting of two pence by having the point of the arrow touching the number "2" pence conductor which leads into the cable 147. As previously explained, the contact 143 pertaining to the pence group and in the X2 row makes contact in the described setting of the apparatus with the number "4" contact 146, and accordingly the arrow in the pence unit and in the X2 row is shown with its point contacting the number "4" pence conductor. Similarly the arrows pertaining to the pence unit, as shown schematically in Fig. 1a and in the rows X3, X4 and so

on to X9, are shown with their points engaging the conductor that is connected to the contact 146 selected by the present set-up of the multiplier selecting apparatus. The other of the arrows 143, shown in Fig. 1a, likewise have their points disposed on conductors connected to the contacts 146 that are selected in the present set-up of the multiplier selecting apparatus, which set-up is for one pound, three shillings, two pence, and which set-up has been fully explained heretofore. Thus Fig. 1a schematically illustrates, by the use of the arrows 143, the present set-up of the multiplier selecting apparatus.

The cables 61 to 66, Figs. 1 and 6, are respectively associated with the sensing fingers 50 in the units, tens, hundreds and so forth orders, and each contains nine conductors which are respectively connected to the sensing fingers 50 representative of the digits "1" to "9" in the particular order with which the cable is associated. The cables 61 to 66 are diagrammatically illustrated in Fig. 1 and, as will be seen by reference to this view, these cables, which is to say, the conductors therein, respectively connect the sensing fingers 50 with the proper of the right hand brushes of the pairs of brushes associated with the bridging contacts on the synchronizer drum 86.

The nine conductors in cable 61 for the units order are numbered 1s to 9s, while in cables 62 to 66 the conductors are designated by numbers 10s to 90s, 100s to 900s, 1000s to 9000s, 10,000s to 90,000s, and 100,000s to 900,000s, respectively. The 1s conductor is connected with the sensing finger number "1" of the units order of the sensing fingers 50, whereas the 9s conductor is connected with the number "9" sensing finger of the units order. The conductors between 1s and 9s are arranged so the number "2" sensing finger is connected with the number 2s conductor, the number "3" finger with the 3s conductor, and so on. As is plainly shown in Fig. 1, the ends of conductors 1s to 9s opposite to those ends connected with the sensing fingers, as just explained, terminate in brushes 90 which are adapted to be engaged by contact strips "1" to "9" in the units order upon the synchronizer drum 86.

Conductors 10s to 90s are connected with the sensing fingers in the tens order in the same manner as are the conductors 1s to 9s connected with the sensing fingers in the units order; that is, the 10s conductor is connected to the number "1" sensing contact of the tens row, whereas the conductor 20s is connected to the number "2" sensing finger, and so forth. The opposite ends of the conductors 10s to 90s terminate in brushes for coacting with the conductor strips 1 to 9, in the tens order on the drum 86. Likewise, in the hundreds, thousands, ten thousands and hundred thousands orders, the sensing fingers 50 are connected by one end of the conductors 100s to 900s, 1,000s to 9,000s, 10,000s to 90,000s, and 100,000s to 900,000s, while the opposite ends of these conductors terminate in brushes 90 which are adapted to be engaged by contact strips on the drum 86, respectively, in the hundreds, thousands, ten thousands and hundred thousands orders.

The control contact strips on the drum 86 associated with the group of contacts thereon pertaining to the various orders are designated 250 to 255. Contact strips 250 to 254 are substantially co-extensive with the contact strips numbered 1 to 9 in the group with which they are

75 respectively associated on the synchronizer drum.

Contact strip 255, however, is considerably longer and reaches from a point in alignment with the leading edge of strip 250, to a point beyond the trailing edges of the strips 1 to 9, in the hundred thousands order, it being observed that the drum 86 rotates in the direction of the arrow B shown in Fig. 1.

Denominational shift section of multiplier apparatus

Conductor 84, Fig. 1, leading from battery, is connected by branch conductors numbered 257 to 262, with the brushes 90 that are positioned for engagement by the contact strips 250 to 255. Paired with the conductors 257 to 261 are conductors 263 to 267, which lead from brushes adapted to be contacted by the strips 250 to 254, into a cable 268. A conductor 269 is paired with the conductor 262, and leads from a brush positioned to be engaged by the conductor strip 255. Cable 268 passes from Fig. 1 and reappears in Figs. 1a, 1b, and 1c, the conductors in the cable leading therefrom in Figs. 1b and 1c, where they are connected to certain relays to be described presently. Conductor 269 passes from Fig. 1 through Figs. 1a, 1b, 1c and 1d, to Fig. 1e, where it is permanently connected with a solenoid 270 for controlling a clutch indicated generally at 271. The clutch 271 has a driven part connected to the shaft of the motor 272. The purpose of clutch 271 will be described presently.

Figs. 1b and 1c jointly show the circuits to which reference is now to be made and should be referred to together. Attention is directed to relays 273 to 277 which comprise multiple contact double-throw switches respectively designated "Unity," "X10," "X100," "X1,000" and "X10,000." For convenience of reference, relays 273 to 277 have been further indicated as the units relay, tens relay, hundreds relay, thousands relay and ten thousands relay. Normally, the relays 273 to 277 are deenergized, thus allowing the springs 278 to 282 to respectively throw the switches "Unity," "X10" and so forth to their leftmost position. The "Unity" switch has five groups of movable contacts which respectively pertain to pence, shillings, units pounds, tens pounds and hundreds pounds. Conductors passed into the cables 147 to 151 in the multiplier selecting apparatus, Fig. 1a, lead out of these cables in Fig. 1b and are respectively connected to the movable contacts of the switch "Unity." Hence the movable contacts of the groups of contacts on the "Unity" switch are respectively connected to the pence, shillings, and so forth, conductors of the multiplier selecting apparatus.

During the time the units relay 273 is deenergized and the "Unity" switch is in its leftmost position, its movable contacts in the various groups pertaining to pence, shillings, and so forth, are connected with fixed contacts to which several sets of diagonally shown conductors are connected, these diagonal conductors leading to movable contacts on the switch X10. Should, however, the relay 273 be energized, the switch "Unity" will be thrown to the right, whereby its contacts will be connected with fixed contacts to which there are connected conductors passed into certain cables leading to the product accumulating apparatus. Thus the fixed contacts to be engaged by the movable contacts in the switch "Unity" pertaining to the pence will be connected individually with conductors passed into a cable 283. The similar fixed contacts in the shillings group pertaining to one to nine shillings are con-

nected with conductors passed into a cable 284, while the contacts of this group pertaining to eleven to nineteen shillings are connected through switch contacts 11a to 19a, contacts 11f to 19f, and conductors 11b to 19b with switch contact "10" of the shillings group and through such contact to a conductor 285. Switch contacts for eleven to nineteen shillings are also connected through switch contacts 11a to 19a with contacts 11f to 19f, conductors 11c to 19c, and thence through contacts for one to nine shillings with the conductors passed into cable 284.

Conductors 11b to 19b have circuit controlling devices 11d to 19d therein, such devices being shown in Fig. 18 and being explained in detail presently. Conductors 11c to 19c likewise have similar circuit controlling devices 11e to 19e therein. The devices 11d to 19d and 11e to 19e permit current to flow therethrough only from left to right, that is, from the switch contacts for eleven to nineteen shillings to switch contacts for one to nine shillings, but prevent the flow of such current in the reverse direction.

The nature of the circuit controlling devices, such as 11d, may be determined by referring to Fig. 18. As there shown there are conductors 286 and 287 from which current is to flow to conductor 288. However, current is not to flow between conductors 286 and 287 or from conductor 288 to either of the conductors 286 or 287; for example, when current is to flow from conductor 287 to conductor 288, the devices prevent flow of current to conductor 286. Thus the circuit controlling devices shown in Fig. 18 prevent feed-backs.

Conductor 286 leads to one end of the winding of relay 289. The other end of the winding is connected to ground through battery 290. Thus when conductor 286 is grounded, while conductor 287 is not grounded, the relay 289 is energized and its armature 291 is attracted whereupon contacts 292 are closed which establishes circuit between conductors 286 and 288. Since, however, contacts 293 of relay 294 are open at this time, there is no connection between conductors 287 and 288 and feed-back to conductor 287 is prevented. If ground should be applied to conductor 287 while conductor 286 remains ungrounded, relay 294 will be energized from conductor 287 to battery at 295, thereby causing the armature 296 to close the contacts 293, thus establishing a direct connection between conductors 287 and 288 but at this time relay 289 will be deenergized and contacts 292 will be open and therefore there will not be a feed-back to conductor 286.

The present use of the circuit controlling devices 11d to 19d and 11e to 19e, Fig. 16, will now be explained. When the "Unity" switch is in its right-hand position during energization of relay 273, contacts 11a to 19a are electrically connected with contacts 11f to 19f, thereby connecting contacts for eleven to nineteen shillings with conductors 11b to 19b and 11c to 19c. The devices, as 11d to 19d therefore function to connect conductors 11b to 19b with the number "10" switch contact. Likewise the conductors 11c to 19c are connected to the contacts for one to nine shillings through circuit controlling devices as 19e.

If, for example, the switch contact for eleven shillings should be energized by the energization of the conductor for eleven shillings, circuit would be established through contacts 11a and 11f, and conductors 11b and 11c, to the contacts for ten and one shillings. This would close a

circuit from the ten shillings contact "10" to conductor 285 which, as will be explained, effects entry of ten shillings in the product accumulator described presently. A circuit would be closed concurrently from the contact for one shilling to a conductor in the cable 284 that leads to a different section of the product accumulator wherein the amount of one shilling is entered. Thus one shilling and ten shillings are entered in the product accumulator and this was occasioned by the energization of the conductor for eleven shillings leading from the multiplier selecting apparatus.

The circuit just traced illustrates how a pre-computed product of eleven shillings is selected when the conductor for eleven shillings from the multiplier selecting apparatus is potentialized. Such a conductor is so potentialized when a sensing finger 50 is grounded and the product of the value represented by the finger times the multiplier selected by the setting of the multiplier selecting apparatus is eleven shillings. This is merely a preliminary description of how the various circuits through the pre-computed product selecting mechanism are established and an actual selection of a product will be explained in detail presently.

Supposing now that the conductor for ten shillings had been grounded, then the "10" contact of the shilling section of the "Unity" switch would have been grounded. If it were not for the circuit controlling devices 11d to 19d, the conductors 11b to 19b would also have been grounded upon this grounding of said "10" contact and thereby the conductors 11c to 19c would have been grounded which would have closed circuit to the conductors for one to nine shillings which would have caused entries of these values to have been made in the product accumulator. However, since the circuit controlling devices permit flow in but one direction, feed-back such as would energize the one to nine shillings conductors in the manner described is prevented and only the intended entry is made in the product accumulator. If one of the contacts in the shillings group on the switch "Unity" for from one to nine shillings is grounded as, for example, the contact for two shillings, feed-back through conductors 12c and 12d to the "10" contact is prevented by the circuit controlling device 12e. Thus a circuit controlling device is provided at each point where feed-back might occur, which insures accurate entries being made into the product accumulator.

When the "Unity" switch is in its right-hand position the movable contacts thereon in the units pounds, tens pounds and hundreds pounds groups individually engage fixed contacts to which conductors are connected and the conductors of each group are respectively passed into cables 297, 298 and 299. The conductors pass out of these cables and are connected to devices in the product accumulating mechanism for receiving or accumulating products in the order to which the cable pertains.

The "Unity" switch is disposed in its right-hand position whenever multiplication is proceeding in the units order of the multiplicand and this is effected by the energization of the relay 273. When multiplication is to proceed in the tens order of the multiplicand, the relay 274 is energized to dispose the switch X10 in its right-hand position and when the multiplication is to be in the hundreds order, the relay 275 is energized to dispose the switch X100 in its right-

hand position and so on and as the multiplication proceeds through the various orders of the multiplicand the relays 276 and 277 are energized to dispose the switches with which they are associated in their right-hand positions. As soon as multiplication is completed in any order of the multiplicand, the relay as 273 for this order is deenergized and this switch returns to its left-hand position so that circuits pass directly through this switch to the next higher order of the column shift devices shown in Figs. 1b and 1c.

When multiplication is to proceed in the tens order and the relay 274 is energized to dispose the switch X10 in its right-hand position and the "Unity" and all other switches are in their left-hand position, circuit is closed from the conductors in the multiplier selecting apparatus through the switches "Unity" and X10 to conductors which lead from the X10 switch to the product accumulator; that is, the switch X10 is then connected to the product accumulator. With the exception of a conductor 307 (pertaining to ten shillings), all the conductors which lead from the contacts on the switch X10 to the conductors leading to the product accumulator are passed into cables 300 to 305 which respectively join the cables 283, 284, 297, 298, 299 and 329. Said conductor 307 connects the ten shillings contact on this switch to the conductor 285. The effect of this arrangement is that when the switch X10 is energized (thrown to its right-hand position), the products determined by the contacts thereof for setting up in the product accumulating apparatus will be ten times the amounts determined or represented by the "Units" switch contacts through which the energized of the contacts on the switch X10 are energized.

The manner of determining to which of the movable contacts in the X10 switch the conductors leading from the fixed contacts at the left-hand position of the "Unity" switch are connected, will now be described. It will be assumed that the units relay 273 is deenergized so that the "Unity" switch will assume the normal left-hand position shown in Fig. 1b. Attention is directed to the number "1" contact of the pence group of contacts in the "Unity" switch. Such contact is to be connected with such a contact or contacts of the X10 switch as will cause the "1" conductor of the pence unit of the multiplier selecting apparatus to be connected with such a conductor in the cable 283 as will cause to be set up in the product accumulator an amount equal to ten times one penny or ten pence when the switch X10 is in its right-hand position. It follows, therefore, that a lead shown diagonally in the schematic drawing of Fig. 1b extends between the lower fixed "1" penny contact of the "Unity" switch and the movable contact "10" in the pence group of the X10 switch. If now the tens relay 274 were to be energized to throw the X10 switch into its right-hand position, the "10" pence contact of the X10 switch would be effective for selecting a product of ten pence and causing it to be entered in the product accumulator.

The foregoing is an example of where a contact in the "Unity" switch is connected to but a single contact in the X10 switch, but in some instances contacts of the "Unity" switch are connected to two movable contacts of the X10 switch. For example, the "4" conductor in the pence group of the multiplier selecting apparatus will be connected to the contact for four pence in the "Unity" switch. When four pence is multiplied by ten, the product is three shillings and

four pence. Consequently, the left-hand fixed "4" pence contact of the "Unity" switch is connected by a diagonal jumper with the "3" shillings movable contact of the X10 switch and also with the "4" pence movable contact of the X10 switch. Thus in each instance where a product selection under control of the switch X10 necessitates an expression in more than one unit of the pounds, shillings, pence monetary system as, for example, shillings and pence or pounds and shillings, the fixed left-hand contact in the "Unity" switch is connected to the two movable contacts in the switch X10 which will express the product that is to be selected just as the left-hand fixed "4" pence contact in the "Unity" switch was connected to the three shillings and four pence movable contacts in the switch X10.

In those conductors extending from fixed contacts in the left-hand position of the "Unity" switch to common movable contacts of the X10 switch, there are circuit controlling devices or, as they may be called, circuit interrupters, these being similar to those indicated at 11d and 11e, for example, and which have been explained above in detail with reference to Fig. 18. These circuit interrupters serve the same purpose as the circuit interrupters 11d, 11e, and so forth, which is to say, they prevent a feed-back through a conductor that is not to be energized when another conductor connected to the same movable contact is energized.

An example of the foregoing may be ascertained by referring particularly to the contact for two pence of the switch X10. It will be noted that this contact is connected to two fixed contacts in the left-hand position of the "Unity" switch, namely, the contacts connected with the five pence and the eleven pence conductors leading from the multiplier selecting apparatus. Thus, for example, if the conductor pertaining to five pence is grounded, ground will be applied on the movable contact for two pence in the switch X10 and, but for the circuit interrupter in the conductor which leads from this contact to the fixed left-hand contact to which the conductor for eleven pence is connected, the conductor for eleven pence would be erroneously grounded. This same arrangement is followed out in all instances, which is to say, there is a circuit interrupter in each conductor through which a feed-back might occur.

The manner of connecting the contacts to obtain product selection as connection is made from one switch to the next has been explained only with respect to the "Unity" switch and the X10 switch. It will be understood, however, that the manner in which the contacts of one switch are connected to the contacts of the next higher switch depends upon the products resulting from a multiplication of the numerical values of the contacts of the lower switch by ten, and the connections between the contacts of the lower switch lead to the contacts of the higher switch which represent such products.

Product accumulating apparatus

Cables 283, 284, 297, 298 and 299 and conductor 285 extend from Fig. 1b through Figs. 1c and 1d to Fig. 1e where said conductor and the conductors in said cables are connected with a product accumulating apparatus now to be described. The product accumulating apparatus comprises a product translator device which includes a stator 310 and a rotor 311, shown schematically in Fig. 1e, and the mechanical

structure of these parts is shown in Figs. 13, 14 and 15. The stator 310, as shown at the left-hand end of Fig. 14, is segmental in cross-section, thus conforming to the cylindrical surface of the rotor 311. The rotor is driven from the motor 272 through a gear 313, an idler gear 314 and a gear 315 which is connected to the rotor shaft 316. Gear 313 is freely rotatable upon the motor shaft 317 but is adapted to be connected to said shaft by means of a clutch indicated generally at 271, Fig. 13. Normally the clutch 271 is held disengaged against the urge of a spring 318 by means of a bell crank 320. One leg 321 of the bell crank lever 320 is acted upon by a spring 322 whereby the other leg 323 of said lever is held in engagement with the axially reciprocal element of the clutch 271 to force such element out of clutch engagement so that the motor shaft 317 normally rotates without effecting rotation of the gear 313. The leg 323 of the bell crank lever is drawn downwardly, Fig. 13, upon energization of the solenoid 270, thereby permitting the spring 318 to engage the clutch 271 and thus set the gear 313 and the parts driven thereby in operation.

The stator 310 and the rotor 311 which are a part of the product accumulator are mounted within a frame indicated generally at 324, Fig. 13. Said frame comprises two opposite side frame members 325 and 326 which are joined together at their ends by spacing bars 327 and 328.

Referring now to Figs. 14 and 1e and particularly to the elongated stator 310 it will be seen that a plurality of transverse conductor strips CS are provided on the inner surface of said stator. The conductor strips are indicated as pertaining to pence, units shillings, ten shillings, unit pounds, tens pounds, hundreds pounds, thousands pounds, ten thousands pounds and hundred thousands pounds by having these words applied to the cables leading to the contact strips. The pence strips are numbered "1" to "11" and are adapted to be connected electrically through the eleven conductors within the cable 283 to the pence contacts in the various switches, "Unity," X10 and so forth. Alongside of each of the pence strips CS "1" to "11" there are one or more short contact strips which are selectively positioned in longitudinal rows indicated at the right hand end of the stator, Fig. 1e, by the numerals "1," "3," "5," "1" and "5." These short contact strips are the transfer means of the transfer apparatus of which the stator 310 and the rotor 311 are a part and each of the short contact strips has the effect of transferring a numerical value of a magnitude equal to the numerals as "1," "3," "5," "1" and "5" associated with the row in which the short contact strip is positioned. The conductor strips CS and the short contact strips cooperating therewith are mounted in insulating material so that normally no electric current can pass between them.

The shillings group of contact strips CS are numbered "1" to "9" and have alongside of them short contact strips also arranged in the longitudinal rows "1," "3," "5," "1" and "5." The contact strips CS "1" to "9" of the shillings are individually connected to the conductors leading from cable 284 through which they are adapted to be connected with the switch contacts "1" to "9" in the switches shown in Figs. 1b and 1c. The "10" shillings strip CS is permanently connected to the conductor 285 which itself or through branches leads to the "10" shillings con-

tacts of the switches shown in Figs. 1b and 1c. In similar fashion the contact strips CS in the units pounds order, numbered "1" to "9" are adapted to be connected by means of the conductors in cable 297 with contacts in the aforesaid switches and the contact strips CS in the orders of the tens pounds, hundreds pounds, and so on hundred thousands pounds are adapted to be connected individually through the conductors carried in cables 298, 299, 329, 330 and 331 with corresponding contacts in said switches.

Irrespective of the switch such as the "Unity" switch, the X10 switch or the X10,000 switch, Figs. 1b and 1c, with which there are associated one or more contacts which fall within the orders of pence, units shillings, ten shillings, units pounds and so forth, the contact strips CS will be electrically connected respectively thereto by a conductor leading to the conductor of corresponding number and order within the main cables 283, 284, 297, 298, 299, 329, 330 and 331. For example cable 283 sheaths eleven pence conductors leading from the "Unity" switch. The number "2," "4," "6," "8" and "10" of these conductors are joined by the pence conductors "2," "4," "6," "8" and "10" leading from the X10 switch through the cable 300. This same system is followed in so far as other conductors and switch contacts are concerned, as can be determined by an inspection of Figs. 1b and 1c. Furthermore, the nine conductors within the cable 329 are connected respectively with conductors within adjoining cables 333, 334, 335 and 336, Figs. 1b and 1c, whose conductors terminate in the thousands pounds orders of the X100 switch, X1000 switch, X10,000 switch and the terminals in the one hundred thousands pounds order of the X100,000 row of terminals, a switch not being provided or necessary in this row.

Before describing the function of the contact strips CS of pence, units shillings, and so on upon the stator 310 and the manner in which these contacts cooperate with the wiping contacts 337 upon the rotor 311, a description will be given of the remainder of the product accumulator supported in the frame 324, Fig. 15. The side members 325 and 326 of the frame 324 have upwardly extending standards 338 and 339 in which bearings for a shaft 340 are provided. Shaft 340 is movable axially within these bearings as well as rotatively. Said shaft is normally held toward one limit of its axial movement by means of a spring 341, Fig. 13, which bears between a washer engaging the standard 339 and a washer engaging a collar 342 fixed to the shaft. Rotation of the shaft 340 is effected by a ratchet wheel 343 freely rotatable upon the right-hand end of the shaft, as viewed in Fig. 15, and a co-operable pawl 344 on a plate 345 fixed to the shaft by a pin 346. One section of the ratchet wheel 343 has gear teeth 347 of considerable extent axially and which mesh with the teeth of a segmental gear 348 pivoted upon a pin 349 incident to movement of the core 350a, Fig. 13, of a solenoid 351b. A link 351a is provided between the core 350a and the lower end of the segmental gear 348.

When the solenoid is deenergized, a spring 352 about the core 350a holds the core to the left, Fig. 13, but when the solenoid is energized, in a manner as explained hereinafter, the core 350a is attracted and moved to the right, Fig. 13, compressing the spring 352A and rotating the ratchet wheel 343 through the segmental gear 348. During such rotation of this ratchet wheel the pawl

344 causes the plate 345 and the shaft 340 to rotate counter-clockwise as viewed in Fig. 16. When the solenoid 351b deenergizes the segmental gear 348 is rotated by the spring 352 and the ratchet wheel 343 ratchets the pawl 344 and the shaft 340 is not rotated. The gear tooth section of the ratchet wheel 343 is such that the shaft 340 makes a single revolution upon energization of the solenoid 351b.

Such rotation of the shaft 340 occurs in effecting a zero setting operation of the accumulating apparatus. During this zero setting operation a plurality of notationally significant rotors 350, Fig. 15, to be described in detail shortly and which are freely rotatable relatively to and upon the shaft 340 are rotated and left standing at their "0" positions. Operative connection between the shaft 340 and said rotors 350 during the zero setting operation is effected by shifting the shaft 340 to the left, as viewed in Fig. 15, to carry pins 352 thereon into transverse alignment with pins 351 respectively mated therewith upon said rotors. This axial movement of the shaft 340 occurs prior to its rotation by the energization of the solenoid 351B and is accomplished by energizing a solenoid 460 which is held upon the machine frame by a bracket 461. An axially movable core 462 is drawn to the left when the solenoid 460 is energized, thereby pivoting a bell crank lever 463 with which it is operably connected. In this manner the longer leg of the bell crank lever 463 is pressed against the end of the shaft 340 for shifting said shaft endwise while compressing a spring 341, Fig. 13, which is disposed between a bearing standard 339 and a collar 342 fixed to said shaft. After the pins 352 are thus projected into transverse alignment with the pins 351 by energization of the solenoid 460, the solenoid 351B will be energized to impart a single complete revolution to the shaft 340, whereby the rotors standing at "0" will be rotated backwardly through three hundred sixty degrees. Those rotors however which may be standing at some intermediate position as "3" or "8" will be rotated backwardly to the "0" position. There is a rotor 350 for each of pence, "1" to "9" or units shillings, ten shillings, and so on to hundred thousands pounds. In Fig. 15, the rotor 350 farthest to the left is for pence, the next to the right for "1" to "9" or units shillings, and so on until the rotor 350 at the right end of the shaft 340 is for the hundred thousands order of pounds. Normally the shaft 340 is in the axial position that will remove the pins 352 from the path traversed by the pins 351 during rotation of the rotors 350.

Each rotor 350 includes a cylinder 354 of insulating material which carries a rotor bar 355, Fig. 16, that extends axially of the rotor. Spaced a short distance from one end of each of the rotor bars 355, with the exception of the rotor bar pertaining to the hundred thousands pounds order, is a short rotor bar 355a.

A bar 358 extends transversely of the frame 324 between arms 356 and 357, Figs. 14 and 15, and supports a series of stators 359 which enclose the rotors 350. Each stator 359 has a plurality of contacts R, Figs. 16 and 1e, distributed about its inner periphery in such a manner that they will be individually engaged by the rotor bars 355 of the rotors 350. The cross-sectional view, Fig. 16, is taken through the stator pertaining to the ten thousands pounds order. The contacts R upon the stator in this order, as in the other pounds orders, represent digits

one to nine. A terminal 360, Fig. 15, on each stator provides electrical connection with a metallic ring 361 circling the interior of its stator, near one end, as illustrated in Figs. 1e, 15 and 16. A contact 362 is provided on the pounds and units shillings stators between the "9" contact position and the "0" position and, as shown in Fig. 1e, it is paired with a contact 364, in axial alignment therewith. The contacts 362 and 364 on such stators are bridged during certain operations of the accumulator device to cause a carry-over from one order to the next, as will be explained.

The stator 359 pertaining to ten shillings has paired contacts 365 and 366 which serve the same purpose as the paired contacts 362 and 364 upon the pounds stators, which is to say, they effect a carry-over into the units pounds order. A similar pair of contacts 363A and 364A are provided on the pence stator between the "11" pence contact and the "0" position on this stator. The "0" positions on the various stators are indicated by broken line representations of contacts.

The rotors 358 each has a gear 363 and these gears are all driven in the same direction by large ring gears 367, Fig. 14, which are mounted upon shafts 368 and 369 supported in the frame side members 325 and 326. The gears 367 on shaft 368 are in staggered relation with respect to the gears on shaft 369, this arrangement being provided so that the driving units of which the gears 367 form a part may be combined into an apparatus of small width.

The gears 367 are in the transfer units or motors which are all similarly constructed. Hence attention is directed in particular to the right-hand unit illustrated in Fig. 14. The shaft 369 upon which this unit is supported does not rotate during any operation of the machine. The front and back plates 370 and 371 of the unit are journaled upon the stationary shaft 369, axial movement of these plates 370 and 371 being prevented by spacing rings 372 which are snapped into place within grooves (not shown) circumscribing the shaft 369. These rings also serve to so hold the front and the back plates so that they are kept from spreading apart and these plates are held together near their free edges by screws 373 which pass through spacer sleeves 374.

Three studs 375, 376 and 377 are mounted on the back plate and mutilated gears 378, 379 and 380 are respectively journaled thereon. Three gears 381, 382 and 383 are also respectively mounted on the studs 375, 376 and 377 and these gears are capable of rotation independently of the gears 378, 379 and 380. A one-way driving connection is respectively provided between the gears 378, 379 and 380 and the gears 381, 382 and 383 by means of pawls 384, 385 and 386 which are pivotally carried upon the gears 378, 379 and 380 and which are urged toward the teeth of the gears 381, 382 and 383 by springs 387, 388 and 389. Retaining pawls 390, 391 and 392 together with springs 393, 394 and 395 cooperating therewith serve to prevent reverse rotation of the gears 378, 379 and 380 during a certain period of operation, as will be presently explained.

Solenoids 396—1, 396—3 and 396—5 are supported upon the back plate 371 by brackets 397 and screws 398. Each of the solenoids as 396—5 is traversed internally by a brass rod 399 upon one end of which there is an iron core section 400. The opposite ends of the brass rods 399 are connected by links 401 with arms 402 which are rigidly connected with segmental gears 403, the

arms 402 and gears 403 being rotatable about studs 404 which are anchored in the back plate 371. Movement of the arms 402 and hence of the gears 403 about the studs 404 is limited by adjustable stops generally designated 405 and suitably anchored upon the back plate 371. Springs 407 normally hold the segmental gears 403 in their retracted positions illustrated in Fig. 14, in which positions the arms 402 abut against the adjustable stops 405. When, however, one of the solenoids, as 396—5, is energized, the iron core section 400 thereof is attracted inwardly, thereby forcing the brass rod 399 outwardly and through the link 401 and arm 402 causes the segmental gear 403 to rotate counterclockwise, as viewed in Fig. 14, while distending its respective spring 407. During such counterclockwise motion of the gear 403 through the arc permitted by the stop 405, the gear 381 associated therewith makes one complete revolution and through the pawl 384 associated therewith causes the gear as 378 also associated therewith to make a complete rotation. Each of the gears as 378 meshes with the internal teeth 408 of the ring gear 367. Hence when a complete rotation is given to any one of the gears 378, 379 or 380, the ring gear 367 will be caused to rotate a distance depending upon the number of teeth upon the actuation of the mutilated gear 378, 379 or 380.

The back plate 371 of each unit, carries three concentric rings 409, 410 and 411 of conducting material. These rings are shown in dotted outline in Fig. 14 and in full lines in Fig. 17. Current is supplied to the solenoids 396—5, 396—3 and 396—1, respectively, through conductors 412, 413 and 414 from the rings 409, 410 and 411. Battery for the circuits to the solenoids is indicated at 415. Brushes 416, 417 and 418, Figs. 13 and 14, are mounted upon insulating supports 419, which are, in turn, secured to lugs 420 projecting inwardly from the frame cross members 327 and 327A, Fig. 13. A supply of electrical energy is carried to the brushes 416, 417 and 418 by conductors 421, 422 and 423.

The spacer sleeves 374, Fig. 17 hold the front and back plates 370 and 371 a sufficient distance apart to prevent them from pressing the sides of the ring gear 367, to insure freedom of relative movement for the gear relatively to the plates. After the ring gear 367 has been rotated an amount in the forward direction by one or more of the gears 378, 379 and 380, upon electrification of one of the solenoids 396—5, 396—3 or 396—1, the segmental gear or gears 403 which were actuated incident to such rotation are oscillated back to their original position by the springs 407 at which time the gears 378, 379 or 380 are held against rotation in the reverse direction by their respective retaining pawls 390, 391 or 392, while the pawls 384, 385 and 386 permit the smaller gears 381, 382 or 383 to rotate relatively to their mating mutilated gears.

The solenoid 396—5 actuates the mutilated gear 378 while the solenoid 396—3 actuates the mutilated gear 379 and the solenoid 396—1 actuates the mutilated gear 380. These solenoids all move these gears in the same amount, but it is intended that actuation of a solenoid shall cause rotation of the rotor in an amount corresponding to the designation of the solenoid, which is to say, in the case of the solenoid 396—5, five spaces, in the case of the solenoid 396—3, three spaces, and in the case of the solenoid 396—1, one space. Since all the mutilated gears move in the same amount,

which is to say, one complete rotation, the number of teeth thereon is varied and the number of teeth upon each of these mutilated gears corresponds to the amount of movement the gear is to impart to the rotor, so the mutilated gear 378 has a sufficient number of teeth that it will move the rotor five spaces, the mutilated gear 379 has a sufficient number of teeth to move the rotor three spaces and the mutilated gear 380 has a sufficient number of teeth to move the rotor one space. Thus when the gear 378, for example, is rotated in the forward direction, upon energization of the solenoid 395—5, it will rotate the ring gear 367 with which it meshes sufficiently to rotate the rotor gear 353 with which the gear 367 is in mesh an amount sufficient to move connected rotor 350 so that the rotor bar 355 thereon will move from "0" into engagement with the "5" contact R on the stator 359 associated with this particular rotor, or in other words, five spaces.

While the ring gear 367 is being rotated by one of the mutilated gears, rotation of the front and back plates 370 and 371 in the reverse direction about the shaft 368 or 369 is prevented by a retaining pawl 424 which coacts with ratchet teeth 425 extending about the edge of the back plate 371. It will be understood from an examination of Fig. 14 that a solenoid 426 is associated with each of the pawls 424 for cooperating with the teeth 425 on the back plates 371 and has an axially movable iron core 427 connected therewith to effect disengagement thereof from the ratchet teeth 425 incident to energization of the solenoid. Said pawls and solenoids are carried upon small brackets 427B which are distributed along frame cross pieces as 427C; see Fig. 14a. This arrangement has been provided as a means of conditioning the apparatus so that the rotors 350 may be turned to "0" without the disengaging of the rotor gears 353 from their respective ring gears 367. Ball detent devices, indicated generally at 428, Figs. 13 and 14, coact with the spaces between the external teeth of the ring gear 367 to prevent overthrow of the ring gears when actuated by the mutilated gears and further to insure the gears stopping at centered positions.

Means have been provided for effecting a carry-over from each of the rotor-stator devices (with the exception of that pertaining to the highest order) into the device of the next higher order when the lower device rotates far enough to register its capacity. For example, the unit shown in Fig. 16 is so constructed that it will be capable of causing a carry-over into the hundred thousands pounds order when the rotor bar 355 in this unit passes from the "9" contact to the "0" position. The carry-over is effected by apparatus now to be described and energized through an electric circuit which is closed when the rotor bar 355A bridges the contacts 363 and 364 as said rotor bar passes from "9" to "0." The relative position of contacts 363 and 364 may be seen by referring to Fig. 1e.

Carry-over from one order to the next higher order is effected when the solenoid 437 associated with the next higher order is energized. Such energization is effected when a rotor bar as 355A bridges the contacts as 363 and 364 in the order from which a carry is to be made, circuit incident to such bridging of these contacts being traced presently.

When such a solenoid 437, Fig. 14, is energized, the core 438 thereof is forced to the right as viewed in Fig. 14, and through the brass portion 439 thereof and the link 440 imparts movement

to a segmental gear 434 which meshes with a pinion 432 rotatably mounted on the shaft 433. A single tooth gear 430 is also mounted on this shaft and carries a pawl 431 that meshes with the teeth of the pinion 432 and when the gear 432 is rotated upon movement of the segmental gear 434 when the solenoid is energized, the pawl 431 drives the gear 430 through a complete revolution in the course of which the tooth thereon meshes with the teeth 425 on the back plate 371 to cause it to be rotated in an amount sufficient to so rotate the associated ring gear 367 that the rotor associated therewith is advanced one space. When the gear 430 is at rest it is engaged by a retaining pawl 436 and after making a complete revolution as above described it remains in engagement with this pawl while the spring 435 attracts the segmental gear 434 upon deenergization of the solenoid 437.

Circuit to a solenoid 437 when a carry-over is to be made is established as follows: Battery is found in conductor 269', Fig. 1e, to which each of the contacts as 354 is connected so that when a rotor bar 355A bridges the contacts 363 and 364 battery is applied to one end of the winding of the solenoid 437 through a conductor as 451, Figs. 1e and 14, the other end of which winding is grounded at 452. Such energization of the solenoid 437 is momentary because the rotor bar as 355A will quickly move out of association with the contacts 363 and 364 but by the time this occurs the contact strip 445 on the segmental gear 434 operated upon energization of the solenoid engages the contact 447 connected to battery 449 through conductor 448 and, through conductor 455, contact 453 and contact 454, battery is supplied to the winding of the solenoid 437, the contacts 453 and 454 being engaged upon energization of relay 454A concurrently with the energization of solenoid 437. The circuit through strip 445 and contact 447 is a holding circuit for the solenoid 437 and relay 454A so that when the strip 445 passes beyond contact 447, this solenoid and relay release whereupon the spring 435 returns the segmental gear 434 to its initial position. In this return the pawl 431 ratchets over the teeth of gear 432 and retaining pawl 436 prevents movement of gear 430.

When the rotors 350 have been advanced to position the rotor bars 355 thereon in selected positions representing numerical values, by the action of solenoids as 396-1, and this set-up of the rotors has been utilized to effect operations of the machine described in detail hereinafter, the rotors are returned to zero by energizing the solenoids 351B and 460 as hereinabove described so that a succeeding product may be accumulated therein.

The apparatus shown in Figs. 13 to 17 is schematically shown in Fig. 1e along with the electrical connections of such parts. Various conductors which supply current to the parts shown in Fig. 1e for effecting the operative functions of these parts will first be described.

The conductors for supplying battery to the stator conductor rings 361 are contained within a cable 466 and are numbered from 467, beginning with the pence, to 475 in the hundred thousands pound order. Cable 466 extends from Fig. 1e into Fig. 1d where the conductors 467 to 475 emerge and terminate in brushes 90 for coaction with contacts upon the synchronizer drum 86. The line $a'-a'$ upon the end section of the drum as shown in Fig. 1d corresponds to the line $a'-a'$ upon that section of the drum shown in

Fig. 1. That is, the synchronizer drum 86 comprises the two sections that are shown in Figs. 1 and 1d and which are assembled along the line $a'-a'$.

In alignment with the brushes to which the conductors 467 to 475 are connected in Fig. 1d are drum contacts 501R to 501Z also designated pence, units, shillings, and so on to hundred thousands pounds. When during the rotation of the drum 86 the contact strips 501R to 501Z are passed successively into engagement with the brushes to which the conductors 467 to 475 are respectively connected, said brushes are connected by said contacts with brushes paired therewith that are connected by suitable conductors with the conductor 34 which leads from battery as indicated in Fig. 1. In this manner the conductors 467 to 475 are adapted to be successively connected with the battery to place a potential upon the stator conductor rings 361 of the several stators 359, Fig. 1e.

A conductor 269, Fig. 1, which receives battery from the conductor strip 255, Fig. 1, provides battery through conductor 269', Fig. 1e, to the carry-over contacts 364 upon the various stators 359 and in addition conductor 269 supplies battery to the clutch solenoid 270. Conductor 464 hereinabove mentioned in connection with solenoid 460 leads into a cable 479, Fig. 1e, and is carried through the cable into Fig. 1d where the conductor reappears connected to a brush 90 adapted to be engaged by the reset conductor strip 430 on the drum 86. Conductor 464, Fig. 1e, is connected to a conductor 481 which leads to the solenoids 426 which are for actuating the back-stop pawls 424 described hereinabove with reference to Fig. 14. A conductor 482 leads from the solenoid 351B and into cable 479 and reappears in Fig. 1d where it terminates in a brush 90 which is adapted to be engaged by a conductor strip 483 on the drum 86.

At this point an explanation will be given of the functions of the long contact strips CS, such as the contact strips "1" to "11" in the pence group upon stator 310 and particular reference is made to Fig. 1e. As has been hereinabove explained, the long contact strips CS operate in conjunction with several short contact strips arranged alongside thereof in the longitudinal rows designated "1," "3," "5," "1" and "5" at the right in Fig. 1e. In each of the groups as pence, "1" to "9" or units shillings, ten shillings, and so on, the short contact strips in the number "1" longitudinal row are connected to a common conductor as 3501I the contacts in the number "3" row to a conductor as 350B, the first number "5" row to a conductor as 350C, in the second number "1" row to a conductor 350D and in the second number "5" row to a conductor 350E. The conductors 3501I and 350D common to the short contact strips of both number "1" longitudinal rows are connected to the solenoid 396-1 of the pence unit whereas the conductor 350B common to the short contact strips in the number "3" longitudinal row is connected to the solenoid 396-3, while the conductors 350C and 350E common to the short contact strips in both "5" longitudinal rows are both connected to the solenoid 396-5. Likewise in the units shillings, ten shillings, units pounds groups and so on, on the stator 310 the conductors common to the short contact strips in the number "1" rows, the number "3" row and the number "5" rows are connected respectively with the solenoids 396-1, 396-3 and 396-5 in the corresponding units, respectively for these orders.

When the rotor 311 is in operation the rotor bars 337 thereon are adapted to ride over contact strips CS on the stator in such a way as to bridge and close circuit between the contact strips CS and the short contact strips associated therewith. Such bridging of the long and short contact strips actuates the solenoids as 396-1. The contact strips CS are selectively grounded in the operation of the machine and, as will be brought out presently, the source of this ground is the sensing fingers 50 which pass through perforations on the card on the printing and control device under control of which a calculation is being performed.

Thus, if ground is applied to the number "1" long contact strip CS in the pence group and the rotor 311 is rotated it will pass into such a position that one of the bars 337 thereon will close circuit between this long contact strip and the short contact strip adjacent thereto in the number "1" row and thereby ground is applied to the conductor 350X common to all of the short contact strips in the number "1" row and through this conductor to the solenoid 396-1 which thereupon energizes. Energization of the solenoid 396-1 causes rotation of the ring gear 367 associated therewith such a distance as will set the rotor bar 355 of the rotor 350 in the pence group opposite the number "1" contact strip on the stator 359. If instead of the number "1" long contact strip being grounded, the number "2" long contact strip had been grounded, the solenoid 396-1 would have been energized while one of the short bars 337 upon the rotor 311 bridged the number "2" long contact strip and the number "1" short contact strip adjacent thereto in the first of the number "1" rows, but as the rotor 311 continues rotation it will eventually bridge the number "2" long contact strip and the contact strip adjacent thereto in the second of the number "1" rows thereby energizing the solenoid 396-1 a second time, and thereby cause the rotor bar 355 to be moved another step into registry with the number "2" stator contact strip in the pence group.

Assume now that the number "11" long contact strip in the pence of the stator 310 should be grounded while the rotor 311 makes a rotation to wipe the contact strip "11" and the short contact strips adjacent thereto, with one of the short rotor bars 337, the rotor bar 337 will first bridge the space between the long contact strip and the first of the number "1" short contact strips to cause the rotor bar 355 to be moved to a position in registry with the number "1" contact strip of its stator 359, providing the rotor 350 had been previously standing at "0." During continued rotation of the rotor 311, the bar 337 will subsequently bridge the space between the long contact strip and the short contact strip in the first number "5" row thereby causing energization of the solenoid 396-5 and the advancement of rotor bar 355 to the number "6" contact upon stator 359, and during the remainder of the rotative movement of rotor 311 the bar 337 will eventually bridge the space between long contact strip "11" and the short contact strip within the second number "5" row thereby again energizing the solenoid 396-5 and cause the rotor bar 355 to be advanced to the number "11" contact strip upon stator 359.

Selection of a pre-computed product

A description will now be given of the operation of that part of the machine which has thus

far been described, and the understanding of this operation will be aided by reference to the timing chart shown in Figs. 40 to 51. Along the left-hand edge of this chart, in Figs. 40, 44 and 48, the names of various machine parts entering actively into the machine operation are listed, and the times at which these parts are active in the operation of the machine are indicated by heavy horizontal lines to the right and in respective horizontal alignment with the said names. The length of these heavy horizontal lines is proportional to the length of time the respective parts are active. For example, a horizontal line as that set opposite the names Clutch 271-Accumulator rotor 311 in Figs. 40 and 41, and marked with the explanatory notations, 1st rev., 2nd rev., and so forth to 8th rev., indicates the time when the clutch 271 is closed and during which time the transfer mechanism rotor 311 is rotating. This line shows that the rotor 311 makes eight revolutions, the rotation beginning at the instant indicated by the left end of the line and ending at the instance indicated by the right end of said line. Likewise, the horizontal chart-line set oppositely to the names Relay 273-"Unity" multiplier switch, indicates at its left end the instant the relay 273 energizes and at its right end the instant the relay 273 deenergizes. During such energization of the relay 273, the "Unity" multiplier switch is closed.

This timing chart also shows all of the contacts or contact strips upon the synchronizer drum 86, these contact strips being distributed from left to right in the order they pass beneath the brushes 90, Figs. 1 and 1d, during rotation of said drum. Each of these contact strips is identified by the reference character applied in Figs. 1 and 1d. The bars, in their relation to the first machine operation are shown in full lines, while the relation of these bars, in point of time, to the second machine operation which starts before the first operation is completed, are shown in dotted outline. The horizontal lines representing times of operation of the active machine parts all relate to the first machine operation, and hence have their position determined by the bars shown in full line.

Operating cycles of the machine occur during the periods within those sections of the chart indicated by the words First cycle, Second cycle and Third cycle, and their associated arrows near the top of the chart. Also in the upper part of the chart there are explanatory notes regarding the nature of the operation proceeding during the time period coinciding with the space between short vertical lines on opposite sides of these notes. For example, as shown in the upper part of Fig. 40, the note "Sensing of printing and control device and entry in product accumulating apparatus" appears between the short vertical lines L1 and L2, to convey the information that during the time embraced by these lines the printing and control device is sensed and the entry controlled jointly by this device and the multiplier selecting apparatus is entered in the accumulating apparatus.

As is customary in this art, a conveyor chain 72, Fig. 4, and driving means therefor (not shown) are provided for intermittently advancing the printing and control devices 73. In the first operating cycle of the machine a printing and control device 73, Figs. 2 and 3, will be advanced into a position Y1, in which position it is in registry with the sensing fingers 50. At the beginning of the second cycle of the machine

said printing and control device 73 will be advanced into an inactive position Y2 while a next succeeding device is advanced into the position Y1, and at the beginning of the third operating cycle said device 73 will be moved into a position Y3 while said succeeding device will be advanced from position Y1 to position Y2 and a third device 73 will be advanced into the sensing position Y1. By the time a device sensed in the position Y1 has reached the position Y3, the data sensed therefrom in the position Y1 will have had computations made from it, and these computations together with other desired information, hereinafter fully explained, will have been printed upon a paper sheet comprising a check and its attached counterfoil, and this sheet will have been advanced into a position in registry with said printing device at the position Y3 preparatory to having the identification information borne by this printing device imprinted thereon by the actuation of a platen Pd. At present, however, attention need be directed only to the printing and control device 73 in the position Y1.

It will be recalled that the amount of one pound, three shillings and two pence has been set up in the multiplier selecting apparatus. This setting, as stated heretofore, is represented upon the schematic drawing in Fig. 1a. It will be assumed that the card 77 upon the printing and control device 73 advanced into the sensing position Y1, Figs. 2 and 3, has been perforated to contain an aperture registering with the number "2" sensing finger 50 shown in heavy outline in the hundreds order, Fig. 1. The conductor 200S within the cable 63 is connected to the aforesaid number "2" sensing finger 50 and leads to a brush 90 paired with the brush to which conductor 214 is connected, and these brushes are adapted to cooperate with the number "2" contact strip of the group of contact strips associated with the word "Hundreds" upon the synchronizer drum 86.

Thus the set-up of the machine is such that a multiplicand of two hundred is provided, which in the present machine means that the stockholder owns two hundred shares of stock, and a multiplier of one pound, three shillings and two pence has been set up which, as heretofore explained, is the dividend rate.

The motor 272, Fig. 1e, is set in operation whereupon the means (not shown) for intermittently driving the chain 72, Fig. 4, is set in motion as well as the synchroniser drum 86, said drum being driven from said motor through a suitable gear train including the gears 88 and 89 shown in Fig. 2. The timing chart picks up the operation of the machine at a time represented by the vertical dot-dash line Ch1, Fig. 40, at which time the number one printing and control device 73 begins movement into the position Y1 as indicated by the horizontal chart-line Ch2. The right end of the line Ch2 marks the instant when the number one printing and control device arrives in the position Y1 and ceases movement. The intermittent movement of the chain 72 and the rotation of the synchroniser drum 86 are so synchronised that shortly after the number one printing and control device 73 has arrived at the position Y1, the group of "Units" contact strips on said drum will reach their co-operative brushes 90, which are connected to the conductors 1s to 9s. Since the drum 86 rotates in the direction of the arrow B in Fig. 1, the drum contact strips 250 and 255 engage their

cooperative brushes 90 shortly prior to the "Units" contact strips 1 to 9, as will be observed in Figs. 1 and 40, this condition being indicated in Fig. 40 by the left ends of the strips 250 and 255 being slightly to the left of the left end of the block designated "Units 1-9" which has been chosen to collectively represent the units order contact strips 1 to 9 in Fig. 1, inasmuch as all of said strips are of the same length and engage their respective pairs of brushes 90 at the same time. The same system is followed in the representation of the contact strips 1 to 9 in each of the other orders so far as the timing chart is concerned. That is, the block designated "Tens 1 to 9" is representative of the nine contact strips associated with the word "Tens" in Fig. 1, whereas the block designated "Hun. 1 to 9" in Fig. 40 is representative of the nine contact strips 1 to 9 associated with the word "Hundreds" in Fig. 1, and so forth.

When the contact strip 255 engages its associated pair of brushes 90, a circuit will be completed from battery through the conductor 84, Fig. 1, conductor 262, said contact strip 255 and its brushes 90, conductor 269, Figs. 1 and 1e, and through the solenoid 270 to ground for engaging the clutch 271 and thus establishing a driving connection between the motor 272 and the product translator rotor 311 of the product accumulating apparatus. The contact strip 255 is sufficiently long to remain in engagement with its brushes 90 to maintain the just traced circuit established long enough for the rotor 311 to make eight revolutions. The beginning and end of each of these eight revolutions are indicated in conjunction with the chart line Ch3, which is co-terminus with the contact strip 255.

When the contact strip 250 engages its associated brushes 90, a circuit is completed from battery through the conductor 84, Fig. 1, conductor 257, said contact strip 250 and its brushes 90, conductor 263, Figs. 1 and 1b, and through the winding of the units relay 273 to ground, thus energizing this relay and shifting the "Unity" switch to its right-hand position.

It will be conceived, therefore, that when the "Units" contact strips 1 to 9 reach their associated brushes 90, that the translator rotor 311 will be rotating to sweep its wiping contacts 337 over the long and short contacts upon the stator 310, and that the "Unity" switch, Fig. 1b, will be in the position for electrically connecting the "Units" contact strips 1 to 9 with certain of the contacts upon said stator through conductors in the cables leading along the right hand edges of Figs. 1b, 1c and 1d. But since there is no units order perforation in the card 77 aligned with any of the units order sensing fingers 50 which are respectively connected to the conductors 1s to 9s, the action of the "Units" contact strips 1 to 9 in bridging the aforesaid brushes will be ineffective. Hence, as the units contact strips on the drum 86 pass their group of brushes 90, no ground is applied to the multiplier selecting apparatus. This is also true when the "Tens" contact strips on the drum 86 pass their brushes 90 for there are no card perforations through which sensing fingers 50 in the tens order may pass. Horizontal lines Ch4 and Ch5, pertaining to the relays 273 and 274, and respectively vertically aligned with the contact strips 250 and 251 in the timing chart show the times when the relays 273 and 274 are energized, and hence when the "Unity" switch and the switch X10 are closed. At times other than that coinciding with the

duration of the line Ch4, the relay 273 will be deenergized and the "Unity" switch will be in the position shown in Fig. 1b. Likewise, excepting during the time coinciding with the duration of the line Ch5, the relay 274 will be deenergized and the switch X10 will be in the position shown in Fig. 1b.

It will be recalled that conductors 194 to 202 lead through cable 203 from which they emerge in Fig. 1a where, when grounded, they are effective for respectively energizing the relays 177 to 185, thereby attracting the armatures of these relays and supplying ground to the conductors 170 to 175 in the cables as 161 associated with the various "X" rows, as X1, X2 and so forth. If, for example, conductor 194 were to be energized, the armature of relay 177 would be connected with conductors 170 to 175 in the X1 row and thereby supply ground to each of the plates 138, Figs. 7 and 10, in such row and to the contacts 143 associated with said plates. When a printing and control device 73 is in position beneath the sensing head 51 the conductor 194 may be grounded from the metallic frame of such printing and control device by any of the number "1" sensing fingers 50 which may, through an aperture in the card 77, come in contact with the frame. For instance if the card had a perforation aligned with the number "1" finger in the hundreds order said finger would be grounded and this ground would be carried from this finger through the conductor 100S, the number "1" contact in the "Hundreds" group on the drum 86 and the associated brushes 90, conductor 213, and said conductor 194 in the cable 203 to the relay 177.

Now referring back to the rotating synchronizer drum 86, after the contact strip 251 has passed from engagement with the brushes with which it cooperates the "Hundreds" contact strips on said drum move into association with their respective pairs of brushes 90. The conductors as 200s, Fig. 1, are respectively connected to a brush of each pair of such brushes, and, as previously explained, the conductors 194 to 202 are respectively connected to the other brushes of these pairs of brushes through lateral or branch conductors numbered 213 to 221. Hence, in this instance, since the card 77 bears a perforation in the number "2" position in the hundreds order, the sensing finger 50 in this position will ground on the metallic frame of the printing and control device 73 by reason of its passing through this perforation.

It follows that when the hundreds contact strips move into bridging relation with their brushes 90 ground is picked up at said sensing finger 50 and is transmitted through the conductor 200s and its brush 90 to the number "2" hundreds contact strip on the drum 86 and then to a brush to which conductor 214 is connected, said conductor 214 leading to the conductor 195 in the cable 203. The conductor 195 leads to the relay 178, Fig. 1a, which therefore energizes at the time indicated by the chart-line Ch6, Fig. 44, when the hundreds number "2" contact on the drum bridges the just mentioned brushes 90. Meanwhile the contact strip 252 closes the circuit from battery through conductor 84, lateral 259, said strip 252 and its brushes 90, and the conductor 265 which therefore energizes the relay 275, Fig. 1b, to dispose the switch X100 in its right-hand position during the time indicated by the chart-line Ch7.

The energized relay 178 is in the X2 row of the

multiplier selecting apparatus, Fig. 1a, and has the previously explained effect of grounding the conductors 170 to 175 in the X2 row and those contacts 143 of this row that are in cooperative relation with the contacts 146. This arrangement for closing circuit to only the contacts 143 in one row at a time (as the X2 row) prevents feed-backs; for instance, at this time all of the other relays 177 and 179 to 185 are deenergized, wherefore circuits to the contacts 143 in the rows with which these relays are disposed are open. By reason of the setting of the multiplier selecting apparatus for one pound three shillings and two pence the contacts 143 in the X2 row are electrically connected with those of the notational conductors in Fig. 1a representative of two pounds six shillings and four pence. Thus ground is now applied to a conductor representing two pounds in the cable 149, to a conductor representing six shillings in the cable 148, and to a conductor representing four pence in the cable 147.

The grounded pence conductor passes out of the cable 147 in Fig. 1b and leads to the movable contact in the pence portion of the switch "Unity," representative of four pence, which movable contact, since the switch "Unity" is in its left-hand position, engages the left contact of the pair of fixed contacts with which it is to cooperate and this left contact is connected to the movable contact representing three shillings upon the shillings portion of the X10 switch and also to the movable contact in the pence portion of the X10 switch representing four pence.

The grounded shillings conductor passes out of the cable 148 in Fig. 1b and leads to the movable contact in the shillings portion of the switch "Unity" representative of six shillings which movable contact, since the switch "Unity" is in its left-hand position, engages the left contact of the pair of fixed contacts with which it is to cooperate and this left contact is connected to the movable contact representing three pounds upon the units pounds portion of the X10 switch.

The grounded units pounds conductor passes out of the cable 149 in Fig. 1b and leads to the movable contact in the units pounds portion of the switch "Unity," representative of two pounds, which movable contact, since the switch "Unity" is in its lowermost position, engages the left of the pair of fixed contacts with which it is to cooperate and this left contact is connected to the movable contact representing twenty pounds upon the tens pounds portion of the X10 switch.

The switch X100 is in its right-hand position at this time since the relay 275 is energized as indicated by the chart-line Ch7. Hence the movable contacts of this switch are engaged with the right-hand of the pairs of fixed contacts with which they cooperate.

The circuit from the above described grounded pence conductor continues on through the switch X10 into the switch X100 as follows. From the left of the contacts engaged by the movable contact representing four pence at the X10 switch, circuit leads to a movable contact in the X100 switch representing four pence and also to a movable contact in said switch representing three shillings and from the movable contact in the X10 switch representing three shillings the circuit continues on to a movable contact in the X100 switch representing ten shillings and to a movable contact in this last named switch representing one pound.

shillings conductor continues on through the switch X10 into the switch X100, that is, from the left of the contacts engaged by the movable contact representing three pounds circuit leads to a movable contact in the X100 switch representing thirty pounds.

The circuit from the above described grounded units pounds conductor continues on through the switch X10 into the switch X100, that is, from the right-hand of the contacts engaged by the movable contact representing twenty pounds circuit leads to a movable contact in the X100 switch representing two hundred pounds.

It will thus be seen that movable contacts in the switch X100 are grounded in such a way that those movable contacts which are grounded represent the answer to the present problem which is two hundred times one pound, three shillings, two pence, the product of which is two hundred thirty-one pounds, thirteen shillings, four pence. The switches as X100 function essentially as column shift apparatus since they determine whether the finally expressed product shall be one, ten, one hundred, one thousand, and so on times an amount initially determined by the multiplier selecting apparatus and the circuits leading thereto from the multiplicand sensing fingers. If none of the switches as X100 is shifted to the right at the time the conductors in the cables 147 to 152 are grounded to represent said initially determined amount, said initially determined amount will be expressed as the power of 100,000 through the X100,000 group of conductors, Fig. 1c, but when such time coincides with the closing of any of said switches, they being closed singly in rotation, said initially determined amount will be expressed as the power of the numerical part of the reference character of such closed switch and will be represented by energized notational conductors leading from such switch into the cables traversing the right-hand edges of Fig. 1c and 1d.

The movable contacts in the switch X100 when in their right-hand position close circuit to contacts that are connected through conductors which lead into cables 283, 284, 297, 298, 299, 329 and 330 and also into conductor 285. In the present instance conductors lead from the grounded contacts in the switch X100 into cables 283, 284, 297, 298 and 299 and also into conductor 285.

The grounded conductors pass out of these cables and lead to respective long contacts of identical notational and digital significance on the stator 310, Fig. 1e. The grounded conductor leading out of cable 283 in Fig. 1e is electrically connected with the movable four pence contact in the switch X100 and ends in the long four pence contact strip CS in the pence unit on the stator 310. The grounded conductor leading out of cable 284 is electrically connected with the movable contact in the switch X100 that represents three shillings and ends in the three shillings contact strip CS in the shillings unit on the stator 310.

The present product involves thirteen shillings and the just described circuit pertains to the three shillings of this thirteen shillings. In order to enter the ten shillings of this thirteen shillings a conductor 285' leads from the right-hand of the fixed contacts which is now engaged by the grounded movable contact in the switch X100 representing ten shillings and this conductor 285' is connected to the conductor 285. The conductor 285 ends in the long contact strip CS

The circuit from the above described grounded

representing ten shillings in the ten shillings unit on the stator 310.

The grounded conductor leading out of cable 297 is electrically connected with the movable contact in the switch X100 that represents one pound and ends in the long contact strip CS that represents one pound in the units pounds unit on the stator 310. The grounded conductor leading out of cable 298 is electrically connected with the movable contact in the switch X100 that represents thirty pounds and ends in the long contact strip CS that represents thirty pounds in the ten pounds unit on the stator 310. The grounded conductor leading out of cable 299 is electrically connected with the movable contact in the switch X100 that represents two hundred pounds and ends in the long contact strip CS that represents two hundred pounds in the hundreds pounds unit on the stator 310.

Referring now to Fig. 1, the leading end of the contact strip 255 on the drum 86 is aligned with the leading end of the most advanced group of the contacts on said drum, which is to say, those contacts for digits in the units order of the multiplicand, and this strip terminates beyond the end of the last of the contacts on the drum 86 pertaining to the multiplicand which is to say, the contacts for the hundred thousands order of the multiplicand. This contact strip bridges and closes circuit between a pair of brushes 90 to which conductors 262 and 269 are respectively connected. Thus, whenever the synchronizer drum is moving the contacts thereon for the respective orders of the multiplicand past the brushes 90, the long contact strip 255 is closing circuit through the conductors 262 and 269, and thus closing a circuit through these conductors energizes the clutch 271, Fig. 1e, which sets the rotor 311 in operation during the time represented by the chartline Ch3 in Fig. 40.

The circuit for so energizing the clutch 271 is as follows, from battery conductor 84, Fig. 1, through conductor 262 and its brush 90, conductor strip 255, the other brush of the pair, through conductor 269 to one end of the winding of the solenoid 270, Fig. 1e, the other end of which winding is grounded.

Thus at the time the contacts on the synchronizer drum 86 pertaining to the multiplicand start moving past the brushes 90, the rotor 311 will be in operation by reason of the energization of clutch 271 upon energization of the solenoid 270. The speed of operation of the rotor 311 is such that it makes one complete revolution during the passage of each notational group of contact strips on the synchronizer drum 86 past the brushes 90, said rotor 311 making one revolution while the contact strips for the units order pass the brushes 90, another revolution while the contact strips for the tens order pass the brushes 90, and so on as is clearly illustrated by the timing chart in Fig. 40 where the contacts "Units 1-9" are shown to coincide in point of time with the first revolution of the rotor 311, the contacts "Tens 1-9" to coincide in point of time with the second revolution of said rotor, and so on.

The effect of this is that if a sensing finger 50 for the units order of the multiplicand is grounded by reason of its having passed through a perforation in the control card 77, the long contact strips CS on the stator 310 selected in the manner just described are grounded and the rotor 311 moves the rotor bars 337 thereon over these grounded contact strips CS in such a way that the bars 337 successively close circuit between the long

contact strips CS and the short contact strips associated therewith, and it is the successive passage of the rotor bars 337 over grounded contact strips CS and their associated short contact strips that energizes the solenoids as 396-1.

In the present instance however where the multiplicand is two hundred, none of the fingers 50 are grounded during the time the contact strips on the synchronizer drum 86 for the units order are passing the brushes 90. Hence none of the long contact strips CS is grounded at this time. This likewise applies in so far as the contact strips on the synchronizer drum 86 for the tens order are concerned. Hence the rotor 311 makes two rotations in the present instance without effecting operation of any of the solenoids as 396-1.

However as the contact strips on the synchronizer drum 86 for the hundreds order move into association with the brushes 90, ground is applied therethrough in the manner previously described to a contact strip CS in the hundreds pounds unit of the stator 310 representing two hundred pounds and also to contact strips CS respectively representing thirty pounds, one pound, ten shillings, three shillings and four pence. Simultaneously with the grounding of these contact strips CS the rotor 311 starts its third revolution (see chart line Ch3, Fig. 40) and the rotor bars 337 thereon respectively move into wiping engagement with the contact strips CS with which they are aligned and move along these contact strips, it being appreciated that only the grounded of the contact strips CS will be effective.

There is a motor unit consisting of front and back plates as 370 and 371, solenoids as 396-1, and a ring gear as 367, for pence, "1" to "9" or units shillings, "10" shillings, units pounds, hundreds pounds, and so on.

Now referring first to the pence unit on the stator 310, associated with the long contact strip CS thereon for four pence, there is a short contact in the first longitudinal row numbered "1" at the right-hand end of the stator as shown in Fig. 1e and there is also a short contact in the longitudinal row associated with the numeral "3." Now as the rotor bar 337 for this four pence strip CS moves along this strip it first engages the short contact in the first of the number "1" longitudinal rows whereupon circuit between the contact strip CS and this short contact is closed. This short contact is connected through conductor 350X to the solenoid 396-1 of the motor unit for pence and as circuit between the contacts is closed ground is applied to one end of the winding of this solenoid, the other end being connected to battery, and thereupon this solenoid energizes at the time indicated by the chart-line Ch8 and actuates the segmental gear 403 thereof, Fig. 14, in such a way that the ring gear 367 of this unit is advanced one space. As the rotor bar continues movement along the four pence contact strip CS it disengages the short contact in the number "1" longitudinal row and moves into engagement with the short contact in the number "3" longitudinal row and in this instance the solenoid 396-3 in the pence motor unit is energized during the time spanned by the chart-line Ch9 whereupon the ring gear 367 on this unit is advanced three additional spaces. This ring gear was already advanced one space so that the advancing thereof three additional spaces causes it to be advanced four spaces in all.

The final entry in the product accumulator is made in the rotor stator assembly comprising

the rotors 350 and the stators 359, Figs. 1e, 14, 15 and 16. This entry in these rotor units is effected by setting the bar 355 thereof in engagement with a contact on the stator 359 representative of the value to which the rotor 350 is to be set. More specific reference to these contacts will be made hereinafter so that for the present the rotors 350 will be described as being set to various values. Each rotor of the assembly comprising the rotors 350 and the stators 359 as heretofore described has fixed thereto a gear as 353 and these gears respectively mesh with the ring gears as 367 of the motor units. The gear 353 on the pence rotor 350 meshes with the ring gear 367 of the pence motor unit and as the ring gear 367 was moved in an amount equivalent to one penny and then in an amount equivalent to three pence, the gear 353 advanced the rotor into a position first representative of one penny and then into a position representative of four pence and in this particular cycle of operation this rotor 350 comes to rest in this position because as the rotor bar 337 continues to move along the four pence strip CS it does not contact any more short contact strips and hence no more of the solenoids as 396—1 are energized and therefore no additional movement is imparted to the ring gear 367 of the pence unit and hence no movement is imparted to the rotor 350.

Simultaneously with the advance of a rotor bar 337 over the four pence contact strip CS another rotor bar advanced over the three shillings contact strips CS and as this rotor bar moved along this contact strip it closed a circuit between this contact strip and a short contact strip in the number "3" longitudinal row, Fig. 1e, and when this circuit was closed ground was applied to the solenoid 396—3 in the "1" to "9" or units shillings motor unit whereupon the ring gear 367 of this unit and the gear 353 meshing therewith and the "1" to "9" or units shillings rotor 350 were advanced during the time period represented by the chart-line Ch10 and brought to rest so that this rotor is positioned to represent three shillings.

Simultaneously with the advance of rotor bars 337 over the four pence and three shillings contact strips CS a rotor bar 337 advanced over a contact strip CS to which the conductor 285 is connected. This contact strip has a short contact associated therewith in the number "1" longitudinal row, Fig. 1e, and when the rotor bar 337 closed circuit between this short contact and the just mentioned contact strip CS circuit was closed to the solenoid 396—1 of the ten shillings motor unit whereupon the ring gear 367 of this unit and the gear 353 associated therewith were rotated during the time period represented by the chart-line Ch11 with the result that the ten shillings rotor 350 was set to represent ten shillings.

In the manner just described, and also during the third revolution of the rotor 311, the rotors 350 for units and tens pounds are respectively set to represent one pound and thirty pounds and the rotor 350 for hundreds pounds is advanced to represent two hundred pounds. Entry of the one pound upon the units pounds rotor 350 occurs at the time represented by the chart-line Ch12 while a rotor bar 337 bridges the one pound contacts CS and the short contact alongside thereof in the number "1" longitudinal row, Fig. 1e, whereas entry of the thirty pounds upon the tens pounds rotor 350 occurs at the time represented by the chart-line Ch13 while a rotor

bar 337 bridges the thirty pound contact C5 and the short contact alongside thereof in the number "2" longitudinal row. The entry of two upon the hundreds order rotor 350 is accomplished in two steps, there being a first entry of one upon this rotor at the time represented by the chart-line Ch14 while a rotor bar 337 bridges the number "2" contact CS in the hundreds pounds order and the short contact alongside thereof in the first number "1" longitudinal row, and a second entry of one upon this rotor at the time represented by the chart-line Ch15 while said bar 337 bridges said contact CS and the short contact alongside thereof in the second number "1" longitudinal row.

It will be appreciated that the short contact strips associated with the contact strip CS are so arranged that the energization thereof will bring about advance of the rotor unit 350 pertaining to the contact group with which the long contact strip is associated, in an amount equivalent to the value of the particular contact strip CS. This is done by providing one or more short contact strips in association with the particular contact strip CS. In connection with the entry of four pence and two hundred pounds the manner in which two short contact strips are employed has been explained but if for example any of the rotors 350 would need to have been set to represent a "7" the short contact strips would have been provided in both number "1" longitudinal rows, Fig. 1e, and also in one of the number "5" longitudinal rows. The number and arrangement of the short contact strips to secure any particular numerical value is a mere matter of permutation and will be readily understood by one skilled in the art.

The product of the particular multiplication now being described has now been entered on the rotors 350 and only the rotors adapted to receive a quantity represented by a significant digit have been advanced for where a zero condition prevails either because the rotor is in an order greater than required by the product or because there is no value, as where there would be no pence, the rotor remains in zero position.

It will be appreciated that the rotors 350 might be printing wheels, recording dials or any other type of amount manifesting device but, in the present instance where the machine is adapted to do more than compute a product, these rotors are set up to represent the value of the product so that further operations in the machine may be effectuated from the setting of such rotors. Such additional operations in the present instance are the computing of the amount of tax that is to be paid on the dividend which the computed product represents as well as determination of the net value of the dividend, which is to say, the gross dividend which is the aforesaid product minus the amount of tax. One manner in which the amount of tax and the net dividend may be ascertained will be described presently.

However, before explaining how the amount of tax and net dividend is ascertained in the present machine, it will be explained that if, for example, a sensing finger 50 in the units order had been grounded an entry would have been made in the rotors 350 in the manner previously described. Thus, supposing that the sensing finger in the units order had passed through a perforation representative of the digit "9" and the multiplier selecting apparatus was set as heretofore, which is to say, for one pound, three shillings and two pence, the resulting product would be

ten pounds, eight shillings and six pence, this multiplication being effected by actuation of the switch "Unity." With this product the tens order pounds rotor 350 would be set at "1" to represent ten pounds, the "1" to "9" or units shillings rotor 350 would be set to represent eight shillings, while the pence rotor 350 would be set to represent six pence.

Now supposing further that a sensing finger 50 in the tens order had passed through a perforation representing the digit "3," the resulting product would be ninety-two pounds, thirteen shillings and four pence, this multiplication being effected by actuation of the switch X10. In this instance, in the manner previously described, the four pence of this product is to be entered on the pence rotor 350. This rotor already stands at six pence so that as a result of this operation this rotor is advanced to represent ten pence.

At this point it should be noted that the pence rotor 350 and the motor unit for pence have a capacity of twelve pence, which is the number of pence in a shilling, although only eleven pence are ever actually entered on this rotor, for in the entry of a twelfth pence thereon a carry-over is made into shillings. A unit having a capacity of twenty shillings could have been provided but so to do would have required providing a unit for shillings twice the size of the units provided for the various order of pounds but this wide discrepancy in size does not occur in the pence unit which is arranged to accommodate twelve pence. In fact, the unit for pence may be the same size as the other units, it merely being arranged to accommodate twelve units instead of ten. In view of this structural characteristic the rotors 350 and the parts associated therewith that pertain to units shillings, ten shillings, units pounds and so forth, are all arranged in such a way that the entry of each unit therein causes an advance of the rotor one-tenth of a revolution. But in so far as the pence rotor 350 is concerned the entry of each unit, which is to say, each penny therein, causes the rotor to advance one-twelfth of a revolution. In order that this condition may be brought about the internal gear teeth on the gear 367 for pence and the teeth on the mutilated gears meshing with this internal gear are arranged differently than the internal gear teeth and the mutilated gears of the other motor units and it is in this way that the advancing by twelfths in pence is accomplished whereas elsewhere the advancing is by tenths.

Now returning to the multiplication of eighty times one pound, three shillings and two pence, the product so far as shillings is concerned is thirteen. The "1" to "9" or units shillings rotor 350 stands at "8" and the entry of the "3" of this 13 shillings will tend to advance this rotor to represent "11." This rotor however has a capacity for only an entry of "10" so that, in this entry operation, as it passes from "9" to "0" a carry-over will be made onto the ten shillings rotor 350 and this is effected in the following manner.

It will be recalled that all rotors 350, except that pertaining to the highest order or hundred thousand pounds in the present machine, have thereon a special rotor bar 355A. Furthermore, each stator 359, except that of the highest order, has a pair of special contacts as 363 and 364 which are disposed on the stator in alignment

with the space between, in the case of the rotors having a capacity of ten, the "9" and the "0" positions, the "0" position being indicated by broken lines while the "9" position is indicated by a contact. In so far as the pence arrangement is concerned, special contacts as 363 and 364 are located between the contact for eleven pence and the zero position indicated by broken lines. Another special condition, to be explained presently, is provided in the unit for "10" shillings.

In an entry such as the aforesaid entry of thirteen, as the rotor bar 355A on the "1" to "9" or units shillings rotor 350 passes over the contacts 363 and 364 on the cooperating stator, the following circuit is closed: Battery is found at conductor 269 Fig. 1e which at this time is potentialized to maintain clutch 271 energized, and the circuit is extended through a conductor 269' leading from said conductor 269 to contacts as 364. From each contact as 363 a conductor as 451 leads to one end of the winding of a solenoid as 437, the other ends of such windings being grounded. It will thus be seen that when a rotor bar as 355A bridges a pair of contacts 363 and 364 a circuit is closed which energizes a solenoid 437.

In each instance the solenoid 437 which is energized is associated with the motor unit which drives the next higher rotor 350. These solenoids 437 are those which have been described as operating segments 434, Fig. 14, which drive gears as 432 and single tooth gears as 430 which impart movement to the teeth about the periphery of the back plate 371 associated therewith to advance the entire motor unit a distance which causes the rotor 350 driven by the particular ring gear 367 of the motor unit to be advanced an amount equivalent to one unit.

The drive imparted to the rotor 350 from each motor unit is normally against the back plate 371, which acts as a reaction member, but the movement incident to a carry-over, effected as just described, advances this back plate which, being the reaction member, causes advancement of the gear 367 associated therewith. If the gear 367 is in motion at the time a carry-over is being made the back plate moves concurrently with the gear and the cumulative effect of this combined movement is to advance the rotor 350 being driven by the particular gear 367 the distance it should be driven by the actuated of the solenoids as 396—1 plus the movement imparted to the back plate 371 or movement which will cause entry of one additional unit. If the gear 367 is not in motion at the time a carry-over is made the result is to advance the proper rotor only one unit. An important advantage of this arrangement is that the carry-over can be made at the same time an entry is being made which obviously speeds up operation of the device since it is not necessary to await a carry-over before proceeding with a succeeding action.

When a carry-over is made at the time an entry is being made, the connection between the ring gear 367 and the back plate 371 is through the teeth of a mutilated gear as 378. But when a carry-over is made at the time when an entry is not being made, as in the present instance, the motivation of the back plate 371 imparts drive through a pawl 425A, Fig. 14, to the ring gear 367, the effect of this pawl being suppressed when the back plate 371 is connected to the ring gear 367 through a mutilated gear as 378 because when

an entry is being made the ring gear 367 is being dragged past the pawl which is therefore ineffective. The electro-magnet 426A associated with the pawl 424A is actuated in a zero-setting operation that will be described later.

In the present instance where the units digit "3" of the "13" is entered on the "1" to "9" or units shillings rotor 350 and the tens digits "1" of the "13" is entered on the ten shillings rotor, the carry is made onto the ten shillings rotor while it is stationary for while conductor 285 is energized in the entry of this particular product so that ten shillings or one unit will be entered on the ten shillings rotor, this entry of one unit will be completed before the rotor bar 355A on the "1" to "9" or units shillings rotor passes the contacts 363 and 364 on the cooperating stator; that is said digit "1" is entered while the rotor bars 337 pass the first number "1" longitudinal row of short contacts on the stator 310 whereas said digit "3" is entered later while the rotor bars 337 pass the number "3" longitudinal row of contacts on the stator 310.

At the end of the operation which involves the entry of "3" on the "1" to "9" or units shillings rotor 350, this rotor stands in such a position that it represents one shilling inasmuch as three shillings have been added to the eight shillings already standing therein. The carry-over operation incident to this entry of "3" caused a unit to be added on the ten shillings rotor 350 into which, as above explained, a unit or ten shillings was entered prior to the entry of the carry-over. Thus when the carry-over is entered on the ten shillings rotor 350 this rotor in effect stands in such a position that it would normally represent twenty shillings. Twenty shillings however equal one pound so that instead of the rotor 350 for ten shillings standing in such a position that it represents twenty shillings, it in reality stands at a zero position and a carry-over is made into the units pounds rotor 350.

The ten shillings stator 359 has carry-over contacts 365 and 366, respectively corresponding to the contacts 363A and 364A on the pence stator and to the contacts 363 and 364 on the other stators in Fig. 1e, these pairs of carry-over contacts 365 and 366 being located between each contact representing an odd digit and the position the rotor will occupy when it stands to represent an even digit these later positions being indicated by broken lines in Fig. 1e. The reason for this is that whenever this rotor 350 is positioned to represent say "1," "3," "5" or so forth digits it is representing only ten shillings because whenever it is positioned to represent an even digit a carry-over is made into the units pounds rotor 350.

Thus in the present instance where it was set to represent one unit or ten shillings in an ordinary entry operation and where it was set to represent two units or twenty shillings by reason of the carry-over, this rotor is positioned so that it actually is set to represent zero because as it passed from the position representing one unit or ten shillings a rotor bar 355A on this rotor passed a pair of contacts 365 and 366 which effected energization of the solenoid 437 associated with the units pounds motor unit to therefore advance the units pounds rotor 350. Now if an additional entry of one unit or ten shillings were to be made onto the ten shillings rotor it would be advanced into a position physically representative of three units or thirty shillings, but in so advancing to such position there would have

been a carry-over to the units pounds rotor 350 so that in reality the rotor 350 for ten shillings would again only be representing ten shillings. Still further, if still another entry were made onto this rotor again a succeeding pair of contacts 365 and 366 would be bridged and again a carry-over would be made into units pounds so that while at the end of this entry the rotor 350 for ten shillings would be standing in its fourth position it would actually be representing zero shillings.

Now referring again to the multiplication of one pound, three shillings and two pence by eighty, it has been explained how the rotor 350 for pence has been positioned to represent ten pence because in the previous multiplication of the multiplier one pound, three shillings and two pence by nine this rotor was set to represent six pence while, in the later multiplication of the aforesaid multiplier by eighty, four additional pence were entered therein.

Furthermore, in the first multiplication, that is, nine times the multiplier, eight shillings were entered on the "1" to "9" shillings rotor 350 and then, in the multiplication by eighty, three more shillings were entered therein which caused this rotor to be advanced to represent one shilling. A carry-over incident to this entry, in addition to a direct entry incident to the multiplication by eighty, caused the ten shillings rotor 350 to be set to represent zero shillings, an entry of one unit onto the units pounds rotor 350 having been effected incident to such zero positioning of the rotor 350 for ten shillings.

In the multiplication of nine times one pound, three shillings and two pence the units pounds rotor 350 was not advanced since the product in so far as pounds was concerned was ten pounds wherefore the entry of one unit was made onto the tens pounds rotor 350. In the multiplication of eighty times the aforesaid multiplier there is in addition to the carry-over from the ten shillings rotor 350 an entry of two pounds on the units order pounds rotor 350, this latter entry being made under control of a long contact CS and associated short contacts. Hence at the end of the multiplication of eighty times the aforesaid multiplier the units order pounds rotor 350 stands in a position to represent three pounds.

In this latter multiplication an entry of nine units or ninety pounds is to be made onto the tens order pounds rotor 350 which already stood at "1" by reason of the multiplication of the aforesaid multiplier by nine. This entry of nine units onto this tens order pounds rotor 350 in addition to the one already standing thereon causes this rotor to be advanced to its zero position and incident to the advancement of this rotor into its zero position a carry-over is made, in the manner previously described, into the hundreds order pounds rotor 350 which is advanced one unit or to represent one hundred pounds.

The multiplication of nine times one pound, three shillings and two pence and then of eighty times this multiplier is in effect a multiplication of this multiplier by eighty-nine and at the end of this multiplication rotors 350 are set to represent one hundred three pounds, one shilling and ten pence.

Now referring back to the multiplication of one pound, three shillings and two pence by two hundred, which is to say, the operation illustrated in the timing chart and in the present instance the multiplication of a dividend rate of one pound, three shillings and two pence by the

holdings of a stockholder which are two hundred shares, the hundreds order pounds rotor 350 has its rotor bar 355 positioned to engage a contact on the cooperating stator 359 representative of two hundred pounds; the tens order pounds rotor 350 has its rotor bar 355 positioned to engage a contact on the cooperating stator 359 representative of thirty pounds; the units order pounds rotor 350 has its rotor bar 355 positioned to engage a contact on the cooperating stator 359 representative of one pound; the ten shillings rotor 350 has its rotor bar 355 positioned to engage a contact on the cooperating stator 359 representative of ten shillings; the "1" to "9" or units shillings rotor 350 has its rotor bar 355 positioned to engage a contact on the cooperating stator 359 representative of three shillings; and the pence rotor 350 has its rotor bar 355 positioned to engage a contact on the cooperating stator 359 representative of four pence.

Following this entry of two hundred thirty one pounds, thirteen shillings and four pence in the accumulating apparatus during the third revolution of the translator rotor 311 as is illustrated in Fig. 40 of the timing chart, said rotor continues rotating until it completes an even number of revolutions so it will maintain its phase relation with the other parts of the machine. During the fourth and fifth revolutions of this rotor the solenoids of the relays 276 and 277 are respectively energized to shift the X100 and X10,000 switches to the right in Fig. 1c and during the times indicated by the chart-lines Ch16 and Ch17, but no entries are incurred since no perforations exist in the thousands and ten thousands orders of the control card 77. Concurrently with the sixth revolution of the rotor 311 the "Hundred thousands 1 to 9" contacts on the drum 86 and as shown in Fig. 40 wipe their brushes 90 but also without effect because of the absence of perforations in the hundred thousands order of said control card. The seventh and eighth revolutions of the rotor 311 which are indicated in Fig. 41 would accommodate enlargement of the machine capacity to the extent of two more orders in the multiplicand determined by the control card. Such enlargement would, of course, necessitate a corresponding increase in the notational rows of sensing fingers 50, additional groups of contacts 1 to 9 on the drum 86, additional column shift switches as X10, and the enlargement of the circuit connections for these parts. Rotation of the rotor 311 ceases at the end of the eighth revolution at the point in vertical alignment with the right or trailing end of the synchronizer drum bar 255, Fig. 41, upon such end of this bar passing from contact with its brushes 90 and the opening of the actuating circuit for the clutch 271, Fig. 1e.

As stated heretofore, this set-up of the rotors 350 and the selection of digitally significant contacts as above described might be used for printing or for recording or for any other purpose and it might be used to control the set-up of printing means or the like independent thereof such as the means for printing the gross dividend in the present instance. But in the machine as illustrated this setting is utilized to control other computations and the manner in which this is done will now be described.

Proportionating apparatus

In the present instance the product ascertained and entered upon the rotors 350 is proportionated, which is to say, in the present in-

stance the amount of tax due and payable on the gross dividend represented by such product is computed as well as the net dividend, which is the gross dividend less the amount of tax, and while the proportionating apparatus is shown herein as receiving the numerical data which the product represents from the rotors 350, it is to be understood that in so far as this particular apparatus is concerned the numerical value might be derived from any source, as directly from punched cards or from other apparatus determining numerical values.

In the present instance the proportionating apparatus is set up manually and this is done by properly interconnecting, in the present instance, bus bars, but it is to be understood that other suitable means might be employed in place of the bus bars, the object of the apparatus being merely to establish predetermined interconnections between certain conductors.

The proportionating apparatus, as illustrated in the accompanying drawings, consists of a grid comprising a plurality of longitudinally extending bus bars and a plurality of transversely extending bus bars, the bus bars being so arranged that each longitudinal bar traverses each transverse bar. The interconnections referred to heretofore are made at the points of traversing or intersection as it may be called, of the bus bars. In the present instance the proportionating apparatus is employed for two purposes and therefore two grid arrangements are provided and it is to be understood that a greater or less number might be provided without departing from the purview of my invention.

The structural arrangement of the bus bars is illustrated in Figs. 19 and 20. All of these bus bars are mounted in a casing 999 which has brackets as 909 on the side walls thereof and between which brackets strips of insulating material as 908 are extended in spaced apart relation, these strips of insulating material being supported by said brackets. Other strips of insulating material as 907 are mounted above the strips as 908 and extend in parallel relation between the side walls of the casing, and the strips as 907 are supported from the strips as 908, spacers as 907A being interposed between the strips in alignment with the horizontal shelf-like portions of the brackets as 909. The longitudinal bus bars as 910A are rested upon the insulating strips as 907, said bars being supported by said strips. At spaced intervals along the overlying bus bars 910A and insulating strips as 907 openings are provided and grommets as 906 are mounted in these openings to firmly interconnect the bus bars and insulating strips. The transverse bars as 911A, to which reference has been made, extend beneath the insulating strips as 908 transversely of said strips, each bar as 911A being aligned with the grommets interconnecting the bars as 910A and the strips as 907. The transverse bars as 911A are connected to the insulating strips as 908 at their points of intersection by grommets as 906A. The consequent arrangement is that there is a grommet as 906A in alignment with each grommet as 906 and all of these grommets are made of conductive material.

A plurality of plugs as 911 are provided which pass through openings in the upper wall of the casing 999 aligned with the aligned grommets as 906 and 906A. Locking rods as 915 extend between the end walls of the casing 999 in parallel relation with the bus bars as 911A and these

rods are insulated from said casing. Each plug 911 has two spaced notches as 913 and 914 in the stem thereof that are selectively engageable with the locking rods as 915. When the lowermost of the notches as 914 in the stem of a plug as 911 engages the associated locking rod, the plug is held in such a position that it extends only into a grommet as 906, but when the uppermost of the notches as 913 is engaged with the locking rod as 915 then the plug extends through both the grommet as 906 and the grommet as 906A with which it is to cooperate. Normally the plugs as 911 are all disposed in an upper position with the lower notches as 914 thereon engaging the cooperating locking rod, but when a finger piece as 912 on the plug is grasped and the plug is pushed inwardly into the position occupied by the next to the last plug to the left in Fig. 20, it is in, what may be called, its operative position.

Referring now to the schematic views Figs. 1f to 1j wherein the longitudinal and transverse bus bars generally indicated by 910A and 911A respectively, are diagrammatically shown and also to Fig. 1e, it will be seen, when the lower end of Fig. 1f is aligned with the upper end of Fig. 1e, that each digitally significant contact on each stator 359 is respectively connected to a longitudinal bus bar as 910A. The longitudinal bus bars, in common with other apparatus previously described, are arranged in groups and the group of longitudinal bus bars 910A at the right hand end of Fig. 1f pertains to pence, the next group to the left pertains to "1" to "9" or units shillings, the next to the left to ten shillings, the next to the left to units pounds and so on. The aforesaid interconnection between the contacts on the stators as 359 and the longitudinal bars as 910A is such that the contact on the stator as 359 pertaining to one penny is connected to the bus bar as 910A pertaining to one penny, and as further examples the contact pertaining to three shillings is connected to the bar as 910A pertaining to three shillings and the contact in the units order pounds pertaining to four pounds is connected to the bar as 910A pertaining to four pounds in the units pounds group. Hence it will be seen that for each contact on a stator as 359 there is a longitudinal bus bar as 910A.

In so far as each grid structure is concerned, the longitudinal bars as 910A are the incoming bars while the transverse bars as 911A are the outgoing bars. In other words, when a computation is to be continued on through a grid of the proportionating apparatus, a connection is established between the proper longitudinal bars and transverse bars and which constitute the proper bars is determined as follows:

Referring now to Figs. 1f, 1g and 1h where, for the purpose of the present machine, a proportionating apparatus or grid is shown for determining the tax to be paid on the gross dividend, selected of the plugs as 911, Fig. 20, represented by dots in these views are pressed inwardly into operative position to interconnect selected of the longitudinal bars with selected of the transverse bars and which of these plugs is to be so pushed inwardly is to be determined as follows:

In the present instance the tax rate is five shillings per pound and it will be remembered that each of the longitudinal bars 910A represents a predetermined amount. Likewise, each of the transverse bars 911A represents a predetermined amount. Hence in the present in-

stance interconnection is established between each longitudinal bar 910A and one or more transverse bars 911A in such a way that the selected, that is to say, connected, transverse bar or bars represents the amount of tax on the amount represented by the longitudinal bar under the rate of five shillings per pound.

For example, the longitudinal bar 910A representative of one pound, which bar in Fig. 1f is indicated by 910P has the plug 911 therein above the transverse bar 911A, representing five shillings, which bar in Fig. 1f is indicated by 911S, pushed inwardly to operative position so that electrical connection is established between this longitudinal bar 910P and this transverse bar 911S so that if the longitudinal bar is potentialized the transverse bar will also be potentialized, which means, in the present instance, that if a dividend of one pound were payable a tax of five shillings would be determined thereon. A further example is that if the bar 910A representative of ten shillings is selected, which bar in Fig. 1f is indicated by 910S, this bar will be connected by moving plugs 911 thereon into operative position so as to establish connection between this bar 910S and the transverse bars representative of two shillings and six pence, which is the amount of tax on ten shillings at the rate of five shillings per pound, these transverse bars being indicated by 911T and 911P in Fig. 1f. A still further example is the bar 910A for seven pounds, which is indicated by 910G in Figs. 1f and 1g. The tax on seven pounds at the rate of five shillings per pound is one pound, fifteen shillings, and this amount of tax would be impressed upon the transverse bars 911A by moving plugs 911 into operative position to establish connection between the seven pounds bar 910G and a transverse bar 911A, indicated in Fig. 1g by 911G, representative of one pound, also between a transverse bar indicated by 911Y in Fig. 1f representative of ten shillings and a further transverse bar, indicated by 911S in Fig. 1f, representative of five shillings.

It will thus be seen that one or more connections between a bar 910A and bars 911A may be required depending upon the result of the computation. Furthermore, referring to the just set forth examples, it will be recalled that there is a connection between the transverse bar 911S for five shillings and the longitudinal bar 910P for one pound and also the longitudinal bar 910G for seven pounds so that two connections are made to the five shillings transverse bar 911S. The effect of this would be that if the one pound bar 910P were potentialized, the seven pounds bar 910G would also be potentialized. When the one pound bar 910P is potentialized, it is intended that only the transverse bar 911S for five shillings should be potentialized, but if, as here, the seven pounds bar 910G would also be potentialized, the result would be to potentialize the transverse bars 911G and 911Y for one pound and ten shillings, respectively as well as the five shillings bar 911S because the seven pounds bar is connected not only to the five shillings transverse bar 911S but also to the one pound and ten shillings transverse bars 911G and 911Y. The effect of this would be to compute a tax of one pound and fifteen shillings on one pound instead of a tax of five shillings.

This is overcome by providing the following arrangement: A plug board 533, Fig. 21, of insulating material is provided in which there are a plurality of sockets 534, in each of which sock-

ets there is an upper contact 535 and a lower contact 536 insulated one from the other. Jacks 527 are also provided and each of these jacks includes an upper contact strip 528 and a lower contact strip 529, respectively adapted for engagement with the contacts 535 and 536 when the jack is inserted into a socket 534. In addition to this plug board, special plugs 411A are provided which are similar to the plugs 911 except that the plugs 411A include a tip 521 of conductive material and a sleeve 523 of insulating material about the periphery of which sleeve there is a sleeve of conductive material 524, the sleeve of conductive material 524 being insulated by the sleeve 523 from the conductive tip 521. When a plug 411A is to be inserted in lieu of a plug 911 in the grid shown in Figs. 19 and 20, the jack 527 associated with said plug 411A will be concurrently placed in any conveniently available socket 534 in the board 533. The sleeve 524 has upper and lower notches 413A and 414A therein for the same purpose as the notches 913 and 914 in the stem of the plugs 911. A conductor 522 extends through the sleeve 523 and is in conductive relation with the tip 521. Said jacks 527 and plugs 411A are connected together in pairs of both mechanically and electrically by a flexible cable (not shown) including conductors 525 and 526, and it is anticipated that those paired units not in use will be stored out of association with both the board 533 and the grid, Figs. 19 and 20. Each conductor 526 interconnects the contact strip 529 of a jack with the sleeve 524 of its cooperating plug while each conductor 525 interconnects the contact strip 528 of a jack with the conductor 522 and therefore with the conductive tip 521 of its cooperating plug. Circuits respectively including conductors 539 and 539A interconnect each contact 536 with the contact 535 in the same socket 534. A circuit interrupter 537 similar to those illustrated in Fig. 18 is provided in series with each pair of conductors 539 and 539A. The next to the lowermost of the circuit interrupters, enclosed by a dotted line, is completely illustrated diagrammatically whereas the lowermost of said interrupters is shown symbolically similarly to those in Fig. 1b. It will be seen that the impression of battery on a contact 536 will result in energization of the associated electromagnet 537A, and the pivotal movement of the armature 537B for closing the contacts 539C and 539D, thereby completing the circuit for the flow of current from the contacts 36 to its associated contact 535. However, the current limiting devices 537 will not facilitate the flow of current in the opposite direction should battery be applied to a contact 535 because this would merely potentialize a circuit dead-ended at the associated contact 539C.

Plugs as 411A are employed in each instance where two or more of the longitudinal bars 910A are connected to a common one or more of the transverse bars 911A as, for example, in the instance set forth above where the bars 910G and 910P are connected to the common transverse bar 911S. When a plug 411A is inserted at an intersection as just described, the sleeve 524 thereof is electrically connected with the longitudinal bar while the conductive tip 521 thereof is connected with the transverse bar. When current is to flow from a first longitudinal bar to the transverse bar, the flow will be in the direction of the arrow F, Fig. 21, and in this instance the circuit interrupter 537 will function

in the manner previously described to enable this circuit to be established. However, in an instance where a second longitudinal bar that is also connected to said transverse bar is potentialized to potentialize said transverse bar, the conductive tip 521 of the plug 411A at the first bar will be potentialized, but this will merely potentialize the associated contact 535 of the board 533 and hence will not result in energization of the electromagnet 537A, wherefore circuit cannot be established through the circuit interrupter 537 to the first longitudinal bar. The effect of this will of course be to prevent a feedback and erroneous potentialization of longitudinal and consequently transverse bars 911A.

In the present instance where potential for the longitudinal bars 910A is to be derived from contacts on the stators 359 and more specifically when the rotors 350 associated with these stators are set to represent the above described product of two hundred thirty-one pounds, thirteen shillings and four pence, longitudinal bars as follows are potentialized, the bar 910B representing four pence, the bar 910C representing three shillings, the bar 910S representing ten shillings, the bar 910P representing one pound, the bar 910D representing thirty pounds and the bar 910E representing two hundred pounds, each of these bars being located in its respective group.

In computing taxes under various tax rates, there will be instances where the result will be in fractions of a penny and provision is made to take care of such a condition and to this end a group of nine transverse bars, generally indicated by SP, Fig. 1f, are provided in addition to the regular transverse bars 911A, which regular transverse bars, like the longitudinal bars 910A, are arranged in groups for pence, "1" to "9" shillings, ten shillings, units order pounds, etc. The group of bars SP are arranged adjacent to and are in addition to the eleven transverse bars 911A for pence, and plug connections are intended to be respectively established between the transverse bars of the group SP and the longitudinal bars 910A in the same manner as that in which connection is made between the regular transverse bars with the longitudinal bars, which is to say, by means of plugs as 911 or 411A. The manner in which the bars of the group SP effect entries is explained more fully hereinafter, it being sufficient for the present purpose to explain that no entry is made when a bar or bars in the group SP representative of one-tenth penny to five-tenths penny is or are potentialized, but when a bar or bars in this group representative of six-tenths penny to nine-tenths penny is or are potentialized, the entry of an additional penny is effected.

Prior to the time the machine is set in operation plugs 911 or 411A will be moved into their operative position for every possible contingency within the capacity of the machine according to a given tax rate. Different tax rates require different arrangements of the plugs, and in the present instance where the rate is five shillings per pound the plugs will be placed in operative position at the intersections at which small circles are placed. It so happens with this tax rate that most of these plugs commonly engage a transverse bar with one or more other plugs which are respectively engaged with a different longitudinal bar or bars wherefore it is essential that most of these plugs shall be of the character as the plug 411A, although this is not the situation with all tax rates as will be pres-

ently explained with respect to a tax rate of 10 per cent. But referring to the drawings in Figs. 1f, 1g and 1h, where the set-up for a tax rate of 25 percent is illustrated, it will be seen that a plug 411A of the longitudinal four pence bus bar 910B is in operative position to establish connection with the transverse bar 911B representative of one penny which monetary amount is 25 percent of said four pence. A plug 411A interconnects the bar 910C representative of three shillings with the transverse bar 911C representative of nine pence; plugs 411A interconnect the bar 910S representative of ten shillings with transverse bars 911T and 911P respectively representative of two shillings and six pence; a plug 411A interconnects the bar 910P representative of one pound with the transverse bar 911S representative of five shillings; plugs 411A interconnect the bar 910D representative of thirty pounds with transverse bars 911H and 911Y respectively representative of seven pounds and ten shillings; and a plug 411A interconnects the bar 910E representative of two hundred pounds with the transverse bar 911K representative of fifty pounds. Likewise, each of the other longitudinal conductors is connected by fully inserted plugs 411A with transverse conductors singly or in groups, as the case happens to be, which respectively represent 25 percent of the value of such longitudinal conductors.

Had the tax rate been 10 percent instead of 25 percent the grid in Figs. 1f, 1g and 1h would have had plugs inserted at the intersections marked with small crosses, which in some instances coincide with the aforementioned small circles. As an example of the method of selecting the positions of the plugs for the 10 percent rate and with reference to the one pence longitudinal bar, this bar will be connected to the one tenth penny transverse bar in the fractional pence group SP. In the shillings group of longitudinal bars the one shilling conductor is shown connected with both the one penny transverse bars and the two tenths penny bar since ten percent of one shilling is one and two tenths pence. It will be noted that for the most part the plugs arranged according to this 10 percent schedule establish connection between but single longitudinal and transverse bars, thus making it possible to use the simple plugs 911 in these instances. However as before, where a transverse bar is joined to more than one longitudinal bar by means of plugs, these plugs will be of the character of plugs 411A.

The effect of the foregoing interconnecting of the longitudinal bars 910A with the transverse bars 911A according to the schedule indicated by the small circles at the grid intersection points in Figs. 1f, 1g and 1h is the selection of such transverse bars 911A that potentialization thereof may be utilized to effect the entry of a predetermined tax upon any amount represented by the stator contacts at which the rotor bars 355, Fig. 1e, stand, and in the present example to effect an entry of fifty-seven pounds, eighteen shillings and four pence in a manner which will be described presently, this amount being the tax on two hundred thirty-one pounds, thirteen shillings and four pence under a tax rate of five shillings per pound.

The proportionating apparatus in the present instance not only includes the above described arrangement for determining the tax on various amounts presented thereto but also provides a grid arrangement structurally similar to that

employed for determining the tax, and this additional grid is employed for determining, in the present instance, the net amount of the dividend, which is to say, the difference between the gross amount of the dividend set up in the rotors 350 and the amount of the tax.

This additional grid is illustrated in Figs. 1i and 1j and the longitudinal bars 910A thereof are respectively connected to the longitudinal bars 910A in the grid shown in Figs. 1f, 1g and 1h by suitable conductors generally indicated by AB which extend between the respective longitudinal bars. Plugs as 911 and 411A are employed in the grid shown in Figs. 1i and 1j to establish such interconnections between the longitudinal and transverse bars thereof so that the selective potentialization of the longitudinal bars will result in potentialization of the transverse bars that represent the net dividend to be paid pursuant to the amount of the gross dividend less the amount of the tax. As in the case of the grid shown in Figs. 1f, 1g and 1h, either a plug 911 or 411A, as may be required, is disposed in operative position for every contingency within the capacity of the machine. The small circles at the intersections of these bars indicate the positions of inserted plugs necessary to prepare this part of the grid for reading out the net incurred by deducting a 25 percent tax from the gross.

Inasmuch as the longitudinal bars of the grids respectively shown in Figs. 1f, 1g and 1h and in Figs. 1i and 1j are respectively connected one to the other, they are potentialized simultaneously so that the transverse bars representative of the amount of tax and the net are energized simultaneously and since the gross amount of the dividend is represented by the longitudinal bars which are potentialized, potentialized conductors, representative of the gross, tax and net are available and in the present instance such potentialized conductors are employed to effect set-up of devices which will print the various amounts represented by the potentialized conductors. In this connection, however, it should be noted that not all of the selected longitudinal and transverse bars are potentialized simultaneously for the potentialization proceeds group by group under control of contacts on the synchronizer drum 86. Thus first the selected longitudinal bar for pence is potentialized which, of course, results in the potentialization of the transverse bar or bars connected to this selected pence bar, then the selected of the "1" to "9" or units shillings bars is potentialized along with the transverse bar or bars connected thereto and so on.

In the present instance where the product or gross dividend is two hundred thirty-one pounds, thirteen shillings and four pence and the tax thereon is fifty-seven pounds, eighteen shillings and four pence, the net amount of the dividend is one hundred seventy-three pounds, fifteen shillings and no pence. The net in the present instance does not include any sum expressed in pence, but this does not mean that it is not necessary to install a plug as 911 or 411A in the longitudinal bar 910F for four pence in the grid shown in Figs. 1i and 1j, and in order that the correct net will be produced a plug 411A is moved into operative position so as to connect this longitudinal bar 910F with the transverse bar 911L in this grid representative of three pence. That is, each of the longitudinal bars in this net portion of the grid is connected with one or more transverse bars representative of

75 percent of the respective of said longitudinal bars. Thus continuing specifically with the longitudinal bars which will be potentialized in the present machine operation according to a gross of two hundred thirty one pounds, thirteen shillings and four pence, the longitudinal bar 910H in this grid for three shillings in the "1" to "9" or units shillings group has a plug 911 therein moved to operative position to establish connection with a transverse bar 911M representative of two shillings. This bar 910H also has, in the present set-up, a plug 411A therein to establish connection with the transverse bar 911L representative of three pence, it being observed that the plugs 911 are used for the connections where but a single longitudinal bar is connected with a single transverse bar and that the plugs 411A are used where a longitudinal bar is connected with a transverse bar which is connected with one or more additional longitudinal bars and to prevent feed-back as explained hereinabove with respect to the "Tax" portion of this proportionating device. Furthermore, the ten shillings bar 910K in the grid shown in Figs. 1i and 1j has plugs 911 and 411A therein moved into operative position with transverse bars 911Q and 911R respectively representative of seven shillings and six pence, and also the one pound bar 910M in the units order pounds group of bars in this grid has a plug 411A therein moved into operative position to establish connection with the transverse bar 911U representative of ten shillings, and a plug 411A therein to establish connection with a transverse bar 911V representative of five shillings. The thirty pounds bar 910N in the tens order pounds group of bars in this grid has plugs 411A therein moved into operative position to establish connection with transverse bars 911W and 911X respectively representative of twenty pounds and two pounds. This bar also has a plug 411A therein moved into operative position to establish communication with the ten shillings transverse bar 911U. The two hundred pounds bar 910Q in the hundreds order pounds group of bars in this grid has plugs 911 and 411A therein moved into operative position to establish connection with transverse bars 911J and 911Z respectively representative of one hundred fifty pounds.

The set-up of the proportionating apparatus or grids shown in Figs. 1f, 1g and 1h or Fig. 1i or 1j will be facilitated by preparing tables exemplifying the various results to be obtained by the use of the apparatus, and then by the use of such tables the moving of plugs 911 or 411A into operative position is facilitated since it is only necessary to refer to such table in order to determine which of such plugs in each instance is to be moved into operative position.

The proportionating apparatus has been described herein as embodying two sections or grids in one of which, in effect, a multiplication is performed and in the other of which, in effect, a subtraction is performed, but it is to be understood that since such grids are manually set up as in the present instance by moving plugs 911 or 411A into operative position, such a grid or proportionating apparatus might be used to effect an addition or a division, the aforesaid multiplication in the present instance being effected in the grid shown in Figs. 1f, 1g and 1h and the aforesaid subtraction is effected in the grid shown in Figs. 1i and 1j.

Printing mechanism setting-up apparatus

In the present instance the product or gross amount of the dividend, the product of this gross amount times a rate, the amount of tax in this instance, and the difference of the subtracting operation, the net amount of the dividend in this instance, are derived from the proportionating apparatus and passed through a transferring mechanism or motor units similar in construction and operation to those employed to effect set-up of the rotors 350, and this transferring mechanism sets up the printing mechanisms. The manner in which the foregoing amounts are derived from the proportionating apparatus and are entered in the transferring apparatus will be described first, and in this connection it should be noted that the transferring mechanism, to which reference has just been made, includes a stator 501 and a rotor 502.

The stator 501, Figs. 1k, 1L, 1m, 1n, 22 and 24, includes long contact strips 501X similar to the long contact strips on the stator 310, Fig. 1e, and short contact strips 515B are associated with the long contact strips 501X on the stator 501. One group of such long and short contact strips is employed to effect operation of the transfer or motor units pertaining to the net amount, another group of such long and short contact strips effect operation of units pertaining to the gross amount, and still another set of such long and short contact strips effect operation of units pertaining to the amount of tax. Each of these groups contains a set of contacts that pertains to pence, another that pertains to "1" to "9" or units shillings, another for ten shillings, and so on. In addition, the groups that pertain to the net and the tax each contains an additional set of long and short contact strips that pertain to fractional pence.

The transverse bars of the grid pertaining to the net each has a conductor connected thereto, and these conductors are passed into a cable 519, Figs. 1i and 1j, which is referred to hereinafter as the net cable, and these conductors pass out of this cable in Figs. 1k and 1L where they are respectively connected to long contact strips 501X in the net group that pertain to the same value as the transverse bar to which the conductor is connected. Likewise, the transverse bars of the grid, Figs. 1f, 1g and 1h, which pertain to tax have conductors connected thereto which are passed into a cable 545, and these conductors pass out of this cable in Figs. 1m and 1n where they are respectively connected to long contact strips 501X in the tax group that pertain to the same value as the transverse bars to which these conductors are respectively connected. Furthermore, it has been explained that conductors AB respectively connect the longitudinal bars in the tax grid to the longitudinal bars in the net grid. Conductors CD are respectively connected to these interconnecting conductors AB, and these conductors are passed into a cable 547, Fig. 1h, and pass out of this cable in Figs. 1L and 1m where they are respectively connected to long contact strips 501X in the gross group that pertain to the same respective values as the transverse bars in the grid to which these conductors are electrically connected through the conductors CD.

The short contact strips 515B that are associated with the long contact strips 501X on the stator 501 are selectively disposed in longitudinal rows that are, as in the case of Fig. 1e, respec-

tively numbered "1," "3," "5," "1," "5" in Fig. 1n, which of course means that when a rotor bar on the rotor 502 associated with the stator 501 passes along the long contact strips 501X it successively closes circuit to the short contact strips 515B, whereupon solenoids similar to the solenoids 396—1 are energized to drive the associated motor unit an amount equivalent to the numerical value of the longitudinal row in which the engaged short contact strip is arranged in Figs. 1k to 1n.

The advancing of the motor or transfer units is under control of the rotor bars 503 on the rotor 502, and these rotor bars traverse the contacts on the stator 501. The rotor 502 is shown in Figs. 22 and 23 and in Figs. 1k to 1n. Referring first to Figs. 22 and 23, the rotor 502 is in the form of an elongated cylinder which is axially fluted to thereby define spaced ledges along its periphery. Corresponding ends of leaf springs 504 are connected to the ledges and the rotor bars 503 are mounted at the free ends of these leaf springs. There is a ledge and a row of leaf springs and rotor bars 503 for pence, "1" to "9" or units shillings, ten shillings, unit pounds and so on up to hundred thousands pounds so that, in effect, there is a row of rotor bars 503 for each rotor 350 and its cooperating stator 359.

As in the case of the rotor 311 and the stator 310, the selective energization of the long contact strips 501X is to be effected successively, but, whereas in the case of the rotor 311 and the stator 310 the successive energization was for the units order, tens order, hundreds order and so forth of the multiplicand, in the case of the successive energization of strips 501X on the stator 501, the energization is for pence, "1" to "9" or units shillings, ten shillings, units order pounds, and so forth. This is due to the fact that the selective energization of the long contact strips on the stator 501 is ultimately under control of the selected contacts on the stators 359. It is of course to be understood that this ultimate energization might be through perforations or some other means and the successive energization of the groups of long contact strips on the stator 501 would correspond to whatever arrangement was employed at the ultimate source of energization.

It will be recalled that the rotor 311 was timed to make a complete revolution each time a set of contacts as "Units 1-9" on the synchronizer drum 86 for a particular order in the multiplicand moved past the brushes 90; see Fig. 40 of the timing chart. However, in the case of the rotor 502, it is arranged to rotate at such a speed that one of the plurality of rows of rotor bars 503 thereon moves over the contacts on the stator 501 each time a contact 501R to 501Z, Fig. 1d, on the synchronizer drum 86 moves past the brushes 90. This is illustrated graphically in Figs. 41 and 45 of the timing chart where operations of the brush sets one to nine, indicated with respect to the chart-lines Ch18 and Ch19, will be seen to coincide in point of time respectively with the contacts 501S to 501Z, that is to say, a first brush set will wipe the long contacts 501X while the contact 501S wipes its brushes 90, a second brush set will wipe the long contacts 501X while the contact 501S wipes its brushes 90, and so on. The contacts 501R to 501Z are mounted on the synchronizer drum in such a position that they move into cooperation with the brushes 90 well after the sets of contacts on this drum for the various orders of multiplicands have moved out

of cooperation with the brushes, the spacing of these contacts and the speed of operation of the drum being such that sufficient time is allowed to effect set-up of the rotors 350 in the manner previously described.

However, in so far as time of operation of the machine is concerned, after the rotors 350 have been set up, the synchronizer drum attains such a position in its rotation that the contact 501R, which pertains to pence, bridges the circuit between the pair of brushes 90 with which it is adapted to cooperate, and in this instance a circuit is closed as follows: from battery conductor 84 through conductor 502R and its brush 90, contact 501R to conductor 467 through its brush 90, this conductor leading into a cable 466. The conductor 467 passes out of cable 466 in Fig. 1e and is connected to a contact ring 361 on the stator 359 pertaining to pence. This contact ring 361 is co-extensive with the spaced contacts R on the stator 359 so that so long as the rotor bar 355 on the rotor 350 cooperating with this particular stator is in engagement with any contact R on the stator 359 circuit will be closed from the contact ring 361 to the contact so engaged by the bar 355. In the present instance the rotor bar 355 is in engagement with the contact on the stator 359 representative of four pence and hence circuit is closed to this contact.

It will be recalled that each of the contacts on the stators 359 is respectively connected electrically with longitudinal bars 910A in the grid shown in Figs. 1f, 1g and 1h so that when circuit is closed to the four pence contact R on the pence stator 359 circuit is closed to the four pence longitudinal bar 910B. This bar, as has been described heretofore, is connected to the transverse bar 911B in the grid shown in Figs. 1f, 1g and 1h that represents one penny. It will also be recalled that the longitudinal bars in the grid shown in Figs. 1i and 1j are connected to the longitudinal bars in the other grid so that if a longitudinal bar in one grid is potentialized the corresponding longitudinal bar in the other grid will be potentialized. Thus in the instance where the longitudinal bar 910B in the grid shown in Figs. 1f, 1g and 1h, representative of four pence, is potentialized, the longitudinal bar 910F representative of four pence in the grid shown in Figs. 1i and 1j will be potentialized through conductor AB2. This bar 910F, as will be recalled, is connected to a transverse bar representative of three pence.

It will be recalled that the transverse bars 911A in the grids are respectively connected electrically with correspondingly valued long contacts on the stator 501. It will also be recalled that a conductor CD is connected to each conductor AB interconnecting the respective longitudinal bar in the two grids. Hence in this instance the conductor CD2 connected to the conductor AB2 interconnecting the four pence longitudinal bars in the two grids is potentialized. The conductor CD2 leads out of the cable 547 in Fig. 1L and it is connected to the long contact strip 501X on the stator 501 in the gross group representative of four pence. Moreover, a conductor CT2 leads from the now potentialized transverse bar 911B in the tax grid, representative of one penny, to a long contact strip 501X on the stator 501 in the tax group, representative of one penny, and a conductor CF2 leads from the potentialized transverse bar 911L in the net grid, representative of three pence, to a long contact strip 501X in the net group on the stator 501.

Thus battery is applied on three long contact strips 501X on the stator 501 in the present instance by the passage of the contact 501R past the brushes 90, Fig. 1d.

In the present machine where dividend warrants or checks are being printed and also receipts or counterfoils and where both ordinary warrants and bankers warrants are to be printed, there arises a condition which will be explained in detail hereinafter where certain operations of the machine are rendered ineffective. This is under control of a switching arrangement, shown in Figs. 1k to 1n, wherein a switching bar 518 is shown. The movable elements of this switching arrangement are connected to this switching bar which is under control of solenoids 508, Fig. 1n, and 511, Fig. 1k. In the present instance this switching arrangement is operated by the solenoid 508 to dispose the switching arrangement in a position which might be called a normal operation, and in which position the switch is illustrated in Figs. 1k to 1n. The energization of the solenoid 508 is effected, at the time indicated by the left end of chart-line Ch19, Fig. 45, from a contact 501P on the synchronizer drum 86, Fig. 1d, where an adjacent contact 501Q substantially coextensive in length is also shown. The normal operation, as stated, is under control of contact 501P whereas the alternate operation is under control of contact 501Q. Which of these contacts is to be selectively potentialized is determined from the printing and control devices, which is to say, special perforations are provided in cards 77. When a perforation is provided in the control card 77 in a position to cooperate with the sensing finger 51D, Figs. 1 and 5, this sensing finger is grounded. This sensing finger, as shown in Fig. 1d, is connected through a conductor 502T to a brush 90 that cooperates with the contact 501P. The contact 501P moves into cooperation with the brushes 90 prior to the time the contact 501R reaches these brushes so that circuit is closed by this contact 501P to a conductor 506 which leads into a cable 507 and which passed out of this cable in Fig. 1n where it leads to one end of the winding of solenoid 508, the other end of this winding being connected to battery. Hence the switching arrangement including the control bar is properly positioned prior to the time any of the contacts as 501R move into association with the brushes 90 to effect potentialization of long contact strips on the stator 501.

A conductor 506R is connected to the conductor 506, as shown in Fig. 1n, and this conductor 506R leads to one end of the winding of the solenoid 508A, the other end of this winding being connected to battery. Therefore, when conductor 506 is grounded by the contact 501P, the solenoid 508A is energized. This attracts the core 508B of this solenoid which permits the clutch 508C, Fig. 1n, to engage under the action of spring 508D. It is this clutch that controls rotation of the rotor 502 and hence when this clutch engages, the rotor 502 is set in operation, power being derived from the motor 272 through a gear train 508G, shown in Fig. 1n.

The rotor 502 is therefore driven from the same source of power as the synchronizer drum 86 and will therefore operate in timed relation with such synchronizer drum. At the time the rotor 502 is set in operation one of the axial rows of rotor bars 503 thereon is in position to move into association with the long contact strips 501X on the stator 501, and by the time the contact 501R has moved into association with the brushes 90 and

applied battery on selected of the long contact strips on the stator 501, this row of rotor bars will move into association with these contacts, the time of operation of said row of bars being indicated by the designation "Set 1" in association with the chart-line Ch18 in Fig. 45 concurrently with the time circuit is closed by said contact 501R which appears in Fig. 41.

As this row, set number one, of rotor bars moves over the three long contact strips 501X on the stator 501 to which battery has been applied, as previously described, circuit is closed to the short contact strips associated with these long contact strips, and as circuit is closed to these short contact strips the motor units to which they are connected are advanced in an amount corresponding to the numerical value of the longitudinal row in which the short contact strips are respectively located. Thus, so far as the contact strip in the net group in the set pertaining to pence is concerned, the motor unit for pence in the net portion of the apparatus will be advanced to represent three pence; the motor unit for pence in the gross portion of the apparatus will be advanced to represent four pence; and the motor unit for pence in the tax portion of the apparatus will be advanced to represent one penny.

The motor units to which reference has just been made are diagrammatically illustrated in Fig. 1o where it will be seen that a plurality of such units are provided, there being a motor unit for fractional or decimal penny, pence, "1" to "9" or units shillings, ten shillings, and so on. These motor units are structurally like the unit shown in Figs. 14, 16 and 25 and will be explained in detail hereinafter in connection with the description of the structural characteristics of the printing mechanism.

The motor units to which reference has just been made are contained in the gross, tax and net sections of a printing mechanism appearing in Fig. 1o, where the section for receiving the net is shown diagrammatically to illustrate the arrangement of the motor units of which each includes solenoids 875-1, 375-3 and 875-5, which solenoids correspond respectively to the solenoids 396-1, 396-3 and 396-5 and which motor units are structurally like the accumulator units containing said solenoids 396-1, 396-3 and 396-5; see Figs. 14, 16 and 25. The structural environment for these motor units, including the printing wheels as 520 driven thereby, is described in detail hereinafter under the heading "Printing mechanism," wherefore, for the present, it is thought expedient to but briefly explain that this section of the printing mechanism for the net is divided into two parts in which duplicate entries are made. The one part is set to zero after each computation and impression from its printing wheels and includes the printing wheels 520 pertaining respectively to pence, units shillings "1" to "9," ten shillings, and so on, which are carried on a shaft 516. This one part of the net printing section also includes a fractional penny wheel, FP, on the shaft 516, and while this wheel carries no printing characters, a carry-over circuit presently explained and controlled thereby effects entry onto the pence wheel 520 when an entry or successive entries exceeding five tenths penny is made on said wheel FP. The other part of the net printing wheel mechanism that is shown in Fig. 1o is for accumulating the total net and therefore includes printing wheels 520A upon the shaft 515

which are not returned to zero pursuant to each printing operation of the wheels 520. In other respects, so far as is of present concern, this other or totalling part of the net printing mechanism is like the part associated with the shaft 516 and the circuit connections of the motor units in these two parts are connected in parallel so the entries made in the totalling section associated with the shaft 515 will be equal to and be made simultaneously with those entries in the section associated with the shaft 516.

Simplicity of disclosure is had by showing only diagrammatical representations of the casings for the tax and gross sections of the printing mechanism respectively at 542 and 543 in Fig. 10, the tax section being identical with that part of the net shown in Fig. 10, and the gross section differing from such part of the net only insofar as no fractional penny wheels as FP are provided and the reason for the omission of the fractional penny wheels as FP in the gross section is that there is no fractional penny group of conductors in the transverse group generally designated CD in Fig. 1h since this group of conductors are for transmitting the gross amount rather than a fractional part or other numerically related part thereof.

Considering now the entry in the printing mechanism of Fig. 10 which occurs while the contact 501R for pence is engaged with its brushes 90, battery will be carried through a circuit including conductors 84 and 502R, Fig. 1d, contact 501R and its associated brushes 90, conductor 467, Figs. 1d and 1e, pence stator ring 361, the pence rotor bar 355, the four pence contact R engaged by said rotor bar, the four pence bar 910B in the tax portion of the proportionating grid, the four pence conductor AB2 between the tax and net grids, the four pence longitudinal bar 910F in the net grid, the three pence transverse bar 911L, the three pence conductor CF2 leading into the net cable 519, and to the three pence long contact bar with which the conductor CF2 connects upon the stator 501 in Fig. 1k. Therefore, when the first set of wiping contacts 503 upon the rotor 502 pass the number "3" row of short contacts 515B, circuit will be closed from said three pence long contact through the short contact alongside thereof, the associated number "3" contact upon the switching bar 518 which is now in the uppermost position since the solenoid 508, Fig. 1n, is energized, and the number "3" conductor in the net cable 517 to the solenoids 875-3 of the pence motor units of the net section of the printing mechanism in Fig. 10. Thereupon these pence motors are actuated to advance their associated printing wheels 520 and 520A three digital positions during the time indicated by the chart-line Ch20 in Fig. 45.

For the entry in the tax section of the printing mechanism 542, the battery extended from the synchronizer drum contact 501R to the four pence bar 910B in the tax grid is conducted through the one penny transverse bar 911B, conductor CT2, Figs. 1f and 1m, to the one penny long contact on the stator 501. This long contact and the short contact adjacent thereto are swept by a rotor bar 503 while the bar transverse the first number "1" row of short contacts wherefore the battery is carried through the number "1" contact on the switching bar 518 associated therewith and the one penny conductor in the tax cable 544, Figs. 1m, 1n and 1o to the solenoids 875-1 (not shown) respectively

in the motor units for pence in the two sections of the tax section 542. Thus these pence motor units are actuated to advance their associated printing wheels 520 and 520A (not shown) in the amount of one penny at the time indicated by the chart-line Ch21, Fig. 45.

Respecting the entry in the gross section 543 of the printing mechanism, the battery extended from the synchronizer drum contact 501R to the four pence conductor AB2 in Fig. 1h is conducted through the four pence transverse conductor CD2 and through the gross cable 547, Figs. 1h to 1m, to the number "4" long contact in the pence group of the gross group upon the stator 501. This long contact is traversed by a rotor bar 503 to first bridge such long contact and the number "1" short contact associated therewith in the first row and to later bridge such long contact and the number "3" short contact associated therewith. While said number "1" short contact is thus bridged, circuit is completed through the associated number "1" contact on the switching bar 518 and the number "1" conductor in the gross cable 546, Figs. 1L to 1o, to the solenoids 875-1 (not shown) in the motor units for pence in the two parts of the gross printing mechanism section 543 to cause energization of the solenoids and the advance of their printing wheels 520 and 520A the distance to register one penny at the time indicated by the chart-line Ch22 in Fig. 45. Immediately thereafter the rotor bar engages said number "3" short contact, closing circuit through the associated number "3" pence contact on the switching bar 518 and the number "3" pence conductor in said cable 546 to the solenoids 875-3 of the pence motor units in the gross printing mechanism section 543 to cause simultaneous energization of these motor units and the advance of their printing wheels 520 and 520A three additional spaces at the time shown by the chart-line Ch23, Fig. 45, so these pence wheels of the gross printing mechanism section will then each stand at four. Therefore at the time set number one of the brushes or contacts 503 have swept the long contacts on the stator 502, and the synchronizer drum pence contact 501R has swept its brushes 90, the entries in the pence divisions of the printing mechanism sections is: three pence in the net printing mechanism section, one penny in the tax printing mechanism section and four pence in the gross printing mechanism section.

These amounts appear in Fig. 40 of the timing chart respectively above chart-line 20, chart-line 21 and chart-lines 22 and 23 which chart-lines indicate the entries of said amounts in the manner just described.

Immediately after the contact 501R passes from cooperation with the brushes 90, the contact 501S moves into cooperation therewith to control entries in the "1" to "9" shillings divisions of the printing mechanism. Thereupon a circuit is closed similar to the circuit which resulted in the advancing of the aforesaid motor units in Fig. 1o for pence but the contact 501S closes a circuit to the longitudinal bars 910C and 910H in the two grids in the "1" to "9" or units shillings group representative of three shillings and to the interconnecting conductor AB3.

The energization of these longitudinal bars 910C and 910H representative of three shillings results in energization of the transverse bars 911M and 911L in the net grid respectively representa-

tive of two shillings and three pence. Such energization of the aforesaid longitudinal bars also results in energization of the transverse bar 911C in the tax grid representative of nine pence. Furthermore, a conductor CD3 connected to the conductor AB3 interconnecting the energized longitudinal bars 910C and 910H in the tax and net grids is energized along with these longitudinal bars. The result of this is that the long contact strips on the stator 501 in the net group and representative of two shillings and three pence have battery applied thereto; also a long contact strip in the gross group representing three shillings has battery applied thereto; and a long contact strip in the tax group representative of nine pence has battery applied thereto.

The application of battery to the aforesaid long contact strips occurs just at a time the rotor 502 has advanced sufficiently to have disengaged the axial row of rotor bars 503, referred to as "set 1" in Fig. 40, from the long and short contact strips on the stator 501 just wiped by these rotor bars. The rotor 502 is therefore so positioned that the next axial row of rotor bars 503, the second set, is in position to pass over the long and short contact strips on the stator 501. As this axial row of rotor bars 503 moves over the long and short contact strips, the rotor bars 503 cooperating with the long contact strips to which battery has been applied, as above described, close circuit to the short contact strips associated with these long contact strips and, depending upon the longitudinal row in Figs. 1k to 1n, to which the numerals "1," "3," "5," "1," "5" are applied in Fig. 1k, in which the short contact strips are positioned, the motor units diagrammatically illustrated in Fig. 1o are advanced, which is to say, for example, the short contact strips associated with the long contact strips in the tax group for nine pence has short contact strips in the first of the number "1" longitudinal rows, in the number "3" longitudinal row, and in the first of the number "5" longitudinal rows, so that the resettable motor unit associated therewith is advanced first one division, then three divisions, then five divisions upon energization of the associated solenoids 875-1, 875-3 and 875-5 respectively at the time indicated by the chart-lines Ch24, Ch25 and Ch26, Fig. 45, so that in all it is advanced nine divisions, which is to say, it is advanced in an amount which is equivalent to a setting of nine pence thereon. However this particular motor unit had already been advanced to represent one penny so that at the end of this newly imparted movement this particular motor unit is set to represent ten pence.

While the next preceding paragraph describes the advance of nine pence with respect to the resettable motor unit which would be the unit on the shaft as 516 in Fig. 1o, it will be understood that the non-resettable unit for pence and on the shaft as 515 is connected in parallel with the resettable unit and is simultaneously advanced in the same amount. For convenience, however, only the resettable unit has been referred to and this expedient is followed in the ensuing description of entries in the printing mechanism.

Furthermore, during this particular passage of this second axial row of rotor bars 503 over the contact strips on the stator 501, the motor unit in the gross portion for "1" to "9" or units shillings is advanced into a position to represent three shillings by energization of its solenoid

875-3 at the time shown by chart-line Ch27. Still further, the motor unit in the net portion for pence, which already stands advanced to represent three pence by reason of the previous entry operation, is advanced into a position representative of three additional pence when its associated solenoid 875-3 is energized at the time shown by the chart-line Ch28 so that in its advanced position at the end of this entry operation it is positioned to represent six pence. Likewise, a motor unit in the net portion for "1" to "9" or units shillings is advanced in this entry operation to represent two shillings when its associated solenoid 375-1 is successively energized at the times shown by the chart-lines Ch29 and Ch30, first when the second set of rotor bars traverse the first number "1" row of short contacts on the stator 501 and again when the second number "1" row of such contacts is traversed.

The just described advancing of the motor units is effected while the contact 501S is passing the brushes 90 as is plainly shown in the timing chart, Figs. 41 and 45. As soon as this contact is moved beyond the brushes 90, the contact 501T moves into association therewith, and in the manner previously described, this will effect such energization of long contact strips on the stator 501 that when the next axial row or third set of rotor bars on the rotor 502 moves into wiping engagement with these long contact strips, which is simultaneous with the movement of the contact 501T along its brushes 90, motor units such as are illustrated in Fig. 1o are advanced as follows, this operation proceeding by reason of energization of longitudinal bars 910S and 910K in the two grids and their interconnecting conductor AB4 for ten shillings. In the tax portion of the apparatus the motor unit for pence, which as above explained already stands in a position to represent ten pence, is advanced in this operation in an additional six pence so that at the end of this operation it stands at four pence; that is, the pence printing wheel stands at four pence. However, incident to this advance of this motor unit a carry-over is effected into the shillings motor unit in the tax portion of the apparatus because the addition of six pence on this unit which already stands at ten pence causes this motor unit to move past its zero or twelve pence position. The carry-over apparatus which is fully described hereinafter under the heading "Printing mechanism" includes pairs of contacts as 514 in association with each denominational wheel FP, 520 and 520A Fig. 1o, and which are closed by a part rotating with their respectively associated wheels while such wheels are advanced from their highest digital value position to the "0" position. The circuits closed by these contacts include carry-over solenoids 437A associated with the units of next higher denominational significance. These solenoids 437A acting similarly to the above described carry-over solenoids 437. In entering the six digits in the pence unit of the tax section, the solenoid 875-1 pertaining to the pence motor is first energized when the rotor bar 503 cooperating with the one penny long contact in the tax section of the stator 501 engages the short contact alongside of said long contact in the first number "1" row of short contacts, and to thus effect entry of one penny upon the pence printing wheel at the time indicated by the chart-line Ch31. The five additional digits in the entry of said six pence occurs when the rotor bar 503 pertain-

ing to the five pence long contact in the tax section of the stator 501 engages the short contact alongside of said long contact in the first long contact in the first number "5" row of short contacts to energize the solenoid 875-5 in said pence motor of the tax section of the printing mechanism and at the time indicated by the chart-line Ch32. Following the entry of the one penny at the time shown by the chart-line Ch31 the said pence printing wheel stood at "11" so that pursuant to the first of the five digital entries occurring during the time indicated by the chart-line Ch32, the printing wheel is advanced from "11" to "0" to close the associated carry-over contact pair 514, thereby closing the energizing circuit for the carry-over solenoid 437A associated with the shillings motor unit in the tax section of the printing mechanism. Therefore, at the time indicated by the chart-line Ch33 appearing in Fig. 49, this carry-over solenoid 437A is energized to enter an additional shilling upon the shillings printing wheel. The pence unit, after completing the five pence entry indicated by the chart-line Ch32 will come to rest at "4."

The entry of the two shillings in the units "1" to "9" shillings motor unit of the tax section is made in two steps of which the first occurs at the time indicated by the chart-line Ch34 and the second at the time indicated by the chart-line Ch35, which chart-lines respectively coincide with the times when the first number "1" row of short contacts 515B and the second number "1" row of such contacts 515B are traversed by the third set of rotor bars 503 to twice energize the solenoid 875-1 of the units shillings motor. It will be observed from the chart-lines Ch35 and Ch33 in Figs. 45 and 49 that the entry of the second of the two shillings upon the units shillings unit occurred substantially simultaneously with the carry-over of one shilling onto this motor unit so that at the end of this part of the entry operation in the tax section of the printing mechanism, the shillings printing wheel 520 will have had three shillings entered thereon. Said tax section of the printing mechanism will then stand at three shillings and four pence.

Moreover, in the entry for the gross section of the printing mechanism, when the third set of rotor bars 503 traverse the first number "1" row of short contacts on the stator 501, the rotor bar 503 associated with the now potentialized tens long contact 501X in the gross section of the stator 501, and with the short contact alongside thereof, will bridge such long and short contacts for closing circuit to and energizing the solenoid 875-1 of the tens shillings motor to cause it to advance its associated printing wheel one division which amounts to an entry of ten shillings. This entry occurs at the time indicated by the chart-line Ch36 in Fig. 45.

Long contacts in the net section of the stator 501 representative of seven shillings and six pence are potentialized from the net grid. In the entry of this seven shillings and six pence in the net section of the printing apparatus, and considering first the entry of the six pence, such entry of six pence takes place in two steps occurring respectively at the times indicated by the chart-lines Ch37 and Ch38. The chart-line Ch37 signifies the entry of one penny pursuant to energization of the solenoid 875-1 of the pence motor in the net section when the one penny long contact and the first number "1" row short contact alongside thereof are bridged by a rotor bar

503, whereas the chart-line Ch38 signifies the entry of 5 pence pursuant to energization of the solenoid 875-5 of said pence motor when the five pence long contact and the first number "5" row short contact alongside thereof are bridged by a rotor bar 503. Since, however, the printing wheel of this motor unit already stood at six pence, such printing wheel will be advanced from "6" through "11" to "0" and will momentarily close the associated carry-over contact pair 514 while passing between "11" to "0." In this manner the carry-over solenoid 437A associated with the units shillings motor is energized for causing entry of one shilling at the time indicated by the chart-line Ch39 in Fig. 49. Entry of the seven shillings portion of the amount entered in the net section of the printing mechanism involves energization of the solenoid 875-1 of the units shillings motor for this section while the rotor bars 503 traverse the first number "1" row of short contacts on the stator 501 at the time indicated by the chart-line Ch40, energization of the solenoid 875-5 for this motor unit at the time the rotor bars 503 traverse the first number "5" row of the short contacts as indicated by the chart-line Ch41, and a second energization of said solenoid 875-1 while the rotor bars 503 traverse the second number "1" row of short contacts at the time indicated by the chart-line Ch42. Thus the amounts of one, five and one are successively entered upon the units shillings motor. It will be recalled that at the beginning of this part of the operation, as the third set of rotor bars started to traverse the stator contacts, the printing wheel in association with the units shillings motor in the tax section stood at "2." The addition of one to this original amount of two upon the shillings printing wheel at the time indicated by the chart-line Ch40 increased the amount standing on the wheel to three and the five entered on this wheel at the time indicated by the chart-line Ch41 increased the amount standing thereon to eight. This printing wheel is thereafter moved from "8" through "9" to "0" incident to the substantially simultaneous entries of the single digital amounts respectively constituting the carry-over from the pence denomination at the time indicated by the chart-line Ch39 and by the second energization of the solenoid 875-1 of the units shillings motor at the time indicated by the chart-line Ch42. While the units shillings printing wheel is being thus advanced between "9" and "0" the carry-over contact pair 514 associated therewith is closed for completing the circuit to the carry-over solenoid 437A associated with the tens shillings motor whereby the number wheel of this motor is advanced one position, which is the equivalent of ten shillings, at the time indicated by the chart-line Ch43 in Fig. 49. At this time, therefore, the net section of the printing mechanism will stand at ten shillings and zero pence.

As the operation of the machine continues the units pounds contact 501U upon the synchronizer drum 86 will be carried against the brushes 90 concurrently with the fourth set of rotor bars 503 beginning their traverse of the contacts upon the stator 501. When the contact 501U bridges its associated brushes 90, circuit will be extended through the units pounds stator 359, Fig. 1e, in the manner previously described to the units pounds longitudinal bars 910P and 910M respectively in the tax and net grids. The conductor 75 AB5 appearing in Fig. 1h and which connects

these two grid bars is also potentialized. Said conductor AB5 is connected by means of the lateral conductor CD5 with the one pound long contact 50IX in the gross section of the stator 501, whereas the one pound longitudinal bar 910P is connected through the transverse bar 911S and the conductor CT5 with the five shillings long contact in the tax section of said stator 501, and the one pound bar 910M is connected through the transverse bars 911U and 911V with the ten shillings long contact and the five shillings long contact upon the net section of said stator. Thus in the gross section of the stator the one pound long contact is potentialized while in the tax section of said stator the five shillings long contact is potentialized and in the net section of said stator the two long contacts respectively pertaining to ten shillings and five shillings are potentialized.

An entry in the gross section of the printing mechanism occurs while the rotor bars 503 in the fourth set traverse the first number "1" row of short stator contacts at which time one of the rotor bars 503 bridges said potentialized one pound long contact and the short contact adjacent thereto for energizing the solenoid 875-1 in the units pounds motor of said gross section to cause entry of one pound at the time indicated by the chart-line Ch44 in Fig. 45. The gross section of the printing mechanism which previously stood at thirteen shillings and four pence will then stand at one pound thirteen shillings and four pence.

Entry of five shillings in the tax section of the printing mechanism occurs at the time indicated by the chart-line Ch45 when energization of the solenoid 875-5 in the units shillings motor of this section is energized pursuant to a rotor bar 503 bridging the five shillings long contact and the short contact alongside thereof in the first number "5" row of short contacts upon the tax section of the stator 501. After this entry the tax printing wheels which previously stood at three shillings and four pence will stand at eight shillings and four pence.

Regarding the entry in the net section of the printing mechanism, when the fourth set of rotor bars 503 traverse the first number "1" row of short contacts the short contact in this row alongside of the now potentialized ten shillings long contact will be connected with this long contact by one of said rotor bars to become potentialized and thus cause energization of the solenoid 875-1 of the ten shillings printing wheel one division at the time indicated by the chart-line Ch46. This ten shillings printing wheel previously stood at 10 shillings and since the movement thereof through one division amounts to an entry of 10 shillings, this wheel will be advanced from "10" to "0" incident to closing the carry-over contact pair 514 associated therewith and thus energizing the carry-over solenoid 437A in the units pounds motor unit to cause an entry of one pound upon the units pounds printing wheel at the time indicated by the chart-line Ch47. When the fourth set of rotor bars reach the first number "5" row of short contacts, the rotor bar engaging the 5 shillings long contact will engage the short contact alongside thereof and thus potentialize it for causing energization of the solenoid 875-5 in the units shillings motor and the entry of five shillings upon the units shillings printing wheel at the time indicated by the chart-line Ch48. This completes this portion of

the entry in the net section of the printing mechanism so that the printing wheels which previously stood at 10 shillings and "0" pence now stand at 1 pound 5 shillings and "0" pence.

Eventually the contact 50IU for units pounds upon the synchronizer drum 86 passes beyond its brushes 88 to depotentialize the grid bars which were instrumental in the just described entry, and the tens pounds contact 50IV is advanced into bridging relation with its brushes 88 to complete a potentializing circuit through the tens pounds stator 359, Fig. 1e, to the 30 pound longitudinal bars 910D and 910N respectively in the tax and net grids and the conductor AB6 interconnecting these grid bars. Said conductor AB6 with the thirty pound long contact in the gross section of the stator 501, whereas the grid bar 910D is connected through transverse bars 911H and 911Y with the seven pound long contact and with the ten shillings long contact in the tax section of said stator, and the bar 910N is connected through the transverse bars 911W, 911X and 911U with the long contacts pertaining to twenty pounds, two pounds and ten shillings in the net section of said stator.

The just mentioned long contacts will be effective when swept by the fifth set of rotor bars 503. Entry in the gross section of the printing mechanism is effected when said set of rotor bars traverse the number "3" row of short contacts at which time the rotor bar 503 engaging the one pound long contact also engages the short contact representative of thirty pounds for closing the circuit to the solenoid 875-3 in the tens pounds shillings motor for potentializing the same and thus causing entry of thirty pounds upon the printing wheel associated therewith at the time indicated by the chart-line Ch49. This section of the register which previously stood at one pound thirteen shillings and four pence will now stand at thirty-one pounds thirteen shillings and four pence.

For the tax section of the printing mechanism, a rotor bar 503 will bridge the potentialized ten shillings long contact in the tax section of the stator and the short contact alongside thereof for potentializing the solenoid 875-1 in the tens shillings motor for causing entry of 10 shillings upon the printing wheel associated therewith at the time indicated by the chart-line Ch50. One pound is entered upon the units pounds printing wheel at each of two successive times respectively indicated by the chart-lines Ch51 and Ch52 which coincide in point of time with the time when the fifth set of rotor bars traverse the first number "1" row of short contacts and when said set of rotor bars traverse the second number "1" row of short stator contacts, circuit being thus closed to the solenoid 875-1 of the units pounds motor once for each time the short stator contacts along the one pound long contact are engaged. An additional 5 pounds is entered upon the units pounds printing wheel at the time indicated by the chart-line Ch53 which coincides in point of time with the time a rotor bar 503 bridges the potentialized five shillings long stator contact and the short contact alongside thereof in the first number "5" row of short contacts whereby circuit is closed to the solenoid 875-5 in the units pounds motor of this tax section of the printing mechanism. The net section of the printing mechanism will now stand at seven pounds eighteen shillings and four pence. In effecting the entry in the net section of the printing mechanism by this fifth set or axial

row of rotor bars 503, the potentialized tens shillings long contact on the stator 501 and the short contact along side thereof in the first number "1" row of short contacts will be bridged by a rotor bar 503 at the time indicated by the chart-line Ch54 for energizing the solenoid 875—1 in the tens shillings motor for advancing the printing wheel 520 in association therewith one position from "0" to "10." At this same time a rotor bar 503 traverses the number "1" units pounds long contact on the stator 501, as indicated by the chart-line Ch55, to energize the solenoid 875—1 of the units pounds motor for advancing the units pounds printing wheel in the amount of one pound, and later when the short contact along side of this units pounds long contact is bridged in the second number "1" row at the time indicated by the chart-line Ch56, said solenoid will be energized a second time for advancing said units pounds number wheel an additional one pound whereby it is advanced a total of two pounds. The short contacts alongside of the potentialized ten pounds long contact are respectively connected for potentialization simultaneously with the aforesaid potentialization of the short contacts alongside of the one pound long contact in this net section of the stator as indicated by the chart-lines Ch57 and Ch58, whereby the solenoid 875—1 of the tens pounds motor is twice energized for advancing the tens pounds printing wheel 520 associated therewith in the amount of twenty pounds. Thus while the fifth set of rotor bars traverse the net section of the stator 501, the printing wheels in the net section of the printing mechanism will be advanced from one pound five shillings and no pence in the amount of twenty-two pounds and ten shillings to stand at twenty-three pounds fifteen shillings and no pence.

Next the hundreds pounds contact 501W on the synchronizer drum traverses its brushes 90 concurrently with the sixth set or axial row of rotor bars 503 sweeping over the contacts on the stator 501. This action of the contact 501W is to potentialize the two hundred pounds longitudinal bars 910E and 910Q in the tax and net grids and the conductor AB7, Fig. 1h, interconnecting these bars.

The longitudinal bar 910E through the transverse bar 911K and the conductor CT9 then potentializes the fifty pounds long contact in the tax section of the stator 501. From the conductor AB7, circuit is completed through the transverse conductor CD7 to the two hundred pounds long contact in the gross section of the stator 501, and from the two hundred pounds bar 910Q, circuit is completed through the transverse bars 911J and 911Z, respectively for one hundred pounds and fifty pounds, and the conductors CF9 and CF10 to the one hundred pound and fifty pound long contacts in the net section of the stator 501. Therefore, when the sixth set of rotor bars 503 traverse the first and second number "1" rows of short contacts, the two hundred pounds long contact in the gross section of the stator and the short contacts alongside thereof will be bridged at the times indicated by the chart-lines Ch59 and Ch60 for twice energizing the solenoid 875—1 for the hundreds pounds motor in the gross section of the printing mechanism and thus advancing the printing wheel associated with this motor two spaces or in the amount of two hundred pounds wherefore at the end of this part of the operation the gross printing wheels which previously stood at thirty-one pounds thirteen

shillings and four pence will stand at two hundred thirty-one pounds thirteen shillings and four pence.

For the entry in the tax section of the printing mechanism, a rotor bar 503 will bridge the potentialized fifty pounds long contact in the tax section of the stator 501 and the short contact alongside thereof in the first number "5" row at the time indicated by the chart-line Ch61 to close circuit for energizing the solenoid 875—5 of the tens pounds motor to advance the printing wheel in association therewith five spaces or fifty pounds so that the tax printing wheels which previously stood at seven pounds eighteen shillings and four pence will be left standing at fifty-seven pounds eighteen shillings and four pence.

Entry is made in the net section of the printing mechanism when rotor bars 503 bridge the potentialized tens pounds and hundreds pounds long contacts in the net section of the stator 501 and the short contacts respectively alongside thereof at the times indicated by the chart-lines Ch62 and Ch63 for completing circuit to the solenoid 875—5 of the tens pounds motor and the solenoid 875—1 of the hundreds pounds motor whereby the printing wheels 520 respectively associated with these motors are respectively advanced fifty pounds and one hundred pounds, one hundred fifty pounds collectively, so that the net printing wheels which previously stood at twenty-three pounds fifteen shillings and no pence will be left standing at one hundred seventy-three pounds fifteen shillings and no pence.

Inasmuch as the stators 359 pertaining to the thousands pounds, ten thousands pounds and hundred thousands pounds in the product accumulating apparatus, Fig. 1e, stand at "0" the passage of the synchronizer drum contacts 501X, 501Y and 501Z successively into engagement with brushes 90 will be ineffective for potentializing any of the proportionating grid bars and long contacts upon the stator 501 so that no entries will be made in the printing apparatus while the seventh, eighth and ninth sets of rotor bars 503 sweep across said stator, the times at which these sets of brushes sweep across the stator being indicated in Fig. 45 along the chart-line Ch18.

Upon the completion of the single revolution of the rotor 502 for carrying its various sets of rotor bars successively past the contacts upon the stator 501, the amount standing upon the rotors and stators of the product accumulating apparatus, Fig. 1e, will have been transferred onto the gross printing wheels, and the computations of the tax and net based upon the gross will have been respectively entered on the tax and gross printing wheels. Therefore, the rotors 359 of the product accumulating apparatus may be returned to "0" for clearing that portion of the machine, and it is advantageous to do this as soon as the entries have been transferred into what may be called entry storage means which, in the present instance is the motor units and printing wheels of the printing mechanism shown in Fig. 1o. The first cycle in the operation of the machine will have been completed when the above described entries have been made in the printing mechanism.

The operation of transferring the setting of the rotors 359 into the aforesaid storage means will be completed when the contact 501Z has moved beyond the brushes 90, and when this contact is moved beyond the brushes the long contact strip 501P will also have moved beyond the brushes. It will be recalled that the solenoid 508 which

positioned the switching bar 518 was energized from the contact 501P and, since contact 501P is co-extensive with the spread of the contacts 501R to 501Z over the periphery of the synchronizer drum 86, this contact maintained the solenoid 508 energized while said contacts 501R to 501Z were passing the brushes 90.

The contact 501P also effected energization of the solenoid 508A of the clutch 508C and maintained this clutch energized. Hence, when the contact 501P passes beyond the brushes 90 at the time coinciding with the right end of the bar 501P in Fig. 41, the solenoid 508A will be deenergized and this will permit the clutch 508C to release whereupon the rotor 502 will cease rotation, this therefore occurring when the contacts 501R to 501Z have passed beyond the brushes 90.

Zero setting of product accumulating apparatus

As stated, the product accumulated in the product accumulating apparatus has now been entered in storage means whereby it is unnecessary to any longer maintain the product accumulating apparatus in its set-up condition. Furthermore, in so far as the accumulating mechanism itself is concerned, all of the mutilated gears as 378 are demeshed from the ring gears 367 with which they cooperate wherefore these ring gears may be freely rotated relative to the remaining portions of the motor units which are actuated to effect set-up of the rotors 350 which are the portions of the accumulating apparatus finally set up to represent the product.

In a zero-setting operation in the product accumulating apparatus it is not necessary to return the motor units to zero position. The only thing that happens in so far as the motor units are concerned is that the ring gears 367 rotate relative to the remaining portions of the unit, a pawl as 424 being retracted to permit the reverse rotation of the ring gears 367 in the zero-setting operation. When the ring gears come to rest at the end of a zero-setting operation they are so positioned relative to the mutilated gears as 378 that, when the next entry operation is to be effected through these motor or transverse units, the mutilated gears will properly mesh with the internal teeth of the ring gears and effect advancing thereof as well as the connected rotors 350 in the manner previously described.

After the contact 501Z, Fig. 1d, and which ever one of the contacts 501P or 501Q effected engagement of the clutch 508C, Fig. 1n, have passed beyond the brushes 90, a pair of contacts 480 and 483, Fig. 1d, on the synchronizer drum 86 move into cooperation with the brushes 90. The contact 480 is positioned on the drum 86 in advance of the contact 483 so that it will reach the brushes 90 prior to the time contact 483 reaches these brushes.

When the contact 480 moves into cooperation with the brushes 90 the following circuit is closed: From battery conductor 84 through conductor 480R and its brush 90, contact 480, the cooperating brush 90 of conductor 464 and this conductor which passes into a cable 479, said cable reappearing in Fig. 1e where the conductor 464 is led out of this cable. The conductor 464, Fig. 1e, leads to one end of the winding of the solenoid 460, the other end of which winding is grounded at 465. Upon closing of this circuit by the engagement of the contact 480 with the aforesaid of the brushes 90 the solenoid 460, Fig. 1e and Fig. 13, becomes energized during the time

indicated by the chart-line Ch64 whereupon the core 462 of this solenoid is moved. As shown in Fig. 13 the core 462 is connected to one arm of a bell crank lever 463, the other arm of which bell crank bears on the end of the shaft 340 about which the rotors 350 rotate. As heretofore explained a pin as 352 is mounted on the shaft 340 in alignment with each rotor 350 and, when the solenoid 460 is energized and the shaft 340 is moved axially, the pins 352 respectively move into alignment with pins 351, which pins 351 are mounted in the rotors 350.

As best shown in Fig. 1e, a conductor leads from the conductor 464 to each of the solenoids 426A, Figs. 1e and 14. It is these solenoids that effect retraction of the pawls 424 that prevent reverse rotation of the ring gears 367 during the advancing operation thereof. However, in a zero-setting operation the ring gears 367 are to rotate in a direction opposite to that in which they rotated during the set-up of the rotors 350, and hence this energization of the solenoids 426A retracts the pawls 424 from cooperation with the ring gears 367 which therefore may rotate freely in a reverse direction.

As soon as the pins 352 are aligned with the pins 351 and the pawls 424 are retracted, the contact 483, Fig. 1d, bridges the circuit between the brushes 90 to which the conductors 483R and 482 are connected. Since the conductor 483R is connected to the battery conductor 84, a circuit is closed from the battery conductor through said conductor 483R, the contact 483, and conductor 482. This conductor leads into the cable 479 in Fig. 1d. The conductor 482 passes out of this cable as shown in Fig. 1e and is connected to one end of the winding of the solenoid 351B, the other end of which winding is grounded. Hence, when the above described circuit is closed, the solenoid 351B becomes energized during the time indicated by the chart-line Ch65, Figs. 49 and 50. This solenoid is shown in Fig. 13 where it will be seen that the core 350A thereof is connected to the gear segment 348. As best shown in Fig. 15, this gear segment meshes with the gear tooth section 347 of the ratchet wheel 343. A plate 345 is fast to the shaft 340 and has a pawl 344 thereon that seats in the teeth of the ratchet wheel 343.

The solenoid 351B is energized as just described subsequent to the time the pins 352 move into alignment with the pins 351 and when this solenoid is energized and the core 350A thereof is moved, movement being thus imparted through the gear segment 348, ratchet wheel 343, pawl 344, plate 345 to shaft 340 which thereupon starts to rotate and which under the action of the core 350A of the solenoid 351B causes the shaft 340 to be rotated a complete revolution. It will be appreciated that some of the rotors 350 may be standing at zero while others will have been advanced into various positions. Those rotors which stand at zero will have the pins 351 thereof so positioned that they are engaged with the pins 352 at the time the shaft 340 starts its rotation brought about by attraction of the core 350A. However the pins 351 on those rotors which have been advanced into various positions representative of significant digits will be engaged as the shaft 340 so rotates and, when all of the pins 351 have been engaged by pins 352 so that all of the rotors 350 are driven from the shaft 340 in the single rotation of the shaft 340 imparted thereto from the core 350A and shaft 340 has completed its single rotation, all of the rotors

350 will be returned to their zero position. The gears 353 rotate with the rotors 350 to which they are connected and also rotate the ring gears 367 meshed therewith but, as stated, these ring gears merely rotate relative to the remaining portion of the motor unit and, when the shaft 340 has completed the just described single revolution, the ring gears 367 will be in position to advance the rotors 350 into a new position pursuant to the product of the number of shares of stock represented by perforations in the control card 77 on the succeeding printing and control device times the set-up in the multiplier selecting apparatus.

As soon as the shaft 340 has completed the single revolution just described, the contacts 480 and 483, Fig. 1d, will move beyond the brushes 90 whereupon the shaft 340 returns to its initial axial position and the core 350A returns to its initial position and also the pawls 424 reengage the ring gears 367. Immediately after this was completed the means controlling the advancing of the printing and control devices having functioned to advance the printing and control device to position Y2, Figs. 1 and 2, and to bring a succeeding printing and control device into association with the sensing fingers 50 at the time indicated by the chart-line Ch66, Figs. 41 and 42, the machine begins the accumulation of a new product on the rotors 350 in the manner previously described under control of perforations in the control card 77 on this succeeding printing and control device.

While the operation is proceeding to accumulate a new product in the rotors 350 the printing mechanisms to which reference has been made and which are set up pursuant to the settings of the motor units shown in Fig. 10 and which will have been operating, continue to operate so that the data such printing mechanisms are set to represent are printed on the sheets passing through the machine. These printing mechanisms and their mode of operation will now be described.

Printing Mechanism

The printing mechanism in the present instance consists of two different types of printing arrangements. One of these printing arrangements consists of type wheels that are arranged in side by side relation and which bear on the peripheries thereof type characters from which numerals may be printed. The other printing mechanism consists of a plurality of bars which, when operated, print words representative of a numerical value or related subject matter. The reason for this is that it is customary on warrants and checks to express the numerical value to be paid pursuant to such warrant and check in both words and figures or numerals, and it is for this reason that the two different types of printing arrangements are provided.

Heretofore it has been explained how the motor units, shown schematically in Fig. 10 are set up to represent certain numerical values and in connection with this description reference has been made to printing devices that have been set up along with the motor units. The printing devices to which references were so made are the aforesaid numeral wheels.

It has also been stated heretofore that the motor units, which are shown in Fig. 10, are similar to those employed to effect set-up of the rotors 350 of the product accumulating apparatus. However, the structural features of the motor units, diagrammatically illustrated in Fig. 10, are

shown in Fig. 25. Attention is again directed to the fact that not all of the motor units are illustrated in full schematic representation in Fig. 10 for therein only the motor units of the net portion of the apparatus are so illustrated. The motor units for the gross portion of the apparatus and the tax portion of the apparatus are illustrated at the left-hand end of Fig. 10 merely by box-like portions which respectively bear the proper designation.

However, all of the motor units represented in Fig. 10 are structurally similar to that shown in Fig. 25 except that here again the motor units which pertain to pence are arranged to impart to the devices connected therewith a movement equivalent to one-twelfth of a revolution of such devices, whereas all of the other motor units impart to the devices connected thereto a movement equivalent to one-tenth of a revolution of such devices. The reason for this is, as has been explained in connection with the rotors 350 of the product accumulating apparatus, that it is possible to avoid providing an additional unit merely to take care of ten, eleven and twelve pence by providing a single unit which will take care of twelve pence. However, in shillings, if a single unit were provided for this purpose it would need be twice the size of the units provided for pounds, so in this instance two units are provided each of which has a capacity for ten shillings.

In order to conserve space, the motor units in the product accumulating apparatus and the present motor units for the printing mechanism are arranged in staggered relation, which is to say, two rows of such units are provided and the units in one row are positioned between the units on the other row whereby portions of the peripheries of the units are in overlapping relation.

In Fig. 25 the motor units for fractions of a penny and pence are shown and by referring thereto it may be seen that each of these units includes three solenoids 875-1, 875-3 and 875-5 which are similar to and for the same purpose as the solenoids 396-1, 396-3 and 396-5. These solenoids are selectively energized from short contact strips on the stator 501 when the rotor bars 503 pass over the stator 501, as has previously been explained. Thus, in the description heretofore, when reference was made to the motor unit for pence in the net portion of the apparatus, the motor unit C, Figs. 10 and 25, was designated.

The motor units in the printing mechanism include ring gears similar to the ring gears 367 and when these motor units were set up these ring gears were rotated and in so rotating drove gears 555 which correspond to the gears 353 and which gears 555 are respectively connected to a number wheel for printing the data in numerals or figures and which will now be described.

The number wheels to which reference has just been made are mounted for rotation about a shaft 516, said wheels being shown in plan, Fig. 31, and in cross-section, Fig. 32. Each of these wheels has numeral or figure printing type characters on the periphery thereof and all wheels pertaining to units shillings or units pounds or above have ten such type characters on the peripheries thereof and on all of these wheels, except the ten shillings wheel, these type characters are for printing numerals "0" to "9." The wheel pertaining to pence bears type characters for printing the numerals "0" to "11." The ten shillings wheel has a type character at a position corresponding to its first, third, fifth,

seventh and ninth positions for printing the digit "1" and is equipped with type characters at positions corresponding to its zero, second, fourth, sixth or eighth positions for printing "0." The reason the ten shillings wheel is equipped with a type character for printing "1" at each of its odd numbered positions is that in any of its odd numbered positions it can only represent ten shillings for, when it moves into its second position representative of twenty shillings, it is not to print since this is equivalent to one pound and, when it is in its third position representative of thirty shillings, a carry will have been made into units pounds so that in this third setting the ten shillings wheel in fact represents but ten shillings and this applies throughout a complete revolution of the wheel.

Heretofore reference has been made to the tax portion of the apparatus, the net portion and the gross portion. There is a set of type wheels, such as have been described heretofore and which are designated by 520, for printing the amounts of tax, net and gross, and it is these groups of type wheels and their associated mechanism, such as the motor units shown in Fig. 10, which constitutes these portions of the apparatus. Furthermore, each such group of type wheels includes a type wheel for printing pence, "1" to "9" or units shillings, ten shillings, units pounds and so forth. Of course, if it is ascertained that the tax will not extend beyond say thousands pounds, it will not be necessary to provide printing wheels 520 for orders above thousands pounds and this will also be true in so far as net is concerned. However, for the purpose of the present description, it will be assumed that each group of type wheels contains wheels for the same number of orders.

The group of type wheels for printing the net is illustrated in Fig. 26 and is shown adjacent the bracket labeled "Net." The type wheel in this group, and as shown in this view, at the right-hand end is for printing hundred thousands pounds. The adjacent type wheel to the left is for printing ten thousands pounds, the next thousands pounds, the next hundreds pounds, the next tens pounds, the next units pounds, the next ten shillings, the next "1" to "9" or units shillings, and the next pence.

It has been described that the two grids or proportionating apparatus include transverse bars pertaining to fractions of a penny. Fractions of a penny however are not to be printed but nevertheless, in the group of type wheels 520 pertaining to net, there is included a wheel FP which is similar to the type wheels 520 except that it does not have type characters on the periphery thereof. The wheel FP which pertains to fractions of a penny is advanced by a motor unit, just as are the type wheels 520, and it is so arranged that if it comes to rest in a position representative of one-tenth to five-tenths of a penny it is ineffective. When however it is moved into and comes to rest in a position representative of six-tenths to one penny, which is at zero position, and into which one penny or tenth position it will be moved in event it is caused to make a complete revolution in the course of an operation, a carry-over is made onto the pence wheel so that the pence wheel will be advanced to print one more penny than that it is set to print by operation of the motor unit by which it is operated. This carry-over from the fractional or decimal penny wheel onto the pence wheel is effected whenever the fractional penny wheel moves from its fifth to its

sixth position, and this carry-over is effected by mechanism which is similar in construction and operation to the mechanism which effects a carry-over from any one of the type wheels 520 onto the type wheel of next higher value.

Heretofore reference has been made to a carry-over being effected under control of devices set by the motor units shown in Fig. 10 and it was then explained that a circuit was established to a solenoid 437A on the motor unit operating the order next higher to the one from which a carry is to be made. The parts which enter into effecting such a carry are as follows: A bracket 563, Figs. 25 and 33, is carried by standards extending upwardly from the side members 552 of the frame 554, in which frame 554 the motor units shown in Fig. 10 and the type wheels of the printing mechanism are mounted. As shown best in Fig. 33, the bracket 563 has projections 562 thereon which extend between each adjacent set of type wheels 520, one such projection also extending outwardly of the special wheel FP. A pair of contacts as 514 is mounted on and insulated from each of the projections 562. A conductor 514A is connected to one of the contacts of each pair while a conductor 514B is connected to the other contact of each pair. Each conductor 514A is connected to a conductor 512 as shown in Fig. 10 and this conductor 512 leads to battery. Each conductor 514B leads to one end of the winding of the solenoid 437A, that is similar to the solenoid 437, and which solenoid 437A is to effect actuation of the motor unit pertaining to the number wheel next higher to the number wheel with which the particular pair of contacts is associated. The other end of the winding of each of these solenoids 437A is grounded. Hence, whenever a pair of contacts 514 is closed, a solenoid 437A is actuated whereupon the parts associated therewith are operated just as were corresponding parts associated with a solenoid 437. One such solenoid 437A, and its associated parts, is illustrated in Fig. 25.

The pairs of contacts 514 are closed by a pin 514C, Fig. 33, of insulating material mounted on the type wheel 520 or the wheel FP to which the pair of contacts 514 pertains. In so far as the wheels for "1" to "9" or units shillings, and units pounds to ten thousands pounds are concerned, the pin 514C on each of these wheels is located in such position that, as the type character thereon for printing "9" passes beyond printing position to advance the type character for printing "0" thereon into printing position, the pin 514C closes the associated pair of contacts 514. In so far as the number wheel 520 for pence is concerned, the pin 514C is mounted in such position that, as the type character thereon for printing "11" pence moves from printing position to advance the type character for printing "0" thereon into printing position, the pin 514C thereon closes the cooperating pair of contacts 514. The pin 514C on the wheel FP is so located thereon that as this wheel moves from its fifth to its sixth position with respect to what would be printing position if this wheel bore type characters, this pin 514C closes the associated pair of contacts 514. The type wheel 520 pertaining to ten shillings has a pin 514C thereon intermediate each even numbered position thereof and the odd numbered position respectively next preceding and between its ninth and zero positions so that each time this wheel is advanced from an odd to an even numbered position, with respect to printing position of this

wheel, a pin 514C engages the associated pair of contacts 514 for when this wheel so advances a carry-over is to be made on to the units pounds type wheel 520. It will be appreciated that before any one of the type wheels 520 or the wheel FP attains the succeeding position above described, the pin 514C thereon will have disengaged the associated pair of contacts 514 which are therefore only momentarily closed, but such period of being closed is sufficient to effect operation of the proper one of the solenoids 431A, a holding circuit similar to that shown in Fig. 14 and including a relay as 454A being associated with each solenoid 431A to maintain it energized as were the solenoids 437, which is to say, long enough to effect a carry-over.

Heretofore it has been explained that as the contacts 501R to 501Z, Fig. 1d, on the synchronizer drum 86 move past the brushes 90 certain of the motor units shown in Fig. 1c were positioned to represent certain numerical values and it was also explained that this positioning advanced devices associated with these motor units. The devices to which reference was thus made were the type wheels 520, and the type wheels which were so moved and set up and what they were set to represent are as follows.

Referring first to the type wheels 520 in the group from which the net is printed, and which type wheels are shown in Fig. 26, the type wheel 520 at the left-hand end of this group pertaining to pence was advanced a complete revolution in the set-up of this group of type wheels and stands in such position that the type character thereon for printing zero is at the printing position of the type wheel. The type character for printing "5" on the type wheel 520 for units shillings is in printing position as is the type character for printing "1" on the type wheel pertaining to ten shillings. The type character for printing "3" on the type wheel 520 for units pounds, the type character for printing "7" on the type wheel 520 for tens pounds, and the type character for printing "1" on the type wheel 520 for hundreds pounds are all in printing position.

It will be noted that in this setting-up operation the type wheels of the group pertaining to net for printing in the thousands to hundred thousands orders were not moved and, as is customary in the art, it is desirable that in the printing operation to be made from the set-up type wheels on this group that no impression should be made from these type characters. This is accomplished by what may be called a zero-suppressing arrangement and each type wheel 520 in each group includes such an arrangement.

The zero-suppressing apparatus employed herein is illustrated in Figs. 31 to 33 and by referring thereto it will be seen that a substantially U-shaped saddle 569 embraces each type wheel 520 and is supported from the shaft 516 on which the type wheels are supported. All of the wheels 520 in the net, tax and gross groups are mounted on this shaft 516 so as to be rotatable thereon and the type wheels are spaced one from the other along this shaft by interposed spacers 573, Fig. 32, and the aforesaid saddles to which reference has just been made are mounted on these spacers.

The spacers 573 each having a set screw 573A therein which extends into an axially extending groove 573B' in the shaft 516, one such groove being provided below each spacer, the length of that portion of screw 573A which extends into

groove 573B' being slightly less than the depth of the groove. The spacers 573 extend between each adjacent set of number wheels to maintain the wheels in determined spaced relation.

In so far as the sets of type wheels for gross and tax are concerned a sleeve 516A, Fig. 26, extends between each of the outermost type wheels and the interposed parts 558 and 559 and part 551 of the frame, which constitute the supports for the shaft 516. This arrangement in cooperation with the spacers 573 holds the type wheels of these groups in a permanent position in the machine axially of the shaft 516. The grooves 573B' enable the shaft 516 to be moved axially in a zero-setting operation. A similar arrangement of spacers 573 is provided between the type wheels of the net group, and a sleeve 516A extends between the frame member 558 and the outermost type wheel at one end of this group. However, at the other end of this group, which is at the end of the shaft 516 in the direction in which it is moved in a zero-setting operation a somewhat different arrangement is provided. Here a bracket 516B on the frame member 550 bears against the outermost wheel of this group which is the wheel FP. Furthermore, a cam 516C is fast to the frame member 550, the cam surface of which is engageable by a roller 516D on an arm 516E fast on the shaft 516, said roller engaging said cam surface when said shaft 516 is moved axially in a zero-setting operation. A spring 516F extends between washers engaging the cam 516C and the arm 516E and this spring urges the shaft 516 into its normal position.

A shield as 576, Figs. 31 to 33, is mounted on the bight of each saddle 569 and this shield when in its normal position is disposed between the zero type character on the type wheel and the cooperating platen, the upper of the shields 576 shown in Fig. 31 being in this normal position. But whenever the type wheel 520 is operated to move some type character thereon other than "0" into printing position, in which event the type wheel moves in the direction of the arrows 566A in Figs. 31 and 33, the shield 576 of this type wheel is moved out of its normal position so as to expose the type characters thereon to the action of the cooperating platen, the lower of the shields 576 shown by broken lines in Fig. 33 being disposed in such position. This movement of a shield 576 incident to such advance of a type wheel is brought about by the legs as 577A on the saddle and which frictionally embrace the sides of the type wheel so that when the type wheel is moved the shield moves therewith. Of course, it is only desired to move the shield a sufficient distance to expose the type character in printing position to the action of the platen so when a type wheel is moved the shield 576 therefor moves therewith until it engages the bracket 563 or, in other words, the shield moves from the full line position thereof shown in Fig. 33 to the broken-line position shown in this view. A shield moved into the broken-line position will remain in such position until the shaft 516 is operated in a zero-setting operation, in which event, if movement of the associated type wheel moved the shield out of its normal position, the frictional engagement of the legs as 577A with the type wheel starts the shield back to its normal or full-line position shown in Fig. 33 as soon as the type wheel starts to move. When the shield attains this normal position, it engages the free end of the projection 562 extending between the particular type wheel

in the adjacent type wheel and, when engaged with this projection, the shield is held in its normal position irrespective of how far the type wheel may be moved in the zero-setting operation.

As is understood in the art, only those zeros above the highest order in which printing is to be effected are to be suppressed, and it is desirable to print zeros in those orders below such highest order. Hence, the leg 578 of each saddle, except the saddle associated with the pence wheel, has a stud 572 therein which overlaps the leg 577 of the saddle associated with the next lower type wheel. Thus, for example, if the type wheel pertaining to units pounds is the only one that is operated in a particular set up, the shields associated with the type wheels for tens pounds on up are not moved, but the shields associated with the type wheels pertaining to ten shillings, units shillings, and pence, are moved by reason of the successive studs 572 engaging the leg 577 of the saddle associated with the next lower type wheel so that zeros will be printed from all of these type wheels pertaining to values lower than units pounds.

Thus in the present instance in so far as the group of type wheels pertaining to net is concerned, the highest order in which a type wheel is moved is the hundreds pounds order. Thus, shields as 576 remain in normal position in so far as the type wheels for thousands to hundred thousands pounds is concerned so that, when an impression is made from the type characters in the net group set up as just described, no impression will be made from these type wheels.

In the aforesaid set-up of the type wheels of the net group, the type wheel 520 pertaining to pence made a complete revolution so that in the set-up operation it moved, which means that the shield 576 therefor was moved out of its normal position and hence the type character for printing "0" on this wheel is exposed. If the type wheel for pence had not been moved the pin 572 on the saddle 569 associated with units shillings would have moved the shield associated with the pence wheel from its normal position so that again the type character for printing "0" would have been exposed.

The type wheels 520 in the tax group which were set up and what they were set to represent is as follows. The type wheel for pence in this group was set to print "4"; the type wheel for units shillings was set to print "8"; the type wheel for ten shillings was in position to print a "1"; the type wheel for units pounds was set to print "7"; and the type wheel for tens pounds was set to print a "5." Shields 576 remain in normal position in so far as the type wheels in this group for hundreds pounds to hundred thousands pounds is concerned to suppress the printing of zeros from these type wheels.

The type wheels 520 in the gross group which were set up and what they were set to represent is as follows. The type wheel for pence in this group was set to print 4 pence while the units shillings type wheel was set to print "3," and the ten shillings type wheel was set to print a "1." The type wheels for the units, tens and hundreds orders of pounds were respectively set to represent "1," "3" and "2." The shields 576 associated with the type wheels in the thousands to hundred thousands orders in this group remained in normal position to suppress printing of zeros from these type wheels.

Thus all of the type wheels for printing the 75

results of the present problem are set up to be prepared to print in numerals the various numerical values determined in solving this problem.

It has been stated heretofore that it is desirable to totalize various amounts printed on instruments in machines of the character to which this invention pertains and in the present instance means for totalizing the various numerical values ascertained in the course of operation of this machine are provided. Such means are shown in Fig. 10 and Fig. 25.

By referring to Fig. 25 it will be seen that in addition to the aforesaid motor units for fractions of a penny and pence there is shown at the left-hand end of this view a motor unit K. This motor unit is identical in construction and operation with the motor units heretofore described as being employed to effect set-up of the printing mechanism, and also with those motor units which effect set-up of the rotors 350. The group of motor units of which the motor unit K is a part comprises a motor unit for fractions of a penny, pence, units shillings, ten shillings, and for the orders of units pounds to hundred thousands pounds in three different groups which as heretofore respectively pertain to net, tax and gross. These motor units respectively cooperate with type wheels 520A, Fig. 10 and Fig. 25, mounted on a shaft 515 and which type wheels are similar to the type wheels 520 heretofore described as being mounted on the shaft 516, this group of type wheels also including a wheel FP, Fig. 10, similar to the above described wheel FP for fractions of a penny. The solenoids as 876—1 of the motor units as K are also connected to the short contact strips on the stator 501 as were the solenoids as 875—1. Hence, solenoids as 875—1 and 876—1 are operated simultaneously as rotor bars 503 traverse the long and short contact strips on the stator 501. It will therefore be seen that whenever the type wheels on the shaft 516 are set up to represent numerical values, the type wheels on the shaft 515 are set up to represent similar numerical values.

However, after an impression has been made from the type wheels on the shaft 516, in a manner to be described presently, these type wheels are returned to zero, as will also be explained presently, but the type wheels on the shaft 515 are not returned to zero along with the type wheels on the shaft 516. In other words, the various entries made into the type wheels on the shaft 516 are accumulated on the type wheels on the shaft 515 so that, after a number of entries have been made onto the type wheels on the shaft 516, the total value of such entries may be ascertained from the type wheels on the shaft 515, the type wheels on the shaft 515 of course starting from zero at the time the first of the entries for which a total is to be ascertained is made on the type wheels on the shaft 516. The type wheels on the shaft 515 include an arrangement for effecting carry-overs similar to that associated with the type wheels on the shaft 516 and as various numerical values are accumulated on the type wheels on the shaft 515 the carry-overs incident to such accumulation are effected as they become necessary.

In the present instance where type wheels on the shaft 516 were set up to represent a gross of two hundred thirty-one pounds, thirteen shillings and four pence, a tax of fifty-seven pounds, eighteen shillings and four pence, and a net of one hundred seventy-three pounds and fifteen

shillings, type wheels on the shaft 515 were similarly set up.

In the present machine, the sheets S, Figs. 2 and 3, to be printed are deposited on feed tapes F which carry the sheets into position above the type wheels on the shaft 516 and also into position above the printing means, which will be described hereinafter, which print certain numerical data on the sheets in words rather than in numerals or figures and then into printing means wherein impressions are made on the sheets directly from type characters on the printing and control devices. These feed tapes may be similar to those shown in U. S. Patent No. 2,041,183, patented May 19, 1936, and as shown in that patent the sheets may be severed from a web and deposited onto the feed tapes, and constantly re-occurring data on both the back and front faces of the sheets may be printed by the means shown in such patent if it should so be desired. However, the sheets may be cut to size and have the constantly reoccurring data printed thereon prior to the time they are positioned for passage through the machine and, in such event, an arrangement like that shown in U. S. Patent 2,002,773, patented May 28, 1935, may be employed, and the sheets will be stacked in the manner explained in that patent and picked up one at a time and deposited on the feed tapes shown in that patent to be carried through the above described printing positions in the present machine.

As the sheets move along with the feed tapes they may be stopped in the various printing positions by having them move into engagement with successively operating stop fingers which will properly position the sheets relative to the various printing means in the machine and these stop fingers may be of the kind shown in United States Patent No. 1,955,806, patented April 24, 1934, and these stop fingers may be operated in the manner explained in that patent.

In the present instance where a warrant or check and receipt or counterfoil are to be printed, it is advantageous to incorporate the particular warrant and counterfoil that is to be printed under control of each printing and control device in a single sheet and such an arrangement is shown in Fig. 3a where it will be seen that the warrant and counterfoil are separated one from the other by a score-line 3X. The sheets S are deposited on the feed tapes F, Fig. 2, face down, whereby the various devices from which the printing means are made may be disposed in the bed of the machine.

As a sheet S moves along with the feed tapes in the direction of the arrow shown in Fig. 3a, the leading edge thereof first comes into engagement with a stop finger which positions that part of the warrant on the sheet that is to bear an impression of the sum to be paid pursuant to the warrant in alignment with the type wheels 520 set up to print the net and the platen Pb, Fig. 2, is operated in the manner which is described hereinafter to make the impression T1 on the sheet S. This occurs at the time indicated by the chart-line Ch67 in Fig. 49. After this impression has been made the engaged stop finger is withdrawn and the sheet again moves with the tapes to move the counterfoil portion thereof into position above the type wheels 520 on the shaft 516, and when the sheet is so positioned it will engage a second stop finger to be held in this position. When the sheet is in this position both the platens Pb and Pc are operated at the time

indicated by the chart-lines Ch68 and Ch69, Fig. 50, to effect an impression T2 from all of the set-up type wheels on the shaft 516.

The engaged stop finger is then retracted and the sheet continues to move with the tapes until it passes onto a platform 618, Figs. 2 and 3, of the word printing apparatus which will be described presently, this platform being disposed over the feed tapes so that the sheet is out of engagement with the tapes when it passes onto this platform.

After the second of the stop fingers has been elevated, which means that the impression T2 has been made on the sheet, the number wheels 520 on the shaft 516 are returned to zero and in point of timing of the machine this occurs prior to the time contacts as 501R to 501Z on the synchronizer drum 86 move into association with the brushes 90 during the second cycle of operation of the machine. This second cycle of operation will have begun, in so far as entries on the rotors 350 are concerned, about the time the sheet S moves into engagement with the second of the stop fingers to have the impression T2 made thereon at which time the contact strips on the synchronizer drum 86, shown in Fig. 1 and which pertain to the various orders of the multiplicand, start to move into association with the brushes 90.

After the impression T2 has been made on the sheet a pair of contacts 595 and 596, Fig. 1d, on the synchronizer drum 86 move into association with the brushes 90. These contacts are similar to the contacts 480 and 483 which brought about zero-setting of the rotors 350 as previously explained. In this instance the contact strip 595 first moves into association with the brushes 90 and actuates means similar to that actuated by movement of the contact 480 into association with the brushes 90 and the means so actuated shifts the shaft 516 axially so as to bring the pins 584, Fig. 32, thereon into alignment with the pins 585 in the type wheels 520, the pins 584 and 585 respectively corresponding to the pins 352 and 351 on the shaft 340 and the rotors 350. When the contact 595 bridges its cooperating pair of brushes 90, circuit is closed to a solenoid 582, Figs. 1o and 25, which is similar to the solenoid 460, Fig. 13, and this solenoid actuates a bell crank lever 581, Fig. 25a, just as did the solenoid 460, the bell crank actuated by the solenoid 582 moving the shaft 516 axially and maintaining it in the axially moved position during the time indicated by the chart-line Ch70.

After the shaft 516 has been shifted axially the contact strip 596 bridges its cooperating brushes 90 whereupon a solenoid 589, Figs. 1o and 25, is energized during the time indicated by the chart-line Ch71. The solenoid 589 operates devices similar to those operated by the solenoid 351B, Fig. 13, and causes the shaft 516 to make a complete revolution in the course of which the pins 584 on this shaft pick up the pins 585 in the type wheels 520 that are off their zero position so that at the end of a complete revolution of the shaft 516 effected upon energization of the solenoid 589 all of the type wheels 520 on the shaft 516 are in their zero position. The shaft 516 rotates in such a direction that it turns the type wheels 520 in a direction opposite to that in which they were moved when they were set up so that as these wheels return to zero they move the same distance as that in which they were moved to be set up. In other words, the type wheels 520 move forwardly when set up

to represent numerical values in a predetermined amount and move rearwardly in the same amount in a zero-setting operation. Those of the type wheels 520 already at zero are not moved and in this respect the zero-setting operation of the type wheels 520 differs from the zero-setting operation of the rotors 350.

The rotors 350 also move rearwardly in a zero-setting operation so that the pins 351 thereon are so positioned that they may precede the pins 352 on the shaft 340 in a zero-setting operation and at the end of said zero-setting operation will dispose the rotors 350 in their zero positions. Furthermore, all of the rotors 350 are rotated in a zero-setting operation whether or not they are off zero, but this condition cannot prevail in so far as the type wheels 520 are concerned because when these type wheels 520 move in a zero-setting operation they set up the word printing mechanism, and it is only those type wheels which are off their zero-setting position that are moved in a zero-setting operation. In view of this the pins 584 and 585 must so cooperate in a zero-setting operation that those wheels which are already at zero will not be moved, and this is accomplished by causing the roller 516D, Fig. 26, on the arm 516E to ride over the face of the cam 516C. The contour of the face on the cam 516C is such that when the shaft 516 is moved axially under the influence of the solenoid 582 it is forced toward the face of the cam 516C and the roller 516D, as stated, engages this cam face. It is the contour of this cam face that regulates the engagement of the pins 584 and 585. The pins 585 in the type wheels that are at zero lie behind the pins 584 when the shaft 516 is moved axially so that when the shaft 516 is rotated these pins are not picked up. Then as the shaft 516 continues rotation and as the type wheels picked up thereby approach their zero position, the roller 516D starts to move onto a rise on the cam face, and this rise causes the shaft 516 to be moved axially against the urge of the solenoid 582 and when the picked-up type wheels attain their zero position the pins 584 will be disengaged from all pins 585 so that as the shaft 516 finishes its complete revolution no movement is imparted to any type wheel.

It has been explained heretofore that the shields 576, Fig. 33, are returned to their normal position upon movement of a type wheel back into its normal position. It has also been explained that those shields associated with type wheels below the type wheel in the highest order moved are also moved from their normal positions whether or not the type wheels with which they are associated are moved. Of course, as these lower type wheels are moved such shields will be returned to their normal positions in the zero-setting operation, but if the type wheel with which the shield is associated is not moved in a zero-setting operation it would not be returned to its normal position were it not for the fact that a leaf spring as 573B, Fig. 32, on the associated spacing collar 573 engaged the pin 572 on this shield in the course of a zero-setting operation. Such engagement of the leaf spring with the pin causes the shield to be returned to its normal position, and when this normal position is attained the leaf spring 573B merely rides off of the pin 572 engaged thereby so that the collar 573 may continue its movement with the shaft 516 without further effecting the positioning of the shield.

Soon after the type wheels 520 on shaft 516

reach zero and concurrently in point of time with the time period covered by the synchronizer drum strip 501C as shown in dotted outline in the second and third cycle periods in Figs. 42 and 43, the contact strips 501R to 501Z on the synchronizer drum 86, Fig. 1d, move into association with the brushes 80 whereupon the product which will have been accumulated on the rotors 350 in the course of the second cycle of operation will be transferred to the printing wheels on the shaft 516, in the manner previously described. This is effected from the interconnecting conductors AB of the proportionating apparatus so that these type wheels on this shaft 516 are again set up to represent a gross dividend which will be the product of the value represented by perforations in the control card 77, on the second printing and control device to move into association with the sensing fingers 50, times the multiplier for which the multiplier selecting apparatus is set up. Other of the wheels 520 on shaft 516 are set up to represent a tax and a net dividend pertaining to the gross dividend being set up, these amounts being ascertained in the proportionating apparatus in the manner previously described.

Word printing apparatus

As the type wheels 520 on the shaft 516 return to zero they rotate the ring gears 367 with which they are meshed and, while the ring gears 367 are so driven, other gears as 771, Fig. 27, are meshed therewith under control of a solenoid 799, Fig. 28. It is gears as 771 that are under control of the solenoid 799 that effect set-up of the word printing apparatus in a manner now to be described.

It will be recalled that the zero setting of the type wheels 520 on the shaft 516 is initiated and effected under control of contacts 595 and 596 and that it was the contact 595 which first moved into association with its cooperating brushes 90. In so far as the zero setting operation is concerned, the contact 595 caused the shaft 516 to be shifted axially and this occurred prior to the time the contact 596 caused the shaft to be rotated and it is of course the rotation of the shaft 516 that returns the type wheels 520 to zero. Since it is the return of the type wheels 520 to zero that is to set up the word printing apparatus, it is apparent that the gears as 771 must be meshed with the ring gears 367 that are to be operated upon return of the type wheels to zero prior to the time the ring gears are so set in motion. It is also essential of course that the gears as 771 must be out of mesh with the ring gears as 367 when these ring gears are driven by their motor units for otherwise the word printing mechanism would be set up simultaneously with the set-up of the type wheels 520 on the shaft 516. Hence, the gears as 771 are normally out of mesh with the ring gears 367 and are only moved into mesh therewith in a zero setting operation wherefore the word printing mechanism will only be set up in a zero setting operation. The reason the word printing mechanism is set up from the zero setting operation of the type wheels on the shaft 516 is that word printing may be effected pursuant to a preceding cycle of operation while the type wheels 520 are being set up pursuant to a succeeding cycle of operation, this arrangement of course speeding up operation of the machine.

Hence, the conductor 593', Figs. 1p and 28, which is an extension of the conductor 593, Figs. 1d and 1e, is potentialized when the contact 595

moves into contact with its cooperating brushes 90. This energizes the solenoid 799, Figs. 1p and 28, at the time indicated by the chart-line Ch72 simultaneously with the energization of the solenoid 582, Figs. 10 and 25, which is energized through the conductor 593 as indicated by the chart-line Ch70.

The core 799A, Fig. 28, of the solenoid 799, which is attracted when this solenoid is energized, is connected through a link 792 to one arm of a bell crank lever 789, Figs. 25 to 28, that is fast on the shaft 788, Figs. 26, 27 and 28. The other arm 790, Fig. 28, of this bell crank lever has a link 785 connected thereto, and an arm 787, Figs. 26 and 27, corresponding to the arm 790 has a similar link connected to the free end thereof. The other ends of the links as 785 are connected to toggle links as 783 and 798 by pins as 784, Figs. 25, 26, 27 and 28. The free ends of the links as 783 are connected to rockers as 780 by pins as 782, and a shaft 655, Fig. 27, extends between the two rockers 780. The free ends of the links as 798, Fig. 28, are connected to rockers as 795 between which a shaft 773, Fig. 27, extends. The extent of the shafts 655 and 773 is best shown in Fig. 27.

A collar 769, Fig. 27, is fast on the shaft 655, and a pinion 767 on the shaft 655 abuts thereagainst. Another pinion 766 on the shaft 655 is connected to the pinion 767 by a sleeve 768, the pinion 766 abutting a collar 766A which, in cooperation with the collar 769, holds the pinions 766 and 767 against axial movement along the shaft 655. Another pair of pinions 763 and 764 are connected by a sleeve 765 and these pinions are held against axial movement along the shaft 655 by collars 765A and 766A. Another set of pinions 760 and 761 are connected by a sleeve 762, while another set of pinions 657 and 659 are connected by a sleeve 658, and still another set of pinions 653 and 656 are connected by a sleeve 654, and all of these sets of pinions are held against axial movement along the shaft 655 by suitably located collars similar to the collars 769 and 766A.

Other sets of pinions described in further detail hereinafter are provided on the shaft 773. Normally the shafts 655 and 773 are in the position shown in Fig. 28 which may be referred to as the inoperative position but, when the solenoid 799 is energized and the bell crank 789 is pivoted, as well as the shaft 788, this movement is transmitted through the links as 785, 783 and 798 to the rockers as 780 and 795 whereupon the shafts 655 and 773 move upwardly as viewed in Fig. 28. Certain of the pinions as 766, Fig. 26, on each of the shafts 655 and 773 are aligned with ring gears 367 meshing with gears 555 on the type wheels 520 in the group from which the net is printed, as may be seen by reference to Fig. 26, and when the shafts 655 and 773 move upwardly as just described these pinions mesh with the just mentioned ring gears 367. This meshing occurs prior to the time the shaft 516 is set in rotation in a zero setting operation so that, when the shaft 516 is so set in rotation the movement imparted to any of the ring gears 367 meshing with gears on type wheels 520 in the net printing portion of the apparatus, which are off their zero positions, will be transmitted to the pinions on the shafts 655 and 773. It is the movement that is so transmitted to these pinions that effects set-up of the word printing apparatus.

In the present instance type wheels 520 in the net portion of the apparatus for printing one

hundred seventy-three pounds and fifteen shillings are to be returned to zero and at this point it should be noted that when the shaft 516 has rotated in a zero setting operation it turns in such a direction that any type wheels thereon that are set up to represent significant digits are rotated backwardly to zero position. Thus in a zero setting operation the type wheels 520 receive motion corresponding to the value of the significant digits they are set to represent.

Referring now specifically to Fig. 27 and the zero setting operation incident to returning to zero the type wheels 520 set to represent the aforesaid net amount the pinion 775, Fig. 27, will be meshed with the ring gear 367 that meshes with the gear 555 on the type wheels 520 for the hundreds order so that, as this type wheel is returned to zero, the pinion 775 will receive motion sufficient to set it up to represent one hundred pounds. Likewise, the pinion 760 will mesh with the ring gear 367 pertaining to the tens pounds order and therefore this pinion will be rotated sufficiently to be set to represent seventy pounds. Furthermore, the pinion 774 will mesh with the ring gear 367 pertaining to the units order of pounds and therefore this pinion will be rotated sufficiently to be set to represent three pounds. In addition, the pinion 657 will mesh with the ring gear 367 pertaining to the ten shillings type wheel and therefore this pinion will be rotated sufficiently to be set to represent ten shillings. And, lastly, the pinion 770 will mesh with the ring gear 367 pertaining to the units order of shillings and therefore this pinion will be rotated sufficiently to be set to represent five shillings. The pinions just described are the only ones which are rotated in the present set-up but it is to be understood that there is a pinion for every ring gear 367 that effects set-up of a type wheel and hence if other of the type wheels had been advanced from their zero positions other pinions shown in Fig. 27 would have been set to represent whatever value the type wheel with which the ring gear 367 cooperates was set to represent.

Each pinion such as those which have been described as being set up is connected either directly or indirectly to a settable unit SU, Fig. 27, which controls the actual printing of the words on the instruments. Thus, some of the pinions which mesh with ring gears 367 directly mesh with gears on the settable units SU while others are connected through a sleeve as the sleeve 772 with another pinion on the same shaft and in such instances it is such other pinion that effects set-up of the settable units. The settable units to which reference has just been made are in reality switching or selecting devices. These units in connection with a set of contacts on the synchronizer drum 86 select the circuits which bring about operation of the various word printing members.

The word printing members to which reference has just been made are shown in Figs. 34 and 36 and by referring thereto it will be seen that this arrangement includes the platform 618 to which reference was made in connection with the printing of the impressions T1 and T2. An opening 655A, Fig. 34, is provided in this platform and the word printing members makes impressions on the sheets positioned above this opening, while they are resting on this platform, through an ink ribbon 654A.

There is a word printing member for every word that will need to be printed on the sheets within the capacity of the machine. These word

members are used singly or in combination in the operation of the machine and these members and the mountings thereof will now be described.

The word printing members to which reference has just been made are generally indicated by 635A and are arranged in two banks L and R as best shown in Figs. 34 and 36, said banks being located on opposite sides of said opening 655A. The word printing members in the bank L to the left of the opening 655A as viewed in Fig. 34 are mounted on balls 635 to 652, respectively, while the word printing members in the bank R to the right of the opening 655A as viewed in Fig. 34 are mounted on balls 635B to 653B, respectively. Brackets as 654B are provided on the underside of the platform 618 and the balls in the two banks L and R are respectively pivoted on these brackets so that when in inoperative position the balls depend from said platform 618.

As can be seen best in Fig. 36, the balls in each bank successively increase in size downwardly from the platform 618 and the length of the ball and its point of pivoting is such that, when the ball is pivoted toward the opening 655A, the printing member on the right of the ball will be aligned with the opening 655A to make an impression on the sheet above the ink ribbon 654A, all impressions made by the printing members on the balls being in side by side relation as can be seen by referring to the warrant as shown in Fig. 3a.

In addition to the balls being of different lengths they are nested, the smallest ball being nearest the platform and the largest ball being most remote from the platform. Because of this nested arrangement it is apparent that the right of the ball nearest the platform will be shorter than the right of the ball most remote from the platform. Hence, the shorter of the words to be printed can be more easily accommodated on the shorter balls and the longer of the words to be printed are therefore accommodated on the longer of the balls. The shortest words pertaining to numerical values which will need be printed are three letter words and such three letter words are mounted on the shorter balls. The arrangement however also includes a bar for printing the word "No" which is the shortest of all words and which is therefore arranged on one of the balls closest to the platform 618.

The present machine has a capacity for printing up to nine hundred ninety-nine pounds, nineteen shillings and eleven pence, and sufficient word printing members are provided in the machine for printing every amount up to and including the aforesaid maximum amount. The manner in which the printing members are arranged on the balls in the banks L and R in the present instance is as follows:

Bank L	Bank R
ONE	NO
TWO	SIX
FOUR	TEN
FIVE	NINE
SEVEN	THREE
EIGHT	FORTY
FIFTY	PENNY
SIXTY	PENCE
ELEVEN	POUND
TWELVE	POUNDS
TWENTY	EIGHTY
THIRTY	NINETY
SIXTEEN	SEVENTY
FIFTEEN	HUNDRED
FOURTEEN	NINETEEN
THIRTEEN	THOUSAND
EIGHTEEN	SHILLING
SEVENTEEN	SHILLINGS
	**

Referring to the warrant shown in Fig. 3a, the impressions of words on the warrant are always made from the lowest value on up, which is to say, the word "Penny" or "Pence" is always printed first, then the number of pence or the word "No" is printed next, and then "Shilling" or "Shillings" and so on. Furthermore, as will be explained hereinafter, once the sheet to be printed is in its initial position on the platform 618 it is under control of a sheet feeding means independent of the feed tapes F and this feeding means operates to advance the sheet in amounts corresponding to the lengths of the words successively printed thereon, the specific manner in which this is accomplished being explained presently.

Thus, because the words are printed in a reverse order to that in which they are read, it is essential that, in so far as the positioning of the printing members relative to printing position at the opening 655A is concerned, the last letters of the words as they appear on the various printing members be in alignment, such alignment of the words being shown in the above list of the words of which the machine is capable and being indicated along the line a-a in Fig. 36.

The various printing members on the balls in the banks L and R are selectively and forcibly driven into printing position at the opening 655A under control of the above referred to settable members and a set of contacts on the synchronizer drum 86. To this end the settable members are set up pursuant to the amount to be printed on each warrant and then circuits are closed through these settable members from the aforesaid contacts on the drum 86 to selectively bring the printing members into operation. The manner in which this is accomplished will now be described with respect to the operation of the machine being described herein where the amount of "One hundred seventy three pounds fifteen shillings no pence" is to be printed on the warrant portion of the sheet S shown in Fig. 3a.

It will be recalled that selected of the pinions shown in Fig. 28 have been described as being set to represent the net amount of one hundred seventy three pounds, fifteen shillings, which is the amount that is to be printed on the warrant portion of the sheet S shown in Fig. 3a, it being understood that the net amount is the amount to be paid pursuant to the warrant inasmuch as this is the amount that is to be paid to the stockholder in view of the amount of tax that has been deducted from his gross dividend as explained heretofore. In certain instances, one of which will be explained hereinafter, there may be no deduction for tax and in such an event the gross amount determined by the above described multiplication will be entered on the type wheels of the net portion of the apparatus since the pinions shown in Fig. 28 cooperate only with gears 367 of this portion of the apparatus. The entry of the gross amount in the net wheels is effected by operating the switch of which the switching bar 518 is a part and to which reference has been made heretofore, the manner in which this switch is operated to cause entry of the gross amount in the net portion of the apparatus being explained in detail hereinafter in connection with the "No tax operation."

Referring now to Fig. 27 the various gears 367 with which selected of the pinions there shown are to cooperate are illustrated in dot-dash lines and in Fig. 27 in association with such dot-dash lines appear words such as "Shillings," "Units"

pounds," and so forth, which designate the order to which the illustrated gear 367 pertains.

In the present instance pinions shown in Fig. 27 pertaining to the orders for hundreds pounds, tens pounds, units pounds, ten shillings and units shillings have been set up and as these pinions were set up, they positioned settable units SU to represent members in the above described net amount.

In the present example the amount to be paid pursuant to the warrant does not include pence so that the pinion 653 which is to mesh with the gear 367 pertaining to pence has not been advanced, which is to say, set up.

Even though this pinion 653 was not advanced, it should not be assumed that the settable unit with which this pinion cooperates is not set up. This is true because where no pence amount is to be printed, printing members in the group of the bank R are to be actuated to print "No pence." Thus the settable unit for pence is in reality set up and the manner in which this settable unit is set up may best be determined by reference to the wiring diagrams, Figs. 1p to 1r. The settable unit pertaining to pence is indicated by having the words "Pence" applied thereto in Fig. 1p and this settable unit comprises a stator 806C and a rotor 800B. In view of the fact that there is no value in pence the pinion 653 was not rotated, as previously stated, and hence the rotor 800B of the "Pence" settable unit was not rotated through the gear train including the gears 653, 656 and 712A, Figs. 27 and 30, wherefore the rotor 800B remains in position to dispose the rotor bars 802 and 803 thereon in a position such that circuit is bridged from the long contact strip b1 on the stator 800C and the short contact 806D on this stator by the rotor bar 802. The contact 806D as will be explained controls the circuit to the means which operate the bail in the bank R bearing type characters for printing the word "Pence." Also, circuit is bridged between the long contact strip b2 on the stator 800C and the contact 800E on this stator by the rotor bar 803. The contact 800E as will be explained controls the circuit to the means which operate the bail in the bank R bearing type characters for printing the word "No." Further, in so far as this pence settable unit is concerned, the rotor bar 802 would, if the pinion 653 had operated the rotor 800B to represent one penny, have closed circuit between contact strip b1 and a contact 800K which would effect printing of the word "Penny." In addition, if the rotor 800B had been advanced to represent some number of pence between two and eleven, the rotor bar 802 would have closed circuit between the contact strip b1 and a long contact strip 800F which would effect printing of the word "Pence." The rotor bar 803 selectively closes circuit between the contact strip b2 and contacts which control printing of the words "One" to "Eleven." If the rotor 800B is advanced to represent some number of pence between one and eleven, the particular contact controlling word printing which will be selected will of course correspond to the number of pence the rotor is set to represent.

The settable unit indicated by the word "Shillings," Fig. 1p, comprises two rotors 801A and 801B both of which cooperate with a stator 801C. The rotor 801A is set up under control of a pinion 770, Fig. 27, which pertains to "1" to "9" or units shillings. The rotor 801B is set up under control of a pinion 657 which pertains to ten shillings. It will be recalled that after the cir-

cuits pass out of the multiplier selecting apparatus, separate means have been provided for "1" to "9" or units shillings and ten shillings in each of the various mechanisms incorporated in the machine. However, when from ten to nineteen shillings are to be printed in words it is essential that units shillings and ten shillings be handled together in order that amounts as fifteen shillings may be printed. It is for this reason that the two rotors 801A and 801B cooperate with the same stator.

In printing amounts pertaining to shillings in words provision must be made for two different contingencies since, in so far as units shillings are concerned, the same devices in the machine are set up, which is to say, if an amount of five shillings is to be represented in any of the various devices, the device pertaining to units shillings is set in the manner described for this particular device so that it represents the five shillings. However, this same device is set to represent five shillings when the quantity to be represented is fifteen shillings but in this latter instance another device is set to represent the ten of the fifteen shillings.

Furthermore, in printing words on instruments, as in the case of pence in the present instance, it is desirable, for example, that where there is no value pertaining to shillings the words "No shillings" shall be printed, and also provision must be made for printing "One shilling."

On the stator 801C, two rows of contacts are provided for representing zero or "No" shillings to nine shillings. The row illustrated in Fig. 1p in which the contact 815A is included is utilized when "No shillings" to "Nine shillings" is to be printed, while the row in which the contact 815D is included is utilized when "Ten shillings" to "Nineteen shillings" is to be printed. Only one of these two rows of contacts is utilized when impressions are to be made on a particular sheet S, and a switch 807, Fig. 1p, is provided which is in one position, in which it is shown, when the row of contacts including the contact 815A is to be utilized and which is in another position when the row of contacts including the contact 815D is to be utilized or, in other words, if "No shillings" to "Nine shillings" is to be printed the switch 807 remains in the position shown in Fig. 1p, but when "Ten shillings" to "Nineteen shillings" is to be printed the switch moves into its other position where-in the contacts as 806 on the movable bar 807A thereof are engaged with the fixed contacts as 809.

When neither of the rotors 801A or 801B is advanced a rotor bar 819 on the rotor 801A bridges the contact 815E and contact strip b7 on the stator 801C and a circuit will be established that will effect printing of "No." Under this same condition a rotor bar 814 will close circuit between contact 815 and contact strip b6 which will effect printing of "Shillings." If the rotor 801A is positioned to represent one shilling and the rotor 801B is not advanced, the rotor bar 819 will bridge circuit between contact 815A and contact strip b7 to establish a circuit which will effect printing of "One," and rotor bar 814 will bridge circuit between contact 815G and contact strip b6 to establish a circuit which will effect printing of "Shilling."

Whenever rotor 801A is advanced into a position representative of two to nine shillings and rotor 801B is not advanced, the rotor bar 819

will establish circuit between contact strip **b7** and the contact representative of the particular value in shillings to establish a circuit which will effect printing of the number of shillings to be printed. The rotor bar **814** will bridge contact strip **b6** and the shillings contact strip **815B** to establish a circuit which will effect printing of "Shillings."

When however only the rotor **801B** is advanced so that the rotor bar **805** thereon bridges circuit between any one of the contacts **h1** to **h5** and the contact strip **815C**, a circuit is established to the electro-magnet **808** so that when a contact on the synchronizer drum **86**, as will be explained, closes this circuit, this electro-magnet will be energized whereupon the switch **807** will be moved from the position in which it is shown in Fig. 1*p* into its other position. With the switch in this other position and the rotor **801A** standing at its zero position a circuit will be established through the rotor bar **822** which will effect printing of "Ten." At this same time rotor bar **821** will bridge circuit between contact strip **816B** and contact strip **b4** whereby a circuit will be established that will effect printing of "Shillings" because the switch **807** will be closed at the time this printing operation is to be effected, this circuit being made through contacts **806** and **809** of said switch.

If the rotor **801A** is advanced into a position representative of any of from one to nine shillings and the rotor **801B** is so advanced that the rotor bar **805** thereon is engaging any one of the contacts **h1** to **h5** at this same time, again a circuit will be established which will energize the electro-magnet **808** when current flow through the circuit is brought about, this being under control of a contact on the synchronizer drum **86** which will be explained presently. Energization of the electro-magnet **808** will cause the switch **807** to move into the said other of its positions and in so doing contacts **817**, **818** and **812** and **813** are separated, circuit being established through these contacts when the switch is in the position shown in Fig. 1*p* to bring about the printing of any one of the amounts from "No shillings" to "Nine shillings." When, however, the switch **807** moves into the other position as aforesaid, contacts **806**, **809**, **810** and **811** are engaged and a circuit is established which will effect printing of any amount between "Ten shillings" and "Nineteen shillings," "Ten shillings" being printed when the rotor **801A** is not advanced upon the energizing of electro-magnet **808**, and amounts from eleven to nineteen being printed when the rotor **801A** is advanced into a position representative of from one to nine shillings. Printing of the word "Shillings" when the electro-magnet **808** is energized is brought about through circuits established by the rotor bar **821** bridging the contact strips **b4** and **816B**.

It will be noted that the contacts **h1** to **h5** are located at spaced intervals along the stator **801C**. These positions correspond to the odd numbered positions for whenever devices in the ten shillings order are positioned to represent an even number of shillings, one pound is set up because even numbered quantities of shillings in the tens order represent one or more pounds. Hence it will never be necessary to print, for example, "Twenty three shillings" for, if this amount were to be printed, only "Three shillings" would be printed and the other twenty shillings would be taken care of in the units

pounds order. Thus, whenever the rotor **801B** comes to rest in an even numbered position, the electro-magnet **808** is not to be energized and it is for this reason that no contacts as **h1** are provided at the even numbered positions.

Another of the settable units, to which reference has been made heretofore as being set up upon set-up of the pinions shown in Fig. 27, pertains to both units pounds and tens pounds, which is to say, the pinion **774**, Fig. 27, effects set-up of the stator **722**, Figs. 1*p*, 27 and 30, while the pinion **760**, Fig. 27, effects set-up of the rotor **724**, Figs. 1*p*, 27 and 30, of this settable unit. It will be noted that reference has just been made to set-up of the stator **722** and this means that this stator is capable of movement and, while unlike stators to which reference has been made heretofore, this is not in reality a stationary member, it functions similarly to stationary members which heretofore have been referred to as stators, and for this reason this member is referred to as a stator.

The stator **722** has a row of contacts **e0** to **e19** thereon and an associated contact strip **b12**. If the amount to be printed on a warrant is confined to shillings and/or pence the pinions **774** and **760**, Fig. 27, are not moved since no amounts are set up in either the units pounds or tens pounds orders and hence the settable unit under control of these pinions is not moved. In this circumstance the rotor bar **833** remains in position to bridge the contact **e0** and the contact strip **b12** and thereby circuit is established which will effect printing of "No" when the contacts **831B** and **831C** of a switch **831** are closed under circumstances presently described. If, however, the pinion **774** is set to represent any amount from one pound to nine pounds, the stator **722** is moved relative to the rotor **724** and one of the contacts **e1** to **e9** for the corresponding value from one to nine pounds is brought into association with the rotor bar **833** so that circuit is bridged between this particular contact and the contact strip **b12** whereby circuit is established to effect printing of the word representing the particular value as, for example, if the contact **e3** engaged rotor bar **833** circuit would be established to effect the printing of "Three."

If the amount to be printed is ten pounds, the stator **722** is not moved but the rotor **724** is moved relative to this stator in an amount sufficient to bring the rotor bar **833** thereon into such position that it bridges the contact **e10** and the contact strip **b12** whereby circuit is established to print "Ten." Furthermore, if the amount to be printed is from eleven pounds to nineteen pounds, the rotor **724** is again advanced in this same amount with the result that if the stator is moved pursuant to some numerical value in the units order of pounds the contacts **e1** to **e10** are positioned relative to the rotor bar **833** as before but in this instance this rotor bar, instead of being in what might be called the zero position when from "No pounds" to "Nine pounds" was to be printed, now occupies what might be called a tenth position, in which tenth position it will co-operate with contacts **e11** to **e19** and thus, depending upon the numerical value to be printed, circuit will be established to effect printing of the proper word.

In addition to the contacts **e0** to **e19**, other groups of contacts as **f1** to **f9** are provided, and the contacts **f1** to **f9** are respectively electrically connected with the contacts **e1** to **e9**. Now, if the rotor **724** is rotated pursuant to setting of two

on the type wheel for tens order of pounds, which of course is twenty pounds, the rotor bar 833 is brought into cooperative relation with the portion of the stator 722 whereat the contacts *f*1 to *f*9 are provided. If, under these circumstances, no value has been set up in the units order of pounds, the rotor bar 833 comes to rest in a position intermediate the contact *e*19 and the contact *f*1 at which position no contact is provided and therefore the rotor bar 833 does not bridge a circuit over into the contact strip *b*12. But when the parts are in this position a rotor bar 834 bridges circuits between a long contact strip *S*20 that is coextensive with the contacts *f*1 to *f*9 and which also is aligned with the gap between contact *e*19 and contact *f*1. This rotor bar 834 in this position bridges the contact strip *S*20 and a contact strip *b*13 which establishes a circuit which will effect printing of "Twenty." But if, with the rotor bar 833 advanced to twenty, the stator 722 had also been advanced, then one of the contacts *f*1 to *f*9 representative of the numerical value pursuant to which the stator was advanced would be aligned with the rotor bar 833 and therefore circuit would be established to effect printing of a word equivalent to the value in which the stator was advanced as, for example, if the contact *f*3 had been engaged, the rotor bar 833 would have bridged this contact and the contact strip *b*12 and a circuit would have been established to print "Three." At this same time circuit would be bridged between the contact strips *S*20 and *b*13 so that circuits would be established to effect printing of "Twenty three."

This same arrangement of additional contacts similar to the contacts *f*1 to *f*9 is provided on around the stator 722 and in association with each set of such contacts a strip similar to the strip *S*20 is provided so that, depending upon the amount the rotor 724 is rotated, and if the stator 722 is rotated, circuits will be established to effect printing of the proper words corresponding to the amounts of movement of the stator and rotor.

Thus, so far as a complete revolution of the rotor 724 is concerned, the stator 722 never makes more than a revolution equivalent to one-tenth of the revolution of the rotor.

When both the stator 722 and the rotor 724 remain at rest in which instance "No" is to be printed, a rotor bar 832 bridges contact 810B and contact strip *b*11, and this establishes a circuit which will effect printing of "Pounds." If the stator 722 is advanced to bring the contact *e*1 into association with the rotor bar 833, the rotor bar 832 bridges the contact 810C and the contact strip *b*11 and a circuit is established which, when the switch 831 is actuated to close its contacts 831D and 831E as presently described, will effect printing of "Pound" since in this instance the amount which will be printed will be "One pound." If the rotor 724 and stator 722 are positioned to effect printing of any other amount than "No pounds" or "One pound," the rotor bar 832 bridges contact strips 810A and *b*11 and establishes a circuit which will effect printing of "Pounds." At this point it should be noted that when engagement of either the contact 810B or contact strip 810A is effected "Pounds" is to be printed and in both instances the same circuit is established for the conductor 810D leads to the printing mechanisms from both the contact strip and contact, said conductor being connected to the contact strip 810A by tap 810E and to the contact 810B by a tap 810F.

Now referring to the settable unit pertaining to the hundreds pounds order, this is shown in Fig. 1*q* and it comprises a stator 750S and a rotor 750R. In this instance the stator is stationary but the rotor 750R is under control of a pinion 775, Fig. 27, that meshes with 712D, Figs. 1*q* and 27, and these pinions are under control of the type wheel 520 for the hundreds pounds order. A row of contacts *M*1 to *M*9 is provided on the stator 750S and whenever the rotor 750R is operated to represent some significant value in the hundreds pounds order pursuant to setting of the type wheel 520 for the hundreds order to print this significant digit, a rotor bar 825 on the rotor 750R is aligned with one of the contacts *M*1 to *M*9 pertaining to this value. Thus, if the amount represented were three hundred pounds, the rotor bar 825 would engage the contact *M*3 and would establish a circuit from this contact to the contact strip *b*15 which would establish a circuit which will effect printing of "Three." In addition to this a pair of contact strips *b*14 and 750T are provided on the stator 750S and these contact strips are coextensive with the distribution of the contacts *M*1 to *M*9 on this stator. Whenever the rotor bar 825 engages one of the contacts *M*1 to *M*9, the rotor bar 826 bridges the contact strips *b*14 and 750T and establishes a circuit which will effect printing of "Hundred."

It will be recognized that the rotor 750R may be positioned to effect printing of some value without either the rotor 724 or the stator 722 pertaining to the tens and units orders of pounds being moved. It will be recalled that if neither the stator 722 nor the rotor 724 is moved circuits are to be established for printing "No pounds." It will be appreciated that this should not be effected if, for example, the rotor 750R is positioned to effect printing of "One hundred" which is, in effect, one hundred pounds, the word "Pounds" in such instance being printed in a manner to be explained presently. This same condition prevails if an amount is set up in any order from one hundred pounds on up. Hence in each settable unit pertaining to the order of hundreds pounds or a higher order, there is a pair of contact strips as 750U and *b*10 on the stator as 750S which are bridged by a rotor bar as 827 whenever the rotor cooperating with the particular stator as the rotor 750R is positioned to represent a value expressed by a significant digit. When the contact strips as 750U and *b*10 are bridged by a contact strip as 827, circuit is closed to an electro-magnet 830, Fig. 1*p*, which controls a switch 831. This switch 831 includes contacts 831B and 831C which are in the circuit that is established when "No" is to be printed, as is explained fully hereinafter. Whenever the electro-magnet 830 is energized, these contacts 831B and 831C are separated so that the circuit for printing "No" cannot be closed. This means that irrespective of the positioning of the stator 722 and the rotor 724 the word "No" cannot be printed if a significant digit is represented by the setting of any settable unit for hundreds pounds or a higher order.

There is another condition that might arise and that is that if the stator 722 is positioned to establish a circuit which will print "One," it will be recalled that another circuit is established which will print "Pound." Now suppose one hundred one pounds were to be printed. It is obvious that the one pound will be set up by reason of positioning of the stator 722 and in

such an instance the printing of "Pound" is to be prevented and this is accomplished by providing contacts 831D and 831E on the switch 831. These contacts, like the contacts 831B and 831C, are separated whenever a settable unit pertaining to the hundreds pounds or any higher order is set to represent a significant digit.

It will be recalled that it has been explained that the rotor 750R may be positioned to bring about printing of "Three hundred" and it will be recognized that in such an instance "Pounds" is also to be printed. If the amount to be printed in this instance is an even three hundred pounds, or is any amount above ninety-nine pounds and the amount is such that there is a 0 in both the units and tens orders, the rotor bar 832 will be bridging the contact 810B and the contact strip b11 and, as explained heretofore, this closes the circuit which effects the printing of "Pounds." If the amount to be printed pursuant to any setting of the rotor bars in the settable units for the hundreds or any higher order is other than the aforesaid condition where there is a 0 in both the units and tens order or where there is a 1 in the units order, the rotor bar 832 will be bridging contact strips 810A and b11 which, as explained heretofore, establishes a circuit which will effect printing of "Pounds." If, however, under the aforesaid conditions there is a 1 in the units order of the number to be printed, the rotor 724 will be so positioned that the rotor bar 832 will be bridging contact 810C and contact strip b11 and, as explained heretofore, this will bring about printing of "Pound." Obviously, however, in such a condition "Pounds" and not "Pound" is to be printed. Hence the circuit which would normally effect printing of "Pound" is passed through a pair of contacts 831G and 831F in the switch 831, and these contacts are engaged whenever there is a setting above ninety-nine pounds in the settable units. The engagement of these contacts has the same effect as that produced when the rotor bar 832 bridges contact strips b11 and 810A or contact strip b11 and contact 810B, which is to say, it establishes a circuit which effects printing of "Pounds."

The settable unit pertaining to the orders of thousands pounds and ten thousands pounds is structurally similar to and operates in the same manner as the settable unit pertaining to units pounds and tens pounds except that, for one thing, this unit does not include contacts and rotor bars which will effect printing of "No Pounds" and "One pound." In other words, the stator 760S, Fig. 1q, of this unit is moved through a distance only one-tenth as great as the distance the rotor 760R of this unit is moved, the stator being moved pursuant to settings of the type wheel in the thousands pounds order and the rotor being moved pursuant to settings in the ten thousands pounds order. Another difference between the settable unit comprising the rotor 760R and the stator 760S and that comprising the rotor 724 and stator 722 is that the stator 760S does not include any contact strips for effecting the printing of "Pounds." Instead, this stator bears contact strips 760T and b16 which are engaged by a rotor bar 844 whenever this unit is set to represent a significant digit, and this contact strip and rotor bar establish a circuit for printing "Thousand." Still another difference is that the stator 760S bears a pair of contact strips 760U and b9 with which a rotor bar 838 cooperates and when cir-

cuit between the contact strips is bridged by this rotor bar, the electro-magnet 830 is energized for the purpose heretofore explained.

The settable unit including the rotor 770R Fig. 1q, and the stator 770S pertains to the hundred thousands pounds order and is similar to the settable unit for the hundreds pounds order which comprises the rotor 750R and stator 750S, except that the stator 770S bears a pair of contact strips 770T and b19 which, when bridged by rotor bar 855, establish a circuit that will print "Thousand" whenever the settable unit comprising the thousands pounds stator 760S and the ten thousands pounds rotor 760R stand at "0." For example, if the rotors and stators pertaining to the pounds orders in the circuit controlling apparatus should stand at Two hundred thousand pounds, the words signifying this amount would be printed in the order of "Pounds," "Thousand," "Hundred" and "Two." Inasmuch as the rotor bar 839 would then stand in the number "2" position, the contact strips b8 and G1 would be bridged by this rotor bar to cause energization of the electro-magnet 830 in Fig. 1p at the time of potentialization of the conductor c8. This energization of the electro-magnet 830 would separate the switch contacts 831B and 831C to suppress the printing of the word "No" in the manner hereinabove described at the time the conductor c12 potentializes the contact strip b12 on the units pounds stator 722. However, the impression of battery upon contact strip b11 of said pounds stator 722 would result in the potentialization of the stator contact 810B through the rotor bar 832 and hence the potentialization of the conductor 810D which results in the printing of the word "Pounds." Subsequently the conductors c19, c20 and c21 are successively potentialized in the order named, the conductor c19 potentializing the hundred thousand pounds stator contact strip b19 which is then connected through the rotor bar 855 with the contact strip 770T wherefore a circuit is extended through a conductor G2, contact G3 on the thousands pounds stator 760S, rotor bar 837 of the ten thousands pounds rotor 760R which now stands at zero, contact G4, and conductor G5 to the solenoid for printing the word "Thousand." Following this, when the conductor c20 is potentialized, circuit will be completed through stator contact strip b20, the cooperative rotor bar 846, and the contact strip 770U for causing the printing of the word "Hundred." Finally the potentialization of the stator contact strip b21 energizes a circuit including the rotor bar 856 which now stands at "2" and the number "2" contact HT2 and the solenoid for causing the printing of the word "To." The words thus printed in the reverse order of the reading thereof will then read "Two hundred thousand pounds." Now if the amount to be printed had been one in which there had been a significant digit in the thousands or ten thousands pounds order, as for example, Two hundred sixty four thousand pounds, it would be necessary to suppress the printing of the word "Thousand" just prior to the printing of the word "Hundred" as above described, inasmuch as the words "Four" and "Sixty" are to be written just prior to the word "Hundred." Since, in this second example, thousands pounds stator 760S and the ten thousands pounds rotor 760R stand at sixty-four, the rotor bar 844 will bridge the contact strips b16 and 760T for causing printing of the word "Thousand" at the time

the conductor c16 is potentialized. Thereafter the word "Four" is caused to be printed when the conductor c17 is potentialized for potentializing the contact strip b19 and the number "4" contact TH4 opposite the contact strip TH60. The circuit will be completed from said contact TH4 to the solenoid in Fig. 1r for printing the word "Four." Next the conductor c18 is potentialized and through the contact strip b18 and the rotor bar 837 which now stands at "60" in bridging relation with the contact strip b18 and the contact TH60, potentializes said contact TH60 for causing the printing of the word "Sixty." When the conductor c19 is next energized, circuit connections will be set up through the contact strip b19 on the hundred thousands pounds stator, the cooperative rotor bar 855, contact strip 770T, and the conductor G2 to the contact G3 on the thousands pounds stator, but since the rotor bar 837 now stands at "60" it fails to bridge the contacts G4 and G3 wherefore the circuit is dead-ended at the contact G3 so that the word "Thousand" which would have been printed by this circuit, if complete, is suppressed. Subsequent successive potentializations of the conductors c20 and c21 in the order named cause successive printing of the words "Hundred" and "Two" in the manner above described. At this time the printed words in the reverse order of their printing will read "Two hundred sixty four thousand pounds."

It will be recalled that the apparatus is so set up that it will print "No pounds" so that if the amount to be printed on a warrant is expressed only in shillings and/or pence, these words "No pounds" will be printed on the warrant. However, to prevent the value of the warrant being raised, it is customary even in this instance and certainly in instances where the warrants are for one pound or more to, as it is called, "blank out" the space on the warrant above the highest figure appearing thereon, and in the present instance this is accomplished by printing asterisks in such circumstances, a type member being provided in the bank R for this purpose. This type member prints "****" and is to be operated only after the highest amount has been printed on the warrant. Thus if the highest amount on the warrant is in the units or tens order of pounds, asterisks are to be printed as soon as this amount is printed. If the highest amount is in the hundreds order of pounds, then the printing is to be effected after this amount in the hundreds pounds order has been printed. In order to accomplish this, an auxiliary contact is provided in the stator for the hundreds order of pounds and stators for all higher orders, these contacts in the respective orders being designated 750V, 760V and 770V. Such contacts are arranged adjacent the battery conductor strips on these stators which are respectively the conductor strips b14, b16 and b20.

When the rotors cooperating with these stators are in "0" position the rotor bars 826, 844 and 846, respectively, bridge the contact 750V and contact strip b14, contact 760V and contact strip b16, and contact 770V and contact strip b20. The contact 750V is connected to the contact strip b16 by a conductor 857, contact 760V is connected to contact strip b20 by a conductor 845, and in the operation of the machine, as will be explained presently the battery strips b14, b16 and b20 are successively energized. If the rotor for the hundreds unit stands at "0" as well as those for the higher orders, energization of the

contact strip b14 closes a circuit which causes the printing member bearing the asterisks to be moved into printing position. If, however, the rotor bar 826 is not bridging the contact strip b14 and contact 750V by reason of the fact that the hundreds settable unit has been set to represent a significant digit, then the foregoing circuit is not closed upon energization of the battery strip b14 and energization of this circuit must await the energization of the strip b16. If the higher units are at their zero positions, this energization will effect the aforesaid printing operation, and this same arrangement progresses on up to the hundreds order. It will thus be seen that in effect a series circuit is provided and the reason for this is that, for example, the settable unit pertaining to hundreds order may be on zero while the unit pertaining to the hundred thousands order may be off the zero position. When this condition prevails the energization of strips b14 and b16 will not result in closing of the aforesaid circuit and printing of the asterisks will not occur until the strip b20 is energized. It will be seen from the foregoing that the printing of asterisks is not effected until after the highest value has been printed on the warrant.

In the present instance where "One hundred seventy three pounds fifteen shillings no pence" is to be printed on the warrant the various units are set up as follows.

Since no monetary value is to be printed so far as pence is concerned the settable unit for pence is arranged as follows: the rotor bar 802, Fig. 16, is bridging the contact 800D and contact strip b1 thereby establishing a circuit to effect printing of "Pence" and the rotor bar 803 is bridging the contact 800E and the contact strip b2 thereby establishing a circuit which will print "No."

In so far as the unit pertaining to shillings is concerned it is set up as follows: the rotor bar 805 is bridging the contact h1 and the contact strip 815C thereby establishing a circuit to the electro-magnet 808 so that when the circuit is potentialized the switch 807 will be moved into its other position described heretofore; the rotor bar 821 is bridging the contact strips b4 and 816B thereby establishing a circuit to effect printing of "Shillings"; and the rotor bar 822 is set to bridge contact 815H and contact strip b5 thereby establishing a circuit through the switch 807 to effect printing of "Fifteen."

In so far as the stator 722 for units pounds is concerned, the stator has been rotated to have a setting equivalent to three pounds and the rotor 724 of this unit has been rotated to have a setting of seventy pounds. With these parts in these positions, the rotor bar 832 is bridging the contact strips b11 and 810A thereby establishing a circuit to effect printing of "Pounds"; the rotor bar 833 is bridging the contact k3 and the contact strip b12 thereby establishing a circuit for printing "Three" for the units order of pounds; and the rotor bar 834 is bridging the contact S70 and the contact strip b13 thereby establishing a circuit for printing the word "Seventy."

The settable unit for the hundreds order pounds is so set that the rotor bar 827 is bridging the contact strips b10 and 750U, whereby a circuit is established through conductors 828 and 829 to the electro-magnet 830 so that the switch 831 will be moved into the position in which it is shown in Fig. 1p; the rotor bar 826 is bridging the contact strips b14 and 750T thereby establishing a circuit for printing "Hundred"; and the

rotor bar 825 is bridging the contact M1 and the contact strip b15 thereby establishing a circuit for printing "One." Because of the setting of the rotor bar 826 the series circuit for effecting printing of asterisks is open in the hundreds order. However the rotor bar 844 in the unit pertaining to the thousands and ten thousands orders of pounds is bridging the contact 760V and contact strip b16 so that when said contact strip is energized the printing member for printing asterisks will be actuated.

The thousands order is the one next above the highest order in which printing is to be done in the present instance and therefore the series circuit is closed at this thousands order and through all higher orders.

In describing the manner in which the settable units for controlling the printing of words are set up, the order in which these units are brought into operation and the order in which the words to be printed are printed was followed. The various units are successively energized under control of contacts a1 to a21, Fig. 1d, on the synchronizer drum 86, but just prior to this, a contact 680A on the synchronizer drum encounters its brushes 90 to close a circuit from the battery conductor 84, through the brushes cooperative with said contact 680A, the conductor 680C which leads into a cable 680D and reappears in Fig. 1r, and the solenoid r11 to ground thereby energizing the solenoid at the time indicated by the chart-line Ch73, Fig. 50. As will be explained more fully hereinafter, the sheet S upon which the printed words are to appear will have been carried by the feed tapes F, Figs. 2 and 3, onto the platform 618 and stopped by means of the conventional stop means in predetermined relation with respect to the sheet advancing rollers of which the roller 632 is shown in Fig. 1r, and upon energization of the solenoid r11 the rack 679A associated therewith will be advanced and later returned under the influence of the spring 686 attached thereto after the contact 680A has passed from engagement with its brushes 90 to break the energization circuit for said solenoid. Such return movement of the rack 679A will drive the roller 632 which, as presently explained more fully, will have had the sheet S clamped therebetween and a roller 626, Fig. 34, the drive being through a gear 685, a pawl 699, a ratchet wheel 696, a shaft 698, bevel gears 697 and 701 and a shaft 702 for advancing the sheet S into a predetermined position with respect to the opening 655A in the platform 618 preparatory to having the words printed thereon by the selectively actuated type bars. Immediately thereafter, the leading one of said contacts a1 to a21 will move into association with the pair of brushes 90 with which it is to cooperate, said contacts a1 to a21 being arranged in stepped relation on the synchronizer drum 86 so that they will move into association with the brushes 90 with which they are to cooperate in such a manner that the successive energization of the settable units for controlling word printing will be brought about in a manner which will effect the word printing in the order intended.

When the contact a1 moves into association with the pair of brushes 90 with which it is to cooperate, the following circuit is closed: From battery conductor 84, Fig. 1d, through conductor d1 and its brush, contact strip a1, the brush on conductor c1, and this conductor, which passes into cable 801 in Fig. 1d and which leads out of this cable, as shown in Fig. 1p, to be connected

to contact strip b1 in the pence settable unit and therefore battery is applied on this strip b1. The circuit is continued on through the rotor bar 802, contact 800D, conductor 804 to contact strip 800F, conductor n1, which conductor, as shown in Fig. 1r, is connected to one end of the winding of a solenoid r1, the other end of which winding is grounded. Therefore the solenoid r1 is energized and the energization of this solenoid actuates the printing member which prints the word "Pence" at the time indicated by the chart-line Ch74, Fig. 50, in the manner now to be described.

The solenoid r1 and all similar solenoids are like the solenoids indicated by 675 in Fig. 34. Each includes a core 676 which, when the solenoid is energized, is attracted against the action of a spring 686. Referring to the structure at the left side of Fig. 34, the core 676 is connected to a lever 677 that is pivotally mounted on a shaft 678 and which is connected to a rack 679 as indicated at 680. When the solenoid 675 is energized the lever 677 is pivoted clockwise. Each rack 679 has a slot 681 therein in which a pin 682 on a lug 683 extending outwardly from one arm of a bail as 635 is disposed. When said rack 679 is pivoted clockwise incident to the energization of the solenoid 675, by reason of this pin and slot connection, the associated bail 635 is so pivoted that the printing member thereon is forced toward the ink ribbon 654A and thereupon this printing member makes an impression on the sheet S disposed on the platform 618.

In the present instance the energization of the solenoid r1 causes the bail 646B to be moved. This bail bears the printing member which prints the word "Pence", wherefore the movement of this bail upon movement of the rack connected thereto causes the word "Pence" to be printed upon the sheet S in the position in which this word appears on the sheet shown in Fig. 3a. In a manner to be described presently after this impression has been made, the sheet S is advanced to be positioned to receive the next impressions which in this instance is the word "No."

Shortly after the solenoid r1 has been energized as just described, the contact a1 moves beyond the brushes 90 which deenergizes the aforesaid circuit including the solenoid r1 and the contact a2 then moves into association with the brushes 90 whereupon a circuit similar to that just described is closed through contact strip b2, Fig. 1p, rotor bar 803, contact 800E, to the solenoid r2, Fig. 1r, which energizes at the time indicated by the chart-line Ch75 to cause actuation of the bail 653B that carries the printing member for printing "No" on the sheet. After this word has been printed on the sheet, the sheet is advanced and by this time contact a2 will have moved beyond the brushes 90 and the contact a3 will have moved into association therewith.

The contact a3, which is elongated, as shown in Fig. 1d, closes the circuit which energizes the electro-magnet 808 during the time indicated by the chart-line Ch76 so that the switch 807 is moved into its above described other position by the time the contact a4 moves into association with the brushes 90. When the contact a4 reaches the brushes 90 a circuit is established through the contact strip b4, Fig. 1p, rotor bar 821, contact strip 816B to the solenoid r3 which energizes at the time shown by chart-line Ch77

for actuating the bail 636B bearing the printing member for printing "Shillings."

The contact a4 then moves beyond the brushes 90 and the contact a5 moves into association therewith, the contact a3 still closing circuit between the pair of brushes 90 with which it cooperates. The contact a5, under control of the switch 807, closes a circuit to the contact strip b5, rotor bar 822, contact 815H and thence to the solenoid r4 which energizes at the time indicated by the chart-line Ch78 to actuate the bail 639 that bears the printing member for printing "Fifteen" on the sheet. After this impression has been made the sheet again advances and comes to rest in a position to receive the next impression.

The contact a5 moves beyond the brushes 90 and the contacts a6 and a7 successively move into association therewith. These contacts, however, do not effect any operation in this instance and are only operative to effect an operation when the switch 807 is in the position shown in Fig. 1p, in which position it would be if an amount from "No" to "Nine" shillings was to be printed, the contact a6 being effective to establish a circuit which would effect printing of "Shilling" or "Shillings" depending upon the value of the number that would be printed under control of the contact a7. It will be noted that the contact a3 is sufficiently elongated to maintain the electro-magnet 808 energized until the contacts a6 and a7 have passed beyond the brushes 90 for if operations are to be effected under control of the contacts a4 and a5 no operations are to be effected under control of the contacts a6 and a7 have passed beyond the remains in engagement with its cooperating pair of brushes 90 long enough to maintain the switch 807 in the other position into which it is moved when operations are to be effected under control of the contacts a4 and a5.

It will be recalled that whenever an amount in excess of ninety-nine pounds is to be printed that the electro-magnet 830 is to be energized and it will also be remembered that the electro-magnet 830 may be energized from the unit pertaining to hundreds pounds or from the unit pertaining to thousands and ten thousands pounds or from the unit pertaining to hundred thousands pounds. If there is a setting in any one of these units representative of a significant digit the electro-magnet 830 is to be energized. Hence the contacts a8, a9 and a10 next simultaneously move in association with their cooperating brushes 90 and place potential on the contact strips b8, b9 and b10, respectively, so that if any one of the aforesaid units is set to represent a significant digit the electro-magnet 830 will be energized and the switch 831 will be moved into the position in which it is shown in Fig. 1p. Thus in the present instance where the unit for hundred pounds is set to represent one hundred pounds the electro-magnet 830 will be energized at the time indicated by chart-line Ch79 through the contact strip b10, rotor bar 827 and contact strip 750U.

After the contacts a8, a9 and a10 have placed potential on the contact strips b8, b9 and b10 and the electro-magnet 830 has been energized, if it is to be energized as it is in the present instance, the contact a—11 moves in association with its cooperating pair of brushes and closes a circuit, in the present instance, to the contact strip b11 which, through the rotor bar 832 and contact strip 810A, energizes the solenoid r5 which

actuates ball 644B bearing the printing member for printing "Pounds" at the time indicated by the chart-line Ch80. The solenoid r5 is directly connected with the contact 810A through conductors 810D and 810E, Fig. 1p for in the present instance, the devices are set up to print "One hundred seventy three pounds." But if the devices had been set to effect printing of "One hundred pounds" circuit to the solenoid r5 would have been as follows: From contact a—11 to contact strip b11, rotor bar 832, contact 810B, conductor 810F and conductor 810D to the solenoid. If the devices had been set to effect printing of "One hundred one pounds" circuit to solenoid r5 would have been as follows: From contact a—11, contact strip b11, rotor bar 832, contact 810C, conductor 840, contact 831G, on the switch 831, contact 841F, conductor 841 and conductor 810D to the solenoid.

It is to be understood that after an impression such as "Pounds" has been made on the sheet the contact a—11 moves out of association with the brushes 90 and the sheet advances. Hence after the contact a—11 has moved out of association with the brushes 90, the contact a12 moves into association therewith and closes a circuit through contact strip b12, rotor bar 833, and contact k3 to solenoid r6 which energizes at the time indicated by chart-line Ch81 for operating the bail 649B that carries the printing member for printing "Three."

By the time the contact a12 is ready to move out of association with the brushes 90 there is no longer any need to maintain the electro-magnet 830 energized and therefore substantially concurrently with the movement of the contact a12 from association with the brushes 90 the contacts a8, a9 and a10 move out of association with the brushes 90, whereupon the electro-magnet 830 deenergizes and the switch 831 returns to its deenergized position.

The contact a12 then moves out of association with the brushes 90 and the contact a13 moves into association therewith and circuit is closed to the contact strip b13, rotor bar 834, contact S70 and solenoid r7 which energizes at the time represented by the chart-line for effecting operation of bail 641B that bears the printing member that prints "Seventy" on the sheet.

The contact a13 moves out of association with the brushes 90 after "Seventy" has been printed on the sheet and the contact a14 moves into association with these brushes whereupon potential is applied to the contact strip b14, 1q, and circuit is closed through rotor bar 826 and contact strip 750T to solenoid r8 which energizes at the time represented by the chart-line Ch83 for operating the bail 640B that bears the printing member for printing "Hundred" and by the time this printing member moves toward the ink ribbon 654A the sheet S will have been advanced into position to receive this impression.

The contact a14 then moves from association with the brushes 90 and the contact a15 moves into association therewith whereupon circuit is closed through contact strip b15, rotor bar 825 and contact M1 to solenoid r9 which energizes at the time indicated by the chart-line Ch84 for operating the bail 652 that prints "One" on the sheet.

The amount "One hundred seventy three pounds fifteen shillings no pence" is now printed on the sheet S and no other ones of the settable units controlling word printing are set up. Hence, when a15 moves out of association with

the brushes 90 and the contact a16 moves into association therewith, potential will be applied upon contact strip b16. The thousands and ten thousands unit in which the contact strip b16 is included is standing at zero as is every other unit pertaining to higher orders and, since these units are at zero, the application of potential on contact strip b16 closes circuit through rotor bar 844, contact 760V, conductor 845, contact strip b20, rotor bar 846, contact 770V, conductor 847 to one end of the winding 848 of the electro-magnet 849, the other end of which winding is grounded at 850. This energizes this electro-magnet at the time represented by the chart-line Ch85 for closing the contacts 850C and 850D upon a switch 851, Fig. 1g, whereupon circuit is closed to the solenoid r10 which then energizes at the time represented by the chart-line Ch86 for operating the bail 635B that carries the printing members which print asterisks, the circuit to the solenoid r10 being as follows: Battery is picked up at conductor 847, and through contacts 850C and 850D circuit is closed through conductor 854 to said solenoid r10.

The various solenoids as r1 shown in Fig. 1r are not illustrated as being disposed in banks L and R and it is only in Figs. 34 and 36 that the printing members are shown arranged in the order listed hereinabove. In Fig. 1r the various printing members have been shown in a manner which avoids numerous crossings of wires and the like which would have been necessary had the solenoids for controlling the various printing members been shown in Fig. 1r in an arrangement corresponding to that in the banks L and R.

In the foregoing operation battery was applied to both contact strips b16 and b20 but inasmuch as the units in which these contact strips are included stood at zero this did not effect the energization of any solenoids as r1 so it may be said that this energization, except in so far as the printing of asterisks is concerned, was without effect. Furthermore, since these settable units for thousands and ten thousands orders and for the hundred thousands order are at zero, the passage of the contacts a17, a18, a19 and a21 past the brushes 90 does not have any effect, but when the contact a20 passes the brushes potential is applied upon contact strip b20 whereupon electro-magnet 849 is again energized as well as solenoid r10 at the time represented by the chart-lines Ch87 and Ch88, wherefore the printing member which prints asterisks again operates, and by the time this printing member so operates the sheet will have advanced and the result is that four asterisks are printed on the sheet. If the amount to be printed had extended into the thousands or ten thousands order, only two asterisks would have been so printed and if the quantity had extended into the hundred thousands order no asterisks would have been printed because this would have filled up all the available space on the warrant portion of the sheet. In addition to this, if there had been no set-up in the unit pertaining to the hundreds order, six asterisks would have been printed on the sheet.

It has been stated heretofore that after each impression is made on the sheet it is advanced. It is of course essential that the words printed on the check be printed in close side by side relation. Hence each time the sheets are advanced during their passage through the word printing mechanism they are advanced in an amount proportionate to the length of the word.

However, since it is necessary that there be a space between words to enable distinction, the sheet is not advanced a number of spaces corresponding to the number of letters in a word but is advanced the amount equivalent to one additional letter in each word.

As soon as the sheets have disengaged the stop finger which positions them while an impression as the impression T2 is being made thereon they move onto the platform 618, and when the sheet has attained a predetermined position on the platform it engages a stop finger, similar to those previously described, which orients the sheet in a predetermined position relative to two pairs of rollers, shown in Fig. 34, which effect movement of the sheet through the word printing mechanism.

Among the rollers to which reference has just been made are the rollers 625 and 626 mounted on an arm 624 and held in spaced relation by a sleeve 629. Collars 627 and 628 prevent axial movement of said rollers along the arm 624 on which they are mounted. The arm 624 is pivotally mounted, as indicated at 621, on a bracket 622. A roller 623' is mounted at the free end of a lever 623 and bears on a cam 633 mounted on a shaft 634 that is driven from the motor 272 so that it rotates in timed relation with the other parts of the machine. Immediately after the sheet S moves into engagement with the stop finger which positions it relative to the aforesaid pairs of rollers, a rise on the cam 633 acts through the roller 623' and the lever 623 to pivot the arm 624 and the rollers 625 and 626 downwardly so that the rollers 625 and 626 respectively move into cooperating relation with rollers 631 and 632.

When the sheet moves onto the platform 618 it passes into a slot 620 that is defined between the top of the platform and the guide plate 619 on the platform and the sheet is confined in this slot during the time impressions are made thereon by the printing mechanism of the word printing apparatus. The guide plate 619 serves as a platen during the impression operation of such printing members. The rollers 625 and 626 pass through an aperture 630 in the guide plate 619 as they move into cooperating relation with the rollers 631 and 632 so that the sheet disposed in the aforesaid slot 620 is tightly clamped between these rollers. The peripheries of the rollers 631 and 632 extend through openings 631A and 632A in the platform 618.

The rollers 631 and 632 are fast on shafts as 702 which are journaled in bearings as 703 depending from the platform 618. Each of these shafts has a bevel gear as 701 at the outer end thereof and these bevel gears mesh with bevel gears as 697 rotatable on shafts as 698 journaled in bearings in the side frame members 692 and 692A. A plate as 694 is mounted on each shaft as 698 and carries a pawl as 699 that meshes with the teeth of a ratchet as 696 that is fast to the bevel gear as 697. Because of this the shaft 698 may be rotated in either direction but only when it is driven in a counterclockwise direction, as viewed in Fig. 38, does the pawl as 699 so engage the teeth of the ratchet as 696 that rotative movement is imparted to the bevel gear as 697 and consequently the bevel gear as 701, and consequently also to the shaft as 702 and the roller as 632.

In the operation of the machine only one or the other of the rollers 631 or 632 is driven at

one time due to the fact that the roller 631 receives movement from racks associated with the bank L while the roller 632 receives movement from racks associated with the bank R. The racks to which reference has just been made are those to which movement is imparted by levers as 677 upon the energization of solenoids as 675 which, it will be recalled, are the solenoids identified in the wiring diagram, Fig. 1r, as solenoids *r1* to *r10*. Each of such racks as the rack 679, shown in Fig. 34, has a number of rack teeth therein which mesh with an elongated gear as 689, Fig. 35, fast on the shaft as 698, the elongated gear as 689 extending across all of the racks as 679 in the bank in which these racks are included.

Hence when any one of the racks is operated to cause the printing member on the bail connected therewith to make an impression, the movement imparted to the rack is transmitted through the rack teeth thereon to the elongated gear 689 and therefore to the shaft 698. It will be recalled that it has been stated that the sheet S is to be moved through the word printing mechanism in steps corresponding to the length of the words printed thereon, and this is accomplished by providing as many rack teeth on each rack as there are letters in the word to be printed upon operation of the particular rack, plus one additional rack tooth which causes such additional movement to be imparted to the sheet that spaces are provided between the words printed thereon. There is one exception to this arrangement of providing an additional rack tooth and that is that the rack, which is operated to effect printing of asterisks, does not have an additional tooth thereon, so that when asterisks are printed by more than one operation of the printing member bearing the asterisks the asterisks of the two impressions will be printed in close side by side relation.

There is also an additional rack 679A which is shown schematically in Fig. 1r. This rack is intended to drive the roller 632 and after a sheet has been moved onto the platform 618 and engaged with the stop finger, as described, to be positioned relative to the rollers 625 and 631 and 626 and 632 and these rollers have moved into clamping relation with the sheet, the engaged stop finger is retracted and thereupon the additional rack, which is indicated by 679A in Fig. 1r, is operated. Such operation of the rack 679A is brought about by energization of the solenoid *r11*.

Energization of the solenoid *r11* is effected by the passage of a contact 680A, Fig. 1d, past the brushes 90. This contact is positioned on the synchronizer drums 86 in a position in advance of all of the contacts *a1* to *a21* which, as explained heretofore, are the contacts which bring about the energization of the other solenoids shown in Fig. 1r. Thus prior to the time any solenoid as *r1* is energized, the solenoid *r11* is energized. The rack 679A operated by this solenoid has a sufficient number of teeth thereon to impart such movement to the roller 632 that when the sheet is moved from the position on the platform 618 which it occupied when it engaged the stop finger, as above described, the sheet is positioned above the opening 655A to receive an impression from the printing member on the bail 646B or 647B depending upon whether or not the word "Pence" or "Penny" is to be printed. When the solenoid *r11* is energized the rack

679A is moved to the left, as viewed in Fig. 1r, which drives the gear 689 with which it is meshed, but as the rack moves in this direction the pawl 699 merely rides over the teeth of the ratchet wheel 696 and no movement is imparted to the bevel gear 697 on the shaft 698, which shaft rotates with the gear 689 upon this movement of the rack 679A to the right. A retaining pawl 700, Fig. 38, engages the teeth of the ratchet wheel 696 during movement of the rack to the left to prevent movement of the wheel 696 as the pawl 699 rides over the teeth thereof. However, when the rack 679A has completed its movement to the left, the contact 680A moves out of association with the brushes 90 whereupon the solenoid *r11* is deenergized, and then under the influence of the spring 686, Figs. 1r and 34, the rack 679 is driven to the right and during this movement the pawl 699 seats in a tooth of the ratchet wheel 696 and thereupon the bevel gear 697 and the bevel gear 701 on the shaft as 702 are rotated so that the roller 632 is rotated, and this rotation of the roller 632 by reason of the fact that the sheet S is clamped thereagainst by the roller 626 advances the sheet into position to receive the impression "Pence" or "Penny" as the case may be, as previously described.

It will be observed that both the words penny and pence contain five letters. Thus six teeth are provided on the racks which drive the bails that carry the printing members for effecting printing of these words since six teeth are equivalent to the number of letters in each of these words plus one space.

Thus whenever one or the other of these words is to be printed the rack operated by the solenoid which brings about printing of the particular word is moved to the left, as viewed in Fig. 1r, during the time the word is being printed, and after the word has been printed and this solenoid is deenergized the rack is returned by its associated spring 686 and during this return movement either the roller 631 or 632 is driven depending upon in which of the banks the operated solenoid is located. Of course, in the present instance both the printing members for printing "Penny" and "Pence" are in the bank R so that it is the roller 632 that is operated but, for example, when the word "Fifteen" is printed it is the roller 631 that is operated.

The rise on the cam 633 heretofore described as causing the rollers 625 and 626 to move into clamping relation, respectively, with the rollers 631 and 632 is elongated sufficiently that the rollers are held in this clamping position until a sufficient period of time has elapsed that every printing operation that need be made in so far as the sheets are concerned will have been made, which is to say, impressions in the hundred thousands order will have been made, and after the contact *a21* has moved beyond the brushes 90 the rise on the cam 633 moves beyond the rollers 623' whereupon the rollers 625 and 626 return to the upper position in which they are shown in Fig. 34. By the time this occurs the sheet will be so extended over the platform 618 and be in engagement with the feed tapes F that when the rollers 625 and 626 disengage the rollers 631 and 632 the sheet will again be picked up by the feed tapes to receive an impression from the printing and control device bearing the perforations which determine the calculation of the numerical accounting data that is by this time printed on the sheet S.

Zero-setting operation word printing mechanism

After the contact A21 has passed beyond the brushes 90 the word printing mechanism may be returned to zero and this zero-setting operation is effected in substantially the same manner as that in which the zero-setting operation for the rotors 350 was effected.

All of the settable units for the word printing mechanism either have the rotors thereof mounted on a shaft 706 or rotatable members including gears meshing with movable parts of these settable units are mounted on this shaft. The rotors or rotatable members just referred to have pins as 713, Fig. 30, mounted therein which are adapted to be engaged by pins as 714 on the shaft 706 when this shaft is moved axially in zero-setting operation. The shaft 706 is moved axially upon energization of a solenoid 738, Figs. 27 and 1p, and this is brought about by movement of a contact 749, Fig. 1d, into association with the brushes 90. When this solenoid is energized at the time indicated by the chart-line Ch89 it operates through a link 739 and a bell crank 740 similar to those devices which effect axial shift of the shafts 340 and 516, Figs. 13, 26 and 27, to shift said shaft 706 axially. After the shaft 706 has been shifted axially and the pins 714 on the shaft have been aligned with the pins 713, a contact 752, Fig. 1d, moves into association with the brushes 90 and thereupon circuit is closed through a conductor 751 to a solenoid 738A, Figs. 1p and 27, which whereupon energizes at the time indicated by the chart-line Ch90 to act through its core 745, a gear segment 744, a pinion 743 freely rotatable on the shaft 706, ratchet teeth 742 on said gear, a pawl 741A, and a plate 741 carrying said pawl and fixed to the shaft to cause the shaft 706 to be rotated a complete revolution similarly to the devices which effect a complete revolution of the shaft 516, Fig. 26, and in the course of this complete revolution of the shaft 706 the pins 714 pick up the pins 713, and when the shaft 706 has completed its single revolution all of the movable parts of the settable units for the word printing mechanism will have been moved backwardly into their zero positions ready to be set up pursuant to the next zero-setting of the type wheels as 520 on the shaft 516 which by this time will have been set up, pursuant to the data derived from the card in the printing and control device in the succeeding cycle of operation.

Platen structure and machine timing

As is customary in machines such as those shown in the patents to which reference has been made heretofore, the various platens employed in the machines are driven from the same shaft and the stop fingers are under control of a cam shaft operated in timed relation with this platen shaft. In the present instance, such platen shaft is indicated by 925, Figs. 2 and 3, and a pair of cams 926 and 927 are provided on this shaft. The cam 926 controls operation of the platen Pc while the cam 927 controls operation of the platen Pb. It is the platen Pb which, when operated, makes impressions from the type wheels 520 in the group thereof pertaining to net and, as will be recalled, this platen is operated twice with respect to each sheet so that the amount of net will be printed on both the warrant and the counterfoil in each sheet. The shaft 925 is driven from the motor 272 and makes one complete revolution for each cycle of operation of the

machine. Hence, a lobe 927A is provided on the cam 927 in such a position that as the shaft 925 rotates this lobe will move into association with the roller 929 on an arm of the platen Pb at the time the warrant portion of the check is disposed above the type wheels for printing the amount of the net, and when this lobe engages this roller the platen Pb is forced downwardly at the time indicated by the chart-line Ch67, Fig. 49, to make an impression from these type wheels. The spring 930 retracts the platen to its inoperative position after this impression has been made.

The portion of the sheet bearing the counterfoil next moves into position below the platens Pb and Pc, in which position a sheet S' is shown in Fig. 2. At the time the sheet attains this position a lobe 927B on the cam 927 moves into association with the roller 929 and a lobe 926B on the cam 926 aligned with the lobe 927B moves into association with a roller 931 on an arm of the platen Pc. These lobes cause both the platens Pb and Pc to be forced downwardly respectively at the times indicated by the chart-lines Ch68 and Ch69, Fig. 50, so that the impression T2, Fig. 3a, is made on the counterfoil portion of the sheet from all of the set-up type wheels 520 on the shaft 516 and after this impression has been made the springs 930 and 932 respectively retract the platens Pb and Pc for by this time the lobes 927B and 926B will have moved from association with the rollers 929 and 931.

The printing of words on the sheets of course is not effected from the shaft 925 but after the sheet has moved from association with the word printing mechanism and has engaged a stop finger which retains it in position to receive an impression directly from the printing and control device, as above described, the platens Pe and Pd are to be operated. The cycles of operation are marked off by lines so identified and extending horizontally along the upper section of the printing chart, and by referring to this chart it will be readily perceived that the operation of the machine is so timed that the impressions are made by the platens Pd and Pe in the third cycle of operation, which is to say, a control card 77 on a printing and control device is sensed in what may be called a first cycle of operation and then, as explained heretofore, by the time the data pertaining to this sensing operation has been set up in the word printing mechanism the second cycle of operation will be under way. A printing and control device is in the position Y1, Fig. 2, where it is sensed by the sensing fingers 50 and it advances into the position Y2 during the second cycle of operation. It is during the second cycle of operation as explained heretofore that the words are printed on the warrant portion of the sheet.

After the words have been printed on the sheet S the third cycle of operation gets under way and at this time the printing and control device, of which the record card 77 determined the printed data on said sheet, moves into the position Y3 where impressions are made therefrom upon said sheet which by this time will be below the platens Pd and Pe.

The number of shares of stock owned by a stockholder or, as it is called, the registered holding, is embossed on the printing and control device, as well as the account number. The printing and control device also has the name and address of the stockholder embossed therein.

The number of shares owned and the account number is not to be printed on the warrant which is the first portion on the sheet S to move into association with the platens Pe and Pd. Hence, a lobe is not provided on the cam 934 to effect operation of the platen Pe at the time the warrant portion of the sheet is above the printing and control device at the position Y3. However, a lobe 935A is provided on the cam 935 to operate the platen Pd when the warrant portion of the sheet is beneath this platen and at the time indicated by the chart-line Ch91. Operation of the platen Pd causes only the name and address or, in other words, the identification, to be printed on the warrant portion of the sheet. After this impression has been made the stop finger which has been holding the sheet in position to receive this impression is retracted and the sheet moves into engagement with another stop finger which positions the counter-foil portion of the sheet above the printing and control device in the position Y3 which is the position shown in Fig. 3. When this position is attained the lobes 934B and 935B on the cams 934 and 935 move into position to effect operation of the platens Pe and Pd at the time indicated by the respective chart-lines Ch92 and Ch93 so that the identification or name and address and the account number and the registered holding are printed on the sheet. The stop finger with which the sheet is engaged is then retracted and passes into a receiving galley provided beyond the end of the feed tapes F.

It will be observed that it is the positioning of lobes on cams that determines the time at which the various platens are to be operated and these cams are mounted on the shaft 925. Hence, to insure proper timing of the machine, the synchronizer drum 86, Fig. 2, is also mounted on this shaft 925. Thus, the synchronizer drum 86 rotates with the shaft 925 and effects the operations heretofore described as being under control thereof in properly timed relation with the operation of the platens.

The developed views of the synchronizer drum, Fig. 1 and Fig. 1d, should be considered together and the left-hand end of the drum as shown in Fig. 1 should be joined to the right-hand end of the drum as shown in Fig. 1d. In so considering these views it should be remembered that the contacts a1 to a21 do not enter into control of the same cycle of operation as that which is proceeding under control of the contact strips associated with the words "Units," "Tens," "Hundreds," and so forth, and the contacts 501R to 501Z in a given rotation of the synchronizer drum. The contacts a1 to a21 are always controlling an operation preceding the operation that is proceeding under control of the contact strips associated with the words "Units," "Tens," and so forth, and the contact strips 501R to 501Z. Thus, when reference is made to the developed views of the synchronizer drum in Figs. 1d and 1, it should not be assumed in so far as point of timing in a given operation is concerned, that there is any relationship between the positioning of the contacts a1 to a21 and the other contact strips on the synchronizer drum. However, the positioning of the contact strips 501R to 501Z relative to the positioning of the contact strips associated with the words "Units," "Tens," and so forth, is a definite relationship in so far as a particular cycle of operation is concerned.

Total accumulating and printing mechanism

Heretofore it has been explained how the type wheels on the shaft 516 are set up and it has been explained that type wheels 520A on the shaft 516, Fig. 25, are also set up at this same time. It has also been explained that while the type wheels on the shaft 516 are returned to zero intermediate setting-up operations thereof the type wheels on the shaft 515 are not so returned to zero, and the effect of this is that after a plurality of printing and control devices have passed through the machine and have effected a plurality of set-ups on the type wheels on the shaft 516 the type wheels on the shaft 515 have accumulated a total of the various amounts which the type wheels on the shaft 516 were set to represent.

The shafts 515 and 516 and the mechanisms which effect set-up of the type wheels on these shafts are all mounted in a frame 554, Figs. 25 and 26, which as shown has two shafts 605 and 606, Fig. 25, journaled in the lower portions thereof. Supports 607 are mounted on the shaft 605 adjacent each side of the frame 554 and supports 608 are mounted on the shaft 606 in similar positions. An arm 608' is fast on the shaft 605 and another arm 609 is fast on the shaft 606. These arms are interconnected by a link 610 so that if rotative movement is imparted to the shaft 605 it will be transmitted to the shaft 606 through the arm 608', link 610 and arm 609.

A crank 611, Fig. 26, including a handle 612 is fast on the shaft 605, said handle 612 being mounted on a pin 613 slidable in the crank 611. So long as the type wheels on the shaft 516 are aligned with the platen Pb, as shown in Fig. 25, it is intended that the supports 607 and 608 should rest on the bed plate 615, in which position they are shown in Figs. 25 and 26, and at this time the pin 613 on which the handle 612 is mounted is seated in a socket 614, Fig. 26. When, however, the type wheels on the shaft 515 are to be aligned with the platen Pb and its cooperating platen Pc, the handle 612 is grasped and when pin 613 is withdrawn from the socket 614 and the crank 611 is turned in a clockwise direction, as viewed in Fig. 25, the rounded lower ends of the supports 607 and 608 roll on the bed plate 615 and thereupon the frame 554 is lowered.

A pair of rails 617, Fig. 26, are provided on the bed plate 615 and rollers 616 on the frame 554 cooperate with these rails, said rollers including flanges which embrace the sides of the rails when the frame 554 is in its upper position and resting on the supports 607 and 608. When, however, the frame is lowered as just described, the peripheries of the rollers 616 seat on the rails 617 and the frame 554 is thereupon supported on said rails.

When the frame 554 rests on the rails 617 the entire frame may be positioned to travel along these rails. Hence the type wheels on the shaft 516 may be moved from position below the platen Pb and the type wheels on the shaft 515 may be moved into association with said platen. Then by operating the platens Pb and Pc an impression may be made from the type wheels on the shaft 515 whereupon the amounts accumulated upon these shafts may be ascertained. After such printing operation has been completed the type wheels on the shaft 516 are again brought into alignment with the platens and the crank 611 is returned to the position in which it is

shown in Figs. 25 and 26, wherefore the frame 554 is again carried by the supports 607 and 608, these supports at this time moving into an over-center position to insure rigid support for the frame 554.

If the impression made as above described from the type wheels on the shaft 515 is to be a subtotal, then the machine operation is continued and additional sums will be accumulated on the type wheels on the shaft 515. If, however, the impression made from the type wheels on the shaft 515 in a manner just described is to represent a final total, the type wheels on the shaft 515 are returned to zero before further machine operations are effected, and such return of these type wheels to zero is effected in the manner now to be described.

As shown diagrammatically in Fig. 10, a hand wheel 602 is mounted on the shaft 515 and normally a spring 601 acts against this hand wheel to hold said shaft 515 in an outer axial position. However, the hand wheel 602 may be grasped and the shaft 515 may be moved upwardly, as viewed in Fig. 10, against the action of said spring 601 whereupon pins as 599 on this shaft are brought into alignment with pins as 600 on the type wheels on the shaft 515. By turning the hand wheel 602 rotative movement may be imparted to the shaft 515 and the pins 599 pick up the pins 600 and when the hand wheel 602 has been rotated far enough to return all the type wheels on the shaft 515 to zero, this hand wheel is released whereupon the spring 601 returns the shaft 515 to the position in which it is shown in Fig. 10 which brings the pins 599 out of cooperative relation with the pins 600 and thereupon the accumulation of a new total on the type wheels on the shaft 515 may proceed.

No tax operation

Heretofore in explaining how a multiplicand representing two hundred shares of stock could be multiplied by a multiplier or dividend rate of one pound, three shillings and two pence, it was also explained how a gross amount, a tax amount and a net amount were ascertained, and it was also explained how these gross, tax and net amounts were entered up on type wheels on the shaft 516 and how printing impressions were taken therefrom. It has also been explained heretofore that it is only the amounts that are entered on the type wheels from which the net amount is printed which are entered in the word printing apparatus.

The foregoing is what may be called a normal or tax operation of the machine but in certain instances instead of computing a tax and determining a net, the gross amount of the dividend or, in other words, the product of the multiplication is the amount that is to be paid pursuant to the warrant, and in such an instance the gross amount is entered on what has heretofore been referred to as the type wheels from which the net amount is printed.

In the foregoing explanation reference was made to a switching bar 518, Figs. 1k, to 1n and it was explained that a solenoid 508 was energized and that the energization of this solenoid caused the switching bar 518 to be disposed in the position in which it is shown in said Figs. 1k to 1n. When the switching bar 518 is in this position it disposes the movable contacts as 515A thereon in the position in which they are shown in said views and so closes circuits which connect the short contact bars 515B on the stator 501

with the motor units, Fig. 10, which when operated set up the type wheels on the shafts 515 and 516, and this connection is such that amounts are set up on type wheels from which the aforesaid gross, tax and net amounts are printed.

The energization of solenoid 508 which positioned the control bar 518 in the position mentioned was effected from the contact strip 501P, Fig. 1d, on the synchronizer drum 86. This strip 501P may be referred to as the tax operation bar and, as explained heretofore, this bar is potentialized from a sensing finger 51D. This sensing finger was grounded in the aforesaid operation by reason of the fact that it passed through a perforation 50Q, Fig. 6a, wherefore the sensing finger 51D was grounded. Whenever a tax operation is to be effected a perforation is provided in the control card 77 on the printing and control device at the position 50Q. When, however, a no tax operation is to be effected, a perforation is not provided at the position where the perforation 50Q is located but instead a perforation 50M is provided in the control card 77 at the position in which this perforation is located on the control card shown in Fig. 6a. When a perforation is in this position the sensing finger 51C passes therethrough and is grounded on the frame of the printing and control device carrying the particular control card 77.

It will be recalled that grounding of the sensing finger 51D applied potential to the tax operation contact strip 501P on the synchronizer drum 86. But when a no tax operation is to be performed potential is to be applied to the no tax operation strip 501Q on the synchronizer drum 86. This strip 501Q cooperates with a pair of brushes 90, one of which brushes is connected through a conductor 509 with the sensing finger 51C and the other of these brushes has connected thereto a conductor 510. It will be recalled that the application of potential on the contact strip 501P effected energization of the solenoid 508A, Fig. 1n, which caused engagement of the clutch 508C and this set the rotor 502 in operation. The application of potential on the contact strip 501Q also effects engagement of the clutch 508C but in this instance the solenoid 510A is energized.

It will be recalled that the solenoid 508 Fig. 1n, was energized to effect positioning of the control bar 518 when the solenoid 508A was energized to cause engagement of the clutch 508C. In this instance, however, where the solenoid 510A, Fig. 1n, is energized the solenoid 511, Fig. 1k, is energized. The energization of the solenoid 511 causes the switching bar 518 to move downwardly, as viewed in Figs. 1k to 1n, and such movement of the control bar causes the movable contacts as 515A thereon to disengage the fixed contacts with which they are shown engaged in Figs. 1k to 1n and to engage the fixed contacts from which said movable contacts are shown disengaged in Figs. 1L and 1m. Such connection of the movable contacts 515A connects the short contact strips 515B on the stator 501, that in the preceding described operation caused the entry of the gross amount on the type wheels 520 on the shaft 516 pertaining to gross, to be connected in this instance with the type wheels 520 on said shaft 516 which, in the preceding described operation, printed the net amount. Hence when the solenoid 511 is energized and the switching bar is shifted downwardly, Figs. 1k to 1n, as above described, the gross amount will be entered on the type wheels 520 on the shaft 516 which print the net, and in this instance

the type wheels which heretofore were employed to print the gross are also set up. Since in this instance the short contact strips 515B on the stator 501 are connected to motor units which will set up the type wheels pertaining to gross and the type wheels pertaining to net, both sets of type wheels are set to represent the same amounts. In this instance, however, the type wheels which were heretofore employed to print the tax are not set up since the movable contacts as 515A are now so positioned that circuit to the motor units which effect set-up of these type wheels for printing net is opened.

In this instance where the gross amount is set up on the type wheels which pertain to net, it is manifest that as these type wheels return to zero the word printing apparatus will be set up to print the gross amount on the warrant. Except in so far as has just been described, the no tax operation corresponds to the tax operation which heretofore has been described in detail.

Bankers warrant operation

In addition to the tax operation described in detail heretofore and the no tax operation which has just been described, the present machine is capable of still another operation and this pertains to printing what are called bankers warrants. This condition arises as has been explained heretofore when a group of printing and control devices are passed through the machine and instead of a warrant being made out under control of each such device only one warrant is to be made out and in such an instance the amount to be printed on the warrant is the total of the net values ascertained from all of the printing and control devices of the group. This condition arises due to the fact that where printing devices are grouped as just mentioned, the printing devices pertain to customers of a particular bank who have designated the bank as their collecting agent. Hence, only one warrant or check is made out, instead of a plurality of warrants or checks, and this warrant is made payable to the bank. However in such instances counterfoils or receipts are made out pursuant to the perforations in the control cards on the printing and control devices in the group.

In so far as the counterfoils are concerned, the operation under control of printing and control devices of a group for which a bankers warrant is to be made out, these counterfoils are made out by operations of the machine similar to those described heretofore in what has been called a tax operation, which is to say, in so far as the contact strips 501P and 501Q are concerned, the operation is effected under control of contact strip 501P. However, in so far as the warrant portions of the various sheets bearing these counterfoils are concerned, the operation proceeds as heretofore described but an additional operation is performed. It will be appreciated that in order to advance the sheet from the position in which the impression T2 is made on the counterfoil into the position in which the first identification is printed on the sheet that it is necessary that the sheet advance through the word printing mechanism. Hence in this circumstance where a bankers warrant is to be made out, the words are printed on the warrants of each sheet and this advances the sheets through the word printing apparatus.

Whenever printing and control devices are arranged in a group, and a bankers warrant is to be printed, a perforation is provided in the con-

trol card 77 on certain of these devices at the position in which the perforation 50R is indicated in Fig. 6a. A sensing finger 51A is provided to cooperate with a perforation in the position of the perforation 50R and circuit from this sensing finger is under control of a contact 501N, Fig. 1d, on the synchronizer drum 86. This contact is so located that it will move into association with the brushes 90 at a time in the third cycle of operation of the machine during which the second impression is being made directly from the printing and control device by the platens Pd and Pe at which time the warrant portion of a sheet will be disposed between a printing member PM, Fig. 3, located below the feed tapes F to lie below the warrant portion of a sheet at the time both the platens Pd and Pe are making the second impression directly from the printing and control device. A suitable ink ribbon extends between the type on the printing member PM and the warrant portion of the sheet disposed thereabove. An electromagnetically controlled platen EM is provided in alignment with the printing member PM and a conductor 700A, Fig. 3, extends between one of the brushes 90 cooperating with the contact 501N and one end of the winding of the electro-magnet controlling the platen EM, the other end of this winding being connected to battery as shown in Fig. 3. A conductor 505A, Fig. 1d, interconnects the sensing finger 51A and the other brush of the pair of brushes 90 that cooperate with the contact 501N.

Whenever a group of printing and control devices pertaining to a bankers warrant passes through the machine the first two devices in the group do not have a perforation in the position of the perforation 50R but the third and all subsequent of such devices do bear such a perforation. The first two devices, however, and all other devices except the last two, bear perforations at the position of the perforation 50Q, Fig. 6a. It will be remembered that a printing and control device which bears perforations under control of which type wheels on the shaft 516 are set up, does not move into cooperative relation with the platens Pd and Pe until two cycles of operation after the cycle of operation in which such printing and control device effected set-up of the type wheels. It is for this reason that the first two of the printing and control devices in a group pertaining to a bankers warrant are not equipped with perforations in the position of the perforation 50R. However, in the third cycle of operation pertaining to a particular group of printing and control devices the first printing device of the group will be in association with the platens Pd and Pe, and, during the time these platens are making the second impression from the printing and control device, the contact 501N on the synchronizer drum moves into association with the pair of brushes 90 with which it cooperates (see Figs. 43 and 51 of the timing chart) and a circuit is established which energizes the electro-magnet platen EM and this platen therefore operates to make an impression on the warrant portion of the sheet from the printing member PM. This printing member bears large type characters and when the platen EM makes the aforesaid impression and the word "Void" is printed across the warrant.

All printing devices in the group from the third on have a perforation in the position of the perforation 50R, and the group will include as the next to the last printing and control device in the

group one which will have no type characters embossed thereon and the control card 77 thereon will only have a perforation in the position of the perforation 50R. This perforation on this printing and control device will cause the word "Void" to be printed on the sheet bearing numerical data printed under control of the fourth from the last printing and control device in the group. Furthermore, the last printing and control device in each group will bear a plate which will have embossed thereon the name of the bank to which the bankers warrant is to be made payable and this printing and control device will have a control card thereon bearing a perforation in the position of the perforation 50R and this perforation will bring about printing of the word "Void" on the sheet bearing numerical data printed from under control of the third from the last printing and control device in the group which is the last printing and control device in the group bearing a control card 77 perforated to effect printing of numerical accounting data.

A sheet will be fed onto the feed tapes F at the time in the operation of the machine when this sheet would attain a position to engage the stop finger which would position it to receive the impression similar to the impression T1 on the sheet shown in Fig. 3a that should pertain to the numerical data on the next to the last printing and control device in the group but, since this next to the last printing device does not cause the printing of any numerical data, the operator will remove this sheet from the machine when apprised of this condition and this will be accomplished as follows. The last printing and control device in the group will bear a perforation in the position indicated at 50S in Fig. 6a which cooperates with a sensing finger 51B. This sensing finger is under control of a contact 501M, Fig. 1d, that is positioned on the synchronizer drum 88 alongside of the contact strip 501N. When this contact strip 501M moves into association with its brushes 90 and the sensing finger 51B has passed through said perforation 50S, circuit is closed to an audible or visible signal such as the bell, Fig. 3, through a conductor 700B, Figs. 1d and 2, and the signal produced by operation of this bell advises the operator that the last printing and control device of the group pertaining to a bankers warrant is in position below the sensing fingers 50. Soon after the bell or other signal is set in operation a sheet passes onto the feed tapes F.

When the audible signal is produced the operator of the machine removes from the machine the last and the next to the last sheets therein, neither of which sheets will bear any impressions. The operator then manually operates the crank 611, Fig. 26, and brings the type wheels 520A on the shaft 515 into printing position. With these type wheels in this position the operator then takes one of the two sheets that has been removed from the machine and disposes this sheet in the position in which it will receive an impression similar to the impression T1. Prior to the time the particular group of printing and control devices pertaining to a bankers warrant will have been started through the machine, the type wheels on the shaft 515 will have been returned to zero so that by the time the operator brings these type wheels into printing position they will have accumulated the total of all the amounts printed on the sheets under control of the printing and control devices of the group. The operator thereupon causes the machine to

make another cycle of operation in the course of which the platen Pb makes an impression from the type wheels on the shaft 515 and this impression is made on the warrant portion of the sheet and represents the total amount of money to be paid pursuant to the value ascertained by reason of the passage of the printing and control devices of the group through the machine.

The operator next manually positions the sheet on which this last impression has been made in position to receive the first of the impressions made directly from a printing and control device. By reason of the intervening operation of the machine, the printing and control device bearing the name of the bank will be in position in this cycle of operation to print the name of the bank on the warrant portion of the sheet and the operator causes the machine to make another cycle of operation in the course of which the name of the bank is printed on the warrant.

In the foregoing operation the amount to be paid pursuant to the warrant is not printed in words but this may be done in a manner which is customary in the art or this amount may be written in.

It will be understood from the foregoing description that it is necessary that printing and control devices pertaining to a bankers warrant be grouped and that these groups be separately passed through the machine and when this is done in the manner just described a bankers warrant will be made out whereby a custom prevalent in the art may be complied with in this machine.

Summary

In the foregoing it has been explained how printing and control devices are passed through a machine and it has been explained that sensing means cooperates with the control means on these devices to ascertain a numerical value which, as stated, represents the multiplicand of a multiplying operation or, more broadly, one factor of a multiplication.

It has been explained that means are provided in the machine which are manually settable to represent a predetermined amount and, in the present instance, this has been described as being the multiplier of a multiplying operation or, more broadly, a factor of a multiplication.

It will be noted from the foregoing description that all of the possible products that may be ascertained in the course of operation of the machine are included on means in the machine so that selective operation of the machine under control of one factor of a multiplication, the multiplicand in the present instance, causes the particular product of the particular multiplication to be selected. This is done by successively energizing circuits through the means which represent the significant digits in the multiplicand of the multiplying operation so that, in other words, the multiplication proceeds order by order through the multiplicand in contradistinction to the usual arrangement where multiplication proceeds order by order through the multiplier. It is to be understood however that while the machine has been described in such a way that multiplication proceeds order by order through the multiplier, it could be the multiplicand that would be set up in the machine and, in this instance, it would be the multiplier that was ascertained, and in such an instance the multiplication would proceed order by order through the multiplier. More broadly stated, the multiplication proceeds order by order through the factor of a multiplying

operation that is ascertained in the course of operation of the machine while the machine is set up to contain the other factor of the multiplying operation.

In the machine as described the product which is ascertained in the course of operation is passed into what has been called a proportionating apparatus but with reference to this particular apparatus it should be observed that the numerical value passed thereto might be derived from any source such as perforations or manually operable keys. In the present instance the proportionating apparatus has been described as effecting what amounts to a multiplication and also what amounts to a subtraction. However, by reason of inherent characteristics of this proportionating apparatus and the fact that it is manually set up to represent a predetermined pattern, the apparatus could be used to effect any kind of a mathematical computation as, for example, addition or division, and furthermore it is not at all essential that the mathematical computation follow a predetermined arrangement for the proportionating apparatus could be set up pursuant to an arithmetical, algebraic or geometric progression, or according to trigonometrical relationships, or even for effecting integrating or differentiating calculus computations. So it will be seen from this that while the proportionating apparatus has been specifically described for two specific operations, it is capable of effecting an almost infinite variety of computations.

The machine as described also includes what have been called rotors and staters and it has been explained that the staters include paired long and short contact strips whereas the rotors include bars or contacts that ride over these paired contact strips. Circuit is selectively closed to the long contact strips, and the short contact strips associated therewith are so arranged that the amounts represented by the potentialized long contacts trips may be read out into other devices so that said other devices may be set pursuant to the numerical values represented by the energized of the long contact strips. Such an operation as explained is effected in timed relation with the operation of other parts of the machine and, as will be apparent from an inspection of the apparatus, a wide variety of instrumentalities and a plurality of instrumentalities could if so desired be set up under control of such read-out devices.

Furthermore, the machine includes devices into which the results of mathematical computations may be entered and these devices so operate that these results may be instantly taken out of such devices or they may be held in such devices or, in other words, stored therein, so that they will be available at some later time in the operation of the machine. Hence, since such storage means are provided in the machine and since it is possible by reason of the arrangement of the machine to store or transfer results of mathematical computations, the machine may be operated relatively rapidly because two or more independent operations may be proceeding simultaneously.

The machine also includes means which print ascertained numerical values both in numerals and in words and, as explained heretofore, these printing means are under control of switching devices so that a variety of information may be printed thereby and it is to be understood that switching arrangements other than that specifically described could be utilized in the machine should the need therefor arise. In connection

with the printing of words, another important and novel feature of this invention is the feature of advancing the sheets during the word printing operation in amounts related to the length of the words so that the words will appear in proper side by side relation when printed on business instruments.

The machine includes many other novel instrumentalities and is capable of a wide variety of uses and the foregoing enumeration is not to be taken as a limitation of the invention which therefore is not to be limited to the precise details set forth but is to include those variations and modifications that fall within the purview of the following claims.

I claim:

1. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor and including a plurality of conjointly operable setting means all operable in a single differential setting of said devices, transfer means intermediate adjoining denominations of said setting means, and readout means settable by said setting means to represent all of the several products which may result from multiplications of the particular factor the settable devices are set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

2. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor and including a plurality of conjointly operable setting means, all of the setting means of each device being operable to produce multiples of the value the device is set to represent upon a single differential setting of said device, and readout means including a plurality of positionable members respectively operable by the setting means of the settable devices, transfer means interposed between positionable members of adjoining denominations and operable by setting means said setting means and said transfer means functioning upon operation of any of said settable devices to dispose positionable members in positions representative of all of the products that may result from multiplications of the value the operated settable means is set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

3. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor and arranged in adjacent relation with each other, each such device pertaining to a different denomination of the reoccurring factor and including a plurality of conjointly operable setting means, all of the setting means of each device being operable to produce multiples of the value the device is set to represent upon a single differential setting of said device, transferring means intermediate adjoining denominations of said setting means, and readout means settable by said setting means to represent all of the multiples which may result from multiplica-

tions of the particular factor the settable devices are set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

4. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor and arranged in adjacent relation with each other, each such device pertaining to a different denomination of the reoccurring factor and including a plurality of conjointly operable setting means, all of the setting means of each device being operable to produce multiples of the value the device is set to represent upon a single differential setting of said device, readout means including a plurality of positionable members each operable by respective of the setting means, and transfer means interposed between positionable members of adjoining denominations and operable by setting means to produce corresponding multiples in adjacent of said settable devices, said setting means and said transfer means functioning upon operation of any of said settable devices to dispose positionable members in positions representative of all of the products that may result from multiplications of the value the operated settable means is set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

5. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor and including a plurality of sets of gears interconnected for conjoint operation, the ratio between each set of gears in each device being such as to produce a predetermined multiple of any value the device is set to represent, and transfer means intermediate adjoining denominations of said devices, and readout means operable by the driven gears of said sets of gears, said readout means being positioned to represent all of the products which may result from multiplications of the particular factor the settable devices are set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

6. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor and including a plurality of sets of gears interconnected for conjoint operation, the ratio between each set of gears in each device being such as to produce a predetermined multiple of any value the device is set to represent, transfer means intermediate adjoining denominations of said devices, and readout means including a plurality of positionable members each operable by respective of the driven gears of said sets of gears to be positionable to represent all of the several products which may result from multiplications of the particular factor the settable devices are set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

7. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plu-

5 rality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor and including a plurality of sets of gears interconnected for conjoint operation, the ratio between each set of gears in each device being such as to produce a predetermined multiple of any value the device is set to represent, readout means including a plurality of positionable members each operable by respective of the driven gears of said sets of gears, and transfer means interposed between positionable members respectively operable by the driven gears in sets thereof on different settable devices having corresponding ratios, said sets of gears and said transfer means functioning upon operation of any of said settable devices to dispose positionable members in positions representative of all of the products that may result from multiplications of the value the operated settable means is set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

8. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor and including a plurality of sets of gears interconnected for conjoint operation, the ratio between each set of gears in each device being such as to produce a predetermined multiple of any value the device is set to represent, a plurality of positionable members each respectively connected to a respective driven gear of said sets of gears to be movable with such gear and each having a contact thereon, a plurality of sets of contacts, the contacts of each set respectively having determined numerical significance, each set of contacts being associated with a respective positionable member to be selectively engageable by the contact thereon, transfer means interposed between positionable members respectively connected to driven gears in sets thereof on different settable devices having corresponding ratios, said sets of gears and transfer means functioning upon operation of any one of said settable devices to dispose contacts on said positionable members in engagement with contacts in the respectively cooperable sets of contacts having a numerical significance equal to all of the products which may result from multiplications of the particular factor the settable device is set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

9. In an electrical multiplying apparatus, a plurality of sets of conductors allocated one set to each of the orders of a first factor of to be performed multiplications and each set comprising a plurality of numerically significant conductors each allocated to a different numerical value, a group of independent contacts allocated to each set of conductors, the independent contacts in each group each being allocated to a different digit which may appear in the second factor of the to be performed multiplications, a setting device for each group of contacts settable to represent digital values which may appear in the order of said first factor to which the setting device pertains, operating means acting between each setting device and the independent contacts of its group operable to concurrently actuate all of the associated independent con-

tacts to connect said contacts respectively to numerically significant conductors to afford a plurality of numerical representations corresponding to the value for which the associated setting device is set to represent times any digit which may appear in an order of said second factor, transfer means operatively interposed between related contacts of the adjoining groups pertaining to the same digit of the second factor for effecting carry-over movement of the contacts, and circuit means for extending circuits to the independent contacts allocated to a selected digit appearing in said second factor to thereby energize conductors in the several sets having numerical significance corresponding to the product of the first factor said devices are set to represent times digit of the second factor.

10. In an apparatus as claimed in claim 9, a product receiver, entry effecting means for said receiver, circuit means for interconnecting said sets of denominational significant conductors to said entry effecting means, to thereby extend circuit from energized of said conductors to said entry effecting means, individual switching means in said circuit means for each of said sets of conductors, and means for closing the switching means of said sets of conductors in succession to effect entry of products of successive digits of said second factor from said sets into said product receiver in succession.

11. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor, a plurality of sets of contacts, the contacts of each set respectively having determined numerical significance, a plurality of positionable contact members for each of said devices each allocated to a different digit that may appear in the second factor of a multiplication and each having a contact thereon, each set of contacts being associated with a respective positionable member to be selectively engageable by the contact thereon, a plurality of actuating connections allocated to each of said devices and operated conjointly by and with the one of said devices to which they are allocated to actuate respective ones of said positionable members to engage the contacts of said positionable members with different contacts of their respective sets in such a relation that the numerical significance of the engaged contacts represent multiples of the numerical value to which the associated device is set times the digit to which the associated positionable member is allocated, transfer means interposed between adjoining positionable members respectively allocated to corresponding digits of the second factor, said plurality of actuating connections and the associated transfer means functioning upon operation of any one of said settable devices to dispose contacts on said positionable members in engagement with contacts in the respectively cooperable sets of contacts having a numerical significance equal to all of the products which may result from multiplications of the particular factor the settable device is set to represent by the several digital values which may appear in any denomination of the second factor of the to be performed multiplications.

12. In an apparatus for ascertaining secondary amounts having a predetermined proportionate relation to variable primary amounts, a plurality of incoming conductors arranged in denomina-

tional groups, there being an individual conductor in each group allocated to each of the various values that may appear in the respective denomination of a primary amount, a plurality of outgoing conductors arranged in denominational groups, each group having a separate conductor allocated to each of the various values that may appear in the respective denomination of a secondary amount, and devices individually settable to establish unidirectional current flow connections between each incoming conductor and selected of the outgoing conductors in accordance with the proportionate secondary values established by said predetermined relation with respect to the primary value which such incoming conductor represents.

13. In an apparatus for ascertaining secondary amounts having a predetermined proportionate relation to variable primary amounts, a plurality of incoming conductors arranged in denominational groups, each group having a separate conductor allocated to each of the various values that may appear in the respective denomination of a primary amount, a plurality of outgoing conductors arranged in denominational groups, each group having a separate conductor allocated to each of the various values that may appear in the respective denomination of a secondary amount, and devices establishing electrical connections between each incoming conductor and selected of the outgoing conductors in accordance with the proportionate secondary values corresponding to the primary value which such incoming conductor represents, at least those of said devices which are connected to outgoing conductors having a plurality of devices connected thereto having means to permit only unidirectional current flow to thereby inhibit feedbacks and insure accuracy of operation.

14. In an electrical calculating apparatus for ascertaining secondary amounts having a predetermined proportional relation to variable multid denominational amounts, a plurality of incoming primary conductors grouped denominationally with respect to the denominations of the primary amounts and having individual conductors in the respective groups allocated to each of the numerical values that may appear in the groups, a plurality of outgoing secondary conductors arranged in denominational secondary groups with respect to the denominations of the secondary amounts and with each group having individual conductors allocated to each of the values that may appear in the respective secondary groups, and means establishing unidirectional current flow connection from each incoming primary conductor to outgoing secondary conductors in accordance with the secondary values having the aforesaid predetermined proportional relation to the primary values represented by the respective primary conductors.

15. An apparatus for ascertaining secondary amounts having a predetermined proportionate relation to variable primary amounts, comprising a plurality of primary bars arranged substantially parallel to each other and in groups of denominational significance, each group having a separate bar allocated to each of the values that may appear in the respective denomination of a primary amount, a plurality of parallel secondary bars arranged substantially transversely of and in spaced relation to said primary bars, said secondary bars consisting of denominational groups each having bars respectively allocated to the various values that may appear in the

particular denomination of a secondary amount, individually settable plugs for establishing unidirectional current flow connections between each of said primary bars and selected of the secondary bars according to the proportionate secondary values corresponding to the primary value which such primary bar represents, means for successively potentializing selected primary bars group by group in accordance with the values in the various denominations of a selected primary amount to thereby apply potential on the secondary bars interconnected with such primary bars and representative of the related secondary values established under the aforesaid predetermined proportionate relation, a register, and means for successively effecting entries into said register of the secondary values represented by the potentialized secondary bars, said register operating to accumulate the successively entered secondary values to determine the complete secondary amount corresponding to the selected primary amount.

16. In an apparatus for effecting multiplying operations entailing a factor which reoccurs in a plurality of successive multiplications, a plurality of devices settable to represent the reoccurring factor, each such device pertaining to a different denomination of such factor and including a plurality of conjointly operable setting means all operable in a single differential setting of said devices, transfer means intermediate at least selected adjoining denominations of said setting means, and readout means settable by said setting means to represent all of the several products which may result from multiplications of the particular factor the settable devices are set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

17. In a multiplying apparatus, a plurality of devices settable to represent one factor of to be performed multiplications, each such device pertaining to a different denomination of such factor and including a plurality of conjointly operable setting means all operable in a single differential setting of said devices, transfer means intermediate adjoining denominations of said setting means, and readout means settable by said setting means to represent all of the several products which may result from multiplications of the particular factor the settable devices are set to represent by the several values which may appear in any denomination of the other factor of the to be performed multiplications.

18. In an apparatus of the character described, a settable device settable differentially to represent a selected one of a plurality of different digital values, such device including a plurality of sets of gears each including a driven gear and a driving gear meshed with the driven gear and interconnected with said device for conjoint operation of all of said sets of gears by said device, the ratio between said sets of gears being such that the driven gears of the respective sets are operated in different amounts bearing different predetermined relations to the digital value the settable device is set to represent, a plurality of

positionable members each respectively connected to a respective driven gear of said sets of gears to be movable with such gear and each having contact means thereon, a plurality of sets of contacts, the contacts of each set respectively having determined numerical significance, each set of contacts being associated with a respective positionable member to be selectively engageable by the contact means thereon, said sets of gears upon operation of said settable device being operable to dispose the contact means on said positionable members in engagement with contacts in the respectively cooperable sets of contacts.

19. In an apparatus for effecting multiplying operations, a plurality of devices settable to represent one factor of a to be performed multiplication, each such device pertaining to a different denomination of such factor and each device including a plurality of conjointly operable setting means, one for each possible digit that may occur in the other factor and all operable in a single setting of the device, transfer means intermediate those adjoining denominations of said setting means where transfers may arise, and readout means settable by said setting means in a single setting of each device pertaining to each order of a factor in which a factor digit occurs to represent all possible products which may result from multiplications of such factor by all possible digital values which may appear in any denomination of the other factor of the to be performed multiplications.

20. In a multiplying apparatus for effecting multiplying operations entailing first and second factors the first factor of which reoccurs in a plurality of successive multiplications, said apparatus embodying a second factor sensing means for reading the denominational digits of the second factor from a record, a final product receiver and entry effecting means for effecting entries into said final product receiver, means for setting up all of the multiples of the first factor comprising a plurality of manually operable devices settable to represent the first factor, each such device pertaining to a different denomination of such factor and including a plurality of conjointly operable setting means all operable in a single differential setting of the respective devices, transfer means intermediate those adjoining denominations of said setting means where transfers may arise, and readout means settable by said setting means to represent all of the several products which may result from multiplications of the particular factor the settable devices are set to represent by the all possible digits which may appear in any denomination of the second factor of the to be performed multiplications, and means governed by said second factor sensing means and effective to selectively interconnect said readout means with said entry effecting means in accordance with the digital values of the second factor to effect entry into the product receiver of the corresponding multiples of the first factor.

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