

Nov. 6, 1934.

O. J. SUNDSTRAND
CALCULATING MACHINE

1,979,295

Filed March 3, 1931

23 Sheets-Sheet 1

Fig. 1.

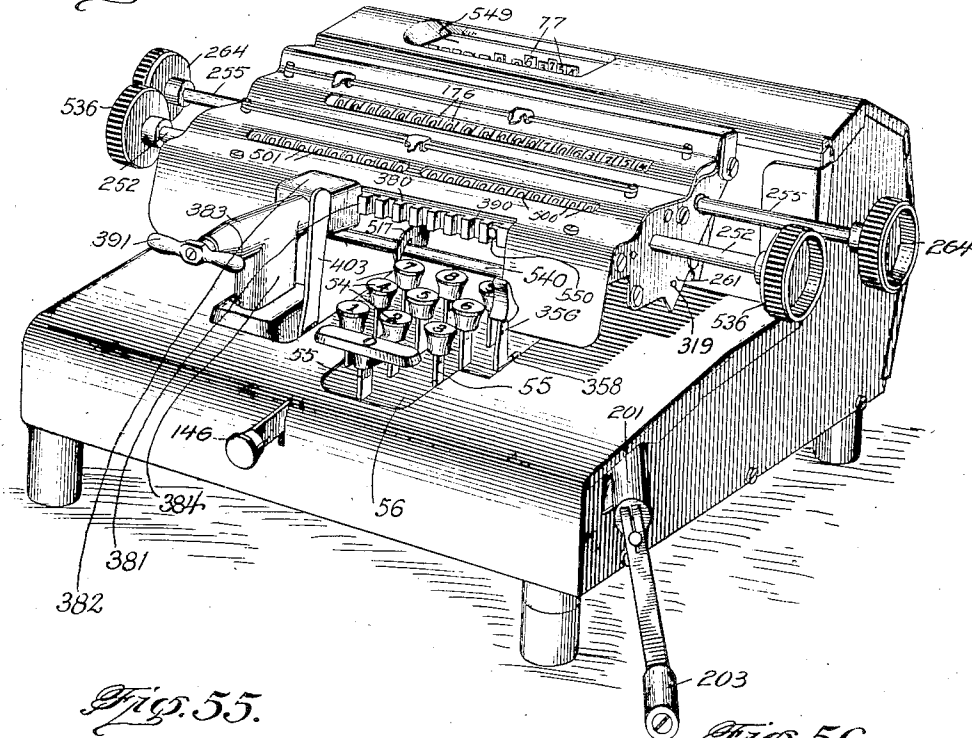


Fig. 55.

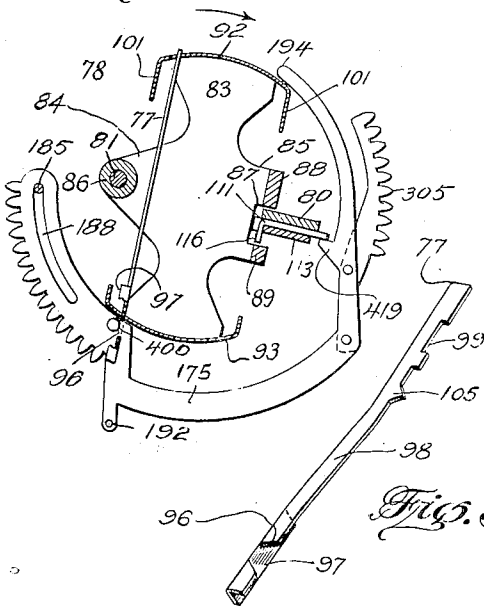


Fig. 56.

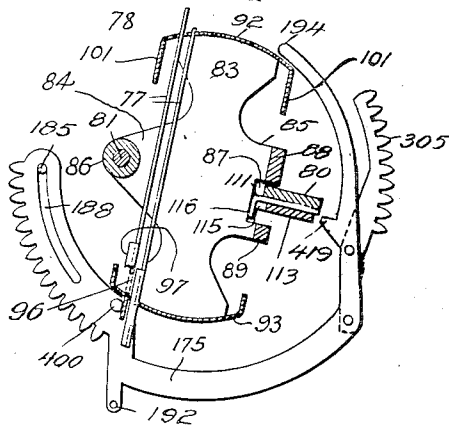
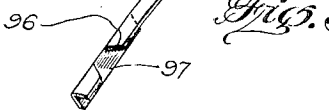


Fig. 57.



Inventor
Oscar J. Sundstrand.

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By

R. E. Julian

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Nov. 6, 1934.

O. J. SUNDSTRAND

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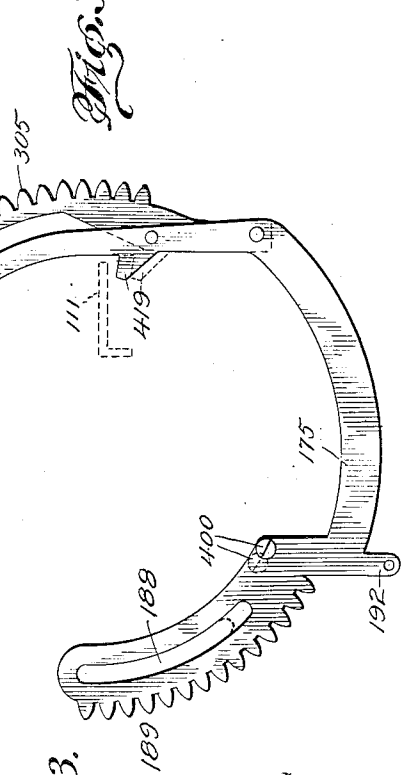
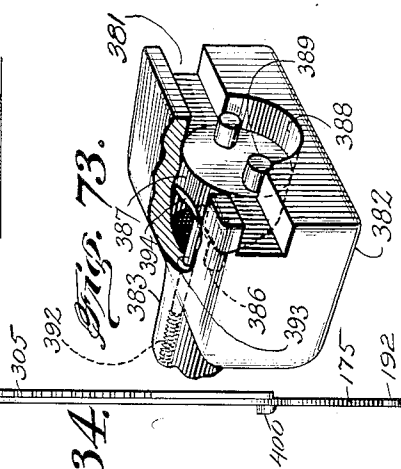
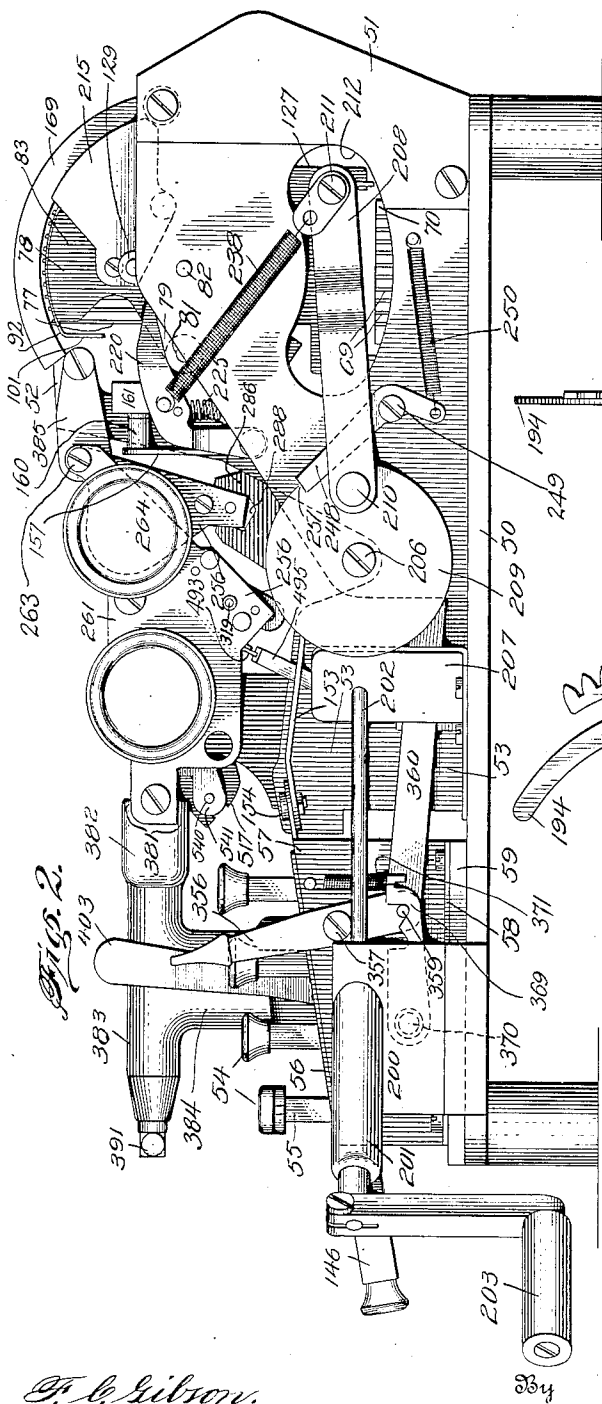


Fig. 33. Inventor
Oscar J. Sundstrand.
E. L. Gibson
Attorney

Nov. 6, 1934.

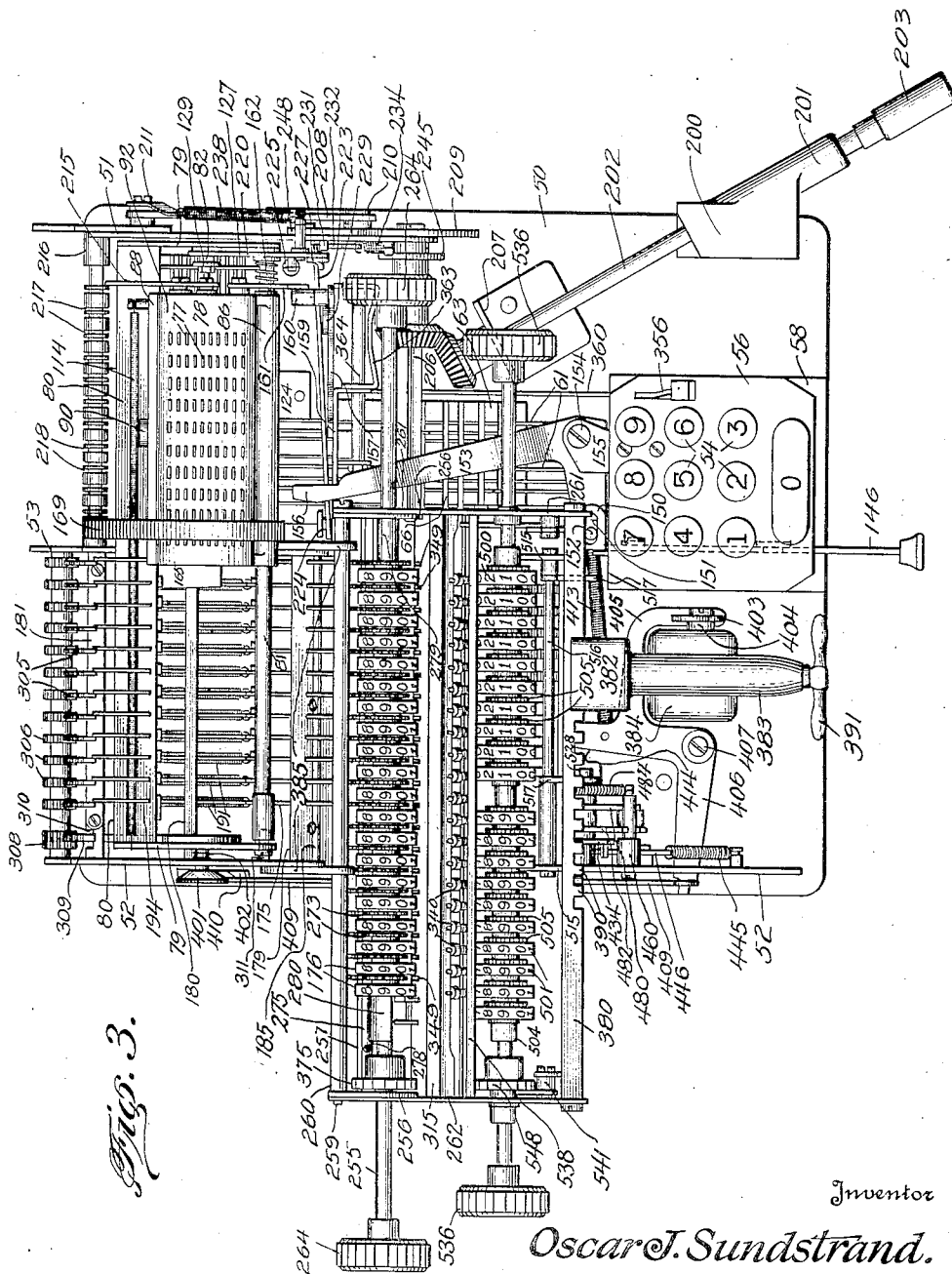
O. J. SUNDSTRAND

1,979,295

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Filed March 3, 1931

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O. J. Sundstrand.

384

R. E. Julian
Attorney

Nov. 6, 1934.

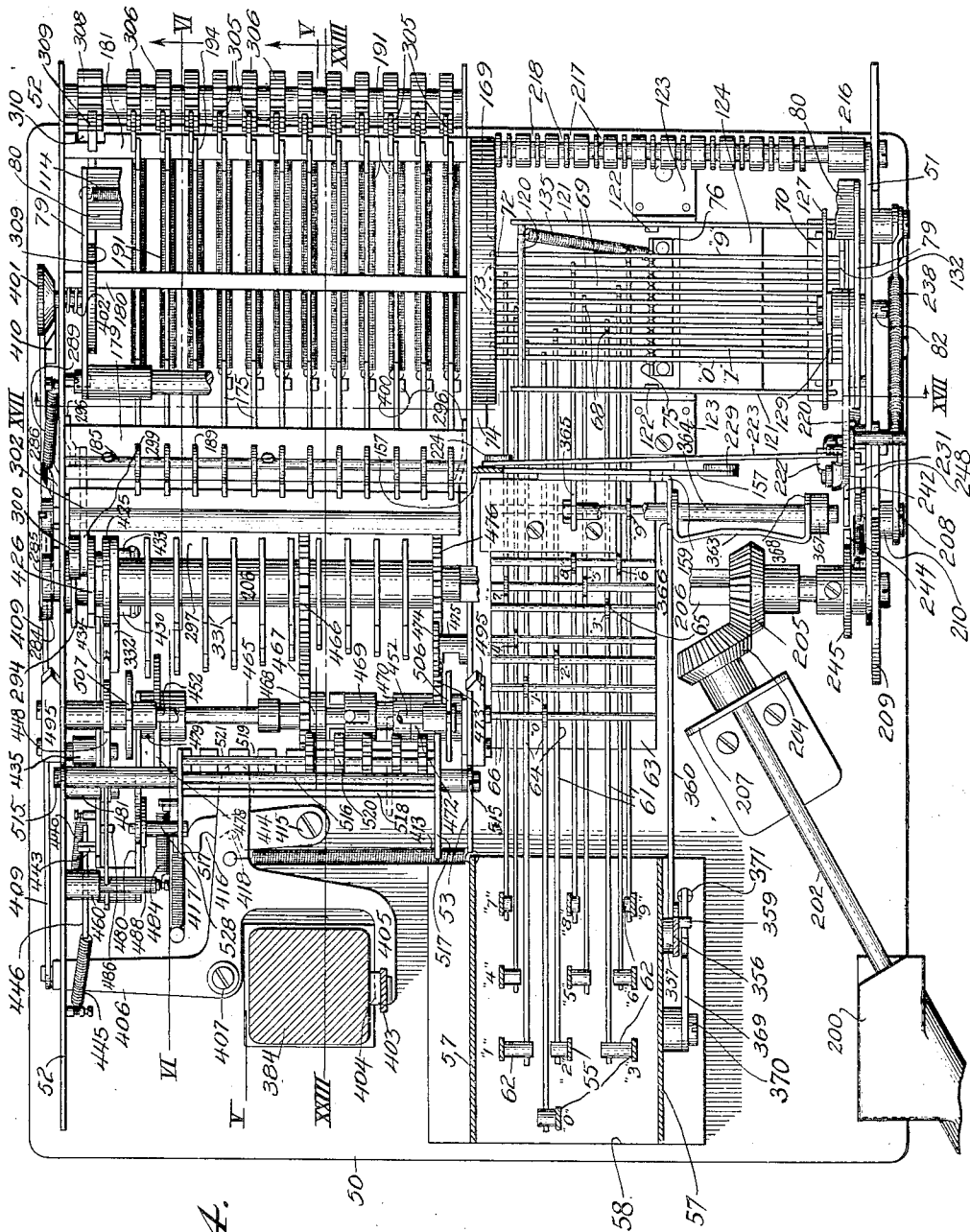
O. J. SUNDSTRAND

1,979,295

CALCULATING MACHINE

Filed March 3, 1931

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F. L. Gibson.

இய

Inventor,
Oscar J. Sundstrand.

R. E. Julia

Attorney

Nov. 6, 1934.

O. J. SUNDSTRAND

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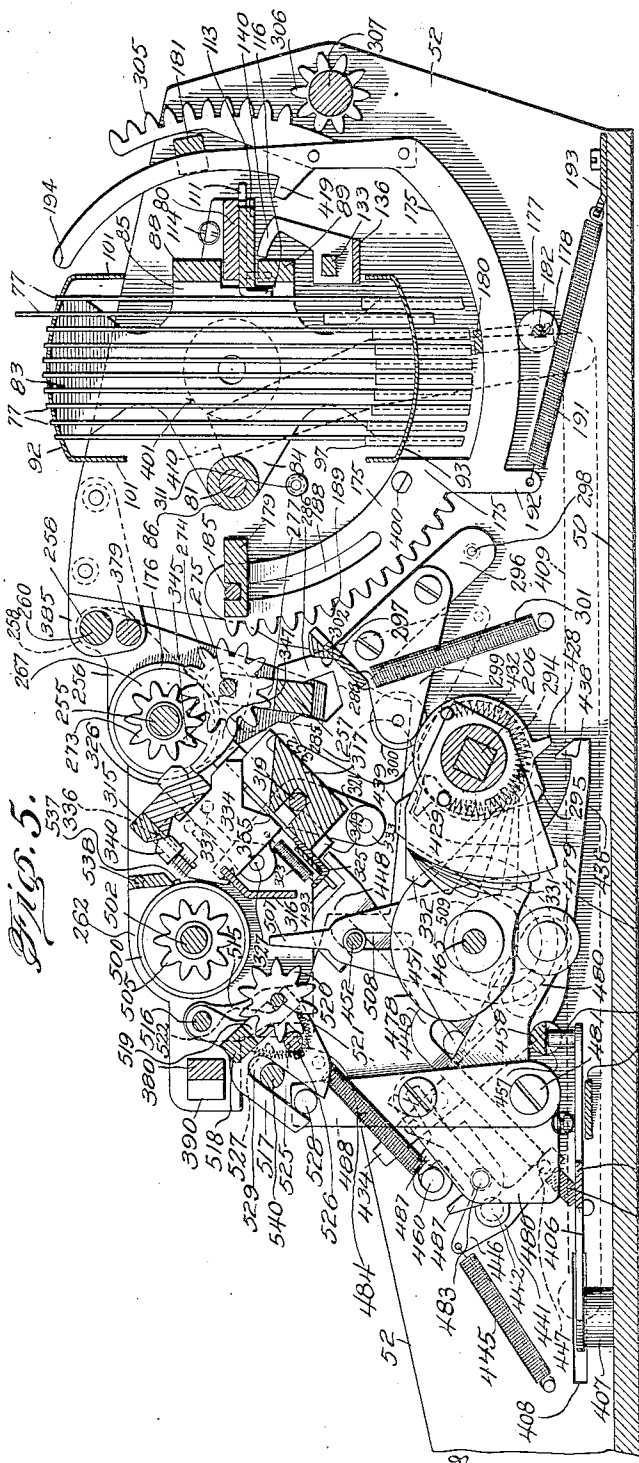


Fig. 5.

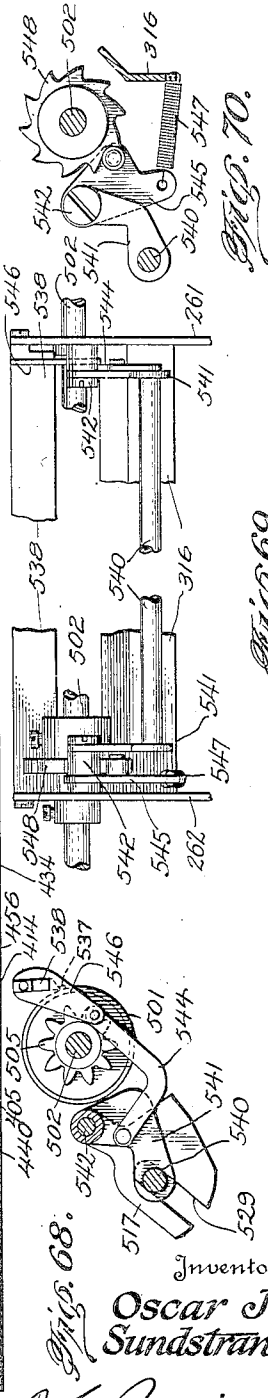


Fig. 68.

Fig. 70.

Fig. 69.

F. L. Gibson.

P. E. Zukin
Attorney

Inventor
Oscar J. Sundstrand.

Nov. 6, 1934.

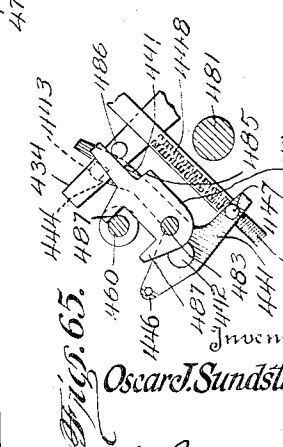
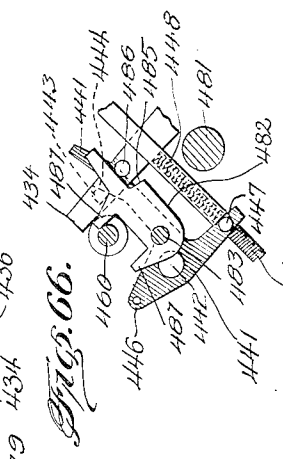
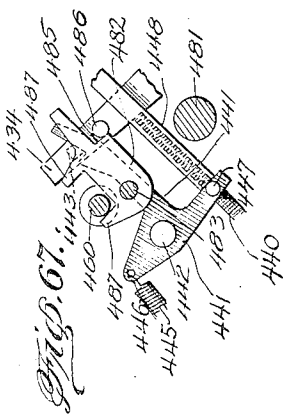
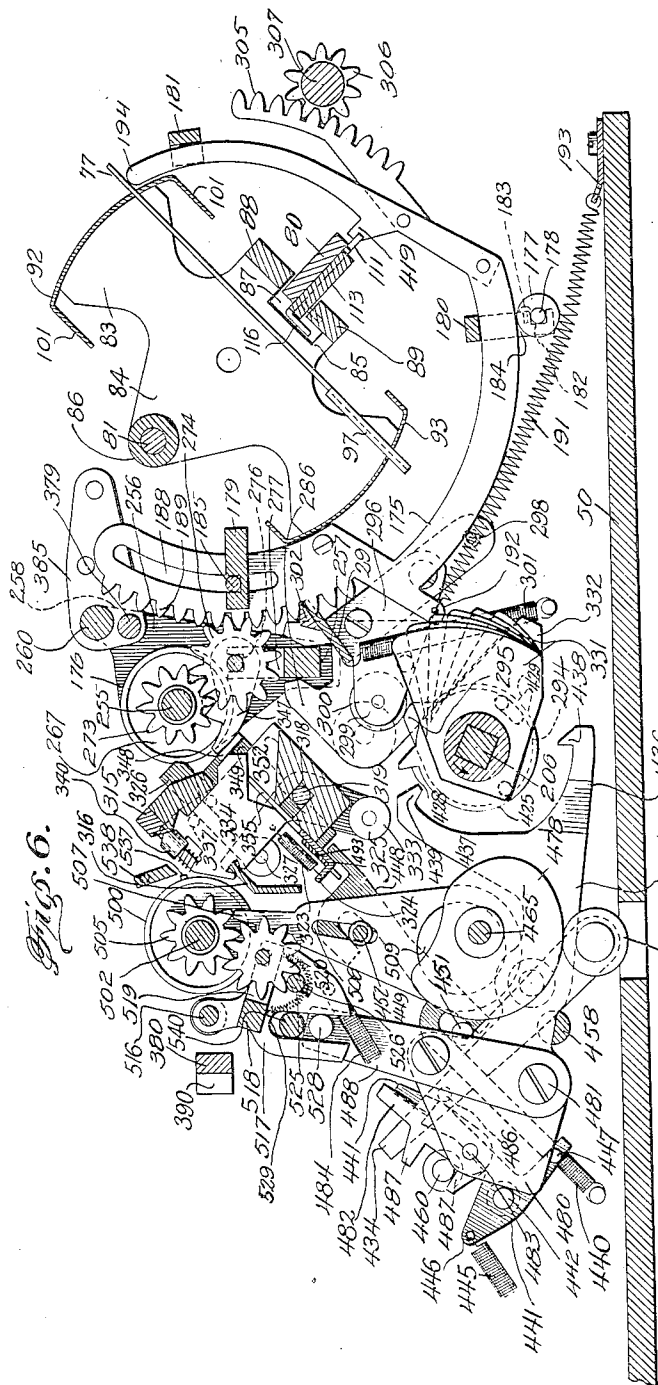
O. J. SUNDSTRAND

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G. L. Gibson.

334

Inventor
Oscar J. Sundstrand.
G. L. Gibson
Attorney

Nov. 6, 1934.

O. J. SUNDSTRAND

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Fig. 7.

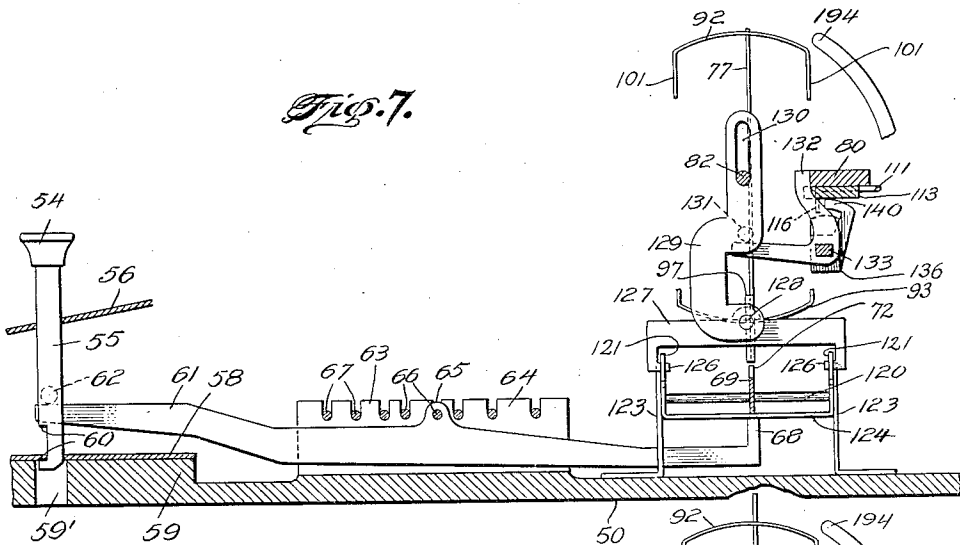


Fig. 8.

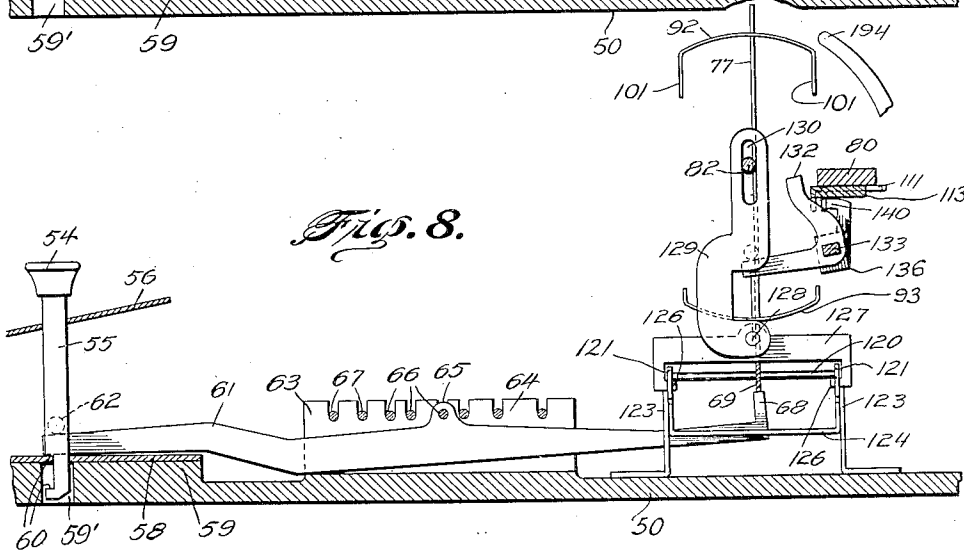
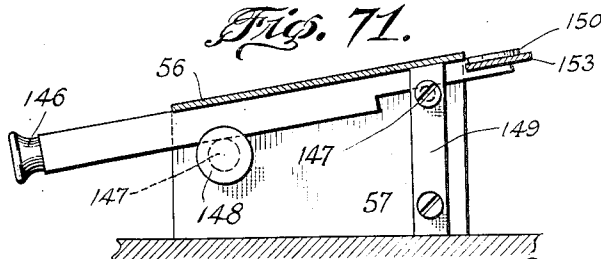


Fig. 71.



Inventor

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F. C. Gibson.

 $\mathbb{R}_{1/2}$

L. L. Julian

Attorney

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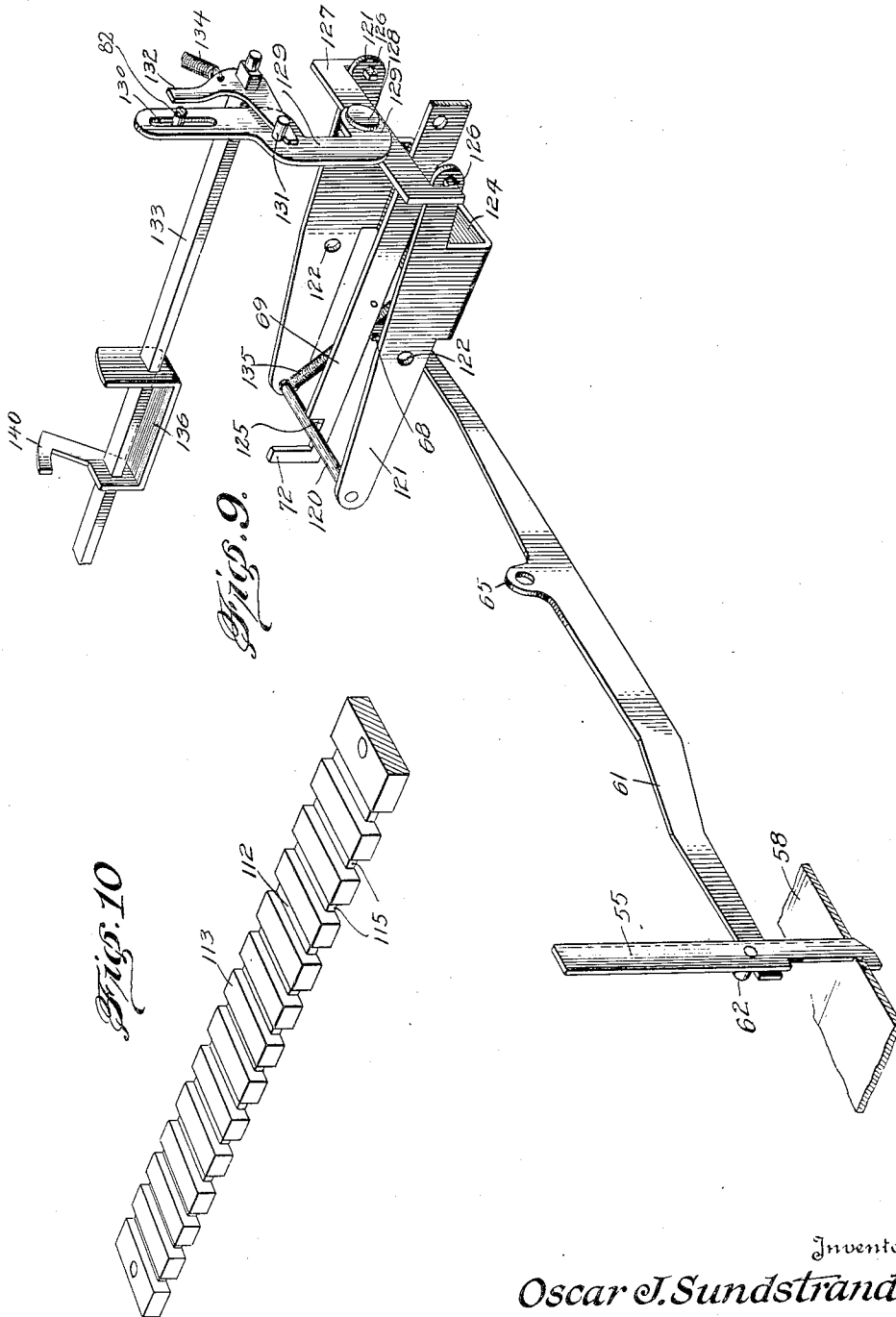
O. J. SUNDSTRAND

1,979,295

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Inventor

Oscar J. Sundstrand.

By

L. J. Julian

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H. L. Gibson

Nov. 6, 1934.

O. J. SUNDSTRAND

1,979,295

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Fig. 11.

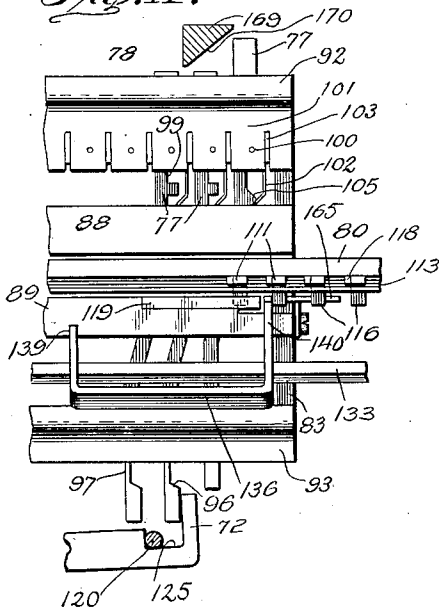


Fig. 12.

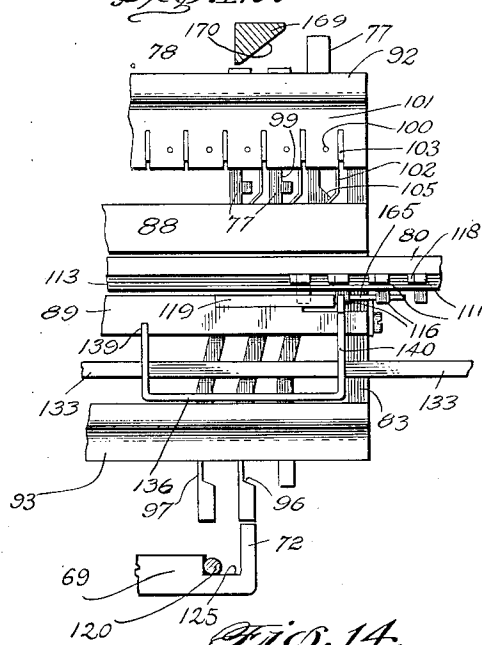


Fig. 13.

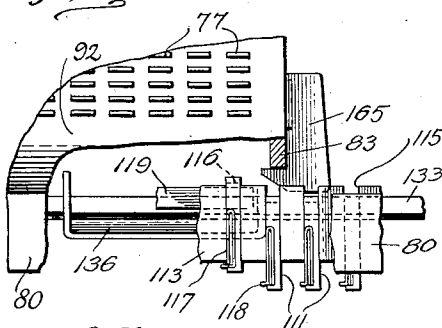


Fig. 14.

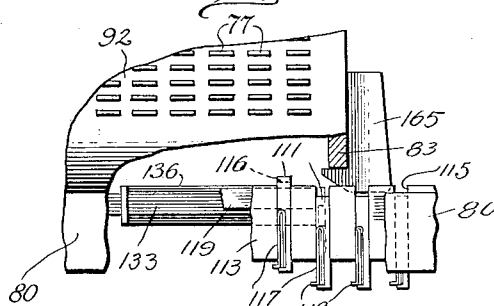


Fig. 15.

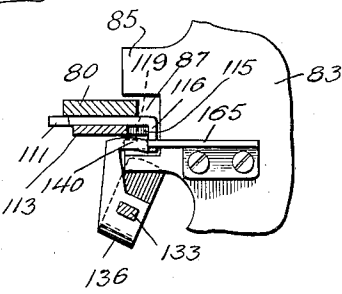
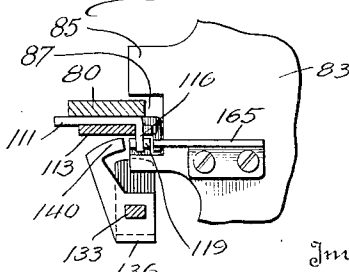


Fig. 16.



Inventor
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F. L. Gilson.

By

L. L. Julihn

Attorney

Nov. 6, 1934.

O. J. SUNDSTRAND

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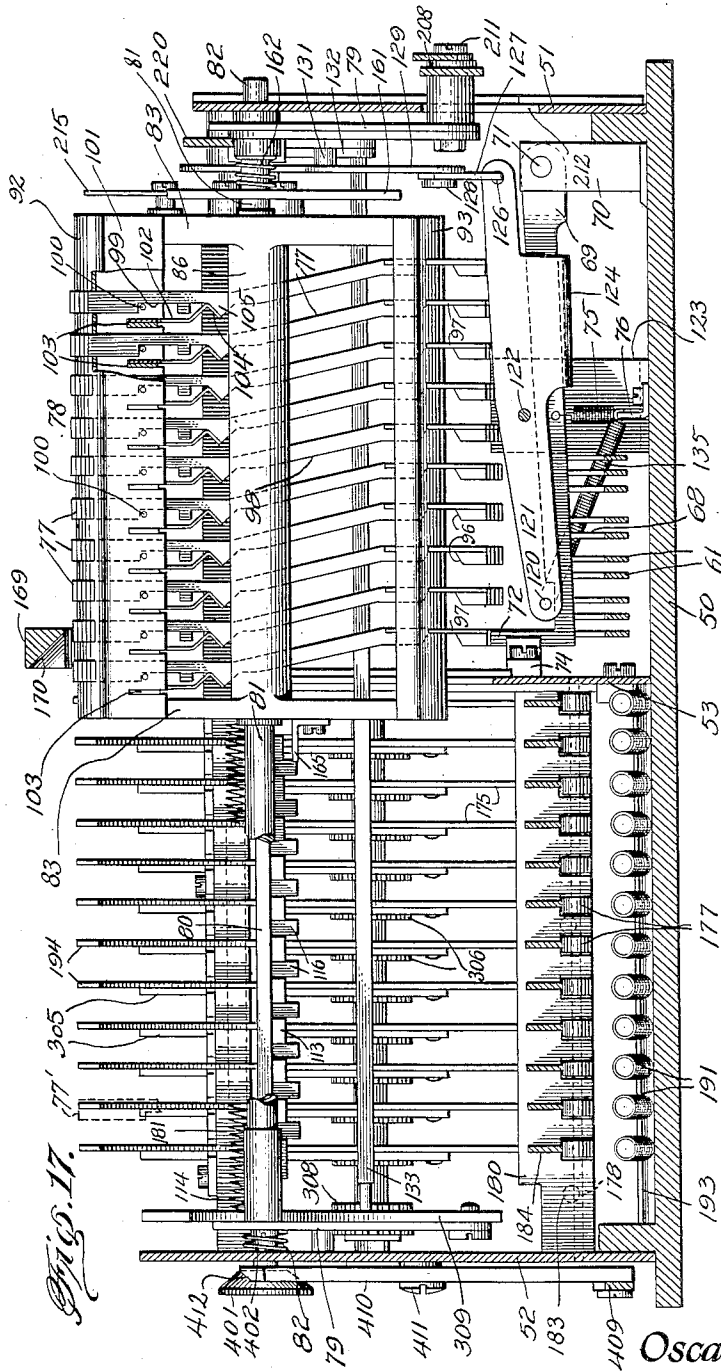


Fig. 17.

H. C. Gibson.

By

Inventor
Oscar J. Sundstrand.

R. E. Julian

Attorney

Nov. 6, 1934.

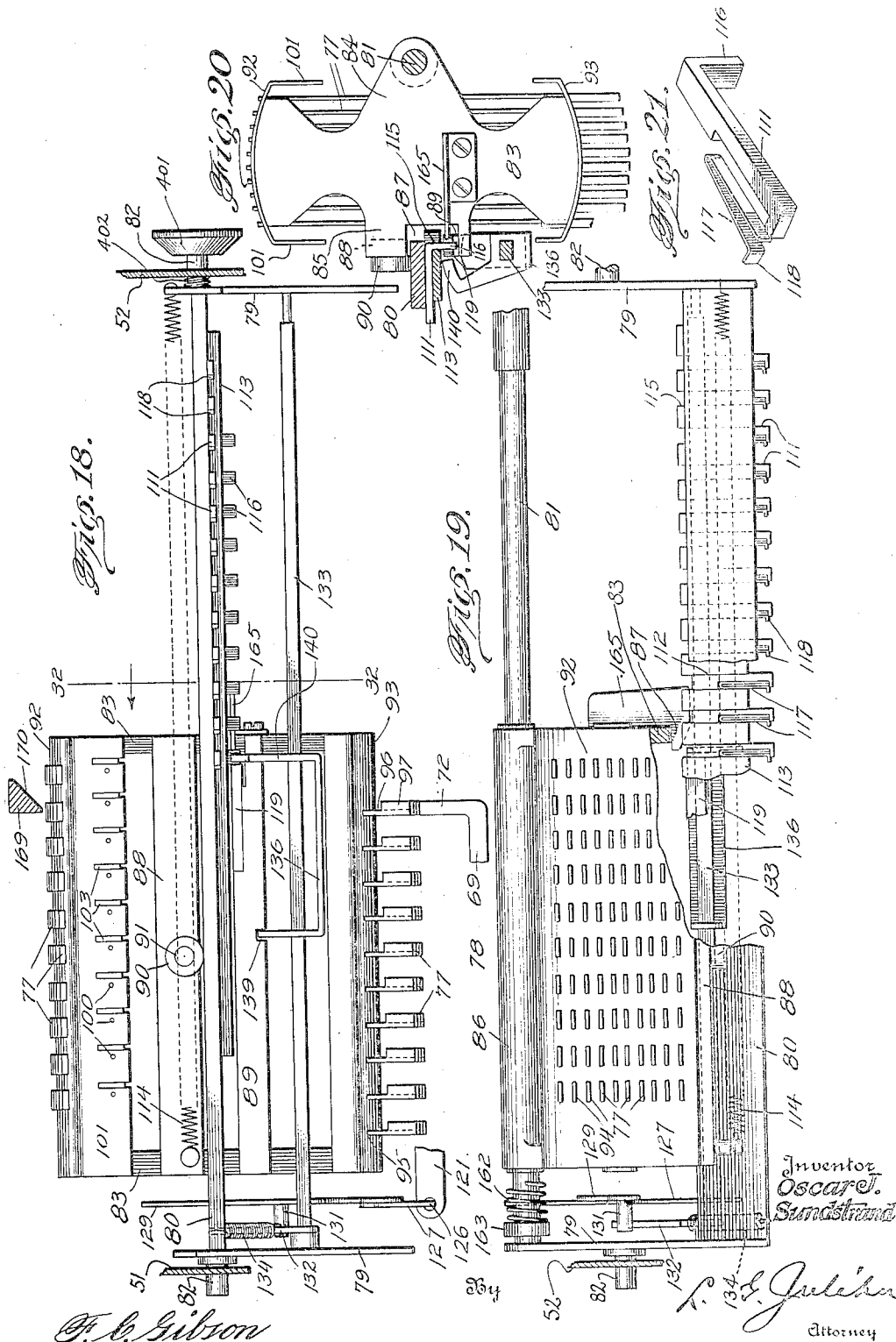
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Fig. 22.

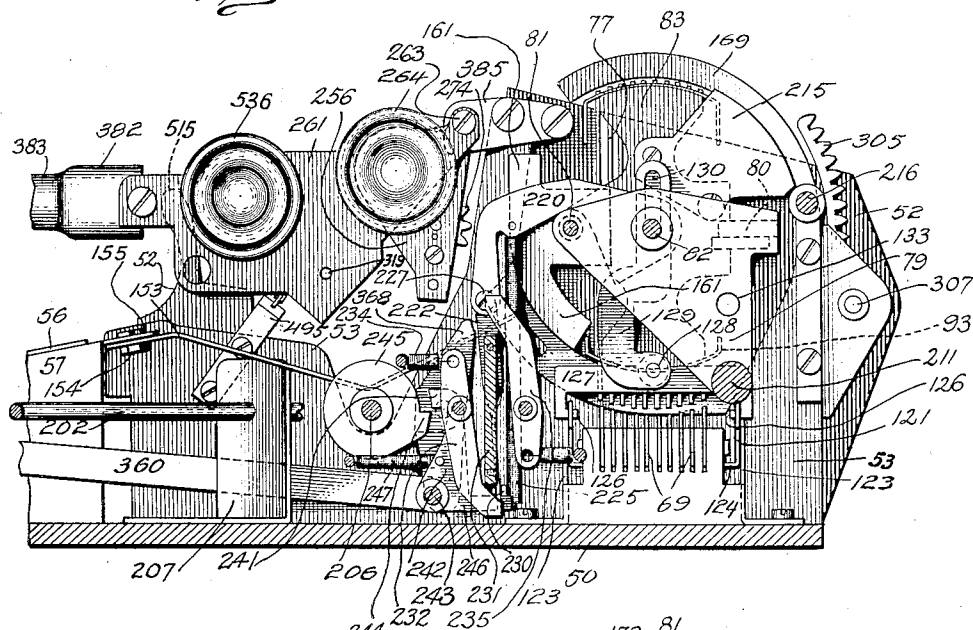
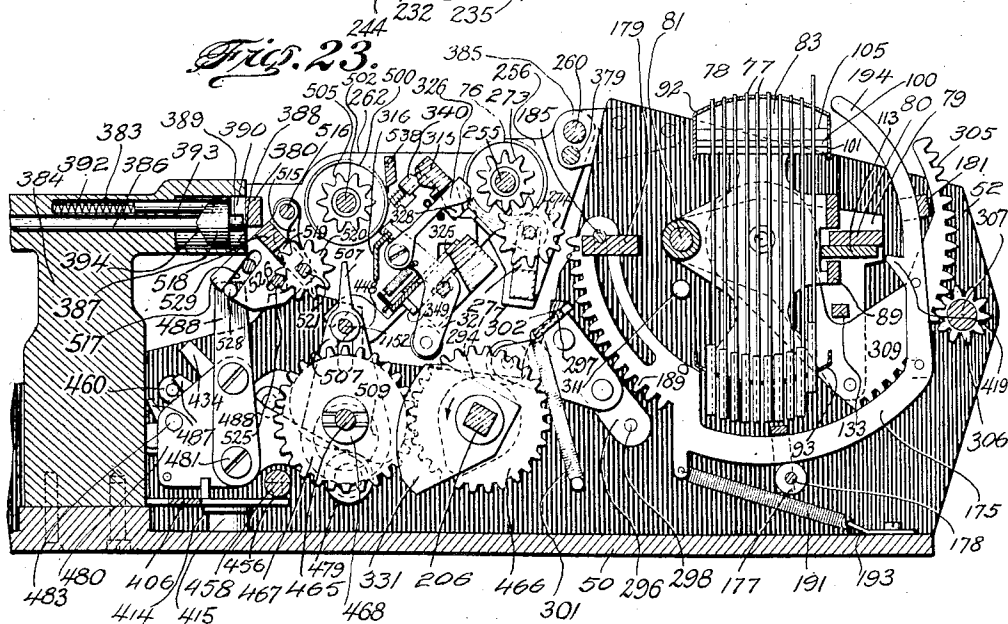


Fig. 23



Inventor

Oscar J. Sundstrand.

L. E. Gulik

Attorney

Nov. 6, 1934.

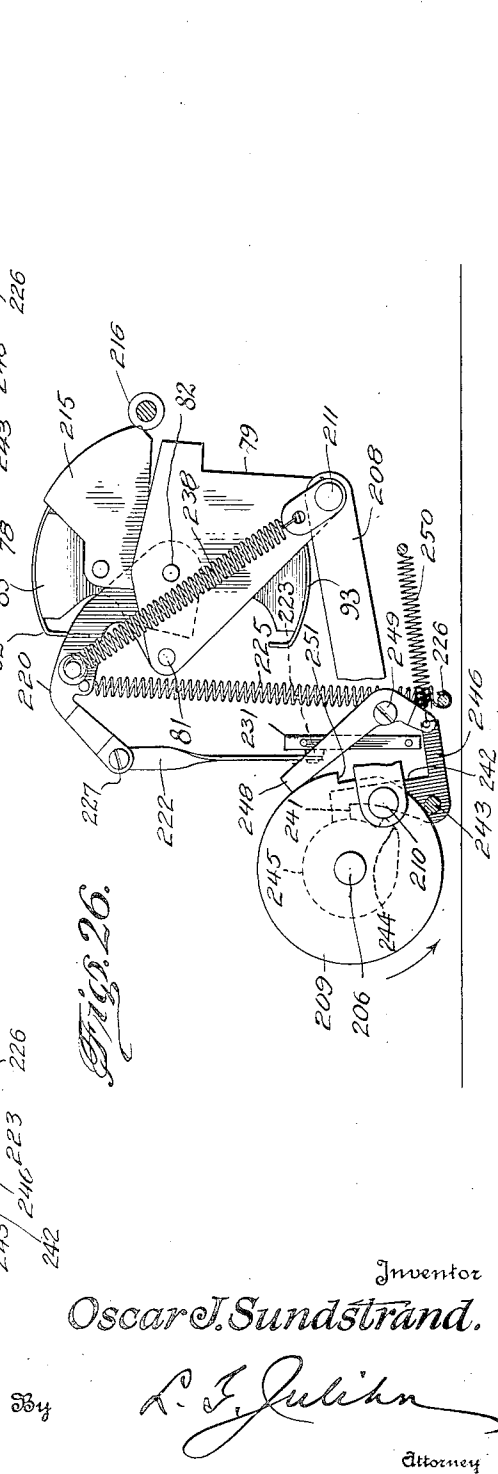
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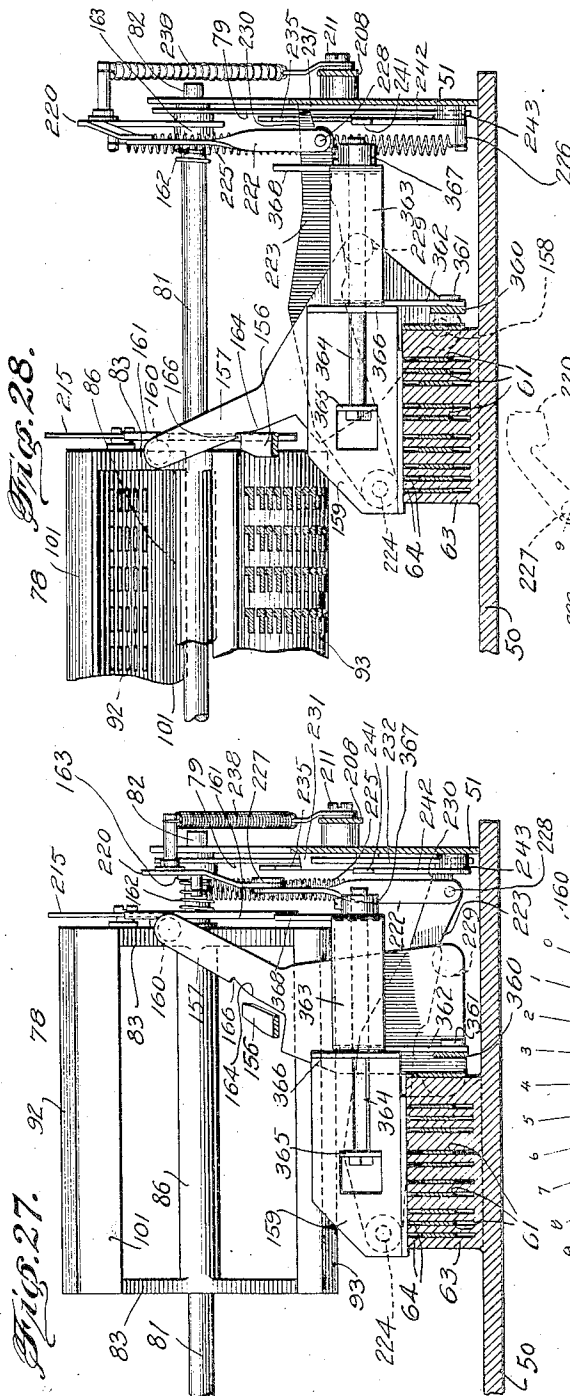
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H. Gibson.

Fig. 28.

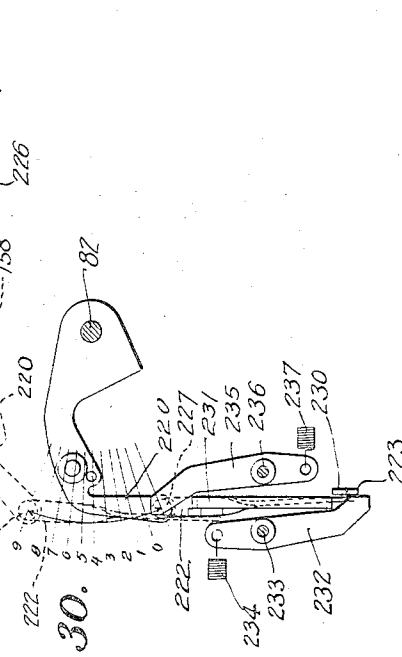
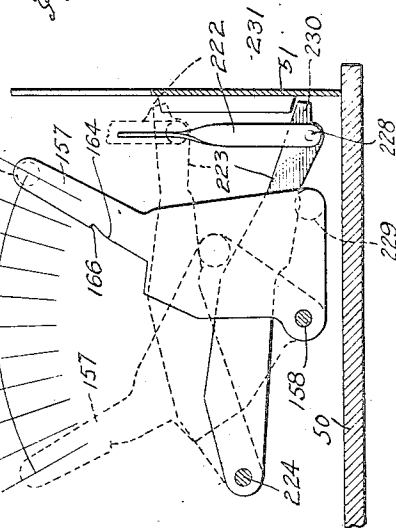


Fig. 29.



Nov. 6, 1934.

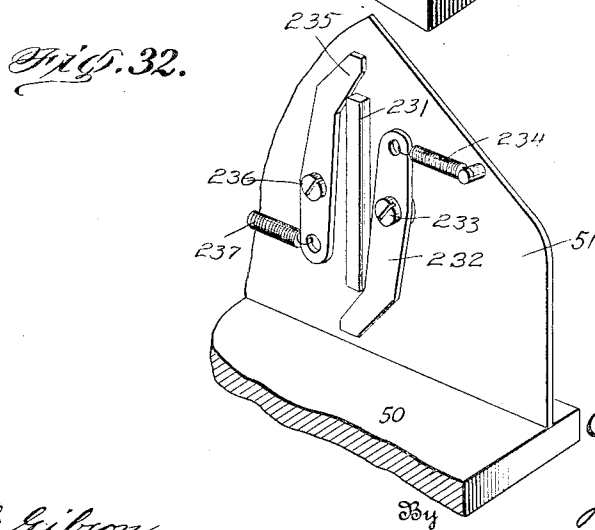
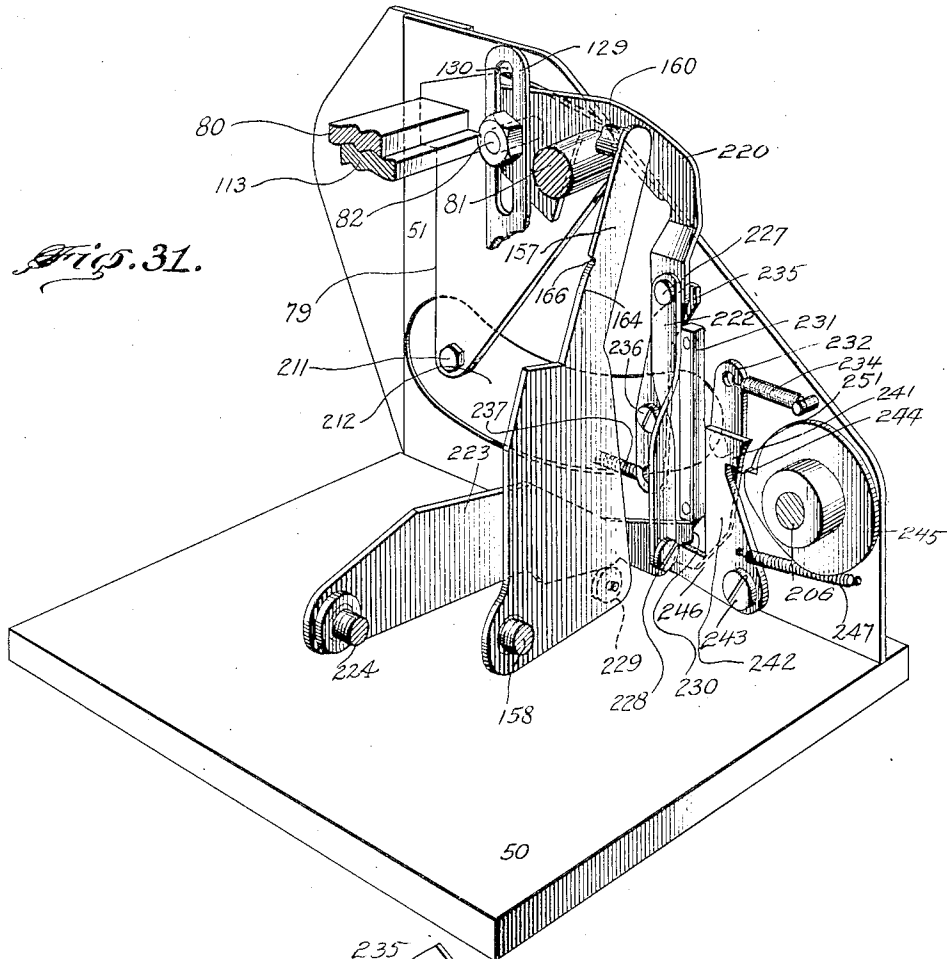
O. J. SUNDSTRAND

1,979,295

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F. C. Gilson.

Inventor
Oscar J. Sundstrand.

L. E. Julia
Attorney

Nov. 6, 1934.

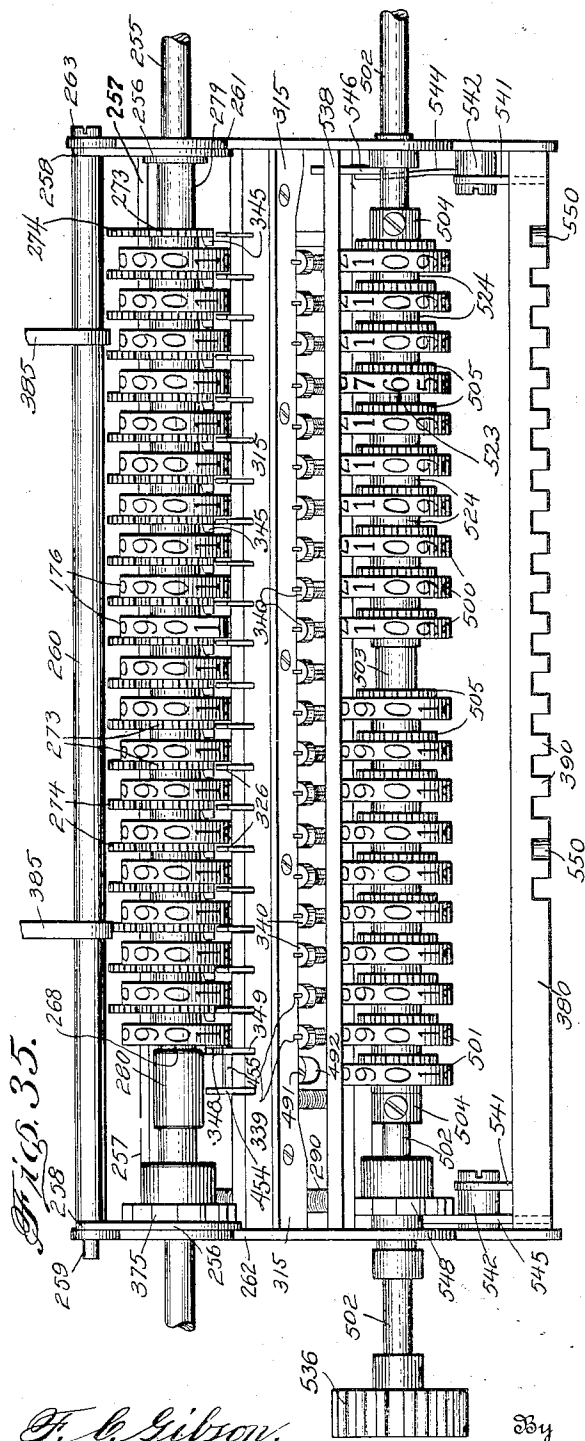
O. J. SUNDSTRAND

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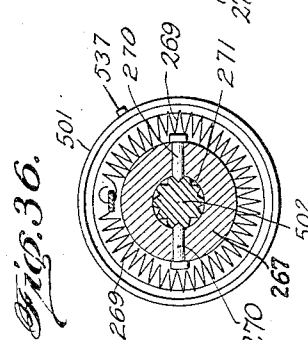
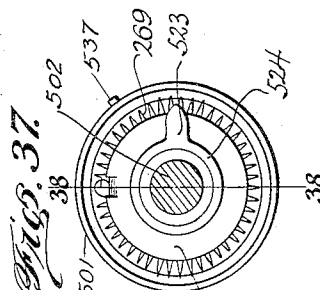
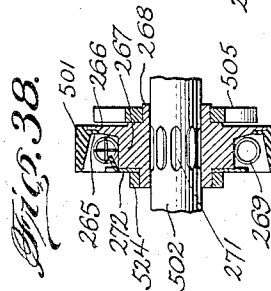
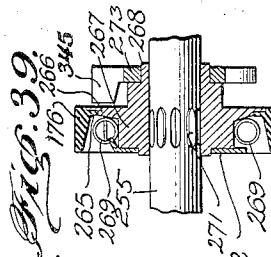
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F. C. Gibson.

88y



Inventor
Oscar J. Sundstrand.

R. L. Julian
Attorney

Nov. 6, 1934.

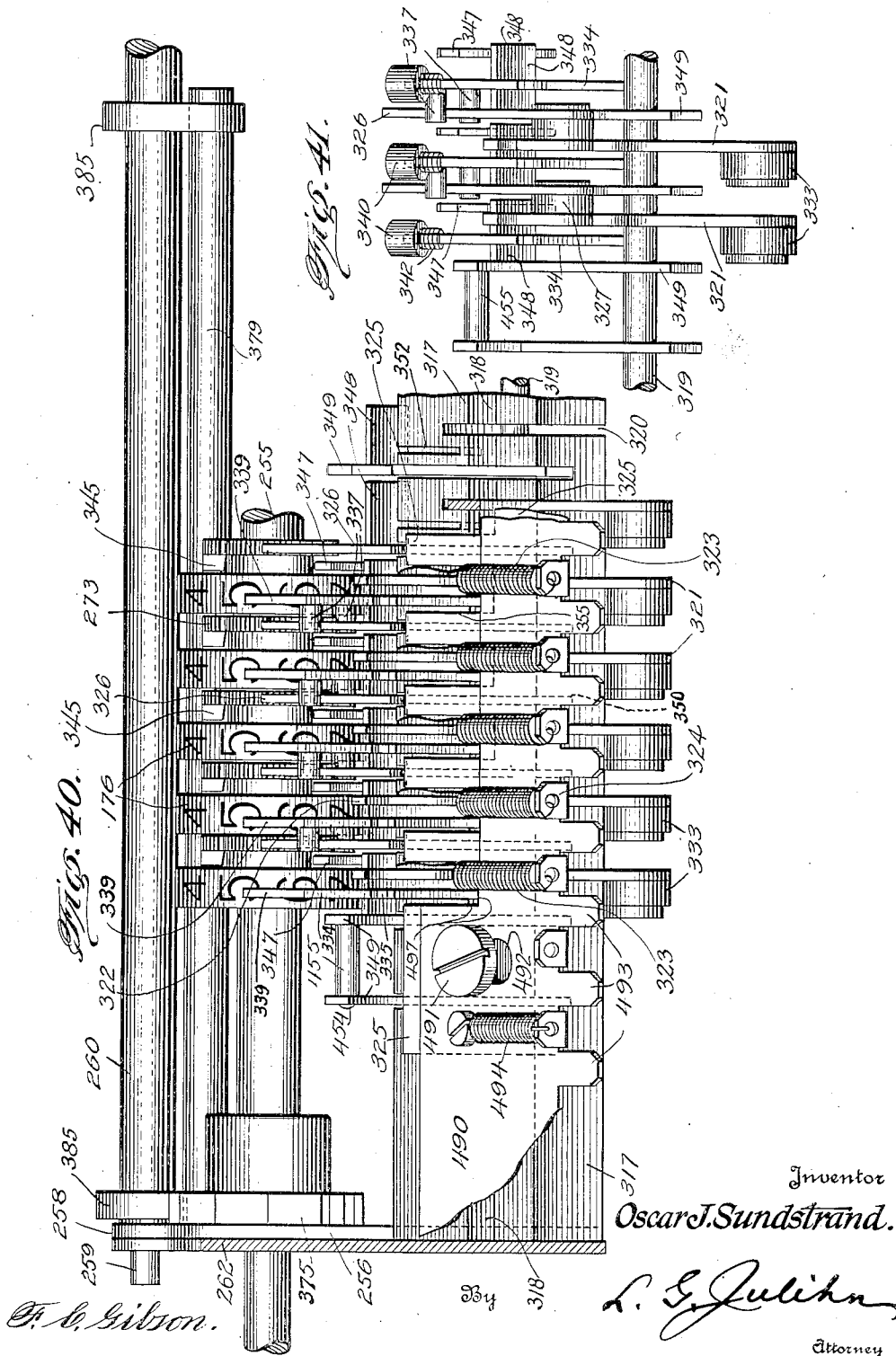
O. J. SUNDSTRAND

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Fig. 43.

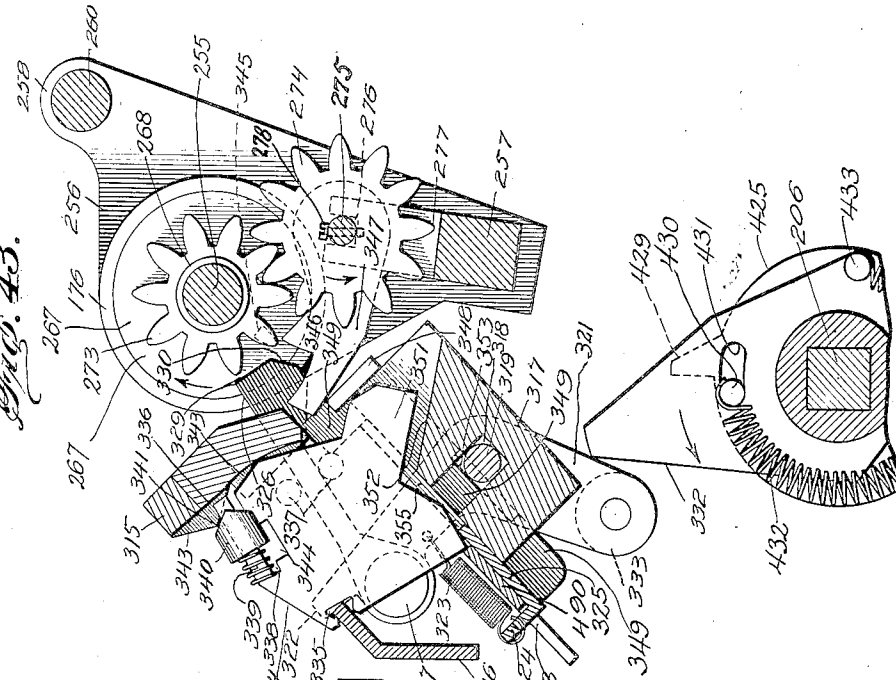
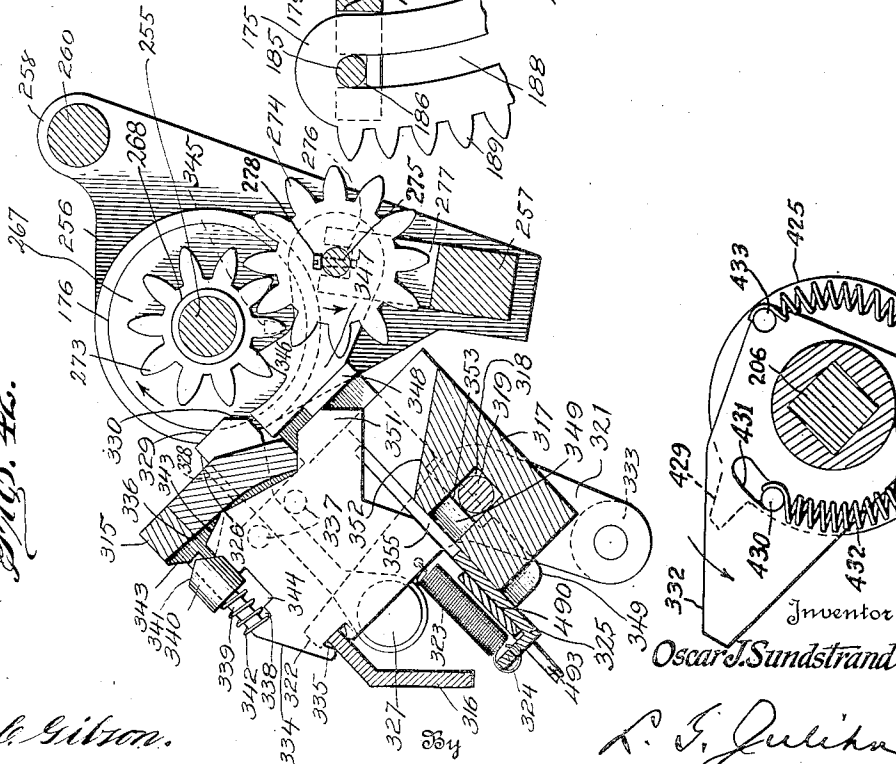


Fig. 42.



H. L. Gilson.

Inventor
Oscar J. Sundstrand.

P. E. Juliano
Attorney

Nov. 6, 1934.

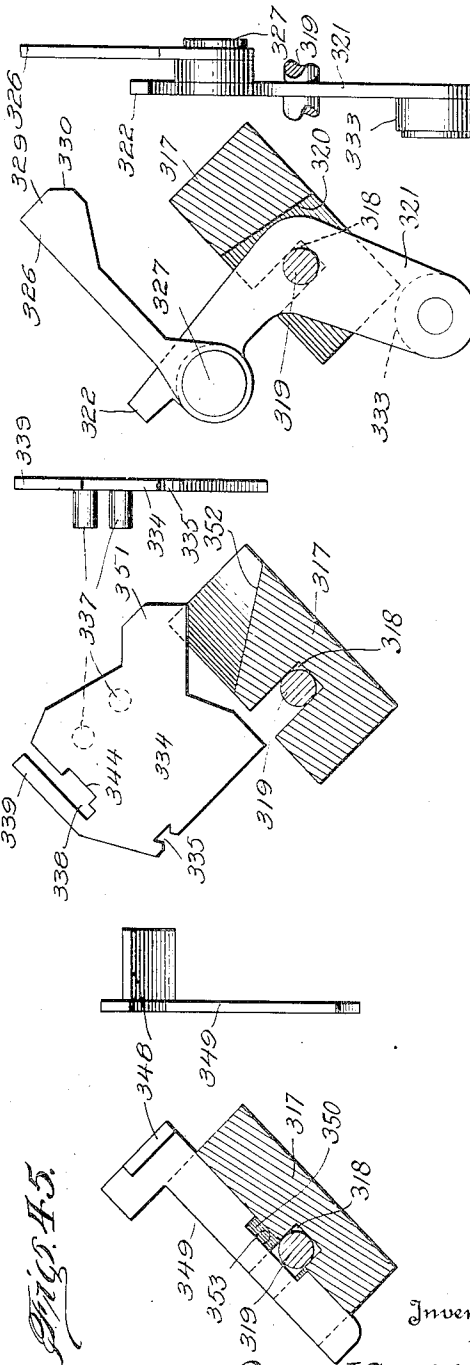
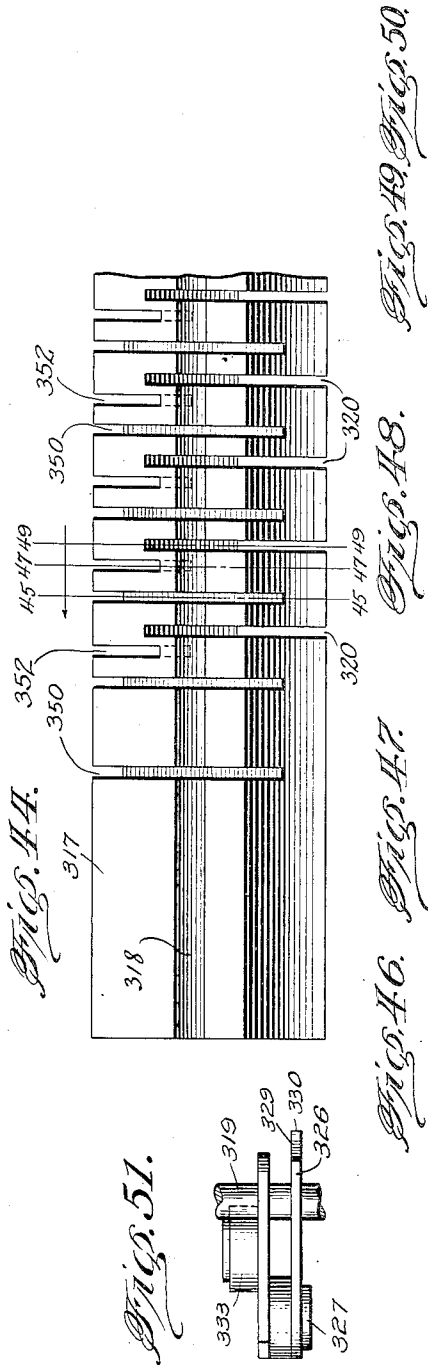
O. J. SUNDSTRAND

1,979,295

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F. L. Gibson.

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Nov. 6, 1934.

O. J. SUNDSTRAND

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Fig. 53.

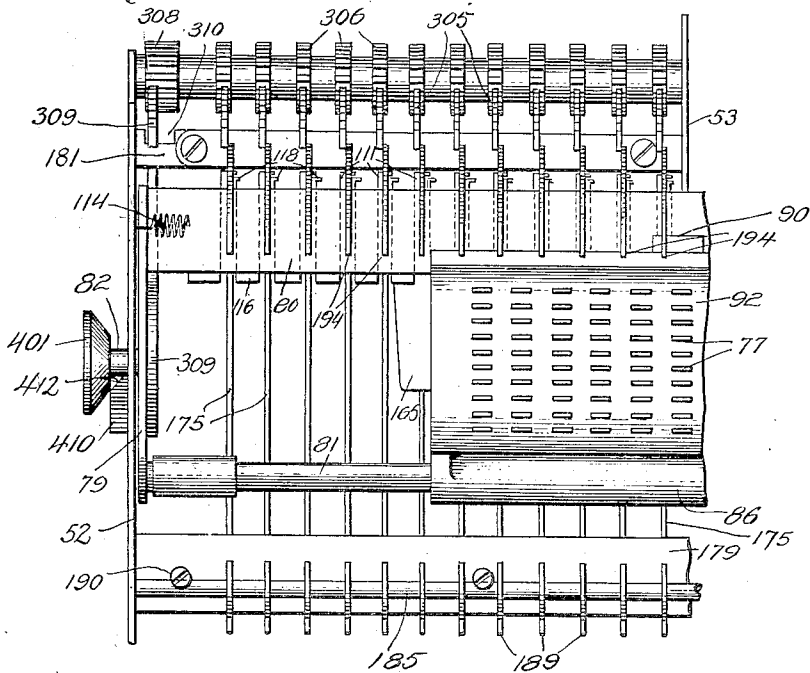


Fig. 52.

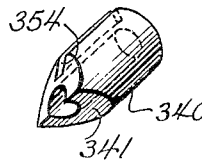
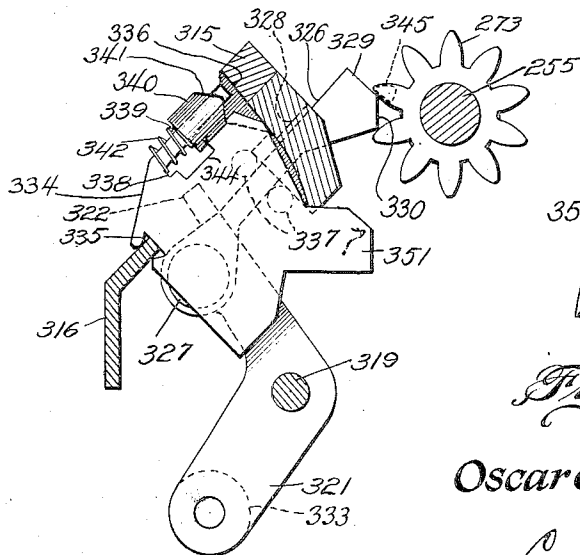


Fig. 72.

Inventor

Oscar J. Sundstrand.

R. J. J. J. J.

Attorney

F. L. Gilson.

By

Nov. 6, 1934.

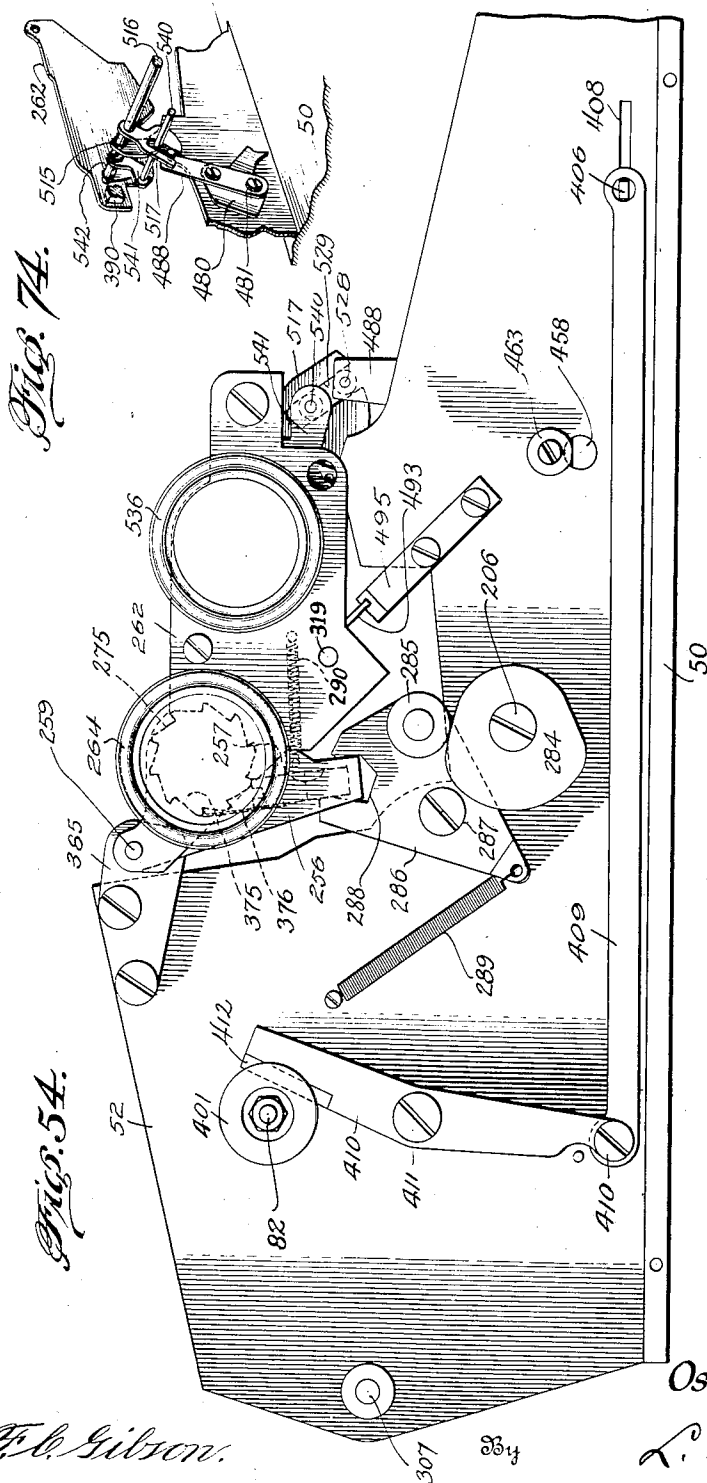
O. J. SUNDSTRAND

1,979,295

CALCULATING MACHINE

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Inventor

Oscar J. Sundstrand

L. E. Julian

Attorney

Nov. 6, 1934.

O. J. SUNDSTRAND

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CALCULATING MACHINE

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Fig. 58.

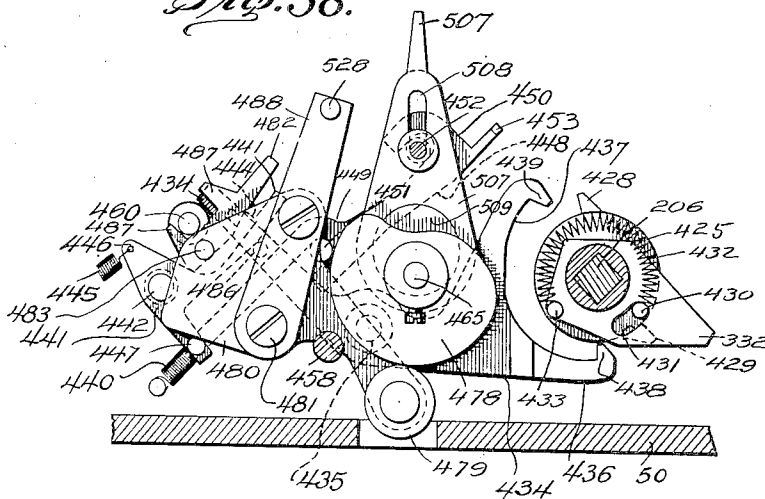
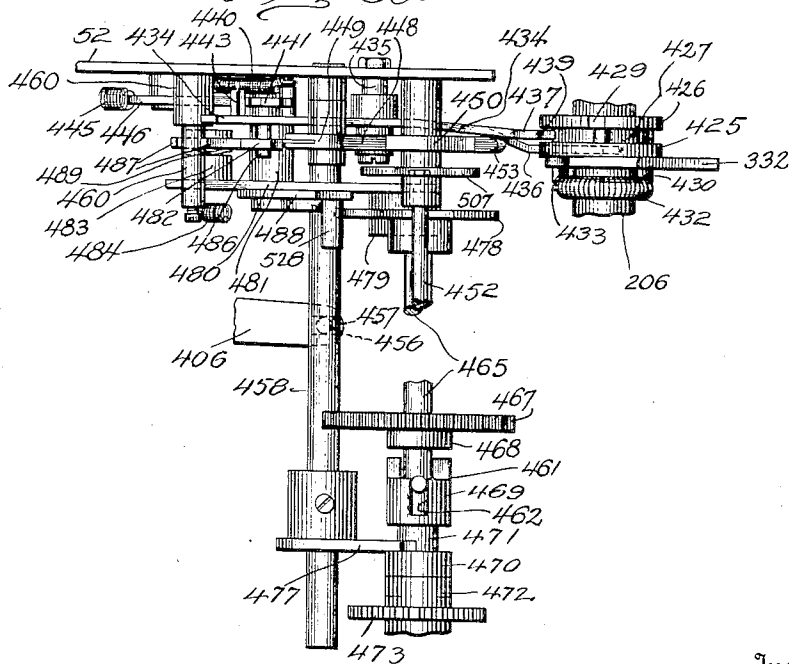


Fig. 59.



Inventor

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Nov. 6, 1934.

O. J. SUNDSTRAND

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Fig. 60.

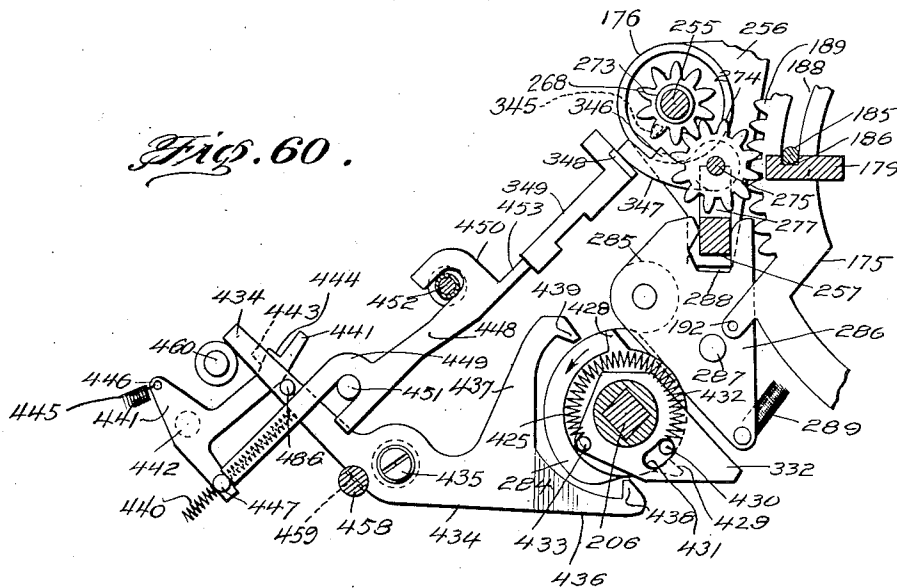


Fig. 61.

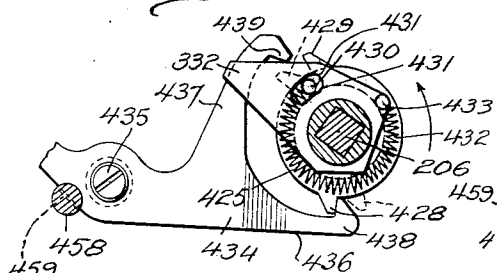


Fig. 63.

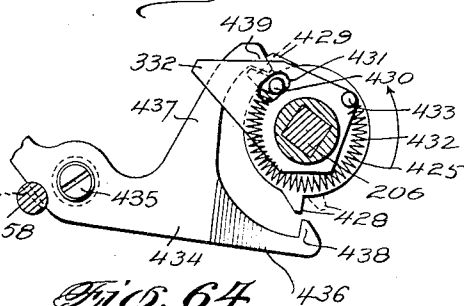


Fig. 62.

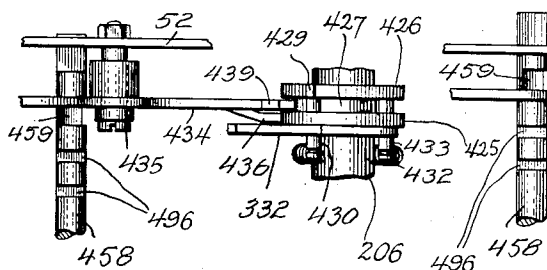
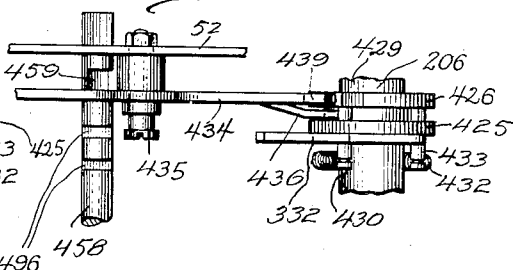


Fig. 64.



Inventor

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F. L. Gibson.

By

A. E. Julian

Attorney

UNITED STATES PATENT OFFICE

1,979,295

CALCULATING MACHINE

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mesne assignments, to Underwood Elliott Fisher
Company, New York, N. Y., a corporation of
Delaware

Application March 3, 1931, Serial No. 519,792

187 Claims. (Cl. 235—60)

This invention relates to that type of adding and calculating machines wherein is provided a field of value-representing elements arranged in denominational rows or groups, and selectively set by keys or manipulative devices in accordance with the actual amounts, such set elements adapted to control the excursions of actuators of corresponding denominations.

More particularly the invention is directed to the adaptation of machines embodying the principle of the well-known ten-key and indexing carriage to the performance of problems involving subtraction, division, and multiplication, without detracting in the slightest from the ease and rapidity with which such machines may be used in straight adding operations.

Many of the novel features of the invention, however, are capable of use with little, if any change, in machines of the 81-key type, and it will be understood that, to this extent, such machines are included in the scope of this invention and the appended claims.

That form of the invention selected for illustration is typified by the arrangement of a field of value-representing elements or pins arranged in denominational rows in a carriage movable step by step transversely, relatively to a series of actuators and to a group of manually operable setting members.

The value-representing elements are selectively set according to the amount to be registered on a totalizer, for instance, and after the carriage with its set elements has advanced differentially relatively to the group of actuators, depending upon the number of integers in the amount set up, the carriage is driven in a plane at substantial right angles to its direction of travel during the selection and setting of the value-representing elements, to press the set elements against the actuators and advance the latter differentially. This idea while not broadly new, is utilized in a novel manner in this invention, as hereinafter explained.

In straight adding operations, the actuators are advanced differentially according to the values of the set elements, and one of the main objects of my invention is to enable the operator to effect a relative adjustment between the field of elements and the group of actuators, whereby to enable the elements, set, it will be remembered, according to the actual value of the amount to be registered, to control the excursions of the elements, according to the complement of such amount.

This object is applicable to machines other

than the ten-key traveling index pin carriage type and it will be understood that this invention covers the application of this idea to such other machines.

In effecting subtraction, the machine embodying the present invention is adapted to follow the complementary method wherein the true complement of the amount to be subtracted, is added to the minuend, and in this relation, another object of the invention is the provision of novel means to automatically introduce into the totalizer the excess nines above the digit of highest significant value in the subtrahend.

There is a divergence of opinion as to what constitutes the "true complement" of a number. The term "true complement" is used herein to designate that number which, when added to another number, will result in a total of the next highest power of "10".

For example, it may be desired to subtract "4" from "5". The true complement of "4" according to the above definition and considering the capacity of the machine, would be "6" preceded by as many "9's" as is necessary to exceed the capacity of the machine, or of the section of totalizer wheels in use.

Associated with the operation of subtraction, is the requirement to supply what has become generally known as the "fugitive one" in instances where the sign of the total changes, as from positive to negative and vice versa, another object of this invention being to provide an exceedingly simple, positive, and effective means for automatically supplying such "fugitive one" whenever required, and without depending upon a special mechanism akin to a carrying mechanism, such as has heretofore been resorted to.

The setting members through which the value-representing elements are effectively positioned, are selectively operated by manipulative devices or keys and key levers arranged in ranks, and it is another object of this invention to so arrange the manipulative devices and setting members that the former will impart strokes of like extent to their respective setting members, whereby to effectively position the selected value-representing elements and maintain an easy and even key touch, all the keys being depressible like distances, irrespective of the differences in the lengths of the key levers.

Another object of this invention is the provision of a novel and compact form of escapement for the field of value-representing elements, to control its step by step advance, relatively to the group of actuators and the setting members,

which escapement is simple in construction and operation, and one wherein the possibility of getting out of order is much reduced.

In that form of the invention herein shown, I have contrived such escapement with a dual purpose, so that it not only functions as an escapement, but under one of the relative adjustments between the field of value-representing elements and the actuators, a part of the escapement mechanism is utilized to control the excursions of those actuators in denominations above that of the set element of highest value.

While the arrangement herein shown, conveniently lends itself to this dual purpose, it is to be well understood that the invention is by no means restricted to this dual capacity of the escapement mechanism, as the two functions might be effected by separate instrumentalities.

A further object of the invention is the provision of novel means to retain or lock the field of value-representing elements in that denominational position to which it is fed as a result of the action of the escapement mechanism during the setting up of the amount to be registered, to hold the field in such adjusted position while the field is traveling in another plane towards and from the actuators to determine the differential advance of the actuators and permit their return to normal position.

A still further object of this invention is to insure the return of the field of elements from any of its advanced positions to its starting position at a uniform speed regardless of the extent of advance.

There is provided the usual motor or spring to advance the field, the energy of which motor progressively decreases as the field advances, and progressively increases as the field is returned towards its starting position.

Heretofore, it has been considered sufficient to provide a return motor or spring, which, at the proper time, is energized to overcome the opposed energy of the feed or advancing motor irrespective of the strength of such last-named motor, at any position which the field may occupy.

As a result the field of value-representing elements was returned at varying speeds depending upon the extent to which it had advanced, with attendant noise and possibility of injury to parts due to shock of arrest upon its arrival at its starting position.

To avoid these and other disadvantages, this invention provides a control for the field of elements during its return, whereby the amount of energy exerted to effect such return is automatically graduated in accordance with the amount of energy remaining in the feed motor at any point in the advance of the field, so as to effect such return at a constant speed irrespective of the distance to which the field has advanced. This results in an even, smooth return which is effected with celerity and without undue force, the degree of power employed being automatically regulated in accordance with the distance through which the field is to be returned, and in view of the resistance opposed by the usual feed motor, which resistance increases as the field returns towards its starting point.

As one means to effect this result, there is provided a compensating motor adapted to supplement the energy of the usual return motor, means being utilized to control the degree of energization of such auxiliary or supplementary com-

pensating motor according to the extent of advance of the field of elements.

Furthermore, since such compensating motor would, under normal conditions, de-energize progressively as the field of elements returns towards its starting position, the energy of the advancing motor increasing incident to such return, resort is had to novel means to maintain the energy of the compensating motor as nearly constant as possible during the return of the field, to counter-balance the progressive increase in energy of the advancing motor, and the decrease in energy of the main restoring motor.

In the particular form of the invention herein illustrated, I have conveniently utilized the denominational lock heretofore referred to for maintaining the field at the position to which it is advanced, as a means to control the degree of energy stored in the compensating motor, it being understood that other means than the denominational lock might be provided to effect the same control, the invention not being restricted to the precise arrangement shown.

In many instances, it is desired to retain the field of elements at the position to which it has advanced, to enable the operator to repeat the operation one or more times, and another object of the invention resides in the provision of novel and simplified means whereby to readily disable the normally effective return mechanism for the field of elements.

A further object of this invention is to automatically prevent the possibility of overthrow of the actuators and totalizer wheels under a sudden forcible operation of the machine.

A still further object is the provision of novel and simplified means to engage the totalizer with and disengage it from the actuators.

Yet another object is the provision of a novel form of carrying or transfer mechanism for the main totalizer, which includes but few parts, not liable to get out of order, and one wherein the load on the drive mechanism is so distributed as to render the operation smooth and even.

In machines adapted to effect the various mathematical calculations accomplished by the present invention, it is customary to mount the totalizer in a carriage which may be variously adjusted denominationally, relatively to the co-related actuators.

In certain operations, it is possible to trip a carrying mechanism located beyond the sphere of action of the actuator of highest value.

An object of this invention is to enable the automatic resetting of such tripped carrying mechanism without attention on the part of the operator, and as an incident to shifting the totalizer carriage in either direction, to avoid the possibility of the registration of a wrong total.

A further object is to simplify and improve the means heretofore used to indicate to the operator that the capacity of the machine has been exceeded, and to utilize such means under other operating conditions of the machine, as in subtraction and division, to indicate the change of sign of the balance or total registered, as from positive to negative and vice versa which is advantageous in notifying the operator of an overdraft, for example, or that the divisor has been subtracted from the dividend an excessive number of times.

In the present illustration of the invention, such indicating means takes the form of a machine lock, which, when effective, prevents operation of the machine, and in this connection, a

further object of the invention is to enable the operator to quickly release the machine lock to enable the entry of an additional overdraft item if necessary, or to add to the totalizer the last amount subtracted therefrom, if a problem in division is being worked, or to add to or subtract from the newly registered positive or negative balance, as the exigencies require.

Since the exceeded capacity and state of balance indicator is controlled by the appropriate totalizer wheel corresponding with the actuator of highest denomination, a still further object of this invention is to insure the arrest of such totalizer wheel in its zero position, in case the totalizer is cleared immediately after an operation during which the exceeded capacity and state of balance indicator has become effective.

In calculating machines adapted to perform problems according to the four rules of arithmetic, it is common to provide a traveling totalizer carriage, with means to enable the operator to shift the carriage and totalizer bodily relatively to the actuators, such characteristic being especially valuable in performing division and multiplication, and one of the objects of this invention is to furnish novel and efficient means whereby the operator may step the totalizer carriage swiftly and accurately from one denomination to another successively, with provisions for enabling the operator, when desirous of skipping several denominations at one time, to disable the step by step feed and manually shift the carriage by one movement to the desired position, after which the step by step feed may be reinstated, such step by step manual feed mechanism including means to insure the proper positioning of the totalizer carriage relatively to the actuators at any place to which the carriage is shifted.

A further object of this invention is the provision of a novel numeral wheel structure of simple and inexpensive form which readily co-acts with a zero-resetting mechanism of the manual resetting type wherein the totalizer-supporting shaft is rotated to clear the totalizer.

In calculating machines of the character herein disclosed, it is desirable that a step by step counting means be provided to register the multiplier in problems of multiplication, for instance, and for other purposes as well. Such multiplier indicator or counter has heretofore been equipped with carrying or transfer mechanism for use in certain so-called "short cut" methods of multiplication, and one of the objects of this invention is the provision of a novel form of carrying or transfer mechanism for such step by step counter which shall be operable upon the counter in any position to which the totalizer may be adjusted, such step by step counter in this invention, being adjustable with the totalizer carriage and relatively to its carrying mechanism.

Still another object of this invention is the association of a zero-resetting means for the step by step counter with the transfer or carrying mechanism therefor, whereby the carrying mechanism controls the effectiveness of the zero-resetting mechanism and renders it operable in any denominational position assumed by the traveling totalizer carriage.

To these and other ends this invention includes certain novel features and combinations of parts, all of which will be referred to in greater detail hereinafter and particularly pointed out in the claims.

In the accompanying drawings forming a part of this application,

Fig. 1 is a perspective view of one form of the machine embodying the invention, as it appears in use, the field of value-representing elements being in an advanced position;

Fig. 2 is a right side elevation with the casing removed, the parts being shown in their positions of rest;

Fig. 3 is a top plan view of the machine, the totalizer carriage being located at the left hand limit of its adjustment, to better disclose the numeral key-controlled setting mechanism;

Fig. 4 is a horizontal sectional plan view of the machine, the totalizer carriage and the traveling field of value-representing elements being omitted;

Fig. 5 is a vertical sectional view longitudinally of the machine from front to rear on the line V—V of Fig. 4, the totalizer carriage and traveling field of value-representing elements being included and at least one value-representing element having been set;

Fig. 6 is a somewhat similar view taken on line VI—VI of Fig. 4, and showing the positions assumed by the parts at about the end of the first half rotation of the main drive shaft, certain structure being omitted for clearness;

Fig. 7 is a detail side view of the numeral key control of the value-representing elements and the escapement for the field of such value-representing elements, the parts being shown in their normal positions of rest;

Fig. 8 is a similar view, showing the positions of the parts when a numeral key is depressed;

Fig. 9 is a detail perspective view of a numeral key, showing its control of the means through which the corresponding value-representing element in any denomination is set, and also showing its control of the escapement mechanism;

Fig. 10 is a detail perspective view of the stop-carrying bar used in connection with the escapement mechanism for the field of value-representing elements;

Fig. 11 is a fragmentary rear view of the left-hand or advancing end of the field of value-representing elements, showing the positions of the parts when a numeral key is held in depressed position;

Fig. 12 is a similar view, showing the positions of the parts when the key has restored, the field of elements being arrested by contact of an abutment associated with the field, against the appropriate stop;

Fig. 13 is a fragmentary plan view, showing the parts in the positions occupied in Fig. 11;

Fig. 14 is a similar view, showing the parts in the positions corresponding to Fig. 12;

Fig. 15 is a fragmentary end view, partly in section, of the parts in the positions corresponding to Figs. 11 and 13;

Fig. 16 is a similar view showing the positions of the parts corresponding to Figs. 12 and 14;

Fig. 17 is a vertical transverse sectional view, taken on line XVII—XVII of Fig. 4, looking towards the rear and illustrating the series of totalizer actuators and the field of value-representing elements in their normal home positions;

Fig. 18 is a detail rear view of the field of elements, including the traveling carriage and the rocking cradle supporting the carriage, with the escapement mechanism for the carriage and the numeral key-controlled setting lever, the parts being in their home positions;

Fig. 19 is a top plan view of the mechanism shown in Fig. 18;

Fig. 20 is a view of the left-hand or advancing

end of the field of value-representing elements, showing the escapement mechanism;

Fig. 21 is a detail perspective view of an escapement stop and its friction spring;

5 Fig. 22 is a fragmentary view in side elevation, partly in section, the parts being shown in their normal home positions, illustrating the switch mechanism employed in connection with the means which restores the traveling field of value-representing elements to its home position;

10 Fig. 23 is a vertical sectional view, longitudinally of the machine on line XVIII—XVIII of Fig. 4, at least one of the value-representing elements being projected, and showing parts not disclosed in Fig. 5;

15 Fig. 24 is a detail side view of the means for rocking the field of value-representing elements, and for restoring the field to its normal position at the end of each operation, the parts being shown in their normal positions;

Fig. 25 is a similar view, showing the positions assumed by the parts at the end of the first half of the cycle of the main drive shaft;

25 Fig. 26 is a similar view, showing the positions of the parts just an instant before the field of value-representing elements is released for return to its normal position, which release occurs near the end of the second half of the cycle of operation of the main drive shaft;

30 Fig. 27 is a detail front view, partly in section, of the means which restores the field of elements to its home position, the parts being in their positions of rest;

35 Fig. 28 is a similar view, showing the positions of the parts at the beginning of the second half of the cycle of operation of the main drive shaft, the field of elements having been advanced in setting up an amount;

40 Fig. 29 is a diagrammatic front view in detail of the means for restoring the field of elements, full and dotted lines illustrating the extremes of travel of the restoring means;

45 Fig. 30 is a detail view taken at right angles to Fig. 29 and illustrating in full and dotted lines, the extremes of travel of the motor tensioning means for controlling the return of the field of elements;

50 Fig. 31 is a detail perspective view of the means for restoring the field of value-representing elements to its home position, the parts being shown at rest;

Fig. 32 is a fragmentary perspective view of the switch device forming a part of the restoring means for the field of elements;

55 Fig. 33 is a detail side view of one of the actuators for a totalizer wheel;

Fig. 34 is a detail rear edge view of a totalizer actuator;

60 Fig. 35 is a top plan view of the totalizer carriage, showing the totalizer and the counters or indicators for the multiplier and the quotient, respectively;

65 Fig. 36 is a detail left side view, partly in section, of one of the indicator wheels on its shaft, and substantially corresponding structurally, with the wheels of the totalizer;

Fig. 37 is a detail left side view of one of the indicator wheels with its carrying tooth;

70 Fig. 38 is a vertical sectional view through one of the indicator wheels, on line 38—38 of Fig. 37;

Fig. 39 is a similar sectional view through one of the totalizer wheels;

75 Fig. 40 is an enlarged front view of a fragment of the totalizer mechanism, partly in section, il-

lustrating the carrying mechanism for the totalizer, parts being omitted for clearness;

Fig. 41 is a detail front view of a group of carrying units;

80 Fig. 42 is a detail cross sectional view from front to rear, through the totalizer and a carrying unit which are illustrated in side elevation, the parts being in their normal positions;

85 Fig. 43 is a similar view, showing the parts in tripped position just prior to the actuation of the carrying pawl to effect the registration of the "carry" on the totalizer wheel of next higher denomination;

90 Fig. 44 is a detail plan view of one of the beams supporting the carrying mechanism, to illustrate the arrangement of slots and grooves therein, which accommodate various elements of the carrying units;

95 Fig. 45 is a detail side view of the transmitting member of the carrying mechanism, for tripping the carry;

Fig. 46 is a front edge view thereof;

Fig. 47 is a detail side view of the means for shifting the carrying pawl from its idle to its effective position, the view showing the normal re- 100 lation of the pawl shifter to the cross beam;

Fig. 48 is a front edge view thereof;

Fig. 49 is a detail side view of the carrying pawl and its driver;

Fig. 50 is a front edge view thereof;

105 Fig. 51 is a fragmentary top plan view of the carrying pawl and its driver;

Fig. 52 is a detail cross sectional view through a carrying unit, showing the positions of the parts during the second half of the cycle of operation of the main drive shaft, the carrying pawl being idly projected rearwardly, as when no carrying action is contemplated.

115 Fig. 53 is a fragmentary top plan view showing the field of elements advanced part way of its full length of travel, and the parts adjusted for performing subtraction by complementary addition;

Fig. 54 is a left side view of the machine, showing the means to adjust the field of value-representing elements for performing complementary subtraction, and the means for engaging and disengaging the totalizers relatively to their actuators;

125 Fig. 55 is a detail side view of one of the denominational actuators for a totalizer wheel, showing the relation of the appropriate escapement stop thereto, when the machine is set for complementary subtraction;

130 Fig. 56 is a similar view, showing the means for and method of advancing one of the actuators by a value-representing element when the machine is to be operated to subtract by complementary addition;

135 Fig. 57 is a detail perspective view of one of the value-representing elements;

Fig. 58 is a detail side view of a means to signal when the capacity of the machine is exceeded, and also when the sign of the balance changes from positive to negative and vice versa. 140

There is also shown a means to drive one of the indicators step by step.

Fig. 59 is a top plan view of the same, and also shows the clutch mechanism for reversing the action of the indicator driving means; 145

Fig. 60 is a detail side view of the means to notify the operator that the sign of the balance on the totalizer has changed, and to indicate when the capacity of the machine is exceeded, 150

the parts being shown in the positions normally occupied when the machine is set for addition;

Fig. 61 is a fragmentary detail view of the change of sign signal in effective position to notify the operator that the sign of the balance in the totalizer has changed from positive to negative;

Fig. 62 is a detail top plan view of the change of sign signal when adjusted to function in the position shown in Fig. 61;

Fig. 63 is a fragmentary detail view showing the positions of the parts when the sign of the balance remaining in the totalizer changes from negative to positive;

Fig. 64 is a detail top plan view showing the parts in the positions illustrated in Fig. 63;

Fig. 65 is a detail side view of the restoring means for the change of sign signal, the parts being shown in their normal set positions;

Fig. 66 is a similar view, showing the parts in their tripped positions as when the signal has become effective;

Fig. 67 is a similar view, showing the positions of the parts at the time when they have just been restored to their normal positions during the first half cycle of the main drive shaft;

Fig. 68 is a detail side view of the zero alignment bar common to both the multiplier and quotient indicators, the bar being shown in its normal effective position;

Fig. 69 is a front view of the zero alignment bar and its associated mechanism;

Fig. 70 is a detail side view of a locking means to prevent reverse rotation of the indicator wheel supporting shaft.

Fig. 71 is a detail view in side elevation showing the manner of supporting the correction key.

Fig. 72 is a detail perspective view of the yielding latch mounted on the shiftable guide plate for the carrying pawl.

Fig. 73 is an enlarged detail perspective view, partly in section, of the means to support the front of the totalizer carriage and to feed the carriage in either direction.

Fig. 74 is a detail perspective view to illustrate the relation between the supporting devices for the transfer mechanism of the multiplier counter or indicator 500, and the universal control for the zero alignment bar 538.

General description

That form of the invention herein selected for illustration, embodies a traveling field of value-representing elements, the elements being arranged in parallel denominational rows to form a field, the home position of which field is offset relatively to a series of denominational totalizer wheel actuators.

A series of key-actuated setting members aligned with the first denominational row of value-representing elements at the left enables the operator to set the element corresponding with the digit of highest value of the amount to be registered on the totalizer.

Escapement mechanism controlled by the numeral keys, advances the field of value-representing elements step by step relatively to the denominational series of actuators, to position the set elements successively into the plane of travel of their corresponding actuators, and to bring the rows of denominational elements successively into the paths of the setting members.

The denominational wheels of the totalizer are mounted in a shiftable frame, means being provided to engage the wheels with and disengage

them from their actuators at the proper times to enable the actuators to register on the totalizer the amount set up by the keys.

There are a greater number of totalizer wheels than actuators, the rocking totalizer frame in which the wheels are supported being mounted in a carriage shiftable transversely relatively to the actuators by a manually operable step by step feed means, whereby any desired sequence of totalizer wheels may be positioned opposite the series of actuators for operation thereby, the manual carriage feeding means normally engaging the carriage to hold it where adjusted, and being releasable from the carriage to enable the operator to manually shift the carriage through two or more denominational positions at a time.

A group of carry-actuating devices which may be less in number than the number of totalizer actuators provided, drives the respective carry or transfer mechanisms for the second and higher denominations of totalizer wheels, successively, each totalizer wheel except that of lowest denomination in the totalizer carriage, having its individual carry or transfer mechanism.

The carry-actuating devices are adapted to coact with any grouping of carrying mechanism whose totalizer wheels may be located opposite the actuators.

Since each totalizer wheel controls the carrying mechanism of the next higher wheel for operation, there being a greater number of carrying mechanisms than carry-actuating devices, it is possible that the wheel of highest denomination, in any position of the carriage relatively to the actuators, except that farthest to the right, may trip the carrying mechanism for the next wheel to the left, but the operation of the tripped carrying mechanism will not be completed, owing to the fact that it lies beyond the group of carry-actuating devices.

Heretofore, should the totalizer carriage be adjusted to the right relatively to the actuators while the tripped carrying mechanism remains in such condition the appropriate carry-actuating device would drive the carrying mechanism, tripped in the operation of a preceding problem, for example, and effect the registration of an incorrect result in the instant problem. Therefore, means is provided whereby any tripped carrying mechanism, the operation of which is uncompleted, shall be reset to normal position incident to the shifting of the totalizer carriage denominationally in one or preferably either direction.

To facilitate the performance of multiplication, division and subtraction, the carriage is provided with separate counters, one of which registers the multiplier or the number of items registered, and the other of which registers the quotient.

For use in registering the multiplier, when multiplying on the machine according to one of the short methods, the appropriate counter is equipped with a carrying mechanism of novel arrangement.

A zero aligning member, common to both counters normally lies in effective position relatively thereto, and is automatically displaced in any position to which the totalizer carriage may be adjusted, at each operation of the machine, to avoid interference with the step by step rotation of the counters.

The carrying mechanism for the counter and the zero aligning member conveniently lend themselves to an economy of parts, effected by connecting the carrying mechanism and the zero

aligning member with a single universal drive mechanism so arranged that as the carrying mechanism is brought to effective position coincidentally with the step by step actuation of the counter, the zero aligning member is rendered ineffective and vice versa.

To positively indicate to the operator that he has exceeded the capacity of the totalizer, or that the sign or state of the balance registered on the totalizer has changed, there is provided a signal in the form of a machine lock, controlled by whichever totalizer wheel is highest in denomination, which, in turn, depends upon the position of the totalizer carriage relatively to the actuators at that time.

An important feature of the invention resides in the provision for effecting subtraction according to the method of complementary addition, known as "complementary subtraction", which is effected by providing a relative adjustment between the field of value-representing elements and the actuators, whereby the elements set according to the actual amount to be subtracted, are adapted to control the excursions of the actuators according to the complement of such amount.

The particular means herein illustrated, as an example of one such mechanism, utilizes value-representing elements, each of which has a plurality of contact faces, forming a plurality of sets of faces, one of which sets of faces controls the excursions of the actuators, according to the value of the amount represented by the set elements, the other set of faces controlling the excursions of the actuators according to the complement of such amount, one or the other of such sets of faces being effective, depending upon the relative adjustment of the field of elements and the actuators.

Many of the foregoing features are applicable to a wide variety of machines, both of the ten-key and eighty-one key types.

Certain other features of this invention relate more particularly to the ten-key, traveling indexing carriage type of calculating machines, and still other features to a special form of such ten-key type wherein the traveling field of value-representing elements, after advancing in one direction to bring the key-set elements into the planes of their corresponding actuators, as in the better-known type of ten-key machines, is then actuated in another direction to advance the set elements themselves into engagement with a special driving means which advances the actuators differentially according to the respective values of the set elements, after which the traveling field restores to the position to which it had advanced in the operation of setting the value-representing elements, and is thereafter returned to its starting position out of line with the actuators.

Such return of the traveling field or indexing carriage to its starting position is effected by novel means, heretofore referred to, including the provision of a compensating motor, the action of which is automatically graduated according to the extent of advance of the carriage, that is to say, its distance from its starting point.

There is also provided a lock to hold the indexing carriage or field in any of the adjusted positions to which it has been advanced by the escapement mechanism, against longitudinal movement while the carriage is being operated transversely to advance the actuators.

This lock remains effective until the carriage

returns from its transverse movement to the position from which it was moved transversely and from which it is then returned to its starting point.

I have contrived to utilize this indexing carriage locking mechanism in controlling the degree of power applied by the compensating or supplementary motor to the carriage in returning it to its starting point.

The usual carriage return motor is energized and deenergized at each operation, but the compensating or supplemental motor remains substantially inert unless and until the indexing carriage or field has been advanced from its starting position and locked in its advanced position, in which event, the lock, while effective to hold the carriage, also arrests the tensioning means for the usual carriage return motor to prevent further de-energization of such motor, and the tensioning means, because of its arrest before the completion of its full cycle, operates to cause the energization of the supplementary motor, so that upon release of the carriage lock, both motors operate to return the carriage against the influence of the feed or advancing motor for the escapement.

The time of arrest of the tensioning means on its de-energizing stroke varies according to the extent to which the indexing carriage or field has advanced, and the tensioning of the supplementary motor is graduated accordingly, the greater the advance of the indexing carriage the greater the power stored in the supplementary or compensating motor.

A novel arrangement and relation of the field of elements and actuators enables the set elements to control the actuators positively in one direction and affords a compact structure, readily portable and of comparatively few parts.

In attaining these results, the actuators are of substantially arcuate form, to enclose an area into which the rotatable field of elements is fed step by step. Spaced contact members on each actuator cooperate with the respective opposite ends of the set element corresponding denominationally therewith, the contact members lying on opposite sides of the set elements, and of the axis of rotation of the field of elements. After the field is advanced differentially relatively to the actuators (depending upon the number of integers composing the amount to be registered), the field is rotated in one direction to cause one end or the other of each set element to strike against one or the other of the contact members on its associated actuator to engage the actuators with a special driving means which advances the actuators according to the actual value of the amount set up or according to the complement of such amount, depending upon the adjustment of the field of elements relatively to the actuators.

In this connection, attention is particularly directed to the fact that the principle of operation of this invention avoids the necessity for providing idle angular movements of the main drive shaft to afford time for other parts to act independently of the shaft.

Instead, the stroke of the main drive shaft may be divided substantially into halves, on the first of which the indexing field and its set elements are driven in one direction to advance the actuators, the main drive shaft, on the remaining half stroke, operating to restore the indexing field to the position from which it was rocked, and simultaneously therewith, operating the carry-actuating members.

Since the totalizer is engaged with its actuators at the beginning of the first half of the stroke and is disengaged therefrom at the beginning of the second half stroke, the "carry", if any, can continue throughout practically the entire second half stroke, which affords sufficient time for the continuance of the "carrying wave" clear across the machine, if necessary.

As the main drive shaft completes the last half of its stroke, the indexing field returns to its starting position, such return being accomplished wholly independently of the main drive shaft.

Means directly connected with the main drive shaft rocks the indexing field, first in one direction and then back, the field traversing an arc of constant extent, and to prevent the possibility of overthrow of the totalizers through uncontrolled advance of the actuators the momentum developed in the totalizer wheels by speedy operation of the actuators and the totalizer engaging and disengaging means, the special actuator drive is provided to positively connect the effective actuators with the main drive shaft, whereby the actuators and shaft move together, the actuators being positively arrested at the end of their advance excursions just prior to the disengagement of the totalizer therewith, to arrest the totalizer wheels and overcome the momentum which may have developed therein.

A novel escapement mechanism of simplified design controls the advance of the index carriage relatively to the actuators and because of the relation of the parts, I have contrived to utilize a part of the escapement mechanism to effect the registration of the true complete complement of the amount set up, when performing subtraction by complementary addition.

As one means to enable the true complement of an amount to be registered on a totalizer equipped for the decimal system of notation, one of the contact members on the units actuator is so located relatively to its corresponding set element that the element representing "zero", when set, will co-act with its contact member, in complementary subtraction operations, to cause the units actuator to advance ten steps, the elements representing the values "1" to "9" in the units denomination, being effective to cause the advance of the units actuator "nine" to "one" steps, respectively, in complementary subtraction, whereas the complementary set of contact members on the remaining denominational actuators are so located that the corresponding "0" value-representing elements, when set, will cause the advance of their corresponding actuators but nine steps or increments in performing complementary subtraction, the value-representing elements "1" to "9" being adapted to effect the advance of their corresponding actuators "eight" to "0" steps, respectively.

It will be noted that in the assemblage of mechanisms composing this invention, I have contrived to utilize certain means having one primary purpose, to assist in accomplishing another purpose. Examples of these mechanisms are the utilization of the rocking carrying mechanism associated with the multiplier counter, for shifting the zero-aligning member for the counter into and out of effective position; the use of a part of the index carriage escapement mechanism to control the actuators of higher orders in complementary subtraction; and the adaptation of the index carriage lock in connection with the carriage return mechanism, to control the amount

of energy stored in the compensating carriage restoring motor.

Having, in general terms, referred to the more important features of novelty, the following description explains in detail the particular construction of one of several mechanisms in which the invention may be embodied.

Frame

Referring to the drawings, a suitable base 50 (Figs. 2-6, 8, 12, 22, 23, 31 and 54) supports parallel right and left side frames 51, 52, and an intermediate partition 53, extending longitudinally of the base from front to rear, and between which the several mechanisms composing the calculating machine are located.

In the form shown, the left-hand side frame 52 extends from back to front of the base, the right-hand side frame 51 extending only about half way from back to front and the intermediate partition 53 extending to a point about half way between the forward ends of the right and left side frames, and dividing the machine into two compartments, the right-hand one containing the manipulative controls and connected parts, and the left-hand compartment containing various mechanisms driven by the main drive shaft.

Keyboard

The invention is illustrated in connection with a ten-key machine, the keys 54, (Figs. 1, 4, 16 and 17) of which are numbered from "0" to "9". Conveniently, the zero key is located in advance of the remaining keys which are arranged in three ranks, one behind the other in rear of the wide-faced zero key, but any other key arrangement may be used without departing from the spirit and scope of the invention.

The numeral keys each include a head or top mounted on the upper end of a stem 55 (Figs. 1-4, 7-9) passing downwardly through slots in an inclined upper guide plate 56, supported near its opposite side edges on sub frames 57 projecting upwardly from a horizontal bottom plate 58 mounted on a vertical boss 59 rising from the base 50 in the right-hand compartment at the front of the machine. The reduced lower ends of the key stems 55 extend through slots in the bottom guide plate 58 into apertures 59' in the boss 59, each key stem being shouldered, as at 60, above and below the bottom plate 58 to limit movement of the keys in either direction relatively to the keyboard frame. The base 50 may be equipped with the usual rubber feet (see Fig. 1) for support.

Key levers 61 (Figs. 4, 7, 8 and 9) corresponding in number to the number of keys 54 extend longitudinally from front to rear of the machine, to the right of the intermediate partition 53, and their forward arms project varying distances into the space between the inclined upper plate 56 and the bottom plate 58.

The keys 54, except the zero key, are arranged in ranks of three abreast and in files three deep, the ends of the forward arms of the levers 61 terminating adjacent their corresponding key stems 55, from which latter project studs 62 to overlie the forward arms of their appropriate key levers 61.

A fulcrum block 63 (Figs. 3, 4, 7, 8, 27 and 28) projecting upwardly from the base 50 of the machine to the right of the partition 53, and at a point about midway between the front and rear ends of the machine, is provided with a plu-

reality of longitudinally extending vertical slits 64 which accommodate and guide the respective parallel numeral key levers 61, each of which levers carries an ear 65 through which passes a fulcrum rod 66, seated in its individual groove 67 extending transversely of the fulcrum block 63 and intersecting the slits 64.

It will be noted that the key levers 61 are differentially fulcrumed for a purpose soon to be explained.

The rear arms of the key levers 61 extend rearwardly from the fulcrum block 63 through varying distances, and terminate in upturned ends 68 (Figs. 4, 7-9 and 17) located beneath the respective units of a series of horizontal and parallel setting members 69, lying transversely of the vertical planes of, and above the key levers 61. Whereas the numeral key levers 61 are arranged in a series from left to right in the arbitrary order 7, 4, 1, 0, 2, 8, 5, 3, 6, 9, as indicated by the quoted numerals in Fig. 4, which order is dictated by the particular arrangement of the keys, the setting members 69 are arranged in regular sequence from "0" to "9" from front to rear. The right-hand ends of the setting members 69 lie in parallel slots in a fulcrum bar 70 (Figs. 4 and 17) fixed to the base 50, a single pivot 71, common to the entire series of setting members 69, passing transversely across the slots and through the respective setting members, so that the setting members rock in parallel vertical planes at substantial right angles to the planes in which the key levers 61 rock.

The free left-hand ends of the setting members 69 terminate in upwardly projecting toes 72 (Figs. 4, 7, 9 and 17) arranged in single file from front to back and guided in vertical slots 73 formed in the outer face of a guide bar 74 fast to the right-hand face of the intermediate partition 53.

Springs 75 depending from the respective setting members 69 are attached at their lower ends to an anchor bar 76 fast to the base 50, the springs operating to return the setting members to, and yieldingly hold them in their normal lowered positions, supported on the upturned ends 68 of their respective key levers 61. The springs 75 also operate through the setting members to restore the numeral key levers 61 and keys 54, 55 to their normal positions.

It is desirable that the key touch be as light and as even as possible so that the keys are each easily depressible, and furthermore, it is desirable that the setting members 69 each have the same extent of travel.

The attainment of an even key stroke of constant extent for all the keys is somewhat complicated by the difference between the arrangement of keys 54 on the keyboard and the arrangement of the setting members 69. This relative arrangement of the keys and setting members necessitates the provision of key levers 61 of varying lengths extending at substantial right angles to the setting members, the rear ends of the key levers contacting their respective setting members at different distances from the pivot 71, common to the several setting levers, which construction would ordinarily result in key strokes, and key lever movements of different extents, and in differential movements of the setting members, to avoid all of which I have arranged a differential system of fulcrums 66 for the key levers 61.

To obtain the proper system of fulcruming the key levers, consideration must be given the distances between the ranks of keys, the points at

which the several key levers contact their respective setting members in relation to the pivot point 71 of the setting members, and the irregular arrangement of the key levers in contrast to the orderly sequence of the setting members.

Therefore, in attaining the desired results, the key lever 61 (Fig. 4) of the foremost or zero key is fulcrumed nearest the front of the machine adjacent the forward end of the fulcrum block 63, the rear arm of the zero key lever extending rearwardly to lie beneath the first or foremost of the pivoted setting members 69, at a point near the free end thereof.

Of the keys 1, 2, 3, of the front rank, the key levers 61 appropriate to the first two are fulcrumed successive and substantially equal steps behind the fulcrum of the zero key lever, the rear arms of the key levers for keys "1" and "2" extending back beneath the respective second and third setting members 69, these key levers 61 lying on opposite sides of the zero key lever, respectively, and having their fulcrums substantially spaced in sequence.

The distance between the fulcrums 66 of the key levers 61 associated with keys "2" and "3" of the front rank is greater than the distance between the fulcrums of the key levers controlled by keys "1" and "2", because the rear arm of the key lever 61 for the "3" key contacts its appropriate setting member 69 at a point much closer to the pivot 71 of such setting member, than the contact points of the "1" and "2" key levers with their respective setting members, and hence the "3" key lever would rock its setting member to a greater extent.

Rather than shorten the key stroke, it is far more desirable to fulcrum the "3" key lever at such point that depression of the "3" key will impart a throw of sufficient length to the rear arm of its key lever to raise its setting member to the same extent that the other setting members are raised.

The keys "4", "5" and "6" of the second rank lie closer to the group of setting levers 69, and their associated key levers 61 are fulcrumed progressively rearwardly along the fulcrum block 63, as indicated by the corresponding numbers in quotation-marks on the drawing Fig. 4, the distance between the fulcrums of the key levers for the "4" and "5" keys being greater than the distance between the fulcrums of the key levers for the "5" and "6" keys, because the rear end of the key lever associated with the "4" key contacts its appropriate setting member near the free end of the latter, whereas the key levers for the "5" and "6" keys contact their setting members at points much closer to the common pivot 71 of the latter.

Because the point of contact of the key lever for the "4" key with its setting member 69 is closer to the free end of the latter than the point of contact of the key lever "3" and its setting member, the fulcrum of the key lever 61 for the "4" key lies in advance of the fulcrum of the key lever for the "3" key, and nearer the front of the machine. This arrangement enables me to provide a keyboard, the keys of which are each depressible to the same extent, to actuate their corresponding setting members 69 through arcs of like extent, despite the differences in the arcs of travel of the key levers 61 interposed between the keys and their setting members.

The key levers for the third rank of keys "7", "8" and "9" are fulcrumed successively farther towards the rear of the fulcrum block 63, it being

convenient to fulcrum the key lever for the "7" key on the same fulcrum with the key lever for the "5" key, the key lever for the "8" key being fulcrumed on the rod 66 on which the key lever for the "6" key swings, whereas the key lever for the "9" key, whose rear end contacts its setting member closer to the pivot 71 of the latter than any of the other key levers, is fulcrumed at the rear of the fulcrum block 63.

While that form of the invention illustrated herein, shows the key levers 61 equipped with upturned ends 68 to contact the setting members 69, it is obvious that lugs might depend from the setting members to be struck by the key levers without departure from the invention. By utilizing the springs 75 attached to the respective setting members 69 to press these members downwardly upon the upturned ends of the key levers 61 and restore the key levers and their keys 54 from their operated positions to their normal positions, I avoid the necessity of equipping the keys or key levers with return springs, and simplify the construction to this extent.

Indexing carriage mechanism.

The aligned toes 72 at the free ends of the group of setting levers 69 enable the operator, through manipulation of the keys 54, to selectively set value-representing elements 77 (Figs. 1-3, 5-8, 11-14, 17-20, 23, 53, 55 and 56) arranged in denominational rows in a traveling indexing carriage 78, which, in the present instance, is mounted for longitudinal or endwise movement on a cradle or carriage support rotatably supported between the side frames 51 and 52 of the machine.

The value-representing elements 77 constitute the indexing field hereinafter mentioned.

The cradle (Figs. 3, 5, 6, 11-14, 17-20, 23, 27, 28 and 53) includes a rectangular skeleton frame extending across the space between the machine side frames 51-52, and formed of end pieces 79 (Figs. 3, 4, 17-19 and 22-28), roughly triangular in shape and connected at their rear angles by a flattened rail 80, and at their front angles by a bar 81.

Trunnions 82 project from the outer faces of the respective end pieces 79 into bearings formed in the adjacent right and left side frames 51, 52, to pivotally support the cradle.

The indexing carriage or field 78 includes end plates 83 inserted between the rail 80 and bar 81 of, and disposed at substantial right angles to the skeleton cradle, the end plates being relieved along their front and rear edges to reduce the weight.

Intermediate their upper and lower arcuate ends, the plates 83 are each provided with forwardly and rearwardly extending arms 84 and 85, respectively, the corresponding forward arms 84 being apertured to accommodate and slide upon the front carriage supporting bar 81. A tube or sleeve 86 connects the front arms 84, the ends of the tube encircling the apertures in the arms, and the tube surrounding and sliding upon the front carriage supporting bar 81 to form a firm bearing for the indexing field.

The opposed rearwardly extending arms 85 are correspondingly recessed, as at 87 (Figs. 55 and 56) and upper and lower tie bars 88 and 89 extend between and connect the rear arms 85 above and below the recesses. A roller 90 (Figs. 3 and 18) turning on a pin 91 projecting from the upper tie bar 88 about midway of its ends, rests on the upper flattened face of the rail 80 and unites with

the apertured forward arms 84 and tube 86 in supporting the indexing carriage or field 78 for travel back and forth lengthwise of the cradle or carriage support, and across the machine.

The upper arcuate ends of the index carriage end plates 83 are connected by an arcuate head or housing 92, a similar housing 93 connecting the arcuate lower ends of the plates 83. Each housing is provided with a series of equidistant, parallel rows of slots 94, 95 (Figs. 18, 19 and 28), the rows corresponding denominationally to the largest amount which can be set up by the keys 54. The individual slots composing each row in the lower head 93 are spaced apart distances corresponding to the spaces between the upwardly projecting toes 72 of the aligned row of setting members 69. The lengths of the slots 94 in the respective rows of the upper head 92 are greater than the distances between the rows of slots, and in the lower head, the slots 95 (Fig. 18) are substantially L-shaped, as indicated in Fig. 28.

The denominational rows of slots 95 in the lower head 93 are offset longitudinally of the carriage relatively to the corresponding rows of slots 94 in the upper head 92 (Fig. 17) by distances approximately equal to the distance between two rows of slots, the offset being in the direction of return of the index carriage.

Thin flat strips or pins 77 are slidably mounted at their ends in the corresponding denominational rows of slots 94, 95 in the opposed heads 92, 93, and constitute the value-representing elements, the upper ends of which normally lie almost flush with the upper head 92. The lower ends of the value-representing elements project below the lower head 93 and are laterally recessed, as at 96 (Figs. 55-57), for a purpose hereinafter explained in connection with the complementary subtraction feature of the invention. In the present instance, the protruding lower ends of the value-representing elements 77 are flanged, as at 97, across the recesses 96, to strengthen the ends against distortion, but the use of heavier material would render such flanges unnecessary.

The invention is illustrated in connection with a machine equipped for problems employing the decimal system, there being ten slots 94, 95, in each denominational row, and of course, ten value-representing elements 77 arranged according to the notation "0" to "9" in sequence from front to rear of each row.

There are ten rows of such value-representing elements 77, which enables the operator to set up amounts of ten denominations, but obviously a larger or smaller number of denominational rows can be provided depending upon the capacity of machine desired.

Each value-representing element 77 extends from top to bottom of the indexing carriage 78 and is bent or offset intermediate its ends, as indicated at 98 (Figs. 17 and 57), to enable the vertical end-portions of the value-representing elements to pass through and work up and down in the corresponding offset guide slots 94, 95 in the upper and lower heads 92, 93, respectively.

To prevent accidental removal of the value-representing elements, each of such elements is recessed, as at 99 (Figs. 17 and 57) along one edge near its upper end to accommodate and loosely embrace a limit rod 100, one of which is common to the elements of each row, the rods extending widthwise of the carriage (Fig. 23) with their opposite ends mounted in the skirts 101 depending from the opposite longitudinal edges of the upper head 92.

The shoulders formed at the opposite ends of the recesses 99 limit the travel of the value-representing elements 77, by contact with the limit rods 100.

- 5 The upper ends of the value-representing elements 77 are adapted to be selectively projected above the outer arcuate face of the upper head 92 by depression of the keys or manipulative devices 54, and are held in either their idle or set positions by spring detents 102 (Figs. 11, 12 and 17) individual to the respective elements, and depending from cross bars 103 extending alongside each denominational row of elements and secured at their opposite ends in the skirts 101
- 10 of the upper head.

The free ends of the spring detents 102 are bent, as at 104, to co-act, in well-known manner, with the opposite faces of cams 105 formed on the several value-representing elements.

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Index carriage escapement

- The indexing carriage or field normally stands one step to the left of the right-hand limit of its travel, and in the right-hand compartment of the machine, in such position that the lower projecting ends of the extreme left-hand denominational row of value-representing elements 77 overlie the aligned row of toes 72 on the free ends of the setting members 69, there being a
- 25 separate setting member for each value-representing element in a row.

- A series of equidistantly spaced escapement stops 111 (Figs. 5-7, 13-16, 55 and 56) are slidably mounted in parallel seats 112, (see Fig. 10) formed across the upper face of an escapement bar 113 fastened to the under face of the rail 80 of the cradle which serves to retain the stops 111 in their seats. These stops normally lie in their outer or rearmost, effective positions, with the depending lip 116 on the first or left-hand stop (when viewed from the rear as in Fig. 18) lies in the path of the right-hand end of the abutment 119 fast on the lower tie bar 89 of the indexing carriage, to arrest the latter in its starting position, as shown in Figs. 12, 14, 16, 18, and 20
- 30 against the energy of a carriage advancing spring or motor 114 (Figs. 3, 5, and 17-19) connected at one end to the carriage, and at the other end to the left-hand end piece 79 of the cradle or carriage supporting frame.

- In the form shown, the inner edge of the escapement stop-supporting bar 113 is notched, as at 115 (Figs. 10, 13, 14 and 15), in line with the grooves or seats 112 formed across the upper
- 35 face of the escapement bar to accommodate the lips 116 depending from the forward, inner ends of the respective stops 111.

- Also, one side edge of each stop 111 is cut away near the outer rear end of the stop (Figs. 19 and 21) to cooperate with the adjacent side wall of the groove or seat 112 in forming a chamber occupied by a friction spring 117 which may be doubled, as shown, to yieldingly retain the stop at one or the other of its limits of movement, determined, in one direction, by the contact of the lip 116 of the stop against the rear wall of the notch 115, and in the opposite direction, by contact of a laterally turned end 118 of the friction spring 117 against the outer edge of the escape-
- 40 ment bar 113, the spring being held against end-wise movement by the shoulders at the opposite ends of the cut-away portion of the stop.

- The leading end of the abutment 119, conveniently mounted on the lower tie bar 89 of the
- 45 index carriage, is adapted to contact the depend-

ing lips 116 of the escapement stops 111 successively, to arrest the carriage 78 and restrict it to a step-by-step advance relatively to the aligned free ends 72 of the setting members 69.

The recesses 87 in the rear edges of the indexing carriage end frames 83 enable the escapement mechanism to be more compactly arranged and brought closer to the carriage.

The step-by-step advance of the indexing carriage 78 presents the denominational rows of value-representing elements 77 seriatim to the row of setting members, the escapement being controlled by the manipulative devices 54 as follows:

The connecting bar 120 (Figs. 4, 7-9 and 17) of an escapement operating bail extends across and just above the group of setting members 69 near their free ends. The bail includes a pair of levers 121 arranged parallel with and on opposite sides of the group of setting members 69, the levers being pivoted intermediate their ends, as at 122, to the opposed inner faces of vertical brackets 123, the feet of which rest upon and are secured to the base 50. The connecting bar 120 is carried by the left-hand ends (Figs. 4 and 9)

50 of the levers 121, a web 124 extending beneath the group of setting members 69 and connecting the levers 121 to the right of their pivot points for strength and rigidity.

The outer or right-hand ends of the bail levers 121, (as viewed in Figs. 9, 17 and 18) are apertured to accommodate the intumed ends 126 on the depending arms of an equalizing yoke 127, the cross bar of which lies above and transversely of the bail levers 121 and setting members 69, and is pivoted midway of its ends, as at 128, to the lower end of a vertically extending transmission link 129.

The upper end of the transmission link is slotted, as at 130, to conveniently embrace the inner end of the right-hand trunnion 82 of the indexing carriage support as a guide, the link carrying a stud or projection 131 (Figs. 7-9 and 17), intermediate its ends, which overlies the inwardly extending arm of a bell crank lever 132 fastened at its angle to a squared escapement shaft 133 journaled at its opposite ends in the end pieces 79 of the cradle or carriage support.

A spring 134 connected to the upwardly extending arm of the bell crank 132, yieldingly holds such arm in contact with the forward inner edge of the flat rail 80 of the carriage-support, as indicated in Fig. 7, and the inwardly extending arm of the bell crank is also held in contact with the projection 131 on the transmission

55 link 129.

A spring 135 (Figs. 4, 9 and 17) connected to the escapement operating bail at the left of its pivotal points 122, tends to hold the bail at the counter-clockwise limit of its travel, with the connecting bar 120 resting upon the upper edges of the setting members 69, the right-hand ends of the levers 121 of the bail holding the equalizing yoke 127 and transmission link 129 at the upper ends of their travel.

An escapement control device in the form of a bail 136, (Figs. 5, 7-9, 11-16 and 18-20) having arms of different lengths, is mounted by its arms to slide along and turn with the squared escapement shaft 133. The free end of the shorter arm of the bail projects into a notch 139 (Figs. 11, 12 and 18), conveniently formed in the lower index carriage tie bar 89, and is of sufficient width to maintain its engagement with the notch during the rocking of the escapement shaft 133.

The longer arm of the bail is bent to form a forwardly extending finger 140, the free end of which is located just in advance of the contact face of the index carriage abutment 119. The escapement finger 140 has a path of travel across the contact face, and just beneath the escapement stop supporting bar 113, to strike the depending lip 116 of the effective stop 111 against which the abutment bears, and displace the stop relatively to the abutment to enable the advancing spring or motor 114 to feed the indexing carriage 78 with the value-representing elements 77 towards the left.

To set up an amount in the field of value-representing elements, the operator depresses the appropriate keys 54, commencing with the digit of highest denomination and concluding with the digit of lowest denomination, in the usual order in which he mentally considers the amount.

Assuming the indexing carriage or field of elements to be in its normal position at the right (Figs. 17 and 19), with the lower ends of the extreme left hand row of value-representing elements 77 above and in alignment with the toes 72 of their respective setting members 69, the key depressed will rock its key lever 61 counter-clockwise (Fig. 8) to cause the upturned rear end 68 of the key lever to swing its co-related setting member 69 upward in clock-wise direction against the tension of the restoring spring 75 of such setting member. The toe 72 strikes the aligned lower end of the value-representing element 77 corresponding to the value of the key depressed, and slides the element upwardly relatively to the heads 92, 93, to project the upper end of such element above the upper head 92 of the index carriage, in which position the element is yieldingly held by its spring detent 102, the cam 105 on the element crowding past the resilient bent end 104 of the detent as the element is forced upwardly.

The selected setting member 69, as it rocks upwardly, will contact the connecting bar 120 of the escapement bail and rock the levers 121 clockwise, tensioning the restoring spring 135.

Because of the rigid construction of the escapement bail it is immaterial at what point on the connecting bar 120 the selected setting member 69 exerts its pressure, and no torsional displacement of the bail can occur, so that as the bail is rocked by any of the setting members, it will draw the equalizing yoke 127 and transmission link 129 downwardly, evenly and without cramping or canting the parts, the link sliding freely on its guide 82.

As the link descends, its projection 131 presses against the inwardly projecting arm of the escapement bell crank 132, rocking the latter and its escapement shaft 133, counter-clockwise (Fig. 8) against the tension of the spring 134.

The traveling escapement control bail 136 (Figs. 7-9 and 11-16) rocks with the escapement shaft, the shorter arm of the bail maintaining its engagement with the lower tie bar 89 while the finger 140 on the longer arm is forced against the rear face of the depending lip 116 of the effective escapement stop 111, (Fig. 8), to slide the latter forwardly until the lip escapes the contacting end of the abutment 119 on the indexing carriage, whereupon the carriage-advancing feed spring or motor 114 draws the carriage to the left.

In slow operations of the key, the carriage advances against the next escapement stop 111 in two steps, it being arrested at a point interme-

diate each two successive stops by contact of the projected finger 140, traveling with the carriage, against the depending lip 116 of the succeeding stop 111 (see Figs. 11 and 13), the finger 140 being held in its projected position by pressure of the operator's finger on the key, it being remembered that all the escapement stops 111 are normally effective until displaced successively by the finger 140.

Upon release of pressure on the key 54, the spring 75 of the actuated setting member 69 draws the latter downwardly, the setting member in turn, rocking the key lever 61 clockwise to restore the key lever and its key to normal position, assisted by the spring 135 which restores the escapement operating bail 120, 121 to normal.

And as the escapement operating bail returns, it raises the equalizing yoke 127 and transmission link 129, thereby withdrawing the projection 131 of the link from the escapement bell crank 131, whereupon the spring 134 rocks the bell crank and escapement shaft 133 counter-clockwise (Fig. 15) to withdraw the finger 140 from between the abutment 119 and the effective stop 111, and enable the carriage-advancing spring 114 to complete the advance of the carriage, the abutment arresting such advance by its contact with the depending lip 116 of the next stop 111 of the series.

In practical operation, where the keys are depressed with a staccato touch, there is no perceptible arrest between successive stops 111, and the escapement control member 136 rocks in, slides along the bar 133 with the field 78, and then rocks out without appreciable pause.

The advance of the field of elements commences just as the key completes its down-stroke, and at a time when the toe 72 of the actuated setting element 69 is in its highest position, in the path of the lower ends of the succeeding row of elements (Fig. 11), contact of any of which with the raised toe 72 would tend to bend the element and cause it to bind in the guide heads 92, 93, or distort the raised toe.

The arrangement whereby the projected finger 140, carried along with the carriage in its advance, strikes the succeeding stop 111 before the lower end of a value-representing element 77 can strike the toe 72, protects the elements 77 and the toes 72 against distortion.

Also the selected setting member 69, when in its elevated position under the influence of a depressed key 54, might raise the escapement operating bail so far that the connecting bar 120 thereof would lie in the path of and interfere with the lower ends of the next row of value-representing elements 77, to avoid which, the setting members are reduced or recessed as at 125 (Fig. 9), at their points of contact with the universal connecting bar 120 to afford clearance between the latter and the lower ends of the value-representing elements.

Operation of the machine under control of the remaining keys 54 representing the amount to be entered is a repetition of the foregoing operation, the stops 111 being successively displaced by the finger 140 as the keys 54 are depressed, to enable the field 78 of value-representing elements to advance towards the left step by step to different extents according to the number of denominational digits in the amount set up.

Correction key

In the event, for example, that the operator sets up an erroneous amount or for some other

reason, desires to restore a part or all of the set value-representing elements 77 to their normal positions, prior to further operation, manual means is provided to enable the partial or complete return of the indexing carriage to its starting position.

To this end, a manipulative device in the form of a key 146 (Figs. 1-3, 22, 27-29, 31 and 71) is arranged for horizontal sliding movement just beneath the upper plate 56 of the keyboard, the key stem projecting forwardly from the front of the keyboard, with its lower edge resting on guide studs 147, 147, (Fig. 71) extending laterally from the inner face of the left-hand sub frame 57 of the keyboard, and its upper edge in sliding contact with the upper keyboard plate 56.

A retaining roll 148 on the forward guide stud 147, and a retaining bracket 149 on the rear guide stud 147, in sliding contact with the outer face of the key stem combine with the inner face of the sub frame 57 to hold the key stem in place.

A laterally bent ear 150 (Fig. 3) on the inner end of the key stem 146 is slotted, as at 151, to embrace a stud 152 on the shorter arm of a bell crank 153 pivoted at 154 to the outer end of a bracket 155 projecting rearwardly from the upper keyboard plate 56.

The longer arm of the bell crank 153 extends rearwardly and terminates in a horn 156 extending into proximity to a substantially vertically arranged carriage-restoring member or angle lever 157 (Figs. 27-29) pivoted at 158 near one angle of its broadened lower end, to the rear face of a vertical fixture 159 conveniently secured to the rear end of the fulcrum block 63.

The upper free end of the angle lever or carriage-restoring member 157 carries a projection 160 (best shown in Fig. 31) extending rearwardly into the path of a segmental contact plate 161 (Figs. 2, 3 and 22) fastened to and projecting forwardly from the right-hand end plate 83 of the indexing carriage 78.

Normally, the carriage-restoring member 157 is freely rockable in either direction so as to oppose no resistance to the indexing carriage as the latter advances during the setting of the value-representing elements, and when the indexing carriage or field of elements is in its home position, the carriage-restoring member 157 may lie at either limit of its travel.

Furthermore, I have contrived to also make use of the manually operable carriage-restoring member in the automatic mechanical return of the carriage incident to the operation of the machine, as hereinafter explained, which is an additional reason for arranging for the untrammelled movement of the carriage-restoring member.

Assuming the carriage-return member 157 to have been left at the end of the previous operation of the machine, at its right-hand limit of travel with its projection 160 resting against the contact plate 161 of the indexing carriage, the carriage, as it is fed step by step to the left during the setting of the value-representing elements by depression of the numeral keys, in the succeeding operation, will rock the carriage return member idly towards the left until the member passes its dead centre position, whereupon it will fall by gravity to the opposite or left-hand limit of its travel, determined by contact of the free end of the member 157 with the intermediate partition plate 53.

Obviously, the carriage-restoring member might have been left in such left-hand position. In case the correction key 146 is left in its partially

or wholly pressed-in position which locates the long rear arm of the intermediate bell crank 153 in the path of the carriage return member 157, the return or restoring member, as it is rocked by the carriage on its advance, will rock the intermediate bell crank lever 153 and project the correction key 146 from the front of the machine.

In any event, if the operator wishes to restore the indexing carriage to its starting position without entering the amount represented by the set elements 77 he may, prior to an operation of the main drive shaft, push inwardly on the correction key 146 to rock the bell crank 153 clockwise (Fig. 3), causing the horn 156 thereof to pick up the carriage-restoring member 157 and swing it also clockwise until its projection 160 strikes the segmental return plate 161 of the indexing carriage at whatever position the carriage may have advanced, whereupon continued pressure on the key will slide the carriage to the right until it is arrested at a point slightly beyond or to the right of its starting position by contact of the right-hand end frame 83 of the carriage with a cushioning spring 162 (Figs. 3, 17, 19, 27 and 28) encircling the front supporting rod 81 and abutting the inner end of a collar 163 on the rod.

The tendency of the horn 156 of the manually actuated bell crank 153 to ride up or down on the edge of the carriage-restoring member 157 depending upon the inclination of the latter when it collides with the segmental restoring plate 161, is overcome by forming the edge of the carriage-restoring member on an arc as at 164 (Figs. 27 and 28) terminated at its upper end in a shoulder 166 and so calculated relatively to the arc traversed by the restoring member, as to lie at right angles to the horn 156 at any point in its contact therewith during the return of the index carriage.

Removal of the pressure against the correction key 146 enables the carriage-advancing spring 114 to advance the carriage slightly towards the left until it is arrested by contact of its abutment 119 with the first escapement stop 111 of the series, at which time the carriage is again in its starting position, means being provided as hereinafter explained, to restore the set value-representing elements 77 to their idle positions, and the displaced escapement stops 111 to their effective positions on the return of the indexing carriage.

Permitting the indexing carriage to return past its starting point, insures that it will pass to the right of the first escapement stop 111 to restore the displaced stop to effective position, and enable the carriage to feed to the left until arrested by such stop.

Returning escapement stops to effective positions

The indexing carriage 78, on its return either manually or incident to the operation of the machine, returns to their normal effective positions the escapement stops 111 displaced in the step-by-step advance of the carriage.

As one means to accomplish this result, the left-hand end frame 83 of the carriage supports a cam plate 165 (Figs. 3, 13-17, 19 and 20) attached to the outer face thereof, and when the carriage is in its starting position the stop-restoring cam 165 lies about opposite and in substantial contact with the front face of the lip 116 on the second stop of the series, so as not to interfere with the displacement of the stops successively by the finger 140 as the carriage is stepped to the left in setting up amounts in the field of value-representing elements.

As the indexing carriage 78 returns towards and past its starting position, the low point of the restoring cam 165 wipes over the depending lips 116 of the successive escapement stops 111 that have been displaced by the escapement control member 136, from highest to lowest denomination, to restore the stops to their effective positions relatively to the carriage abutment 119, with their depending lips 116 in the path of the abutment.

Returning the value representing elements to normal

Also, as the carriage returns towards normal position, the set value-representing elements 77 are restored to their normal depressed positions, by the usual angularly-faced restoring bar 169 (Figs. 2-4, 11, 12, 17 and 18) arranged to overhang the left-hand row of elements when the carriage is in its starting position.

In the present instance, the restoring bar 169 is arcuate to conform to the arcuate arrangement of the rows of denominational elements 77 in the arcuate head 92 of the indexing carriage, such restoring bar being in the shape of an inverted arc, one end of which merges into a vertical post fastened to the right side of the intermediate partition 53 which is cut away, as shown in Fig. 22, to afford clearance for the rocking cradle and the indexing carriage.

As the carriage returns towards its starting position, the set elements 77 successively strike and wipe under the angular face 170 of the restoring bar 169, being thereby forced downwardly to their normal positions, the cams 105 (Fig. 17) on the elements crowding past the flexible detents 102 which snap back to positions above the cams to hold the elements in their normal positions.

Obviously, the operator, by watching the return of the carriage as he presses inwardly on the correction key 146 can relieve such pressure at any time during the return of the carriage. Thus if the last digit set up was erroneous, for example, he need only restore the indexing carriage one step to reset the value-representing element accidentally set, and enable him, by depression of the proper key 54 to set the desired digit without necessitating the restoration of all the previously set elements.

In this connection, the custom of engraving, labeling or otherwise marking the upper ends of the value-representing elements 77, as indicated in Fig. 1, is made use of to enable the operator to read the amount set up, before actuating the machine to enter the amount on the totalizer.

This arrangement also renders it easier for the operator to set the indexing carriage back step by step when making a correction in the last digit set up.

Actuators

The field of value-representing elements 77 is advanced step by step to the left (Figs. 3 and 17) to locate the set elements in position to control the excursions of a group of denominational adding racks or actuators 175 (see also Figs. 5, 6, 23, 33 and 34) which drive the totalizer wheels 176.

In the embodiment of the invention selected for illustration, these denominational actuators are substantially arcuate in form and are arranged in parallel vertical planes spaced apart distances substantially equal to the spaces between the arresting edges of the lips 116 of the escapement stops 111.

The actuators 175 lie to the left of the indexing carriage 78 when the latter is in its starting position, and enclose an area into which the indexing carriage advances step by step, resulting in a telescopic relation between the field of elements 77 and the group of actuators 175 which tends to reduce the size of the machine and make it more compact.

The curved actuators are located at the rear of the left-hand compartment, and rest at their lowest points on anti-friction rollers 177 (Figs. 5, 6, 17 and 23) mounted on a cross rod 178 extending beneath the series of actuators exteriorly thereof, the rod being mounted at its opposite ends in the left side frame 52 and the intermediate partition 53, respectively.

Slitted guide bars 179, 180, 181, spaced around the inner peripheries of the series of actuators, and mounted at their ends in the left-hand side frame 52 and the partition 53, respectively, accommodate and guide the actuators in their oscillatory travel and maintain them in spaced relation in their vertical planes, as well as holding them to their orbits.

The guide bar 180 is conveniently located adjacent the cross rod 178 on which the anti-friction rollers 177 turn, and is longitudinally grooved, as at 182 (Figs. 5 and 6) to fit against and form a seat for the cross rod to afford rigidly and strength thereto.

If desired, headed fastenings 183 (Fig. 6) may be provided on the guide bar 180 to take over the cross rod 178 and hold it in its seat 182, the lower outer ends of the slits 184 (Fig. 17) in the guide bar being enlarged to accommodate the anti-friction rollers 177 and maintain them in spaced relation, in position to support the actuators 175.

In their normal positions of rest, the actuators are additionally supported by a stop rod 185 (Figs. 3-6, 23, 53 and 60) seated in a groove 186 (Fig. 60) extending longitudinally of the guide bar 179 and transversely of the slits 187 (Fig. 42) therein, the ends of the stop rod 185 being mounted in the left-hand side frame 52 and the partition 53, respectively, (see Figs. 3, 4).

The stop rod passes through arcuate slots 188 formed in the toothed forward ends 189 (Figs. 5 and 6) of the actuators 175, the upper end walls of the slots resting upon the stop rod 185 when the actuators are in their home positions. The stop rod, by contact with the lower end walls of the slots 188, limits the advance of the actuators, except the units actuator, to nine increments of movement, in machines arranged according to the decimal notation.

Headed fastenings 190 (Fig. 53) may retain the stop rod 185 in its seat, in a manner like that in which the cross rod 178 is held in place.

Restoring springs 191 (Figs. 4-6, 17 and 23) connected at their forward ends to ears 192 on the respective actuators 175, and anchored at their rear ends to a plate 193 (Figs. 5 and 6) on the base of the machine, return the actuators to, and yieldingly retain them in, their normal or home positions.

Each actuator is equipped with a plurality of series of contact members, of which one series only will be considered at this time, namely, that series comprising, conveniently, the aligned rear ends or tails 194 of the actuators 175.

As the indexing field of value-representing elements 77 advances step by step, under control of the escapement mechanism, as heretofore explained, the set elements are positioned suc-

sively in the planes of the successive contact members 194 of the actuators, until the complete amount set up by the depression of the proper keys 54 is represented by corresponding set elements 77.

Conveniently (Figs. 5, 6, 33, 55 and 56) each individual actuator 175 may be considered as comprising an adding rack 189 and contact member 194, lying in the same plane and forming opposed arcs of a single circle, the adjacent ends of the rack and contact member being united by a connecting bar radially offset outwardly and occupying the arc of a larger circle, to afford clearance for the lower ends of the idle value-representing elements 77 in the indexing carriage.

In many well-known machines on the market, the setting of the value-representing elements is followed by an operation of the main driving mechanism, whereupon, in adding operations, the actuators corresponding denominationally with the set elements, advance until differentially arrested by such set elements, the totalizer being then engaged with the actuators, after which the advanced actuators are restored to their normal positions, thereby registering on their corresponding denominational totalizer wheels the amount represented by the set elements.

And it is obvious that the parts heretofore described might be made to function in a similar manner.

But I have chosen to illustrate the invention applied to a machine wherein the set elements 77, instead of acting as stops to arrest driven actuators, operate upon the actuators according to the values of the digits composing the amount, to advance such actuators differentially, according to the values set up, or as viewed from another angle, to engage the actuators with means which advances them through excursions corresponding in length with such values.

And as one means to accomplish this result I have contrived the mechanism now to be described.

Main drive mechanism

A standard 200 (Figs. 1-4) projects upwardly from the right-hand corner of the base 50 convenient to the hand of the operator and carries a boss 201 projecting outwardly at an angle thereto. The boss is longitudinally bored to form a bearing for a shaft 202 which passes at an angle through an aligned bearing in the standard, the outer end of the shaft being equipped with a crank 203 or other manually operable device, a bevel gear 204 (Figs. 3 and 4) being fast on the inner end of the shaft, in constant mesh with a similar bevel gear 205 fast on a main drive shaft 206 extending across the machine at a point nearly midway of the front and rear ends, and journaled in bearings in the side frames 51, 52, the partition 53 being cut away, as shown in Fig. 22, to afford clearance for the main drive shaft.

A bracket 207 supports the inner end of the crank handle shaft 202, to afford rigidity and hold the bevel gear 204 in mesh with the bevel gear 205.

A link 208 (Figs. 2-4 and 24-26) eccentrically pivoted by its forward end at 210 to a disk 209 fast on the right-hand end of the main drive shaft 206 exteriorly of the right-hand side frame 51, extends rearwardly to connect the disk with the depending arm of the right-hand end piece 79 of the cradle or index carriage support, to which the link is pivoted at 211. The pivot stud 211

projects outwardly from the end piece 79 through an arcuate slot 212 (Fig. 2) in the adjacent side frame 51.

Since the ratio of the gears 204, 205 is one to one, the crank shaft 202, when turned through a complete revolution, will turn the main drive shaft 206 and its disk 209 a complete revolution to rock the cradle clockwise from its normal horizontal position, during the first half of its cycle, and then counter-clockwise back to normal during the second half of its cycle, thereby rocking the normally vertical index carriage 78 supported on the cradle, backwardly and then forwardly, as shown by a comparison of Figs. 5 and 6, or 24 and 25, through a constant, invariable arc equal to nine increments of movement of the actuators 175 plus an additional step of movement to enable the engagement and disengagement of the totalizer 176 relatively to the actuators.

The step of travel during which the totalizer is engaged with the actuators occurs at the beginning of the first half cycle of rotation of the main drive shaft, and the step of travel during which the totalizer is disengaged from the actuators occurs at the beginning of the second half of the cycle of rotation.

Each of these steps of movement may be slightly longer than the steps of movement during which the actuators are advanced, and retracted.

In their normal positions, the pivot points 210, 211 of the link 208 lie in line with the main drive shaft 206 and naturally, they return to such positions at the end of a complete rotation, so that the motion of the cradle and index carriage accelerates from the beginning of their rocking motion to a point midway of their path of oscillation, and then decelerates as they approach the distant limit of such oscillation, at which point they come to rest.

Similarly, on their return towards the position from which they were rocked, the speed of the cradle and index carriage accelerates as they approach their midway positions, and decelerates as they come to rest in their normal horizontal and vertical positions, respectively.

As a result, the action of the machine is very fast, and yet controlled at the limits of oscillatory travel of the cradle and index carriage.

The proportionate leverage is such that a complete revolution of the main drive shaft 206 will rock the index carriage 78 and its cradle or support about 90 degrees in clockwise direction (Fig. 6) and then restore them to the positions from which they were rocked.

The diameter of the circle bounded by the inner peripheries of the opposite ends 189, 194 of the respective actuators is but slightly greater than the diameter of the circle in which the arcuate heads 92, 93 of the indexing carriage 78 lie, the two circles being concentric, so that as the indexing carriage advances step by step into the area enclosed by the series of actuators 175, the projected ends of the set elements 77 are positioned in the planes of the contact members 194 of the actuators.

Since the center of rotation of the cradle and index carriage corresponds with the axial center about which the arcuate actuators 175 turn, it is obvious that the index carriage 78, on its clockwise oscillation, will advance those value-representing elements 77 which have been set or projected by the keys 54, against the aligned contact members 194 of the actuators 175 to differentially rotate or advance the actuators according to the amount represented by the set ele-

ments, in conformity with one of the two theories of operation heretofore referred to.

The value-representing elements in each denominational row are arranged in the regular sequence "0" to "9" from front to rear of the index carriage or field.

The elements representing "9" when set, are but one step distant from the contact members 194 of the actuators 175, opposite which they have been positioned by the step-by-step advance of the carriage, in readiness to drive their actuators rotatively, soon after the index carriage starts to rock and after the totalizer is engaged with the actuators, whereas the elements representing "0", for instance, are located ten increments of movement away from the contact members 194 so that as the carriage arrives at its limit of clockwise oscillation, at the end of the first half cycle of rotation of the main drive shaft, the zero-representing elements, if set, will lie against their corresponding contact members 194 without having advanced the actuators.

From this, it will be seen that any set element will advance idly towards its actuator a number of steps equal to the difference between the value represented by the set element and "10" before driving the actuator.

The machine could be so arranged that the "9" elements, when set, would start to drive their actuators as soon as the index carriage commenced its clockwise oscillation, were it not for the fact that, in the form of machine herein illustrated, the totalizers 176 are normally out of engagement with their actuators. Hence, time must be allowed to engage the totalizers with their actuators and to disengage them therefrom, which is provided by dividing the carriage oscillation in each direction, into ten increments, during the first of which increments the totalizer is engaged with the actuators, and during the eleventh of which increments, the totalizer is disengaged therefrom, such eleventh increment being the first step of the second half of the cycle of rotation of the main drive shaft.

Indexing carriage lock

To insure that the field of value-representing elements shall remain in any of the positions to which it has been advanced by the step-by-step escapement mechanism, while it is being oscillated, there is provided an automatic locking mechanism, including a wing 215 (Figs. 2, 3 and 24-26) segmental in form, the arc of the peripheral edge of the wing being concentric with the center about which the indexing carriage and its cradle oscillate.

As the indexing carriage advances towards the left, the lower outer edge of the wing 215 travels alongside a horizontal locking bar 216 extending between the right-hand side frame 51 and the intermediate partition plate 53, in which its opposite ends are mounted, transverse grooves 217 being formed peripherally in the locking bar and spaced apart according to the length of the steps through which the indexing carriage advances, that is to say, the distances between the successive grooves 217 correspond to the distances between the contact faces of the successive escapement stops 111, and hence the wing lies in alignment with a transverse groove in any position to which the indexing carriage is adjusted or fed in its longitudinal travel.

As the indexing carriage and its support start to oscillate, the lower outer end of the wing 215 enters that transverse groove 217 opposite which

it has been positioned, and thereby locks the indexing carriage 78 against longitudinal movement during the oscillatory travel of the carriage.

The arcuate edge of the wing 215 is of such extent as to maintain its engagement with the walls of the grooves 217 throughout nearly the entire oscillatory movement of the indexing carriage, the lower outer end of the wing being withdrawn from the groove just as the indexing carriage or field of elements returns to the vertical position from which it has been rocked, and such restoration of the carriage to its vertical position occurs as the main drive shaft 206 is completing its cycle of rotation.

The connection between the driving disk 209 and the end plate 79 of the cradle or index carriage support is so arranged that when the main drive shaft 206 has completed half a rotation, the link 208 will lie diametrically across the disk, as shown in Fig. 25, at which time the indexing carriage 78 will have been rocked to its limit of travel farthest from the vertical, the cradle and indexing carriage being returned to the positions from which they were rocked during the second half of the stroke of the main drive shaft.

By so arranging that the pivotal points 210 and 211 of the link 208 shall be in line with the center of the disk 209, as shown in Fig. 24, the link acts as a lock to arrest the cradle in its normal horizontal position and also its limit of travel from the vertical and prevent overthrow thereof and of the indexing carriage at each limit of its movement.

It will be understood that the escapement mechanism, including the motor spring 114, the escapement stops 111, and the stop-displacing member 136 (Figs. 18-20), together with its rocking rod 133 and bell crank 132 (Fig. 9) all oscillate with the cradle or index carriage support on which they are mounted, the forwardly projecting arm of the escapement bell crank 132 traversing an arc about the projection 131 of the link 129, and returning to its normal position with the cradle and indexing carriage. The projection 131 is substantially co-axial with the center of rotation of the indexing carriage.

The locking bar 216 is provided with an additional set of locking grooves 218 (Figs. 3 and 4) with which the locking wing or member 215 co-acts during subtraction operations, as will be more fully explained hereinafter.

Automatic carriage return

The mechanism for restoring the indexing carriage to its starting position preparatory to setting up a new amount, although the last function in the cycle of operation of the machine, will be next explained, as it can be more easily understood in view of the immediately preceding descriptions.

Reference has been made to the escapement spring or motor 114 (Figs. 3, 4, 17-19) which advances the indexing carriage or field of elements 78 endwise step by step as determined by the control of the escapement stops 111 through the manually operable manipulative devices 54.

The advancing motor 114 de-energizes progressively as the indexing carriage 78 advances from its starting position on the right, and becomes progressively stronger as the indexing carriage returns to its starting position.

Heretofore, it has been considered sufficient to provide a return motor superior in energy to the maximum energy exerted by the advancing motor, but as the indexing carriage advances differ-

ententially depending upon the number of denominational places in the amount set up, it was returned at different speeds, and oftentimes necessitated the provision of an elaborate cushioning or shock-absorbing mechanism to prevent damage and injury to the parts.

I have contrived a means to return the field of value-representing elements 78 to its starting position, which means automatically accommodates itself to the differential advance of such field, that is to say, the returning means operates to restore the field of elements at an even, constant speed irrespective of the extent of advance of such field and of the progressive resistance provided by the energization of the advancing motor as the field restores to its starting position.

In effecting this result, the manually operable carriage-return arm or member 157 (Figs. 2, 27-29 and 31) conveniently lends itself for use in the automatic restoration of the carriage, and a further economy of parts is effected by utilizing the oscillatory carriage support or cradle to store energy in the carriage return motor.

As one means to accomplish these ends, there is provided a spring-tensioning or motor energizing arm 220 (Figs. 2, 22, 24-28 and 30), pivotally mounted at its rear end on the right-hand trunnion 82 of the cradle or rocking support for the field of elements 78. The energizing arm extends forwardly, over and beyond the front rail 81, and a depending link 222 connects the free end of the arm with an operating lever 223 extending at right angles to the energizing arm 220, and pivoted at 224 to the bracket 159 on the fulcrum block 63. One end of a counter-balancing carriage return spring or motor 225 is connected to the energizing arm 220, the opposite end of the spring being anchored to a stud 226 projecting from the right-side frame 51, the counter-balancing return spring operating to yieldingly hold the energizing arm down against the front rail 81 and maintain the operating lever 223 in its lowest position.

This counter-balancing spring 225, in the normal idle position of the machine, is under sufficient tension to about counter-balance the tension of the carriage-advancing spring 114 when the latter is fully energized, but with the parts in such positions, the counter-balancing spring has no effect on the traveling field 78, due to the disconnection of the operating lever 223 from the projection 229 on the return arm 157.

Conveniently, the free end of the energizing arm 220 is bent downwardly at such an angle where the link 222 connects therewith, as to impart a substantially vertical pull and thrust on the link and the operating lever, as the energizing arm is rocked upwardly and downwardly, respectively.

The operating lever 223 has a loose connection with its headed pivot stud 224 (Figs. 4 and 31) which permits the operating lever a limited amount of lateral or skew play at its free end, and it will be noted that the pivotal connection 227 between the upper end of the link 222 and the energizing arm 220 lies at right angles to the pivotal connection 228 between the lower end of the link and the operating lever, to permit lateral play of the operating lever.

The operating lever 223 and the manually-controllable carriage return member 157 rock in substantially parallel planes, the operating lever extending across the rear face of the enlarged foot of the carriage return member at a point adjacent a roll or projection 229 on the foot.

The free end of the operating lever 223 terminates in a beak 230 (Figs. 29 and 31) adapted to co-act with the front and rear sides, respectively, of a substantially vertical guide bar 231 fastened to and projecting from the inner face of the right-hand side frame 51.

A depending switch finger 232 (Figs. 22, 30 and 31) is pivoted at 233 to the inner face of the right-hand side frame 51 slightly in advance of the guide bar 231, the lower end of the switch finger being rearwardly inclined and of sufficient length to extend across the lower end of the guide bar and past the plane of the rear face of such bar. A spring 234 connected to the upper end of the switch finger, presses the lower inclined end thereof against the lower end of the guide bar.

A similar switch finger 235 arranged reversely to the switch finger 232, is pivoted at 236 to the inner face of the right-side frame 51 slightly behind the rear side of the guide bar 231, the switch finger 235 extending upwardly behind the guide bar 231 and being inclined forwardly at its free end to extend across the upper end of the guide bar and project past the plane of the front side thereof. A spring 237 presses the inclined free end of the finger against the upper end of the guide bar, and the body portions of the reversed switch fingers 232 and 235 are located sufficiently apart from the guide bar 231 to enable the beak 230 of the operating lever to pass between the sides of the guide bar and the respective switch fingers.

With the parts in their normal home positions, the index carriage-return spring 225 holds the energizing arm 220 down upon the front rail 81, and the energizing arm, through its link connection 222 with the operating lever 223, holds the latter in lowered position.

It will be remembered that the free end of the operating lever 223 is afforded a limited forward and backward lateral play, and as the operating lever, when in its lowered position, lies within the range of action of the foremost spring-pressed switch finger 232, the inclined free end of the finger forces the beak of the operating lever rearwardly so that the beak lies in line with the rear side of the guide bar 231 near its lower end, to hold the operating lever out of alignment with the projection 229 (Fig. 4) on the carriage return member 157.

By maintaining the operating lever 223 normally out of line with the projection 229, the lever is prevented from interfering with the carriage-return member 157 which may lie at either limit of its travel, and is at such times, operable by the correction key 146, as heretofore explained. When the carriage is in its starting position, prior to depression of any numeral key 54, the advancing motor spring 114 is fully energized and is holding the abutment 119 (Figs. 12, 14, 16 and 18-20) of the carriage 78 against the lip 116 of the first of the series of effective escapement stops 111.

The numeral keys 54, when depressed, position the corresponding value-representing elements 77, and displace the escapement stops 111 successively, to enable the carriage-advancing spring 114 to feed the carriage step by step towards the left to an extent equal to the number of denominations in the amount set up, after which the main drive shaft 206 is rotated through a complete cycle to rock the horizontal cradle and the vertical indexing carriage, first clockwise, and then counter-clockwise (Figs. 5 and 6), through an arc of constant extent.

As the cradle rocks clockwise out of its normal horizontal position, its front rail 81 presses against the lower edge of the energizing arm 220, and rocks the latter upwardly, (see Fig. 25), tensioning the counter-balancing spring or main return motor 225, and through the link connection 222, swinging the operating lever 223 upwardly, the free end or beak 230 of the operating lever wiping along the rear side of the guide bar 231 until, as the end of the clockwise travel is reached, the beak 230 escapes past the upper end of the guide bar 231, whereupon the rear switch finger 235, which has been forced backwardly against the tension of its spring 237 by the beak 230 as it approached the upper end of the guide bar and wiped along the inclined end of the switch finger, operates to switch or shift the operating lever forwardly until it lies in line with the front face of the guide bar 231, (see Fig. 28) and overhangs the projection 229 on the foot of the carriage-restoring member 157.

The sweep of the operating lever, under control of the energizing arm 220 is sufficient to locate it above the projection 229, in any position which such projection may occupy, as a result of the differential advance of the indexing carriage, for instance.

As the cradle returns counter-clockwise to its normal horizontal position on the second half-cycle of rotation of the main drive shaft, its front rail 81 releases the energizing arm 220 and operating lever 223 to the action of the counter-balancing spring or return motor 225, which draws the energizing arm downwardly, following the front rail 81, and rocking the operating lever 223 downwardly to cause the latter to pick up the projection 229 on the carriage-restoring member 157 and rock the member clockwise (Fig. 28) until the stud or roll 160, mounted on the upper free end of the carriage-restoring member collides with the segmental return plate 161 of the indexing carriage.

When an amount has been set up in the indexing field 78, the carriage-restoring member 157 will contact with such return plate 161 at some time prior to the completion of the last half of the return stroke of the main drive shaft, and hence, prior to the complete return of the indexing field to its vertical plane, at which point the locking wing 215 is disengaged from the grooved locking bar 216.

Obviously, the maximum energy stored in the counter-balancing spring 225 increases by the lifting action of the rocking cradle on the energizing arm 220 during the first half-rotation of the main drive shaft 206, and decreases proportionately during the second half-rotation of the main drive shaft as the energizing arm returns towards its normal position, until the energizing arm is arrested by contact of the carriage-return member 157 with the return plate 161 on the carriage.

So long as the locking wing maintains its engagement with the locking bar, the carriage return member 157, operating lever 223 and energizing arm 220 remain in the positions in which they were arrested at the time of collision of the carriage-return member with the segmental return plate 161, and as a result the energy remaining at such time in the counter-balancing spring 225 in excess of its normal energy, is conserved for use in returning the carriage to and past its starting position.

It will be understood that if the amount set up at the beginning of the operation exhausted

the capacity of the field of elements, the latter will have advanced to its farthest position to the left, and the energy of the advancing motor 114 will be at its minimum. In such event, the carriage-return member 157 will collide with the return plate 161 of the field of elements early in the second half of the rotation of the main drive shaft 206, at a time when the counter-balancing motor 225 is energized to its maximum effective power, and as soon as the locking wing 215 releases itself from the locking bar 216, at the time when the main drive shaft is completing its cycle, the counter-balancing motor is free to draw the energizing arm 220 and operating lever 223 downwardly, pressing the lever against the projection 229 on the carriage-restoring member 157 to rock the restoring member clockwise towards its starting position, and return the field of elements to and slightly past its starting position.

At the beginning of such return, the counter-balancing motor 225 is superior to the relaxed advancing motor 114, and is capable, under some conditions, of restoring the carriage to and past its starting point by its inherent power.

In so doing, however, the counter-balancing motor must overcome the frictional resistance offered by contact of the set elements 77 with the curved resetting bar 169, and the opposition of the spring detents 102 in passing over the cams 105 on the value-representing elements, and the similar frictional resistance offered by the escapement stop resetting shoe 165 (Figs. 11-16, 19 and 20) in resetting the escapement stops 111, as well as the friction between the indexing carriage and its cradle, and the increasing energy stored in the advancing motor 114 as the carriage travels to the right.

In rapid operations of the machine, during which the energy of the counter-balancing motor is quickly applied to the carriage-restoring member 157, experience has shown that it is possible to impart sufficient momentum to the indexing carriage 78 to return it from its more advanced positions to its starting position, but in slow operations of the machine, when the carriage has been advanced a comparatively short distance the counter-balancing spring alone cannot be always relied upon to restore the carriage to starting position.

It will be noted that the carriage feed or advancing-spring or motor 114 and the counter-balancing spring or motor 225 are in opposition so that as the carriage returns, the tension of the feed spring 114 increases as the tension of the counter-balancing spring 225 decreases, and if no further provision is made, there will be a material slowing up or deceleration of speed of the carriage on such return.

Were this result avoided by providing a much stronger spring in place of the counter-balancing spring 225, to overcome the feed spring when the latter is under its greatest tension, then the application of the power of such stronger spring to the index carriage at a time when the carriage has been fully advanced, with a consequent loss of energy by the feed spring, would result in returning the carriage at an unreasonable speed.

In other words, the advance of the carriage or field of elements 78 to the extreme end of its travel results in the de-energization of the feed motor 114 to its minimum. If at such time, the power of an inherently stronger counter-balancing motor, at its maximum, should be suddenly

applied to the carriage to return the latter to its starting position, the carriage would be returned at very high speed, and the provision of a buffer or cushioning device therefor, would be imperative.

I have deemed it a better plan to provide a compensating or auxiliary spring or motor, associated with the counter-balancing motor 225 in such manner that it will be energized proportionally to the extent of advance of the indexing carriage, and will supplement the counter-balancing motor in effecting the return of the indexing carriage at a substantially constant or even, speed irrespective of the extent of advance of such carriage.

To this end, I conveniently attach one end of a spring motor 238 (Figs. 2-4 and 24-28) to the pivot 211, connecting the rear end of the drive link 208 and the depending arm of the right-hand end piece 79 of the cradle or carriage support, the remaining end of the spring being connected to the energizing arm 220. The compensating spring motor 238 is normally under some tension, but since the axis of rotation of the end piece 79 and of the energizing arm 220 is the same, it is evident that no additional energy is stored in the compensating motor as long as the carriage support and the energizing arm turn simultaneously in the same direction around their common pivot 82.

This condition obtains upon an idle operation of the main drive shaft 206, with the indexing carriage in its starting position, during which idle operation, the driving disk 209 rocks the carriage support, including the end piece 79 and front rail 81 forwardly and backwardly through a fixed arc about the center 82, and the front rail simultaneously raises and lowers the energizing arm 220 about the same center to tension the counter-balancing spring 225, but without further tensioning the compensating spring 238, since its ends move together first in one direction and then in the other.

In effective operations, however, it will be remembered that the energizing arm 220 is arrested on its return, due to the locking engagement of the wing 215 and the locking bar 216, in one or another of its partially raised positions according to the position to which the indexing carriage has been advanced, the main drive shaft 206 thereafter completing its cycle of movement, to return the carriage support, including the end piece 79 and front rail 81, to its normal horizontal position, and the carriage 78 to its vertical position, and it is not until the carriage is completing such return to the vertical that the locking wing 215 disengages from the locking bar 216 to free the counter-balancing spring for operation. The wing 215, therefore, constitutes a means for timing the return of the carriage to occur after the machine has completed its other functions.

The length of time during which the energizing arm 220 remains suspended in its partially returned position varies with the distance through which the carriage has advanced, and determines the degree of energy developed in the compensating motor 238, which is additionally tensioned proportionally to the advance of the carriage, as a result of the arrest of the energizing arm 220.

Thus, as the end piece 79 with its stud 211 continues its uninterrupted return rearwardly, from the position shown in Fig. 25 to the position shown in Fig. 26, notwithstanding the arrest of the energizing arm 220, the compensating spring

238 is progressively energized more or less depending upon the point in its return at which the energizing arm (to which the opposite end of the compensating spring is fastened) is arrested.

It therefore results, that, as soon as the locking wing 215 disengages itself from the locking bar 216, the energy remaining in the counter-balancing motor 225 is supplemented by the energy accumulated in the compensating motor 238, to return the indexing carriage to and past its starting position.

In so doing, the energy of the counter-balancing and compensating motors is exerted upon the operating lever 223 which, it will be remembered, is shifted over by the rear switch finger 235 to the front side of the guide bar 231 when at the upper end of its stroke, the beak 230 of the operating lever riding down between the front side of the guide bar and the forward switch finger 232 to maintain the contact of the operating lever with the projection 229 on the carriage return member 157 until the latter has restored the carriage past its starting position, at which time, the beak 230 has descended to a point below the lower end of the guide bar 231, and has wiped along the inclined lower end of the forward switch finger to force the latter counter-clockwise against the tension of its spring 234. As soon as the beak 230 clears the lower end of the guide and retaining bar 231, the switch finger 232 shifts the operating lever 223 rearwardly to disengage it from the projection 229 on the carriage return member 157 and position the beak in line with the rear side of the guide bar preparatory to another operation of the machine.

Immediately that the carriage restoring member 157 is relieved of the tension of the motors 225 and 238, upon the disengagement of the operating lever 223 from the projection 229 of the carriage return lever 157, the carriage advancing motor 114 asserts itself to draw the index carriage to the left until the carriage is arrested by contact of its abutment 119 (Figs. 12, 14, 16, 18 and 19) with the first of the series of replaced escape-ment stops 111.

The compensating motor 238 shown, is of such nature that its energy decreases as the index carriage restores to its starting position, and to reduce the rate of such loss to the minimum, the terminals of the compensating spring are located on opposite sides of the center 82 about which such terminals rock in the operation of the machine.

The arrest of the energizing arm 220 at any point intermediate its limits of movement while the pivot point 211 continues its rearward travel results in energizing the compensating spring 238 and in positioning it more nearly diametrically of the center 82.

In other words, during an effective operation of the machine, the upper end of the compensating spring remains stationary upon the arrest of the tensioning arm 220, while the lower end is being carried rearwardly by the uninterrupted return of the carriage support.

This movement of the lower end of the compensating spring not only tensions the spring, but also brings it closer to the center 82.

It will be understood that the more nearly the ends of the compensating spring 238 and the center 82 are brought into alignment, the less effective is the power exerted by the compensating spring on the energizing arm 220 when the latter is free to operate.

Similarly the greater the angular relation of

these three points, the greater will be the power exerted by the spring.

It appears, therefore, that the compensating spring 238, having been tensioned as explained, and positioned towards the axis of the energizing arm 220, will exert its minimum energy at the beginning of the return of the carriage when the counter-balancing spring 225 is strongest. As the carriage continues its return with a consequent decrease in power of the counter-balancing spring and increase in power of the advancing spring 114, the spring 238 compensates therefor, because of the fact that the upper end of the compensating spring moves with the energizing arm which shifts the point of application of power of the spring away from the center 82, until finally at the end of the return movement of the carriage, when the advancing spring 114 is at maximum tension and the counter-balancing spring 225 at minimum tension, the compensating spring will be exerting nearly its maximum power notwithstanding some loss of strength.

The arrangement and relation of the three springs 114, 225 and 238 is such that a substantially uniform return speed of the carriage is secured by regulating the energy of the two carriage return springs 225 and 238 in proper proportion to the increase in tension or energy of the advancing spring 114.

The energy normally residing in the counter-balancing spring 225 and the compensating spring 238 is sufficient to overcome the energy of the carriage advancing spring 114, when the parts are in their home positions.

Full stroke mechanism

Since the operating lever 223 is one of the last elements to complete its travel, it is convenient to place the full stroke mechanism under control of such lever, in the following manner:

The tooth 241 (Figs. 22, 24-26 and 31) of a dog 242 pivoted at 243 to the inner face of the right-hand side frame 51 is adapted to co-act with a shoulder 244 formed on a disk 245 fast to and turning with the main drive shaft 206.

Normally the beak 230 of the operating lever 223 rests on the rearwardly extending tail 246 of the full stroke dog 242 when the machine is idle, to retain the tooth 241 of the dog disengaged from the locking shoulder 244 of the disk 245, the tooth lying in position to take over the shoulder when the parts are in their normal positions.

The main drive shaft 206, on starting to rotate, first turns the disk 245 to remove the shoulder from proximity to the dog, and thereafter, as the rail 81 of the carriage support or cradle rocks upwardly and lifts the energizing arm 220 and operating lever 223, the latter releases the dog to the action of a spring 247 which draws the tooth of the dog into contact with the circular periphery of the locking disk 245 in readiness to engage the shoulder 244 and prevent a succeeding operation of the machine until the parts have returned to normal as a result of the preceding operation.

Should the main drive shaft 206 be operated so rapidly as to "beat out" the return of the spring-actuated indexing carriage to its starting position, the locking shoulder 244 of the full stroke disk 245 will contact the locking tooth 241 and prevent a succeeding operation of the main drive

shaft, prior to the arrival of the operating lever 223 in its normal lowered position.

The operating lever returns to its normal position, when the index carriage has been completely returned, and again depresses the tail 246 of the dog to withdraw the tooth 241 from the locking disk 245 and thus free the machine for another operation. The tail 246 is of sufficient length to enable the operating lever to maintain contact therewith in either its forward or rearward positions.

Attention is directed to the fact that the return of the indexing carriage is effected by spring action and may continue past the time of completion of a rotation of the main drive shaft.

The advantage thus obtained is that the entire second half of the cycle of operation of the machine can be devoted to the performance of the carrying or transfer operation, as will be referred to hereinafter.

The main drive shaft 206 is rotatable in but one direction only, thereby differing from many machines of the prior art, the main drive shafts of which are turned in one direction when performing addition, and in the reverse direction when performing subtraction.

To prevent any attempt to reversely turn the main drive shaft 206 from its starting point, there is provided a detent 248 (Figs. 2 and 24-26) pivoted at 249 to the outer face of the right-hand side frame 51, the free end of which detent is pressed by a spring 250 into a cam notch 251 formed in the periphery of the driving disk 209 fast on the outer end of the main drive shaft. With the parts in normal position, the free end of the detent lies in the notch 251 of the disk.

Rotation of the main drive shaft counter-clockwise (Fig. 2) causes the disk 209 to cam the detent out of the notch, but any attempt to turn the main drive shaft clockwise will be obstructed by contact of the detent with the abrupt wall of the notch 251.

Totalizer mechanism

It will be recollected that, in the particular form of mechanism selected to illustrate this invention, the main drive shaft 206, during the first half of its cycle, rocks the cradle or indexing carriage support clockwise through a constant arc of ten increments to press the set or projected value-representing elements 77 mounted in the advanced indexing carriage, against the rear contact members 194 of those actuators 175 corresponding denominationally with the set elements, and, according to the first theory of operation, advance such actuators respectively through the number of increments corresponding to the values of the individual set elements. The actuators are advanced against the tensions of their individual return springs 191 (Figs. 3-5, 17 and 23).

The main drive shaft, on the second half of its cycle, rocks the carriage support and indexing carriage back to the positions from which they were swung, thereby withdrawing the projected or set elements from the contact members 194 to enable the spring 191 to restore the advanced actuators 175 to their normal positions preparatory to another operation of the machine.

The actuators, on their advance, turn their corresponding totalizer wheels 176 to register thereon the amount set up in the field of elements. The totalizer wheels being normally disengaged from the actuator means now to be explained, is operated by the main drive shaft 206

as it starts the first half of its cycle of operation, to engage the totalizer wheels with their actuators, such means being operable as the main drive shaft starts the second half of its cycle, to permit the totalizer wheels to disengage from their actuators.

The totalizer commonly comprises a plurality of totalizer wheels 176 (Figs. 1, 3, 5, 6, 23 and 35-43) journaled for independent rotation on a totalizer shaft 255, which is itself supported for rotation at its opposite ends in the cheek pieces 256 of a rocking totalizer frame, comprising such cheek pieces and a tie bar 257 (Figs. 5 and 6) extending between and rigidly connecting the cheek pieces at points below the totalizer shaft 255.

An ear 258 at the upper rear end of the left-hand cheek piece 256 is pivotally mounted on the reduced left-hand end 259 of a guide rod 260 mounted in the left-hand side 262 of a totalizer carriage, the guide rod extending between the sides 261, 262 (Fig. 35) of such totalizer carriage. A similar ear 258 at the upper rear end of the right-hand cheek piece 256 is pivoted on a lag screw 263 connecting the right-hand side 261 of the totalizer carriage with the guide rod 260, the pivotal connections of the cheek pieces enabling the rocking frame supporting the totalizer wheels to swing back and forth relatively to the totalizer carriage in the operation of engaging the totalizer wheels with and disengaging them from the actuators 175.

The totalizer shaft 255 projects through arcuate apertures (Fig. 1) in the sides 261, 262 of the totalizer carriage and extends some distance beyond the sides of the totalizer carriage, both ends of the shaft being provided with twirlers or finger wheels 264 (Figs. 1 and 3) for use in clearing the totalizer or resetting it to zero, as explained hereinafter.

Totalizer wheel structure

The totalizer wheels are all alike and will be described in connection with the drawings illustrating the indicator wheels 500, 501 which possess many features identical with the totalizer wheels.

One convenient form of indicator wheel is illustrated in detail in Figs. 36-38, both inclusive, which views also serve to illustrate certain features of the totalizer wheels, Fig. 39 being included to bring out certain structure of the totalizer wheels not found in the indicator wheels. Referring to the totalizer, each wheel includes a circular rim bearing the proper indicia, as a series of equidistant numbers from "0" to "9" extending around the periphery thereof, if the machine is designed for working problems according to the decimal system.

The inner periphery of the rim carries an annular flange 265, located near one edge of the rim and mounted upon a peripheral shoulder 266 of a disk 267, the hub 268 of which is journaled on the totalizer shaft 255.

The right-hand face of the disk 267 may lie flush with the right-hand edge of the rim, the left-hand edge of the rim extending past the plane of the left-hand face of the disk body 267 and co-acting with the left-hand end of the hub 268 to form an annular chamber housing a correspondingly shaped coiled spring 269. A friction latch, as a stud 270 (Fig. 36), passes through a radial aperture in the left end of the hub 268, the spring 269 pressing against the head or outer end of the stud to yieldingly hold the inner point-

ed end of the stud in any one of a number of equidistant seats 271 formed about the periphery of the totalizer shaft 255.

The number of seats corresponds with the number of cardinal integers, arranged equidistantly around the rim of the wheel; in this instance, ten, the seats lying in the same radial lines with the cardinal integers on the rim of the wheel. A plurality of friction studs 270 may be employed, as indicated in Fig. 36.

A retaining ring 272 mounted on the extreme left-hand end of the hub cooperates with the disk 267 to hold the annular spring against lateral displacement.

A ten-toothed pinion 273 (see also Figs. 5, 6, 35, 42 and 43) mounted on the reduced right-hand end of the wheel hub 268 is in constant mesh with the corresponding intermediate gear 274 of a series of gears journaled on a cross rod 275 seated in a longitudinally extending groove 276 (Figs. 5, 6, 42 and 43) formed in the upper edge of the tie bar 257, such bar being transversely slitted along its upper edge, as at 277, to accommodate the respective intermediate gears and hold them in spaced relation, the slits intersecting the groove 276.

The ends of the cross rod 275 are rigidly mounted in the opposite cheek pieces 256 of the totalizer frame, and fastening means 278 (Fig. 3), passing through the cross rod and into the tie bar 257, may be provided to secure the cross rod in place.

I preferably form separate denominational rows of seats 271 for the inner ends of the friction latches 270 of each totalizer wheel, the ends of which seats merge into the peripheral face of the shaft, as shown in Figs. 38 and 39. The annular springs 269 press the latches into the deepest parts of the seats, which tends to prevent shifting of the wheels axially of the shaft. A spacing collar 279 (Fig. 35) on the totalizer shaft 255, between the right-hand cheek piece 256 and the units wheel, and a bracket 280 projecting upwardly from the tie bar 257 and hooking over the totalizer shaft 255 in contact with the left-hand end of the hub 268 of the wheel of highest denomination, positively maintain the wheels against axial movement and retain the pinions 273 thereof in line with the intermediate gears 274.

Totalizer engaging and disengaging mechanism

The intermediate gears 274 are automatically engaged with and disengaged from the actuators 175 at the proper times, at each operation of the machine, under control of the main drive shaft 206, the left-hand end of which projects beyond the left-hand side frame 52 of the machine, as best shown in Figs. 4, 54 and 60, and carries a quick-acting cam 284 with which contacts a roll 285 on one arm of a lever 286 pivoted at 287 to the outer face of the left-hand side frame and bifurcated at 288 to embrace the tie bar 257 of the rocking totalizer frame, which frame projects to the left of the left-hand side 52 of the machine. A spring 289 connected to the opposite arm of the totalizer engaging lever 286 yieldingly holds the roll 285 in contact with the cam 284 at all times.

A restoring spring 290 connected to the left-hand cheek piece 256 and the left-hand side 262 of the totalizer carriage tends to hold the totalizer rocking frame at one limit of its rocking movement, with the intermediate gears 274 disengaged from the actuators 175.

The main drive shaft 206, as it starts its cycle of operation, rocks the indexing carriage 78 idly through its first increment of movement, during which, the totalizer-engaging cam 284 turns, forcing the roll 285 on the totalizer-engaging lever 286 to ride up the abrupt face of the cam from the low point to the high point thereof, to thereby rock the lever 286 counter-clockwise (Fig. 54) and swing the totalizer frame, against the tension of its disengaging spring 290, towards the actuators 175 which are still in their normal positions at this time, to mesh the intermediate gears 274 therewith.

During the remaining nine increments of movement of the main drive shaft on the first half cycle of operation of the main drive shaft, the high dwell portion of the cam 284 wipes past the roll 285 of the totalizer-engaging lever 286 to maintain the latter in shifted position with the intermediate gears 274 in mesh with the actuators 175, which advance according to the amount set up on the keyboard and turn their corresponding intermediate gears and totalizer wheels to register such amount thereon.

During the first increment of the second half cycle of rotation of the main drive shaft 206, the totalizer-engaging cam 284 presents its opposite abrupt face to the roll 285, which quickly rides down such face to the low point of the cam, releasing the totalizer-engaging lever 286 to the action of its spring 289 which returns the lever to its normal position. At the same time, the totalizer frame restoring spring 290 assisted by the spring 289 rocks the totalizer frame counter-clockwise (Fig. 54) to disengage the intermediate gears 274 from the actuators.

Totalizer aligning and actuator detaining mechanism

To prevent the possibility of a partial return of the advanced actuators during the first increment of the second half rotation of the main drive shaft, which might cause a reverse rotation of the corresponding totalizer wheels through one or more steps, resulting in an erroneous accumulation, there is provided means to detain the actuators temporarily in the positions to which they have been advanced, and to lock all the actuators until the disengagement of the intermediate gears 274 therefrom is completed, such means also conveniently operating through the actuators to properly align the totalizer wheels 176 to display the proper numerals at the reading line.

To these ends, the main drive shaft 206 (Figs. 4-6 and 23), at a point adjacent the inner face of the left-hand machine side frame 52, carries an aligner-operating cam 294 having a single node 295. One arm 296 of an aligner bail 297, the arms of which are pivoted at 298 to the inner face of the left-hand machine side frame and to the left-hand face of the partition plate 53, respectively, bears a forwardly extending offset 299 on which is mounted a roll 300. A spring 301 attached at one end to the aligner bail 297, presses the roll 300 against the operating cam 294, the node 295 of which cam is so positioned relatively to the high portion of the totalizer-engaging cam 284, that as the descending face of the cam 284 is brought opposite the roller 285 of the totalizer-engaging lever 286, the node contacts the roll 300 of the aligner bail 297 and quickly rocks the latter into engagement with the teeth 189 of the actuators 175, before the latter can retract.

The node 295 is of such extent as to maintain the aligning bail effective during the time necessary to disengage the intermediate gears 274 from the teeth 189 of the actuators 175, after which the node escapes past the roll 300, thereby freeing the aligning bail 297 to the action of its spring 301 which immediately withdraws the aligning bail to its idle position, to enable the actuators 175 to return counter-clockwise (Fig. 6) to their normal idle positions.

The aligning bail 297 is of sufficient length to engage the whole set of actuators, and is equipped along its effective edge with an angular rib 302 adapted to fit snugly in the throats between adjacent teeth 189 to align the actuators in position, and through the actuators, center the totalizer wheels 176 relatively to the reading line.

Over-rotation preventer

The indexing carriage 78 is mounted to oscillate with the cradle, which latter is directly driven from the main shaft 206 by the disk 209 and link 208, and as a result the projected or set elements 77, mounted in the indexing carriage, directly advance the corresponding actuators 175 which rotate the totalizer wheels 176 through angular distances corresponding to the values set up.

The totalizer wheels 176 rotate on their shaft 255, their friction latches 270 riding out of and into the successive seats 267 in the shaft.

Because of the direct drive connection between the main shaft and the index carriage, it might occur that in rapid operations of the machine, the momentum imparted to the actuators 175 and by them communicated to the totalizer wheels 176 would cause the latter to over-rotate, when adding digits less than 9, and the engagement of the aligner rib 302 with the actuators would force the totalizer wheels or certain of them ahead to complete the step, thereby resulting in an incorrect registration.

In the present construction the length of the slots 188 in the forward ends of the actuators 175 may be such that when the actuators advance nine steps, the lower end walls of the slots abut the limit rod 185 to prevent farther advance of the actuators.

Heretofore, many machines have depended upon detents timed to engage the totalizer wheels at the end of the driving stroke of the actuators to prevent the momentum stored in the wheels from causing an over-rotation of the wheels upon the disengagement of the wheels and actuators, but since, in rapidly successive operations, the wheels are hardly brought to rest before they are again turned on the succeeding operations, the timing of the over-rotation detents must be very close.

Rather than depend upon means directly engaging the totalizer wheels to prevent over-rotation thereof, I have considered it better to apply such over-rotation preventing mechanism directly to the cause of such over-rotation, namely, the actuators themselves, and as one such means I have contrived a very simple, strong and positively operating mechanism which is certain in its action and not readily liable to become out of order.

To these ends, the tail of each actuator 175 is provided with a convexly arcuate rack 305 (Figs. 3-6, 22, 23, 33, 34 and 53), the lower ends of which lie just out of mesh with a series of over-rotation preventing pinions 306 fast with each other and with a shaft 307 journaled at its opposite ends in

the left side frame 52 and the intermediate partition plate 53, respectively.

A wide drive gear 308 (Figs. 3 and 4) fast on the over-rotation preventing shaft 307 near its left-hand end, is in constant mesh with an arcuate drive rack 309 fixedly secured to the left end piece 79 of the rocking cradle or indexing carriage support. The transverse guide bar 181 for the rear contact members 194 of the actuators may be cut away, as at 310 (Figs. 3 and 4) to afford clearance for the upper free end of the drive rack 309.

As a result of this arrangement, the over-rotation preventing pinions 306 are turned first in one direction and then in the other, coincidentally with the oscillations of the indexing carriage 78, carrying the value-representing elements 77.

Preferably, the pinions 306 have ten teeth and are driven through a complete revolution in one direction during the first half cycle of rotation of the main drive shaft, and then returned to normal position on the second half cycle.

Obviously, the main drive shaft 206, as it starts to operate, commences to tilt the horizontal cradle to rock the indexing carriage and simultaneously, causes the driving rack 309, in mesh with the drive gear 308, to turn the over-rotation preventing shaft 307 with its pinions 306 counter-clockwise (Figs. 5 and 23).

It will be recalled that the main drive shaft 206, the carriage support or cradle, and the indexing carriage 78 advance idly one increment of movement, to afford time in which to mesh the totalizer 176 with the actuators 175 prior to the advance of the latter.

Assuming the indexing carriage to have advanced towards the left one or more steps, as a result of the setting up of an amount by the selection and projection of the value-representing elements 77, such elements, as they start the advance of their actuators, due to the rocking of the carriage, cause the over-rotation preventing racks 305 to immediately engage their respective over-rotation preventing pinions 306, all of which are at that time in motion.

Since the over-rotation preventing pinions only rotate nine increments of movement in addition to the first idle increment of movement, the actuators can advance but nine steps as a maximum, in adding operations according to the decimal system, but in view of the arrangement of the value-representing elements disclosed, that is, from "9" to "0" reading from rear to front, or counter-clockwise (Figs. 2 and 5) that actuator 175 which lies opposite a projected set element 77 representing "6", for example, is not advanced by such set element, until after the latter has completed four of its ten increments of movement and is starting on its fifth step of movement.

Since any set element only advances ten increments in all, and the particular element under discussion has idly traversed four of such ten increments, it can only pick up and drive its corresponding actuator through the remaining six increments, normally.

Assuming, however, that the projected element, by reason of speedy operation of the machine, imparts a smart blow to its actuator sufficient, in the absence of any over-rotation preventer, to advance the actuator and its engaged totalizer wheel at an unusual rate or speed ahead of the set element, such action is restrained in the present instance by the connection of the drive rack 309 with the universal over-rotation preventing

shaft 307 and its pinions 306, which precludes any attempt of any of the actuators to advance ahead of the others and maintains such advance uniform for all of the actuators which are being advanced.

As the digits in the vast majority of amounts set up will vary in value, resulting in a diverse or scattered arrangement of the set elements in the field, those set elements representing the higher digits being closer to their contact members 194 than the set elements representing digits of lower value, it will be clear that the corresponding actuators will be usually engaged with their over-rotation preventing pinions 306 at various times during the clockwise (Fig. 5) travel of the field of elements, but in no instance, even with the registration of a single digit only, can the actuator advance ahead of its corresponding set element, because of the driving connection between the main shaft, the field of elements and the over-rotation preventing shaft 307 and pinions 306.

Of course, those denominational actuators 175 which are not advanced into engagement with their over-rotation preventing pinions 306 remain idle.

Up to the point at which the over-rotation preventing means just explained, was referred to, the description of the operation of the machine proceeded on the theory that the set value-representing elements, when rocked clockwise from their positions shown in Fig. 5 to the positions shown in Fig. 6, constituted the means for advancing their corresponding actuators 175 against the tensions of the individual return springs 191, and for rotating the totalizer wheels 176.

Also that the withdrawal of the set elements 77 from the contact tails 194 of the advanced actuators 175, as the field of elements is rocked back from the position shown in Fig. 6 to the normal vertical position shown in Fig. 5, enables the tensioned springs 191 to return the advanced actuators counter-clockwise to their normal positions of rest.

And this theory of operation still obtains if the connection between the shaft 307 and the main drive shaft is omitted, since the springs 191 might well be of sufficient strength to turn the over-rotation preventing shaft 307 through the advanced actuators 175, in the retirement of such actuators.

However, the presence of the connection 308, 309 between the over-rotation shaft 307 and the main drive shaft places the work of advancing and returning the active actuators 175 upon the main drive shaft which traverses a single complete cycle at each operation of the machine, and through its connections with the cradle or indexing carriage support 79, 80 and 81, rocks the latter and the drive rack 309 and over-rotation preventing shaft 307 simultaneously through a fixed path of travel.

In view of such fixed path of movement of the over-rotation preventing shaft and the pinions 306 fast thereon, it is necessary, in order to effect the differential advancement of the actuators, to arrange to effect the connection between the actuators and the pinions at different times in the operation of the machine, the actuators, as they are driven forwardly by the pinions 306, operating to tension the return springs 191, which springs co-act with the pinions 306 to retire the actuators and to insure the disengagement of the actuators from the pinions to restore the actuators to their normal home positions.

Therefore, in a machine equipped with a synchronized driving means for the independently operable actuators, capable of advancing and returning the actuators through fixed extents, it is only necessary when registering amounts on the totalizer, to provide means to connect the actuators and their driving means at variable predetermined points in the excursion of the driving means, according to the distances through which it is desired to advance the actuators.

To this end the set elements 77 in the clockwise travel of the field 78, strike the contact members 194 and advance the corresponding actuators into engagement with their pinions 306 against the tensions of the individual springs 191.

The set elements 77 may be considered merely as selectors for engaging those actuators which are to become effective, with the over-rotation preventing pinions 306, these pinions thereafter serving to advance the actuators varying extents according to the denominational values of the respective keys 54 depressed and the corresponding elements set to active position.

This view of the invention is supported by the fact that the over-rotation preventing pinions 306 rotate ten steps counter-clockwise, looking from the right, and then ten steps back to their original positions, at each operation of the machine, and simultaneously with the field of elements.

The set elements 77 are made as light as possible to reduce the weight of the machine, and are supported in light material.

As a result, neither the set elements nor their support are adapted to withstand a considerable strain, and should they encounter unusual resistance during their operation, due, it might be, to some accidental condition which blocks the advance of one or more actuators 175, the elements corresponding to such actuators would be liable to be bent out of position, if not broken off.

Such bending would prevent the free sliding movement of the elements in the upper and lower heads 92, 93, and prevent the return of the set elements to their normal idle positions, which would result in locking up the machine, and warping of the carriage 78.

The presence of the pinion 306 and connected mechanism, with which the actuators are engaged by the set elements, not only prevents over-running of the actuators, but has the further object of governing or controlling the speed of advance of all of the actuators synchronously and uniformly, corresponding to the speed of rotation of the main drive shaft with which the shaft 307 and pinions 306 fast thereon are positively connected for operation.

Thus, though the actuators engage their pinions 306 at different intervals in the operation of the machine, once they are engaged, the racks all advance at the same uniform speed.

Furthermore, the pinions 306 and shaft 307, because of their positive connection with the main drive shaft 206, relieve the set elements 77 from the possibility of having to withstand any unusual strain due to the failure of the actuators to advance freely, from any cause, since the resistance of the actuators would be opposed by the main drive shaft through the pinions 306, which would either overcome the resistance or by slowing up the operation, would advise the operator of its development. Resistance might be occasioned by the presence of dirt, rust, or gummy lubricant in the slots of the guide bars 179, 180 and 181, for instance.

It will be noted that the shaft 307 and pinions 306 tie up the operated actuators in a group, which group is composed of different actuators at each operation of the machine, unless they be repeat operations.

The direct connection between the pinions 306 and drive shaft 206 constitutes a more powerful drive for the actuators 175, than the set elements 77.

Assuming an element 77 representing "9" to have been set and the main drive shaft 206 to be operated, the field of elements will be rocked one step idly to bring the set element just in front of the contact member 194 of its actuator, and simultaneously, the corresponding over-rotation preventing gears 306 will be turned through the first of their ten steps.

The set element 77 at the outset of its second step of advance, will engage its actuator 175 with the corresponding over-rotation preventing pinion 306 which also turns on its second step coincidentally with the advance of the set element and takes the work of advancing the actuator through the first of its nine steps of movement.

Continued rotation of the over-rotation preventing pinion 306 will now advance the actuator, whether the set element presses against the contact member 194 thereof or not. In fact, the set element 77 could be restored to normal after effecting the engagement of its actuator 175 with the over-rotation preventing pinion without affecting in the slightest, the registration on the totalizer of the digit set up.

At the beginning of the second half or return cycle of operation of the main drive shaft, it will be recalled that at the commencement of the first of the ten steps of such return, the aligner bar 297, 302 (Figs. 5 and 6) is engaged with the teeth 189 of the actuator racks 175 to delay return movement of the latter until the intermediate gears 274 of the totalizer can be disengaged from the actuators.

However, the drive rack 309 for the over-rotation preventer is preferably in snug mesh with its drive gear 308 and must turn the over-rotation preventing shaft 307 and its pinions 306 through such first step of return.

To prevent straining the parts at this point in the operation of the machine, which might otherwise result from turning the over-rotation preventing pinions 306 engaged with the actuators, while such actuators are locked by the aligner bail, I arrange for a slight play between the pinions 306 and the over-rotation preventing racks 305, it being understood that the engagement of the aligner bail 297 with the actuators is but momentary, the angular rib 302 being so formed relatively to the teeth 189 of the actuators as to enable the actuators to start their return as the bail disengages from the actuators.

Positive arrest of the set elements at the end of their advance

Reference has heretofore been made to the fact that the drive link 208 and drive disk 209 absolutely determine the limits of oscillatory travel of the horizontal cradle or carriage support, and the vertical indexing carriage 78 mounted thereon, the extent of such travel, of course, being substantially twice the radial distance between the pivotal point 210 of the link and disk, and the axis of the disk, but to insure the arrest of the cradle and carriage at the end of the first half cycle of rotation of the main drive shaft 206 and disk 209, there is provided a stop

311 (Fig. 23) projecting laterally inwardly from the left-hand side frame 52 of the machine to a point corresponding with the end of the clockwise path of the drive rack 309 for the over-rotation preventing shaft 307, against which stop the rack arm strikes to positively prevent overthrow of the parts, in case of looseness due to wear, for example.

Adding operation

From the foregoing, the method of and means for effecting the registration of amounts on the totalizer will be fairly understood, it being necessary merely to set up the amount in the field of value-representing elements 77 by depressing the corresponding keys 54 in the order in which the numerals of the amount are arranged from highest to lowest denomination, after which the main drive shaft 206 is given a single complete rotation.

The keys 54, by their depression, set the desired value-representing elements one by one and trip the escapement mechanism, whereby the indexing carriage 78 advances step by step to the left to position the set elements in line with the contact members 194 of the corresponding actuators.

The main drive shaft during the first half cycle of its rotation, engages the totalizer with the actuators prior to the advance of the latter, and thereafter oscillates the carriage support and index carriage towards and from the actuators, and drives the over-rotation preventer. Referring to Figs. 24-30, as the indexing carriage rocks towards the actuators, the carriage support or cradle energizes the counter-balancing carriage return spring 225 by raising the energizing arm 220 with its link 222 and operating lever 223 through a constant arc of travel, and as the carriage and its support return to the positions from which they were rocked, the operating lever restores until arrested by contact with the projection 229 on the carriage return member 157 when such return member has been arrested by its collision with the contact plate 161 of the index carriage.

During the remainder of the second half of the cycle of operation of the main drive shaft, the compensating spring 238 is energized in the manner heretofore explained, and just as the carriage and its support have arrived at their vertical and horizontal positions, respectively, while the main drive shaft is completing its cycle of operation, the locking wing 215 releases the carriage to the action of the counter-balancing and compensating springs which immediately act upon the energizing arm to rock the operating lever 223 to its lowest position, the operating lever in turn, rocking the carriage-restoring member 157 to cause it to return the indexing carriage to and a little past its starting point.

As the operating lever arrives at its lowest position, the switch finger 232 shifts the operating lever rearwardly to disengage it from the projection 229 on the carriage-restoring member, so that the latter may float back to its opposite limit of travel as the carriage advances during the setting up of the next amount, unobstructed by the operating lever.

Repeat or multiplying mechanism

It frequently occurs that the operator desires to enter the same amount two or more times successively on the totalizer, and to obviate the necessity of again depressing the same keys, as on the previous operation, to set up the amount in

the field of value-representing devices 77, it is convenient to provide means to disable the carriage-restoring mechanism, thereby enabling the operator to turn the main drive shaft continuously through the number of cycles corresponding to the number of times he desires to add the particular amount represented by the set elements 77, such set elements being returned to normal only by the restoration of the carriage to its starting position.

Obviously, multiplication of an amount may be effected by the method of repeated addition, as hereinafter referred to.

As one means to condition the machine for repeat operations, there is provided a key lever 356 (Figs. 1, 2 and 4) pivotally mounted at 357 on the right-hand subframe 57 of the keyboard, the upper arm of which key lever projects through a slot 358 (Fig. 1) in the keyboard to lie in proximity to the keys 54 and to the right thereof for ease and rapidity of operation.

The lower arm of the repeat or multiplying key lever 356 is pivoted at 359 (Fig. 2) to the forward end of a link 360, the rear end of which is pivoted at 361 (Figs. 27 and 28) to the depending arm 362 of a bail 363, the arms of which are journaled on a transverse rod 364 lying above and parallel with the base 50 of the machine. The inner end of the transverse rod 364 is rigidly mounted in a forwardly projecting lip 365 struck from the fixed bracket 159, the rod being supported intermediate its ends by a forwardly extending flange 366 of the bracket, which flange, together with a set collar 367 on the free end of the rod 364, confine the bail between them.

The remaining arm 368 of the bail projects upwardly alongside and normally out of the descending path of travel of the operating lever 223 (see Fig. 22) for the carriage-restoring member 157, the arm being of sufficient length to extend upwardly to or a little past the upper limit of travel of the operating lever.

When it is desired to repeat the addition of an amount set up in the field of value-representing elements 77, the operator rocks the key lever 356 rearwardly to draw the link 360 forwardly and rock the bail 363 clockwise (Fig. 22) thereby introducing the upwardly extending arm 368 of the bail across the return path of the operating lever, and alongside the path followed by the operating lever as it is raised to its highest limit of travel in positioning the lever above the projection 229 on the carriage-restoring member.

It will be recalled that, in the ordinary operation of the machine, the operating lever 223 at the upper end of its travel clears the upper end of a guide bar 231 behind which it is held on its upstroke, whereupon a spring-pressed switch finger 235 snaps the lever laterally forward across the end of the guide bar to position the lever over the projection 229 on the carriage-restoring member, the lever contacting such projection on its return stroke, in the operation of shifting the index carriage back to its starting position.

Positioning the restraining arm 368 of the bail 363 alongside the path of the operating lever on its upstroke, blocks the lateral shifting of the operating lever at the upper end of its stroke, so that on the continued operation of the machine, the operating lever retraces its path followed on the upstroke behind the guide bar 231 and escapes the projection 229.

As a result, the carriage return springs or motors are idly tensioned and relaxed, the carriage-

restoring member 157 is not operated, and the indexing carriage with its projected elements 77 remains in the position to which it advanced on the previous setting up of the amount.

5 Hence, the operator need only rotate the main drive shaft through another cycle to again effect the entry of the same amount into the totalizer.

10 The operating lever 223 releases the latch 242 as it returns to its starting position to enable such continued rotation of the main drive shaft.

15 A spring latch 369 (Figs. 2 and 4) pivoted at 370 to the subframe 57 of the keyboard is provided at its free end with a pair of spaced recesses to fit over an extension of the pivot stud 359 at the lower end of the key lever 356 to hold the latter in either of its set positions. A spring 371 presses the latch into contact with the stud 359.

Carry or transfer mechanism

20 In adding and calculating machines, the carry or transfer mechanism for transferring "one" to the totalizer wheel of next higher order as often as the capacity of the wheel of next lower order is exceeded, constitutes an important feature.

25 The mechanism utilized in the present invention to perform this result is of the independent actuator type, simply and strongly designed for accurate and certain operation, and not likely to get out of order.

30 To this end each carrying unit includes a normally ineffective transfer pawl operable upon the wheel of higher denomination, a combined guide and positioning means for the transfer pawl, a switch member controlled by the wheel of next lower order, and a transmitting element actuated by the switch member and operable upon the means which guides the transfer pawl to cause it to shift the pawl to effective position.

35 Correlated therewith are means to releasably retain the pawl-guiding means in either of the positions to which it may be shifted, and means to successively operate or drive the transfer pawls from the lowest to the highest denomination.

40 The pawl guide is pivotally supported in a novel manner, and ways retain the guide in its predetermined path of travel.

45 Also the pawl guide, transmitting member, and switch member are assembled for relative movement.

50 In operation, the wheel of higher denomination automatically restores the transfer pawl to its normal ineffective position as the pawl advances such wheel, and in so doing, resets the pawl guide, together with the floating transmitting member and the switch member to their normal positions preparatory to the next carrying operation.

55 Referring to the drawings (Figs. 5, 6, 35, 40-51 and 72), it will be seen that the carrying mechanism is mounted on the totalizer carriage just in advance of the totalizer wheels 176, there being, as usual, a carrying unit for each totalizer wheel except that of lowest denomination, which effects the "carry" on the wheel of next higher denomination, the carrying units being similar in construction.

60 A forwardly tilted brace bar 315 (Figs. 3, 5, 6, 42, 43 and 52) extends across the totalizer carriage directly in advance of the totalizer wheels 176, its ends being supported in the opposite sides 261 and 262 of the totalizer carriage.

65 For convenience of manufacture and assembly, the brace bar is preferably made of two pieces, as indicated by the cross-section lines in Figs. 42 and 43, but it will be referred to as a single bar. 70 Spaced in front of and at a somewhat lower plane

than the brace bar 315, is located a transverse rail 316, angular in cross section and having its ends also mounted in the sides 261 and 262 of the totalizer carriage. The rail 316, as a whole, lies parallel with the brace bar 315, one flange of the rail lying at right angles to the overhanging forward face of the brace bar.

80 A rearwardly inclined beam 317 located vertically below the brace bar 315 and at right angles thereto, extends between the sides 261, 262 of the totalizer carriage to which its opposite ends are secured.

85 The brace bar, rail and beam occupy a somewhat triangular relation and support between them the transfer pawls, the individual guide and positioning members for the pawls, and the transmitting members through which the pawls are brought to their effective positions.

90 To these ends, the upper rearwardly inclined face of the beam 317, as best shown in Fig. 44, is longitudinally grooved, as at 318, to form a seat for a cross rod 319 (Figs. 40-43) suitably secured therein against movement and having its ends projecting into apertures formed in the opposite sides 261, 262 of the totalizer carriage (Figs. 1 and 2).

95 Transverse slots 320 (see Fig. 49) along the lower edge of the beam 317 intersect the groove 318 in the beam and accommodate transfer pawl-supporting bell cranks 321 journaled intermediate their ends on the cross rod 319. The upper arms of the bell cranks terminate in fingers 322 (Figs. 42, 43 and 52) overlying the rear edge of the rail 316, with which such fingers normally contact to limit the counter-clockwise travel of the bell cranks under the influence of their restoring springs 323. The outer ends of the springs 323 are anchored to spaced lips 324 struck up from the lower projecting edge of a cover plate 325 superposed upon and secured to the inclined front face of the beam, the upper edge of the cover plate being slotted as shown in Fig. 23, to correspond with the slots 320 in the lower edge of the beam.

100 Transfer pawls 326 pivoted at their forward ends at 327 to the upper arms of the respective bell cranks 321, extend upwardly and rearwardly through transverse slots 328 (see Figs. 23, 42, 43 and 52) formed in the lower edge of the brace bar 315, into proximity to the pinions 273 of the totalizer wheels 176. The free ends of the pawls terminate in heads having an abrupt working face 329 (Figs. 42, 43, and 52) adapted to press against the flank of a tooth of the pinion 273 to advance its corresponding totalizer wheel 176 one step, the lower edge of the head being chamfered as at 330, to form a camming surface against which the succeeding tooth of the pinion operates as the working face 329 presses against the preceding tooth, for a purpose soon to be explained.

105 Normally, the restoring springs 323 maintain the transfer pawls 326 withdrawn from the pinions 273 to prevent interference therewith as the latter are turned by the actuators 175, or are reset to zero.

110 The lower arms of the transfer pawl-carrying bell cranks 321 project below the beam 317 into the orbits of a series of radial cams 331, 332 (Figs. 4-6) spirally arranged about, and turning with, that portion of the main shaft 206 extending between the left side frame 52 of the machine and the partition plate 53, whereby the cams successively contact the respective bell cranks 321 of progressively higher denominations or anti-friction rolls 333 thereon, to actuate the transfer pawls 321 from lowest to highest denomination, one after

the other in regular order. The series of radial cams 331, 332 extend only part way round the main drive shaft, so as to become effective only after the disengagement of the totalizer wheels and actuators.

During the second half cycle of each operation of the machine, the radial cams 331, 332 rock the bell cranks 321 clockwise to cause them to project their transfer pawls 326 rearwardly towards the totalizer pinions 273, and to prevent such action from effecting an undesired advance of the totalizer wheels when no carrying action is required, there is provided a series of guide and positioning members 334, one for each transfer pawl, such members each comprising a rocking plate of an irregular rectangular shape, arranged closely adjacent its transfer pawl 326 and supported between the brace bar 315 and the rail 316 at right angles thereto.

The guide and positioning members 334, near what may be termed their upper forward corners (Figs. 42, 43, 47, 48 and 52) are each provided with an undercut or dove-tailed recess 335 to embrace and pivot upon the rear edge of the angular rail 316, the opposed overhanging forward face of the brace bar 315 being transversely grooved, as at 336, to form ways in which the irregularly contoured rear edges of the respective guide and positioning members are accommodated, to maintain the guide members in their vertical planes.

A pair of spaced studs or projections 337 extending laterally from the left side of each guide and positioning member 334 embrace the neck of the transfer pawl 326 with which the member is associated, to control the position of the latter relatively to its totalizer pinion 273 and to guide the pawl in its reciprocation.

The upper edge of each guide plate 334 is slotted as at 338 (Figs. 42, 43, 47 and 52), to form a rearwardly extending pilot 339, on which a cylindrical latch 340 is rotatably mounted. Each latch is formed with an axially-extending, round bore to accommodate its pilot and enable the latch to slide back and forth thereon. The latch is also provided with a peripheral longitudinally-extending groove 354 (Fig. 72). The rear end of each latch is oppositely beveled, as at 341, and a spring 342, encircling the pilot 339 between the abrupt front end of the latch 340 and the end wall of the slot 338 in the plate 334, yieldingly forces the beveled end of the latch towards the free end of the pilot and against an opposed beveled rib 343 extending longitudinally of the overhanging face of the brace bar 315. The transverse guide ways 336 for the rear edge of the plate extend across the beveled rib 343 to accommodate the free ends of the several pilots 339.

An offset 344 in one wall of the slot 338 facilitates the assembly of the latch and spring on the pilot, the latch 340 being rotatable on the pilot 339 for assembly and disassembly, when manually pushed back against the tension of its spring 342 into register with the offset 344 to release the groove 354 (Fig. 72) from the rear wall of the slot 338, which is normally embraced by the latch, as shown in Figs. 23, 42, 43 and 52, to prevent rotation of the latch on its pilot.

The foregoing construction enables each of the guide and positioning members 334 with their guide studs 337, to have a limited rocking movement on the rear edge of the angular rail 316 as a fulcrum, the spring-pressed latches 340 operating to hold the guide and positioning members 334 in their upper positions, when the lower bevels

of the latches lie in contact with the upper bevel of the rib 343, at which time, the studs 337 hold the transfer pawls 326 at such an angle relatively to their totalizer pinions 273 that the pawls, on their reciprocation, pass over the teeth of the pinions without contacting therewith, as shown in Fig. 52, wherein the transfer pawl is illustrated at the rearmost end of its travel.

However, when a totalizer wheel 176 of lower order has been rotated by its actuator 175 to such extent that upon the next step of movement the capacity of the wheel will be exceeded, it is necessary to arrange for the addition of "1" on the wheel of next higher order on that operation during which the capacity of the wheel is exceeded.

To accomplish this result, the totalizer pinions 273 of the totalizer wheels, are each provided with a trip finger 345 (Figs. 39, 40, 42 and 43) comprising, in the present instance, a lateral extension from one of the teeth of the pinion, adapted, as the wheel passes from its "9" to its "0" position at the reading line, to wipe over the inclined face of a cam 346, best shown in Figs. 42 and 43, carried on a switch member or arm 347, one of which is journaled by one end on the cross shaft 275 alongside each of the intermediate gears 274.

The free end of each switch member 347 rests loosely upon an extension 348 (Figs. 42, 43, 45 and 46) projecting to the right from a transmitting member or slide 349 shiftably mounted in a groove 350 (Fig. 44) formed transversely of the upper inclined face of the beam 317, adjacent the guide and positioning member 334 to the left of the totalizer wheel of lower order.

The transmitting members 349 correspond in number with the number of switch members 347, and lie to the left of their respective guide and positioning members 334 (see Fig. 41) to enable the extensions 348 of such transmitting members to overlie and contact with inclined tails 351 (Figs. 42, 43 and 47) projecting rearwardly from what may be termed the lower right-hand corners of their associated guide and positioning members or plates 334, which tails occupy inclined slots 352 formed in the upper rear corner of the beam 317.

These transmitting members are recessed, as at 353, (Figs. 42, 43 and 45) to afford a clearance for the cross rod 319, the cover plate 325 operating to retain the transmitting members in their grooves in the cross beam 317.

The bottom edges of the switch members 347 ride back and forth on the lateral extensions 348 of their transmitting members 349 as the totalizer frame is rocked to mesh the intermediate gears 274 with, and disengage them from the teeth 189 of the actuators 175.

Assume that the parts of the carrying mechanism are in their normal positions (Figs. 5, 6, 23 and 42) wherein the latches 340 contact the upper beveled face of the universal rib 343 to maintain their respective guide and positioning members 334 in their upper positions, so that the pairs of studs 337 hold their reciprocating transfer pawls 326 at such angles to the totalizer pinions 273 that the pawls, as they thrust rearwardly (Fig. 52) escape the latter. The lateral extensions 348 of the transmitting members or slides 349 lie over and in contact with the tails 351 of their respective guide and positioning members 334, and the free ends of the switch members 347 rest upon the rear faces of such extensions. It will be clear that a trip finger 345

will wipe over the cam 346 of its co-related switch member, as the corresponding totalizer wheel driven by its actuator 175, passes from "9" to "0" during the first half cycle of operation of the main drive shaft 206, to rock the switch member counter-clockwise from the position shown in Fig. 42 to that shown in Fig. 43.

During such counter-clockwise travel, the switch member 347 presses against the extension 348 of the transmitting member 349 to drive the transmitting member downwardly in its groove 350. The lateral extension 348, in turn, presses against the tail 351 of its associated guide and positioning member 334 located opposite the pinion 273 of the totalizer wheel of next higher denomination, and rocks the guide and positioning member clockwise, which, by reason of the control of the studs 337 over the transfer pawl 326, swings the pawl downwardly into line with the pinion of such totalizer of higher order, as shown in Fig. 43.

The throw of the guide and positioning member 334 and consequently the transfer pawl 326, in clockwise direction may be limited by contact of the rear edge of the member 334 against the bottom of the groove 336 in the brace bar 315.

As the guide and positioning member rocks clockwise, the beveled latch 340 rides over the high point of the beveled rib 343, compressing the spring 342, which forces the latch outwardly again as the latch comes opposite the lower beveled face of the rib to assist in switching the guide and positioning plate clockwise in case of lost motion between the transmitting member 349 and the plate 334, and to yieldingly retain the parts in the positions to which they have been adjusted.

The parts remain in such adjusted positions during the remainder of the first half cycle of the main drive shaft 206, and at about the time when the drive shaft 206 completes the first step of the second half cycle, to enable the disengagement of the totalizer from the actuators, it causes the right-hand transfer cam 331 (Figs. 5, 6, and 23) to wipe past the corresponding pawl-carrying bell crank 321, rocking the latter clockwise against the tension of its spring 323 to impart a rearward thrust to the associated transfer pawl 326, the remaining transfer cams 331, 332 operating their respective pawl-carrying bell cranks in close succession as the main drive shaft completes its second half cycle.

Such transfer pawls as are maintained by their guide and positioning members 334 in normal ineffective positions (Fig. 42) merely thrust rearward idly, and are retracted together with their bell cranks 321, by the springs 323, after the transfer cams escape past the pawl-carrying bell cranks.

In this connection, it will be noted that the shape of the transfer cams 331, 332 is such as to retain control of the pawl-carrying bell cranks 321 during their return to normal position under the influence of their springs 323 whereby to reduce the noise hitherto incident to such return.

Where a guide and positioning member 334 has been adjusted by the totalizer pinion 273 of lower order, to locate its transfer pawl 326 in line with the totalizer pinion of next higher order, however, the abrupt face 329 of such pawl, on the rearward thrust, strikes the opposed tooth of its pinion and turns the pinion one step in advancing direction.

As the pinion of higher denomination turns under the action of the abrupt face of the head

of the pawl against that tooth which is in its path of travel, the succeeding tooth of the pinion contacts the obtuse cam face 330 of the pawl and crowds the pawl upwardly towards or to its normal idle position, thereby shifting the abrupt face 329 of the pawl out of contact with the tooth against which it was operating. Obviously, the extent of such abrupt face and the relation between it and the cam face 330 must be such that the pawl can advance the totalizer pinion a sufficient distance before the abrupt face 329 loses contact with its tooth.

As the pawl 326 is rocked upwardly towards its normal idle position, it in turn, rocks the guide and positioning member 334 counter-clockwise because of its contact with the uppermost of the guide studs 337.

The cam face 330 need not be of such extent as to require the succeeding tooth of the pinion to completely restore the pawl 326 and positioning member 334 to their normal idle positions, it being necessary merely for the succeeding tooth to rock the pawl and guide member counter-clockwise (Fig. 43) until the spring-pressed latch 340 crosses the apex of the rib 343, whereupon the pressure of the spring 342 against the latch causes its lower beveled face to ride rearwardly along the upper beveled face of the rib and complete the return of the guide and positioning member and its pawl to their normal positions.

The same action may occur in shifting the guide and positioning member and pawl to their effective positions, it being merely necessary for the trip finger 345 to depress the switch member 347 and transmitting member 349 and rock the guide and positioning member 334 and its pawl clockwise until the latch 340 passes below the apex of the rib 343, whereupon the spring 323 operating upon the latch as above explained, will cause the completion of the movement of the guide and positioning member and its pawl to effective position relatively to its totalizer pinion.

By arranging for the successive operation of the carrying units from lowest to highest denomination, the familiar "carry upon a carry" cannot be lost, but is effected at the proper time.

The arrangement whereby the return of the indexing carriage 78 to its starting position preparatory to the entry of a new amount therein is effected by motors independently of the main drive shaft, enables the division of the time of operation of the main drive shaft into two half cycles, the first of which is utilized to engage the totalizer and actuators and enter the amount on the totalizers, and the second of which is utilized to disengage the totalizer and actuators and effect transfers on the totalizer wheels.

The provision whereby the return of the index carriage to the right occurs independently of the operation of the main drive shaft and may continue after the end of the operation of the main drive shaft, renders unnecessary the provision of a definite phase of the movement of the main drive shaft to effect such carriage return.

Clearing or resetting the totalizer to zero

To clear the totalizer or reset the wheels 176 to zero, preparatory to performing another problem on the machine, all the operator has to do is to grasp either knob 264 (Figs. 1 and 3) on the ends of the totalizer shaft 255 and turn the shaft counter-clockwise (Figs. 5 and 6). The frictional engagement of the spring-pressed latches 270 (Fig. 36), carried by the respective totalizer

wheels 176, with their seats 271 formed about the periphery of the totalizer shaft causes the wheels to turn with the shaft until the lateral extensions 345 of the totalizer pinions 273 abut the abrupt 5 faces of the cams 346 on the switch members 347, in which positions the totalizer wheels present their zeros at the reading line.

Continued rotation of the totalizer shaft 255 after the arrest of the totalizer wheels 176 by the 10 cams 346 merely results in the rotation of the shaft and seats 267 past the inner ends of the spring-pressed latches 265 and is not harmful.

To prevent rotation of the totalizer shaft 255 in clockwise direction, which would not bring the 15 trip extensions 345 against the abrupt faces of the cams 346, and also to hold the shaft against accidental rotation in either direction, I provide a spring dog 376 (shown in dotted lines Fig. 54) projecting upwardly from the cross bar 257 of the 20 rocking totalizer frame, with its free end engaging the teeth of a ratchet wheel 375 (see also Figs. 3, 35 and 40) fast on the totalizer shaft 255, the frictional pressure of the dog against the ratchet operating to yieldingly hold the shaft 25 where adjusted, the engagement of the free end of the dog with the teeth of the ratchet also preventing rotation of the shaft clockwise.

The foregoing description has treated the invention as though designed for simple adding operations only, such plan having been selected as 30 best adapted to explain the basic principles involved.

As a matter of fact, the invention has been designed with other calculating operations in view, 35 as well.

The better engineering principle is to initially design a machine to perform all of the functions desired rather than to present a machine adapted and designed to accomplish but one or two 40 of such functions, and thereafter modify or add to such parts suited to effect such functions in an attempt to fit the machine for the attainment of additional results.

The machine selected to illustrate one form of 45 the present invention is adapted for the performance not only of addition, but of multiplication, subtraction by complementary addition, and division.

Totalizer carriage

To facilitate the attainment of these additional functions, as well as to extend the use of the machine in adding operations, the totalizer carriage, heretofore briefly referred to, is arranged 55 for adjustment across the machine, and is equipped with a larger number of totalizer wheels 176 than is usually provided for commercial additions, there being twenty such totalizer wheels 60 in the present instance, though more or less might be used without departure from the spirit and scope of the invention.

It has been stated, heretofore, that the totalizer carriage includes the right and left side 65 frames 261, 262 (Figs. 3, 35 and 40) united by the cross rod 260, serving as a center about which the totalizer frame rocks, and by the brace bar 315, angular rail 316 and beam 317. The totalizer carriage furthermore includes a supporting 70 rail 380 extending between and secured at its ends to the front ends of the totalizer carriage side frames 261, 262, respectively, the supporting rail intermediate its ends being slidably 75 mounted for longitudinal travel in ways 381

(Figs. 1 and 2) formed in the head 382 at the rear end of a sleeve 383 extending horizontally fore and aft of the machine and carried on the upper end of a pillar 384 projecting upwardly 80 from the base of the machine to the left of the partition plate 53, as shown in Fig. 4.

The supporting cross rod 260 connecting the rear ends of the side frames 261, 262 of the totalizer carriage frame is mounted for longitudinal 85 movement in the forwardly projecting ends of brackets 385, the rear ends of which are fastened to upstanding portions of the left side frame 52 and the partition plate 53 of the machine, respectively. A tie bar 379 connects the 90 brackets 385 to impart rigidity thereto.

This method of supporting the totalizer carriage enables it to be shifted in either direction laterally of the machine to position any group of totalizer wheels opposite the group of actuators 175 for operation thereby. 95

In simple adding operations, this adjustability of the carriage relatively to the actuators enables the operator, in effect, to divide the series of totalizers into two or more groups and to add a corresponding number of rows of amounts separately, so long as the added amounts in the 100 group of totalizer wheels to the right do not extend into the next group of wheels to the left. However, the plurality of totalizer wheels is more particularly adapted for the performance of subtraction and division, or in multiplying large amounts, as will hereinafter appear.

As a convenient means enabling the operator to feed the totalizer carriage in either direction, the sleeve 383 (Figs. 23 and 73) is longitudinally 110 bored to accommodate a spindle 386, the inner end of which carries a barrel 387 rotatable in a similarly shaped chamber 388 formed in the head 382 of the sleeve and communicating with the space formed between the ways 381 in the head. 115

The barrel is of greater diameter than the height of the supporting rail 380, and carries one or more rearwardly projecting driving teeth 389 adapted to co-act with teeth or serrations 390 120 formed in the front face of the rail 380. A finger piece 391 (Figs. 1-3) on the outer end of the spindle 386 which projects forwardly beyond the forward end of the sleeve 383, facilitates rotation of the spindle in either direction to enable the teeth 389 to engage the teeth 390 of the totalizer 125 carriage supporting rail 380 and shift the carriage step by step to the right or left, as desired, in adjusting the totalizer relatively to the group of actuators.

An arresting stop 550 is located between the teeth or serrations 390 of the rack formed on the front face of the rail 380, near the opposite 130 ends of such rack, to limit the feed of the totalizer carriage in opposite directions by preventing the passage of the driving teeth 389 between the teeth of the rack when the carriage has arrived 135 at either predetermined limit of its travel.

Normally the driving teeth 389 remain in engagement with the teeth 390 of the supporting rail to prevent accidental shifting of the totalizer carriage out of its adjusted position, but as one means to allow the operator to shift the totalizer through distances greater than a single step at a time, the chamber 388 is of sufficient length 140 to enable the operator, by an endwise pull on the handle or finger piece 391, to withdraw the barrel 387 and its teeth 389 into the chamber and out of engagement with the teeth 390 of the supporting rail 380, thereby freeing the totalizer car- 145 150

riage for adjustment freely in either direction directly to any point in its path of travel.

A spring 392 seated in a recess (Figs. 23 and 73) formed above and parallel with the bore of the spindle 386 and communicating with the chamber 388, forces a detent pin 393 rearwardly against the forward face of the barrel 387, the detent pin being forced farther into the spring seat or recess and storing greater tension in the spring 392 when the operator draws the spindle and barrel forwardly.

Upon release of the handle or finger piece 391 after the operator has manually positioned the carriage as desired, the spring 392 forces the detent pin against the barrel to thrust the latter with its spindle and driving teeth 389 rearwardly, to re-engage the driving teeth with the teeth or serrations 390 on the carriage supporting rail 380 and hold the carriage where adjusted.

Conveniently, the inner end of the detent pin 393 contacts one or another of a plurality of opposed cam faces 394 formed on the front end of the cylindrical barrel 387 in such relation with the driving teeth 389 that when the rear end of the detent pin lies at the low point of a cam 394, the driving teeth will lie between the teeth 390 of the opposed carriage supporting rail 380 to lock the carriage against longitudinal movement, the barrel with its teeth thus constituting a combined locking and feeding head for the totalizer carriage.

Subtraction mechanism

In effecting subtraction by the well-known method of complementary addition, it is customary to first register the minuend on the totalizer, and then add thereto the true complement of the subtrahend, to obtain the correct result.

The means herein disclosed to accomplish this result differ materially in principle and mode of operation from prior constructions with which I am familiar, in that the operator is able to set up the real subtrahend as in adding operations, after which he may, at will, cause the mechanism set by the numeral keys to enter the item additively or subtractively.

Indeed, it is possible with this machine, for the operator to set up one or more digits or all of the digits forming part of an item for addition, and then, desiring to subtract the amount, the operator, by a novel adjustment, may shift the mechanism to operate subtractively, thereafter completing the setting up of the remaining digits of the item for subtraction, or vice versa.

The identical value-representing elements set up to control the registration of an item additively on the totalizer, may be utilized to set up the true complement of such item for subtraction.

In connection with the subtraction feature of this invention, novel means is provided to positively notify the operator of the presence of an overdraft on the totalizer, which overdraft is indicated on the totalizer by its negative complement, and continued accretions to or reductions of such overdraft may be made at the will of the operator.

Incidentally, the overdraft mechanism is utilized to signal the operator when the capacity of the totalizer is exceeded in straight adding operations, opportunity being afforded the operator to correct such abnormal condition immediately

after its occurrence, i. e., on the next operation of the machine.

The foregoing and other advantages are effected in the present invention, by the use of the mechanism about to be described.

It will be recalled that the value-representing elements 77 (Figs. 17 and 57) are each offset laterally, as at 98, so that the upper and lower ends of any element, though lying in the same vertical plane longitudinally of the indexing carriage or field, occupy parallel vertical planes from front to rear of the carriage, the upper end being in advance of or laterally positioned to the left of the lower end by a distance which may be somewhat less than the distance between any two adjacent actuators 175.

With the machine adjusted for addition, the keys 54, when successively depressed and released to set up an item, project the upper ends of the selected value-representing elements in the successive denominational rows of elements, which by the step by step feed of the carriage coincidentally effected, are positioned to lie across the planes of the ends of the tails or contact members 194 of the actuators 175, as shown in dotted lines at the left of Fig. 17, wherein a single element has been dotted in and numbered 77' to shows the position it assumes relatively to a contact member 194.

The lower ends of the value-representing elements, recessed as at 96 (Figs. 11, 12, 17, 18 and 55-57) normally occupy such positions that the recessed portions protrude just below the lower head 93 of the carriage, the recesses in each denominational row of elements forming a skeleton channel just beneath the lower head 93 and conforming in shape thereto (arcuate, in the present instance).

When a value-representing element in any denominational row is set by its key 54, the recess 96 at its lower end is forced out of line with the recesses 96 of the remaining elements in that denominational row so that the channel normally formed by these recesses is interrupted or blocked by the unrecessed lower end of the set element.

In the advanced position of the carriage when the machine is conditioned for adding, the lower ends of such set elements lie to the right (Fig. 17) of the upper ends thereof and in the same planes with the spaces between adjacent actuators 175, that is, in the adding adjustment, the lower end of each set value-representing element lies to the right of and apart from that actuator to which its upper end is opposed, such lower end being then out of line relatively, to a subtraction contact member in the form of a stud 400 (Figs. 4-6, 33, 34, 55 and 56) carried by and projecting laterally to the right of the toothed section 189 of each actuator 175.

Each subtraction contact member 400, except that on the units actuator, is located one long step in advance of, and occupies the same stepped relation relatively to the lower ends of the corresponding row of value-representing elements that each tail or contact member 194 occupies relatively to the upper ends of the corresponding denominational row of elements, as heretofore explained.

The sequence of appreciation of the upper ends of the value-representing elements is from front to rear, the "0" element in each denominational row being foremost and the "9" element being rearmost, so that, in adding operations, the upper end of the "0" value-representing element 77, for instance, lies so far in front of the corresponding

adding contact member 194 that, at the completion of the clockwise oscillation of the index carriage, the set "0" element will just touch its corresponding actuator without advancing the latter, whereas, in subtracting operations, the lower end of that same "0" element will be positioned in line with a subtraction contact stud or member 400 and, except in the units denomination, will advance the co-related actuator nine steps. This result occurs because the lower end of the set "0" value-representing element in all denominations higher than units, occupies the same position relatively to the subtraction contact member 400 of a co-related actuator, that the upper end of the "9" value-representing element in the same denominational row occupies relatively to the adding contact member 194 of the same actuator.

Because the true complement of a number is such amount which, when added to that number, raises the latter to the next higher power of 10, it is necessary to locate the subtraction contact stud 400 on the units actuator one step closer to the lower ends of the corresponding series of value-representing elements than the studs 400 carried by the actuators of the higher denominations in relation to their respective series of elements, whereby the set element selected to operate the units actuator may advance the latter one step earlier in the operation of the machine than the set elements of similar values in the higher orders advance their actuators, as a result of which, the units actuator advances its totalizer wheel one step before the actuators of the higher denominations start to turn their corresponding totalizer wheels.

As an example of this condition, assuming the selection of two similar value-representing elements to indicate a subtrahend of "66" for instance, the units order value-representing element will have advanced its actuator one step by the time the tens order value-representing element contacts its actuator.

As time must be afforded to effect the engagement of the totalizer with its actuators prior to the advance of the latter, in subtracting as well as adding operations, such early advance of the units actuator by its set element would be futile and render the result incorrect, were it not for the fact that the first step or increment of movement of the field of elements at the beginning of its oscillation is longer than the second and remaining steps of its advance movement, the engagement of the totalizer with its actuators being effected at the very beginning of such long initial step so that the remainder of such step corresponds in length with the second and succeeding steps of movement of the field of elements.

As a result of this arrangement, if the "0" element in the units denomination, is set and the machine operated under the subtractive adjustment, the lower end of such set element impinges against the advanced subtraction contact member 400 of the units actuator 175 to impart an advance of ten steps to the actuator and the units totalizer wheel 176 engaged therewith.

Or the setting of the value-representing element "1" under the same conditions, will result in the addition of "9" on the units totalizer wheel, and so on, the true complement of the units figure of the subtrahend, in each instance, being added on the units totalizer.

To enable the units actuator to advance ten

steps, when necessary, the arcuate slot 188 (Fig. 33) of the units actuator is made one step longer than the arcuate slots 188 of the "tens" and higher orders of actuators, as indicated in dotted lines in said figure. Thus it is seen that when the machine is adjusted for addition, the upper ends of the elements which constitute one field, operate to add on the totalizer the actual amount set up by the numeral keys, and when the machine is adjusted for subtraction, the lower ends of the elements, which may be said to constitute another field, operate to add on the totalizer the true complement of the actual amount set up by the numeral keys.

In straight adding operations, the lower ends of the value-representing elements whether in normal or in set positions, escape past the adjacent subtraction contact members 400, because of the offsets 98.

To adjust the mechanism for complementary subtraction, all that is necessary is to shift the field of elements 77 bodily to the left a sufficient distance to position the upper ends of the elements out of line with their adding contact members 194, and bring the lower offset ends of the elements into such proximity with their subtraction contact members 400 that upon operating the main drive shaft, the recesses 96 of the unselected or idle elements embrace and slip past the subtraction contact members 400 as the field is advanced during the first half cycle of the main drive shaft, and the unrecessed lower ends of the set elements contact their subtraction members 400 to advance the corresponding actuators. Meanwhile the upper projected ends of the set elements pass idly between adjacent contact members 194 without actuating the latter.

It will be recalled that the horizontal cradle or carriage support (Figs. 17-19) including, mainly, the rear rail 80 and the front supporting bar 81 connecting the end pieces 79, is mounted for oscillatory movement in the machine by the trunnions 82, which project laterally outward from central points on the end pieces 79 and are journaled in the respective side frames 51, 52 of the machine.

The length of the cradle is less than the distance between the side frames 51, 52 and the trunnions 82 are sufficiently long to enable endwise as well as rotary movement of the cradle in the side frames, to which end the trunnions project beyond the outer faces of such side frames.

A frusto-conical cam disk 401 (Figs. 3, 4, 17, 18, 53 and 54) is fixed on the outer end of one of such trunnions, as the left hand one, and a spring 402 encircling the trunnion between the inner face of the side frame 52 and the adjacent end piece 79 of the cradle, normally retains the cradle and indexing carriage at their right-hand limits of travel, which is the adding position of these parts.

A finger lever 403 (Figs. 2, 3, and 4) extending upwardly alongside the pillar 384 and conveniently pivoted intermediate its ends thereto, as at 404, engages with its lower end the free end of an angular extension 405 (Fig. 4) of a horizontally positioned bell crank 406 pivoted at 407 to the base 50 of the machine. One arm of this bell crank extends laterally outward through a slot 408 in the side frame 52 and is pivotally connected at its outer end by a link 409 with the lower arm of a cam operating lever 410 pivoted intermediate its ends at 411 to, and lying against the outer face of the side frame 52.

The lever is beveled, as at 412, to co-act with the frusto-conical edge of the cam disk 401, a spring 413 (Figs. 3 and 4) connected to the horizontal bell crank 406, normally holding the cam-operating lever 410 withdrawn from the cam disk.

A latch 414 pivoted at 415 to the base 50 of the machine, is recessed near its free end, as at 416, and a spring 417 rocks the latch to fit its recess over a pin 418 on the horizontal bell crank 406. The end walls of the recess limit the throw of the cam lever and its operating mechanism in opposite directions.

The finger lever 403, when drawn forwardly by the operator, rocks the bell crank 406 against the tension of its spring 413, to draw the link 409 forwardly and rock the cam-operating lever 410 in a direction to press its beveled edge 412 against the frusto-conical edge of the cam 401, and crowd the latter, together with the cradle or carriage support and the indexing carriage, bodily to the left against the tension of the restoring spring 402, as shown in Fig. 53, sufficiently to displace the upper ends of the value-representing elements 77 relatively to the adding contact members 194 of the actuators 175 and to position the recesses 96 in the lower ends of the value-representing elements in the same planes with their subtraction contact members or studs 400.

The latch spring 417 in this instance, is inferior to the returning spring 413, so that the operator must retain the subtraction lever 403 in its moved position, it being obvious that means well-known in the art, might be provided to hold the lever in its operated position, if found desirable.

When the operator releases the subtraction lever, the return spring 413 operates to restore the train of parts to their normal positions, and withdraws the cam-operating lever 410 from contact with the disk cam 401, whereupon the restoring spring 402 encircling the trunnion 82 returns the cradle and indexing carriage to the adding position.

Reversal of operation of the index carriage-shifting mechanism just described, would render it necessary to shift the finger lever 403 when performing straight addition, the indexing carriage, under such condition, being normally in subtracting position.

Obviously, the subtraction lever 403 can be operated at any time prior to starting the operation of the main drive shaft.

If operated prior to the setting up of the value-representing elements, the lower ends of the value-representing elements of the respective rows shift relatively to the upwardly projecting fingers 72 (Fig. 17) of the key-operated setting levers 69, but not far enough to completely displace such lower ends relatively to the fingers, and the unrecessed portions of such lower ends, when set by the numeral keys, lie in position to strike the contact members 400 during the oscillatory travel of the field.

If the item is set up with the machine conditioned for adding and it is then desired to treat it as a subtrahend, the subtracting lever 403 when operated, will shift the cradle and field of elements as above explained, to displace the upper ends of the set elements relatively to their contact members 194 and locate the lower ends of the set elements effectively relatively to their contact members 400.

The distance through which the cradle and index carriage is shifted to the left by the sub-

tracting lever 403 when operated to condition the machine for complementary subtraction, is less than the distance between two denominational positions, and hence the locking member or wing 215 (Figs. 4 and 24-26) on the carriage which co-acts with the locking bar 216 during the rocking movement of the carriage, is displaced relatively to the series of recesses or grooves 217 of the locking bar which correspond with the denominational positions of the index carriage under the adding adjustment.

As the cradle and indexing carriage are rocked during the operation of complementary subtraction exactly the same as in straight adding operations, and as the carriage is returned to its starting position by the same mechanism operating identically as in straight adding operations, it is necessary to provide the locking bar 216 with an additional series of grooves or recesses 218 (Fig. 4) interspersed relatively to the recesses 217 and similarly spaced to accommodate the locking wing 215 and restrain the carriage at the proper time, when the latter is in its subtracting adjustment.

Shifting the cradle and index carriage has no effect on the carriage escapement mechanism which functions equally as well with the parts in either adding or subtracting position, the link connection 222 (Figs. 24-30) with its opposite ends pivoted at right angles to each other affording sufficient flexibility for such adjustment. And the drive link 208, connecting the drive eccentric 209 with the right-hand end piece 79 of the cradle also admits of sufficient play to accommodate the shifting of the cradle.

Likewise the drive gear 308 (Figs. 3 and 4) of the over-rotation preventing shaft 307 is of sufficient width to maintain engagement with the drive rack 309 mounted on the cradle, in any position to which the latter may be shifted.

The operation of setting up an amount to be added or subtracted is performed in identically the same manner—by depressing the numeral keys 54 and setting the value-representing elements corresponding with the actual values of the digits of the minuend or subtrahend.

In the operation of subtracting by complementary addition on an adding machine, it is necessary to complete or fill out the true complement of the subtrahend by the addition of "9's" to the left of such true complement throughout the higher orders to the carrying capacity of the machine, in order to eliminate what may be termed the excess "1" otherwise remaining in the totalizer.

For example, in subtracting "17" from "194", the minuend having one more denomination than the subtrahend, it is not sufficient to merely add the true complement of the subtrahend, namely "83", to the minuend as an erroneous result "277" would be obtained, owing to the excess "1" carried into the hundreds denomination.

To eliminate this excess "1", it is customary to enter "9's" to the left of the subtrahend, to the capacity of the machine. Thus, if the machine has a capacity of ten denominations, the above example might be performed by first entering the minuend "194" on the three wheels at the right-hand end of the totalizer and then entering the true complement "83" of the minuend "17" on the two right-hand wheels of the totalizer, together with eight "9's" in the remaining denominations so that the amount added to the

minuend would be "9,999,999,983", the example appearing as follows:

	0,000,000,194	(minuend)
5	9,999,999,983	(true complement of subtrahend plus additional "9's")
	0,000,000,177	(correct result)

The addition of the excess "1" by the carrying mechanism to the hundreds denomination is transferred continuously across the machine by the successive action of the carrying mechanism because of the presence of the excess 9's, to and beyond the totalizer wheel of highest capacity where it disappears from the machine or is lost, there being no carrying operation beyond the tenth wheel of a ten-denomination totalizer, and no wheel to receive the excess "1".

In former constructions it has been necessary, in performing complementary subtraction, for the operator to manually introduce the required number of excess "9's" one by one, into the set up of the complement of the subtrahend or to set up the "9's" in all denominations by one operation, and then by setting up the complement of the subtrahend, displace the "9's" previously set up in the corresponding denominations appropriated by such complement.

The present machine effects the entry of the excess "9's" automatically, and as an incident to the operation of the machine as it registers the true complement of the subtrahend subsequently to setting up the actual subtrahend. In effecting the automatic entry of the proper number of "9's" according to the variable number of denominations appropriated by the true complement, I have contrived to utilize the denominational escapement stop members 111 (Figs. 11-21, 33, 53, 55 and 56) though obviously I am not limited to the use of such members in obtaining this result.

It will be recalled that the denominationally arranged escapement stops 111 slidably mounted on the escapement bar 113 in the path of the abutment 119 on the index carriage 78, are normally in their effective positions and are successively displaced by the finger 140 (Figs. 15, 16 and 18) as the numeral keys 54 are operated, to enable the carriage to advance step by step to the left under the influence of its feed spring 114.

The escapement stops are arranged transversely to the path of travel of the carriage, and when in their normal effective positions, their rear ends project beyond the rear edge of the bar 113 on which they are mounted, such bar being secured to the rear rail 80 of the cradle or carriage support and accompanying the latter on its rocking movement, as well as its longitudinal adjusting movement under the influence of the subtraction lever 403.

The front bar 81 and the rear rail 80 form a track extending through the area circumscribed by the circular actuators 175 and extending transversely of the actuators, along which track the indexing carriage is fed variable distances into such area, depending upon the number of denominations represented by the amount set up by the keys.

The rear rail 80 lies closely adjacent the concave faces of the arcuate tails 194 of the series of actuators so that when the cradle and its index carriage have been shifted or adjusted to the left by operation of the subtraction lever 403, the rearwardly projecting end of each escapement stop 111 extends over and lies one step above a shoulder or contact member 419 (Figs. 33, 55 and

56) projecting inwardly from the inner face of each of the tails 194.

Of course, when the cradle and index carriage are in their adding adjustment, the projecting rear ends of the escapement stops 111 lie out of line with their co-acting contact members 419 so as to escape the latter during the rocking movement of the cradle.

With the machine conditioned for subtraction, however, the distance between the projecting rear ends of each of the escapement stops and their respective contact members 419 with which they are then aligned, corresponds with the distance between the lower ends of the "0" elements 77 and their respective contact members 400, the contact member 419 on the tail of the units actuator being positioned one step above the remaining contact members 419, and closer to its corresponding escapement stop 111, as shown in Fig. 33, to enable the latter to advance the units actuator one step, by the time the remaining escapement stops strike their associated contact members 419.

As heretofore stated, the initial step of movement of the cradle is somewhat greater than the remaining steps in the first half cycle, to afford time for the engagement of the totalizer with the actuators before any of the latter are advanced.

By positioning the contact member 419 on the units actuator on a plane above that occupied by the contact members on the remaining actuators, so that the units actuator will advance ten steps and the remaining actuators nine steps, the totalizer is automatically cleared on idle operations of the machine when conditioned for subtraction, with the totalizer at zero, which avoids the necessity for making a clearing operation of the totalizer shaft 255, after such idle operation.

Also, assuming an amount to be already registered on the totalizer, a blank or idle operation of the machine when adjusted for subtraction, will not dissipate such registered amount which will remain on the totalizer after such blank subtraction operation, despite, or because of the fact that during such blank operation the carrying mechanism is effective upon the totalizer wheels across the machine.

Subtraction operation

The normal position of the totalizer carriage is at the extreme left of its travel, wherein the twelve totalizer wheels 196 to the right of the entire series of twenty wheels illustrated in the present instance, lie opposite the series of twelve actuators 175.

Each of the twenty totalizer wheels except the first one on the right, is provided with its individual carrying pawl 326 (Figs. 42 and 43), but it will be recalled that there are but eleven pawl-operating cams 331, 332 (Figs. 4-6) on the main drive shaft 206, so that the machine has a working capacity of but twelve denominations, in any of the adjusted positions of the carriage.

It will also be remembered that there are but ten denominational rows of elements 77 and consequently direct addition of items set up by the keys 54, can be effected on but ten of the twelve wheels constituting the effective portion of the totalizer.

The two extra totalizer wheels at the left accumulate by the operations of the carrying mechanism only, and enable the addition of a series of items exceeding the capacity of the ten righthand wheels on which additions may be directly effected, in the well-known manner.

The provision of the two extra actuators 175 at the left (Figs. 3 and 4) corresponding with the two extra totalizer wheels, provides a control for such wheels in subtracting operations through the action of the overhanging escapement stops 111 associated with such actuators, to enable the correct subtraction of a subtrahend from a minuend extending onto the excess capacity wheel or wheels.

By providing a totalizer comprising a number of totalizer wheels greatly in excess of the number of actuators therefor, and adjustable relatively thereto, the operator may run an accumulation of debits on one group of totalizer wheels and an accumulation of credits on another group, thereby preserving running totals of both debits and credits at the same time, after which the total disclosed on one group can be subtracted from the total displayed on the other group, by simply positioning that group of wheels registering the minuend opposite the actuators, setting up by depression of the corresponding numeral keys, the total displayed by the remaining group of wheels, adjusting the mechanism to perform subtraction and finally operating the main drive shaft.

A simple subtracting operation is performed as follows:

Assume the totalizer carriage to be in its normal position at the extreme left of its travel and that there is registered on the effective right-hand group of wheels, a minuend of "870", for example, from which it is desired to deduct a subtrahend of "70".

The operator will depress the numeral keys "7" and "0" successively in the order set forth, to set the elements 77 in the first and second denominational rows counting from the left to represent the item "70", and either prior or subsequently thereto, will operate the subtraction lever 403 to bodily shift the field of elements to the left, as heretofore explained, so as to first displace the upper ends of the set elements relatively to the contact member 194 of the actuators; second, to position the lower ends of the set elements in line with the subtraction contact members 400 on the actuators; and third, to position the projecting rear ends of the escapement stops 111 directly over the contact members 419 on the actuators.

These numeral keys, as they are depressed, operate means heretofore described to successively shift the first two escapement stops 111 forwardly to enable the index carriage to advance step by step until arrested by the third escapement stop from the right.

In such shifted position, the rear ends of the displaced stops 111 lie too far forward to strike the contact members 419 on the inner faces of the tails 194 of the corresponding actuators when the carriage is rocked in a subtracting operation.

The recesses 96 in the lower ends of the value-representing elements of all denominational rows higher than the tens row, wherein no elements have been set, form an unobstructed channel for the laterally projecting contact studs or members 400 and slip past the latter without engaging therewith.

The channel formed by the recesses 96 in the lower projecting ends of the elements of the "tens" denominational row is obstructed part way of its length by the unrecessed end of the set element representing "7" and the channel formed by the recesses 96 in the lower ends of the ele-

ments of the units row is blocked at its forward end by the unrecessed lower end of the set element representing "0", which is the foremost element.

The main drive shaft 206, as it starts its first half cycle of operation, will at once rock the totalizer frame to engage the twelve right-hand totalizer wheels 176 with their actuators and simultaneously rock the index carriage clockwise (Figs. 5 and 6, 55 and 56) and as the engagement of the totalizer with its actuators is completed, the lower unrecessed end of the "0" set element in what has become the units row of elements 77 strikes its contact member 400 on the units actuator 175, such contact member being one step nearer its row of elements 77 than are the remaining contact members 400 with respect to their corresponding rows of elements.

At the end of the first and longest step of movement of the indexing carriage, the lower end of the set element representing "0" in the units row has advanced its actuator one full step, the "tens" row of elements has advanced until its "0" element lies adjacent the contact member 400 on its corresponding actuator, and the projecting rear ends of the effective escapement stops 111 in the hundreds and higher denominations, including the two excess capacity denominations, overhang and lie against the contact members 419 on the tails 194 of the co-related actuators.

In other words, the distance between the contact members 400 of the "tens" and all higher denominational actuators and the lower ends of the "0" value-representing elements of corresponding denominations is the same.

Also, such distance is the same as the distance between all the denominational contact members 194 and the upper ends of the "9's" value-representing elements of corresponding denomination- al rows.

But the distance between the contact member 400 of the units denominational actuator 175 and the lower end of any "0" element 77 of corresponding denomination is one step less than the distance between the contact members 400 of the tens and all higher denominational actuators, and the lower ends of the "0" value-representing elements 77 of corresponding denominations and is also one step less than the distance between the contact members 194 and the upper ends of the "9's" value-representing elements of the tens and higher denominational actuators.

Consequently, in subtracting by complementary addition, and assuming that the lower end of a "0" element is set to co-act with the contact member 400 of the units actuator 175 and that the lower end of an adjacent element representing "0" is set to coact with the contact member 400 of the "tens" actuator 175, the machine being conditioned for complementary subtraction, it will be obvious that by the time the field of elements has been oscillated in clockwise direction through its initial long step of movement (which may be substantially equal to two of the remaining nine steps of movement in clockwise direction), the "0" element 77 co-acting with the contact member 400 of the units actuator will have advanced such actuator one step (due to the shorter distance between the lower end of the "0" element and the contact member 400 on the units actuator) by the time the lower end of the "0" element, co-acting with the contact

member 400 of the "tens" actuator has just arrived at such last named contact member.

The main drive shaft, as it continues its first half cycle rocks the index carriage and its support or cradle throughout the remaining nine lesser steps or increments of its clockwise travel, at the completion of the seventh step of which, (disregarding the initial long step) the lower unrecessed end of the set element representing the value "7" in the tens denominational row strikes the contact member 400 on the "tens" actuator, so that, as the indexing carriage completes the remaining two steps of its clockwise travel, the tens actuator and its totalizer will be advanced two steps.

Meanwhile the effective escapement stops 111 in the denominations higher than the tens have been rocked clockwise by the cradle or carriage support through nine increments in addition to the first long step heretofore referred to, and advance their corresponding actuators and the totalizer wheels associated therewith, nine steps.

From the above, it is seen that although the subtrahend "70" only was set up by depression of the corresponding keys 54, the incomplete complement of that amount, namely, "999,999,999,920" was registered on the totalizer by the action of the lower ends of the set elements 77 in the units and tens denominations and the rear ends of the effective escapement stops 111 in the remaining denominations, including the two excess capacity denominations.

The main drive shaft, as it starts its return half cycle of operation, at once disengages the totalizer from the advanced actuators and thereafter returns the cradle or carriage support and its index carriage counter-clockwise to the positions from which they were rocked.

During such return cycle, too, the transfer operating cams 331, 332 become effective to successively actuate all the carrying pawls 326 from the "tens" to the higher of the two excess denominations, so that the excess "1" transferred from the hundreds totalizer wheel to the thousands wheel is carried out of the machine and lost leaving the correct result "800" preceded by a row of zeros displayed on the totalizer.

In the example listed for illustration, the set element representing "0" in the units denomination of the subtrahend, caused a complete rotation of ten steps of the units totalizer wheel 176 thereby tripping the carrying mechanism between the "units" and "tens" totalizer wheels, so that on the return half cycle operation of the main drive shaft, the appropriate carrying pawl 326 was actuated to add "1" onto the tens wheel of the totalizer, thereby effecting the addition of the true complement of the subtrahend, namely "999,999,999,930" to the minuend "870".

The "tens" wheel originally registered "7" (the "tens" figure of the minuend) to which the set element "7" in the "tens" denomination of the subtrahend has added "2" as above explained, so that upon the addition of the "1" through the carry from the units totalizer wheel, the "tens" totalizer wheel turned to zero, tripping the carry for the third or "hundreds" totalizer wheel.

This third wheel from the right originally registered "8" (the hundreds figure of the minuend) and there being no value-representing element set in this denomination, the corresponding escapement stop 111 became effective on the subtraction operation to add "9" thereto, making "17" to which the transfer from the tens wheel added "1" resulting in "18".

Overdraft or negative balance indicating

It will be obvious from the foregoing, that a series of items may be successively subtracted from a total entered or accumulated upon the totalizer, as in checking a series of withdrawals against a total of deposits.

In using the machine for this purpose, it is advantageous that the operator be made aware of the occurrence of an overdraft, for instance, and this invention includes improved means to automatically indicate an overdraft with the totalizer carriage in any of its adjusted positions, such means permitting the operator to register successive overdrafts, if any, without shifting the totalizer carriage, as well as enabling the addition of positive amounts to a negative account to relieve such overdraft.

Thus, the operator may calculate on either side of zero, that is, he may obtain negative as well as positive balances and although in the present instance, a negative balance is indicated by its true complement on the totalizer, a very simple change such as the provision of two oppositely arranged series of numerals on each totalizer wheel, well-known in the art, would enable such negative balance to appear in its actual form instead of its complementary form.

As in common practice, the totalizer wheel of highest denomination is utilized to control the novel means which indicates an overdraft to the operator, such indication in the present instance, taking the form of a lock to prevent operation of the machine, provision being made to readily release the lock to enable the operator either to increase the overdraft, or to reduce or cancel it by the addition of a sum which will restore the balance to a positive amount, as circumstances dictate.

This overdraft lock will be explained in connection with the present machine as illustrated with two additional or excess capacity totalizer wheels provided with carrying mechanisms and engageable with and disengageable from actuators 175 which rock only in subtraction operations, it being understood that the novel features will operate as well whether any such wheels are provided, or with a different number of such wheels than that shown.

With this understanding, and assuming the totalizer carriage to be in its extreme left-hand position, it will be remembered that in effecting subtraction by complementary addition, the escapement stops 111 (Figs. 11-19, 33, 55 and 56) in those denominations above the digit of highest denomination in the subtrahend, co-act with the subtraction contact members 419 on the tails of their corresponding actuators 175 to cause the latter to advance their co-related totalizer wheels nine steps and thus enable the carrying mechanisms of such wheels to pass the excess "1" developed in this method of subtraction, from wheel to wheel successively, until it is eliminated from the totalizer.

In so doing, that totalizer wheel 176 which is of highest denomination under any adjustment of the totalizer carriage, in turning from "9" to "0", causes its trip 345 (Figs. 39, 42 and 43) to wipe over the cam 346 on the switch member 347 appurtenant thereto, and force the corresponding transmitting member 349 forwardly. The laterally extending flange 348 of the transmitting member, in turn, rocks the guide and positioning member 334 clockwise (Figs. 42-43) until the

spring-pressed latch 340 passes below the apex of the oppositely beveled rib 343 on the brace bar 315, whereupon the spring 342 rocks the guide member 334 to its lowest position to locate the associated transfer pawl 329 in line with the idle totalizer wheel to the left of the effective wheel of highest denomination.

But since the pawl actuating lever 321 for such transfer pawl lies beyond (to the left of) the pawl-actuating cam 332 of highest denomination, the carrying pawl thus set is not operated and the excess "1" is lost, the carrying pawl remaining in its set position.

The radial pawl-actuating cams 331, 332 as heretofore stated, are fast on the main drive shaft 206. Located preferably to the left of and immediately adjacent the pawl-actuating cam 332 of highest denomination which effects carries on the effective totalizer wheel of highest order, are a pair of parallel disks 425, 426 (Figs. 58-64) mounted on a short sleeve 427 journaled on the main shaft 206, the right-hand disk 425 bearing a radial projection 428 extending outwardly from its periphery, and the left-hand disk 426 having a similar tooth or locking projection 429 extending radially from its periphery the respective projections being about 180 degrees apart.

A stud 430 projects laterally from the locking disk 425 nearest the pawl-actuating cam 332 and through an arcuate limit slot 431 formed in the pawl-actuating cam, a spring 432 passing around the hub of the cam and connecting the free end of the stud 430 with a laterally projecting stud 433 fast on the cam.

It is evident that this construction enables a relative movement between the locking disks 425, 426 and the main drive shaft with its pawl-actuating cam 332, the extent of which movement is determined by the length of the slot 431, the spring 432 being effective to return the disks 425, 426 to and maintain them at one end of their travel relatively to the cam 332.

The rear arm of a locking lever or detent 434, the hub of which is loosely journaled intermediate its ends on a stud 435 projecting inwardly from the left side frame 52, is forked to form prongs 436, 437 terminating at their ends in arresting teeth 438 and 439, respectively, to co-act with the locking projections 428 and 429 of the respective disks 425 and 426. The prongs are offset laterally relatively to each other, the lower prong 436 with its arresting tooth 438 normally lying in the same vertical plane with, but out of the path of its associated locking projection 428 on the disk 425, at which time, the upper prong 437 with its arresting tooth 439 lies intermediate the two disks, and out of line with both locking projections 428 and 429.

The single locking projection 428 on its disk 425 is disposed nearly but not quite diametrically opposite the locking projection 429 on the disk 426, which arrangement is made because of the forked locking lever, the prongs of which lie on opposite sides of the shaft, so that the co-action of either locking projection with its arresting tooth will occur at substantially the same point near or at the end of the cycle of the main drive shaft 206.

A spring 440 connected to the forward arm of the locking lever 434 tends to rock the latter counter-clockwise (Fig. 5) to enter the arresting tooth 438 into the path of the locking projection 428 on the locking disk 425, but the locking

lever is normally held in its idle position by a latch 441 (Figs. 5, 6, 58-60, and 65-67) in the form of a bell crank pivoted at 442 on a stud projecting from the left-hand side frame 52.

A lateral projection 443 on the forward arm of the locking lever 434 normally rests against a shoulder 444 on one arm of the latch 441, which thus retains the locking lever in its idle position. A spring 445 connected to an ear 446 on the latch serves to rock the latch to position the shoulder 444 beneath the projection 443.

A lateral stud or projection 447 on the depending arm of the latch 441 lies in the path of the lower end of a sliding trip bar 448 longitudinally slotted at 449 and 450 intermediate its ends to embrace and be guided in its rectilinear travel by a stud 451 projecting laterally from the adjacent side frame 52, and a guide rod 452 extending between the left side frame 52 and the partition plate 53. The upper end of this trip bar 448 terminates in a finger 453 extending upwardly and rearwardly in alignment with the inclined trip bar 448, the upper end of the finger lying closely adjacent the lower end of the transmitting member or slide 349 (see Figs. 5, 6, 23 and 60) operated by the switch member 347 under the influence of the tripping tooth 345 carried by that totalizer wheel which is of highest order under the particular adjustment of the totalizer carriage in effect at the time.

It is evident, therefore, that as a general proposition, one or another of the transmitting members 349 appurtenant to its appropriate totalizer wheel 176, will lie in line with the finger 453 of the trip bar 448 in any position to which the totalizer carriage may be adjusted.

In the particular machine selected for illustration, there is one exception to the foregoing statement, and that is, that when the totalizer carriage is in its extreme right-hand position, the last totalizer wheel 176 at the left of the series and its transmitting member 349 lie one place to the right of and out of line with the trip bar 448.

Hence the totalizer wheel of highest denomination which, in this adjustment, would also be the last totalizer wheel at the left, would not control the overdraft indicator. To enable such totalizer wheel of highest denomination, when the totalizer carriage is in its extreme position to the right, to control the overdraft indicating mechanism, I provide the totalizer carriage with an auxiliary transmitting member 454 (Figs. 35, 40 and 41) mounted to slide in a transverse groove in the cross beam 317 identically like the other transmitting slides 349 and located to the left of the transmitting slide of highest denomination in the series associated with the totalizer wheels 176, a stud 455 connecting the auxiliary transmitting member 454 and the said slide 349 of highest denomination, so that operation of such slide will operate the auxiliary transmitting member 454.

The auxiliary transmitting member 454 is located a sufficient distance to the left of the transmitting slide 349 of highest denomination so that when the totalizer carriage is adjusted to its extreme right-hand position, the auxiliary member 454 will lie in line with the upper end of the finger 453 on the sliding trip bar 448.

The operation of the overdraft mechanism is the same irrespective of the position to which the totalizer carriage is adjusted.

Assume the presence of a minuend registered

on the totalizer by one or a number of additive operations of the machine, and that it is desired to subtract a number of items therefrom, the total of which, unknown to the operator, exceeds the minuend.

The operator will set up the actual items to be subtracted on the keyboard, but before operating the main drive shaft, he will pull the subtracting lever 403 forwardly, to shift the index field 78 relatively to the actuators 175 so as to enter the items subtractively upon the totalizer by complementary addition, as heretofore explained. It will be assumed that the first item subtracted from the minuend is less than the minuend.

The rearwardly extending arm of the subtracting bell crank 406 (Figs. 3-5, 23 and 59) operated by the subtraction controlling lever 403, carries a stud 456, entered in a transverse notch 457 formed intermediate the ends of a shipper cross rod 458 which is slidably mounted at its ends in the left-hand side frame 52 and in the partition plate 53, respectively, for longitudinal adjustment.

The left-hand end of the shipper rod 458 (Fig. 54) at the point where it passes through the left side frame 52, is reduced to semi-cylindrical shape, a shoulder being left at the juncture of the reduced end with the body of the rod.

A stop member 463 fixed to the outer face of the side frame partly obstructs the aperture occupied by the reduced end of the shipper rod to prevent rotation of the rod and to limit the travel of the rod towards the left.

A second transverse notch 459 (Figs. 58 and 60-64) in the shipper cross rod 458 located to the left of the notch 457, embraces the lower edge of the forward arm of the locking lever 434 at a point adjacent the pivot 435 of such lever, which is adapted to shift axially of its pivot stud 435 to displace the arresting tooth 438 from the vertical plane of the path of the locking projection 428 on the disk 425 and to position the normally ineffective arresting tooth 439 in the orbit of travel of the locking projection 429.

The length of the hub of the locking lever may limit the axial movement of the lever towards the left, and since the arc of travel of the rearwardly extending arm of the subtraction bell crank 406, when rocked by the subtraction lever 403, is greater than the axial travel of the locking lever 434, the transverse notch 459 is made sufficiently wide to allow for a certain amount of idle motion of the shipper rod 458 before the end walls of the notch contact the lever to shift it in either direction, such idle motion being required in the present instance, because of the greater travel to be imparted by the subtraction lever 403, its bell crank 406, and connections 409, 410 and 401 to the index field of value-representing elements.

The lip 443 on the locking lever 434 is long enough to maintain contact with the shoulder 444 of the latch 441 in either lateral position of the locking lever.

With the parts adjusted for complementary subtraction, the operator turns the main shaft 206 through a complete cycle each time after setting up an item to be subtracted from the minuend.

It will be evident from an inspection of Figs. 61 and 62, that if the subtraction lever 403 is operated with the parts in the adding positions there shown, the arresting tooth 439 on the upper prong of the locking lever 434 will be adjusted directly into the path of the locking projection 429 on the disk 426, and the arresting tooth 438

on the lower prong 436 of the locking lever 434 will be displaced to one side of the plane of travel of the locking projection 428 with which it is designed to co-act.

Under such adjustment of the parts, and remembering that subtraction is effected in the present form of invention by complementary addition clear across the group of totalizer wheels which lie opposite the actuators 175, it follows that, upon the addition of the true complement of the first of the items to be subtracted, to the minuend registered on the totalizer, the excess "1" will be passed successively along the totalizer wheels of higher orders until it disappears, in effecting which disappearance, the trip tooth 345 (Fig. 60) of the effective totalizer wheel of highest denomination wipes over the cam 346 on the switch member 347, rocking the switch member downwardly or counter-clockwise to depress the associated transmitting member 349, the lower end of which lies in line with the upper end of the finger 453 of the trip bar 448.

The foot of the trip bar 448, as the latter is forced downwardly by the transmitting member 349, presses against the stud 447 on the tail of the latch 441 and rocks the latch against the tension of its restoring spring 445 to cause it to release the lip 443 on the forward arm of the locking lever 434 and free the locking lever to the action of its spring 440, as shown in Fig. 66, which thereupon rocks the locking lever counter-clockwise from the position shown in Fig. 63, thereby withdrawing the arresting tooth 439 out of the path of the locking projection 429 on the disk 426 to oppose no obstruction to the rotation of the disk and main drive shaft 206, the locking tooth 438 rocking upwardly into the space between the disks 425, 426.

The forwardly extending arm of the locking lever comes to rest against the base portion of a stop 460 which limits the travel of the locking lever under the influence of its spring 440.

The withdrawal of the arresting tooth 439 permits the main drive shaft to complete its cycle.

The operator then sets up the actual amount of the second debit item on the keyboard and in the field of value-representing elements 77 and again operates the main drive shaft.

At this time, the locking lever 434 is in its tripped position to which it was rocked during the previous operation, and to reset such lever in time to enable its tooth 439 to co-act, if required, with the locking projection 429 on the disk 426, mechanism is provided which is timed to restore the locking lever to its normal latched position early in the first half cycle of the main drive shaft as follows:

A jack shaft 465 (Figs. 4-6, 23 and 59) journaled at its opposite ends in the left side frame 52 and the partition plate 53, respectively, is arranged parallel with and in advance of the main drive shaft 206. A gear 466 (Figs. 4 and 23) fast on the drive shaft is in constant mesh with a driven gear 467 rotatably mounted on the jack shaft intermediate its ends, the gear 467 having a female clutch member 468 fast therewith opposed to a male clutch member 469 splined on and slidable along the jack shaft 465, by a pin 461 embraced by a slot 462 formed in the clutch member 469 (Fig. 59).

An oppositely facing male clutch member 470 similar to the clutch 469 and connected thereto by a reduced neck 471, is adapted to engage a female clutch member 472 formed on the hub

of a driven gear 473 rotatably mounted on the jack shaft near the inner end thereof and in mesh with an intermediate pinion 474 (Fig. 4) journaled on a stud 475 projecting from the partition 53. A drive gear 476 on the main shaft 206 is in constant mesh with the intermediate pinion 474.

One or the other of the male clutch members 469, 470 is always engaged with its co-acting clutch member 468 or 472, respectively, to enable either drive gear 466 or 476 to turn the jack shaft in one direction or the other according to which driven gear 467 or 473 is clutched to the shaft.

The twin clutch members 469, 470 are controlled by the subtraction lever 403 through its shipper rod 458 (Fig. 59) which carries a fork 477 embracing the neck 471 of the twin clutch member.

In adding operations, the spring 413 operating on the subtraction bell crank 406, holds the shipper rod and its fork 477 at their right-hand limits of travel with the clutch members 470, 472 engaged as shown in Fig. 59, to enable the drive gear 476 (Fig. 4) on the main shaft to turn the jack shaft through the intermediate pinion 474 and driven gear 473 in the same direction in which the drive shaft rotates.

The subtraction lever 403, when operated, shifts the twin clutch members to disengage the clutch member 470 from its co-acting member 472 and engage the clutch member 469 with its co-acting clutch member 468 to effect a direct drive from the main shaft to the jack shaft through the drive gear 466 and driven gear 467 in the opposite direction.

When the machine is at rest, the low point of a reversible cam 478 (Figs. 4-6, 58 and 59) fast on the jack shaft 465 normally lies in contact with a roll 479 on the rear arm of a resetting lever 480 pivoted on a long stud 481 (Fig. 59) projecting inwardly from the left side frame 52, the forward arm of the resetting lever being widened (see Figs. 5, 6, 23 and 58) and carrying a resetting pawl 482 pivoted thereto at 483. An interposed friction washer 489 (Fig. 59) retains the resetting pawl in any position to which it may be adjusted.

The jack shaft 465 is given a single complete rotation at each operation of the machine, and irrespective of the direction of such rotation, the reversible cam 478 operates early in the first half cycle to rock the resetting lever 480 in clockwise direction against the tension of a restoring spring 484 (Figs. 3-6) connected with an operating arm 488 fast on the head of the resetting lever 480.

The resetting lever 480, on its clockwise travel, causes a shoulder 485 (Figs. 65-67) on the resetting pawl 482 to contact a stud 486 projecting from the forward arm of the tripped locking lever 434 (as in Fig. 66) and rock the locking lever clockwise until its lip 443 clears the shoulder 444 on the latch 441 (as shown in Fig. 67) whereupon the latch spring 445 snaps the latch shoulder beneath the lip in readiness to hold the locking lever in set position, as soon as the resetting pawl releases the stud 486.

The resetting pawl is disengaged from the locking lever 434 as soon as the locking lever is reset so as to enable the lever to be tripped early in the first half cycle of the main drive shaft, if required. The resetting pawl 482 on that side opposite the shoulder 485, carries a pair of parallel jaws 487 spaced apart from each other and conveniently lying on opposite sides of the re-

duced outer portion of the stop 460 which arrests the locking lever 434 when released to the action of its spring.

As the resetting lever 480 and its pawl 482 return the locking lever approximately to the position where the latch 441 may snap beneath the lip 443 (Fig. 67) the foremost jaw 487 contacts the stop 460, whereupon continued movement of the resetting lever in clockwise direction causes the resetting pawl to rock counter-clockwise on its pivot 483 to disengage its shoulder 485 from the stud 486 on the forward arm of the locking lever 434, so that shortly after the latch 441 has snapped beneath the lip 443 of the locking lever, the resetting pawl 482 has disengaged itself from the locking lever and the spring 440 has caused the lip 443 on the locking lever 434 to settle against the shoulder 444 on the latch, preparatory to another operation of the overdraft indicating mechanism.

The foregoing restoration of the overdraft indicating mechanism occurs early in the first half cycle of the main drive shaft succeeding that cycle during which the overdraft indicating mechanism was tripped, and during the operation of subtracting the second debit item from the balance remaining on the totalizer, according to the example under discussion.

Assuming that this second item is a larger amount than the balance registered on the totalizer, the addition of the true complement of such item to such balance will not result in the successive transfer of the excess "one" out of the totalizer, the totalizer wheel of highest value will not pass from its "9" to its "0" position, and hence the tripping tooth 345 of such wheel will not actuate its switch member 347 and transmitting slide 349 to release the locking lever 434.

Consequently the arresting tooth 439 of the locking lever will remain in the path of the locking projection 429 of the disk 426 (see Figs. 63 and 64) and as the main drive shaft 206 approaches the completion of its cycle, the locking projection 429 will contact the arresting tooth 439 which prevents farther rotation of the disks 426 and 425 with the stud 430.

However, the main drive shaft 206 with its cams 331, 332 and stud 433 will continue their rotation to complete the cycle, thereby tensioning the spring 432, the length of the slot 431 in which the stud 430 travels permitting the completion of the cycle, at the conclusion of which the opposite end wall of the arcuate slot 431 lies closely adjacent the stud 430 which is locked against farther rotation by the arresting tooth 439 so as to block any attempt to again operate the machine.

The operator, upon attempting to again turn the main drive shaft and finding it locked, is thereby apprized of the fact that the subtraction of the last item from the balance registered, exhausted such balance and resulted in an overdraft, the amount of which corresponds with the complement of the total then registered on the totalizer.

An example may afford a clearer understanding of the foregoing operation.

Assuming a credit balance of \$5.75 registered on the totalizer and that two debit items of \$2.55 and \$3.75 are to be subtracted therefrom:

The operator sets up the first debit item \$2.55 on the keyboard and in the value-representing field of elements 78, and operates the subtraction lever 403 to condition the machine for sub-

traction or complementary addition, after which the main drive shaft is given a complete rotation.

Prior to the operation of the main drive shaft, the totalizer of the present machine read-----

5 000,000,000,575

Setting up the debit item of \$2.55 and operating the main drive shaft with the machine conditioned for subtraction adds the following amount to the credit balance-----

10 999,999,999,745

Leaving a remainder or credit balance of-----

000,000,000,320

The addition of the complement of the debit item to the credit item registered results in the successive transfer of the excess "1" until it disappears, during which the totalizer wheel 176 of highest denomination trips the locking lever 434 which thereupon rocks its tooth 439 out of the path of the projection 429 on the disk 426. Repeating the above operation with the second debit item \$3.75 results in the addition to the remainder of-----

999,999,999,625

Leaving a negative balance of-----

999,999,999,945

Which is the true complement of the negative balance-----

000,000,000,055

It will be noted that, as a result of the last operation, the excess "1" was not transferred out of the totalizer. Hence, the totalizer wheel of highest denomination did not pass from "9" to "0" and its tripping tooth 345 did not actuate the train of mechanism leading to the trip bar 448 to release the locking lever 434, the tooth 439 of which remains effective to arrest the locking projection 429 and lock the main drive shaft against a succeeding operation.

To release the main drive shaft for further operation, either to enter additional debit items; to enter a credit item, or to prepare the machine for the reception of another problem, the operator merely releases the subtraction lever 403, whereupon the restoring spring 413 (Fig. 4) thereof, operating through the bell crank 406, returns the subtraction lever to normal position, withdraws the cam lever 410 (Fig. 54) from the disk cam 401 to enable the spring 402 (Fig. 4) to restore the index carriage and its cradle to their additive positions and slides the shipper rod 458 to the right, to shift the twin clutch members 469, 470 likewise, thereby disengaging the former from its co-acting clutch member 468 and engaging the clutch member 470 with its co-acting clutch member 472 to permit the main drive shaft to turn the jack shaft in the same direction in which the main shaft rotates.

The shipper rod 458, as it completes its travel to the right, causes the left-hand end wall of the notch 459 (Fig. 62) to shift the locking lever 434 axially of its pivot stud 435, thereby removing the arresting tooth 439 (Figs. 63 and 64) from in front of the locking projection 429 and introducing the companion arresting tooth 438 into the orbit of the co-related locking projection 428 (Figs. 5 and 60-62), the stud 486 on the forward arm of the locking lever, with which the resetting pawl 482 co-acts, being of sufficient length to be engaged by the resetting pawl in either adjustment of the locking lever.

Removal of the active arresting tooth 439 from the path of the locking projection 429 on the

disk 426 frees the disks 425 and 426 with their locking projections 428, 429 and stud 430 to the action of the tensioned spring 432, which immediately rotates the disks and their connected parts counter-clockwise about the main drive shaft 206 until arrested by contact of the stud 430 against the forward end wall of the limit slot 431.

This rotation of the disks 425, 426 occurs so rapidly that the locking projection 428 passes beyond the arresting tooth 438 before the latter arrives in its orbit of travel.

The machine is now unlocked for further operation.

Should the next item to be entered be a debit item, it is set up as usual, the subtraction lever 403 shifted to, and held in operated position and the main drive shaft turned, whereupon the locking lever 434 will be reset, as heretofore explained, during the first half cycle of the main drive shaft, and the true complement of such debit item will be added to the true complement of the negative balance on the totalizer.

Since the addition of the third debit item to the complement of the negative balance registered on the totalizer will not cause a transfer of the excess "1" out of the totalizer, the machine will be again locked at the end of such operation in identically the same manner as heretofore set forth.

Additional debit items may, of course, be accumulated by pursuing the same procedure above outlined, the machine locking at the end of each such operation, necessitating the release and resetting of the subtraction lever, as also explained.

Should the third item be a credit instead of a debit, it is entered in the same manner on the keyboard and field of value-representing elements, and the main drive shaft turned without first actuating the subtraction lever 403.

During the first part of the rotation of the main drive shaft, the locking lever 434 is reset to its latched position, and although the jack shaft 465 turns in a reverse direction to that in which it rotates when the subtraction lever 403 is in its operated position, the reversible resetting cam 478 on the jack shaft is so shaped as to rock the resetting lever 480 to effect the restoration of the locking lever 434 irrespective of its direction of rotation, the jack shaft, during the second half cycle of operation of the main shaft 206, bringing the low point of the resetting cam 478 opposite the roller 479 on the resetting lever to enable the latter to return to its normal idle position under the influence of the spring 484.

The resetting pawl 482 for the locking lever 434 might be restored to its normal position relatively to the stud 486 on the locking lever, by a spring, but I prefer to arrange for the return of the resetting pawl through the rearmost projection 487 thereof. As the resetting lever 480 on which the pawl is mounted is returned to its normal position by the spring 484, the rearmost projection 487 contacts the stationary stud 460 and as the resetting lever continues its return, the resetting pawl 482 is switched back to normal position, as shown in Fig. 65.

The resetting lever 480 overhangs the shipper rod 458, and to enable the lever 480 to complete its clockwise rocking movement irrespective of the position of such shipper rod, the latter is provided with a pair of parallel slots 496 extending transversely across the rod (Figs. 58, 62 and 63), and arranged at such distance apart that one or the other of the slots lies beneath and

in registry with the lower edge of the resetting lever 480, in either position of the shipper rod.

When, upon operation of the machine, the resetting cam 478 rocks the resetting lever 480 clockwise, as in Fig. 58, the lower edge of the resetting lever enters that slot 496 in line therewith to lock the shipper rod, subtraction lever and connected parts against movement until the resetting lever restores to its normal idle position. As a result, an adding operation cannot be initiated and thereafter changed to a subtracting operation subsequent to starting the main drive shaft, nor can a subtracting operation be altered to an adding operation after the main drive shaft starts to rotate, because the subtraction key 403 is locked, as above explained, by the main drive shaft, the resetting cam and the resetting lever during operation of the main drive shaft.

In case the amount of the credit to be added as a positive amount be less than the actual debit, the true complement of which is registered on the totalizer, there will be no transfer across the totalizer, and hence no release of the locking lever which, in adding operation, lies in its normal position shown in Figs. 5, 6 and 62, with its arresting tooth 438 in the same vertical plane with, but out of the orbit of, the locking projection 428.

Therefore, the machine will not be locked at the end of such operation.

If the credit amount to be added is greater than the negative balance the complement of which is registered on the totalizer, however, there will be a transfer across the totalizer as such operation converts the balance from negative to positive, and as a result, the locking lever 434 will be tripped to position the arresting tooth 438 on the lower prong of the locking lever in the path of the locking projection 428 (Fig. 61) to prevent the latter and its disk from completing their rotation, and consequently locking the machine.

The object of locking the machine on the passage of the totalizer "through zero" from positive to negative or vice versa is to acquaint the operator of this fact beyond any possibility of error, a glance at the amount registered on the totalizer sufficing to indicate whether the balance is positive, in which case the amount will be preceded by a row of ciphers, or negative, in which event, the true complement of the amount will be preceded by a row of "9's".

Conditioning the totalizer wheel of highest denomination for clearing operations

In effecting the operation of the overdraft indicator it will be noted that the trip tooth 345 (Fig. 60) passes beyond the drop of the cam shoulder 346 after having depressed the switch member 347 to trip the latch 441 and release the locking lever 434.

The switch member 345 actuated by whichever wheel 176 is of highest denomination in any position to which the totalizer carriage is adjusted, remains in its lowered position since there is no corresponding carry actuating cam 332 to effect its restoration.

Consequently, should the operator reset the totalizer to zero prior to another operation of the machine, the tripping tooth 345 on its reverse rotation with the totalizer shaft 255 would not contact with the abrupt face of the cam shoulder 346 when the totalizer wheel arrived in its zero position, as heretofore explained, but would continue to turn with the shaft.

To avoid this disadvantage, provision is made to return the switch member 347 partway towards its normal position immediately after the latch 441 is tripped, whereby to interpose the shoulder 346 into the path of the tripping tooth or projection 345, in the following manner.

The shoulder 346 is of sufficient height to enable the tripping tooth to impart such throw to the latch 441 as will cause it to clear its shoulder 444 from beneath the lip 443 of the locking lever, and as the tripping tooth 345 of the totalizer wheel escapes past the cam shoulder 346 on the switch member 347, the latch spring 445 tensioned by the train of tripping mechanism actuated by the tripping tooth, is free to partially restore the latch towards its normal locking position, until the reduced edge of the latch shoulder 444 contacts the lip 443.

The tail of the latch, on such partial return, presses its stud 447 upwardly against the foot of the trip bar 448 and partially restores the latter, the finger 453 at the upper end of the trip bar in turn pressing against the lower end of the transmitting slide 349 to cause the laterally extending flange 348 of the latter on which rests the switch member 347, to return such switch member partway to its effective position and thereby bring the cam shoulder 346 into the orbit of the tripping tooth 345 to arrest the latter in its zero position if a clearing operation is performed prior to the next operation of the machine on which the switch member will be completely reset.

Should the auxiliary transmitting member 454 (Fig. 35) be in line with the trip bar 448, the transmitting member 349 of highest denomination which is connected by the bar 455 with the auxiliary transmitting member 454, will operate to restore its switch member 347 in the same manner as just described.

Exceeded capacity signal

The overdraft indicator just described is also effective as an exceeded capacity signal during adding operations.

The two excess capacity totalizer wheels in that form of the invention herein illustrated, which are at the left of the ten direct adding wheels 176 in any position of the totalizer carriage except the extreme right-hand position, as heretofore explained, are provided to afford a capacity of twelve denominations, or up to ten billions, but it may happen that the operator is listing a great number of large amounts, as in astronomical calculations, monies of small denominations, such as Brazilian or Portuguese currency, or what not, where such additional wheels are taxed to their capacity.

In such cases, the addition to an amount already registered, of an item which exceeds the capacity of the number of effective totalizers in use under any adjustment of the carriage will operate through the carrying mechanism to turn the totalizer wheel of highest denomination from its "9" to its "0" position, during which step of rotation the tripping tooth 345 of such wheel will actuate the transmitting train of mechanism controlling the trip bar 448 to release the locking lever 434 which immediately rocks its arresting tooth 438 into the path of the locking projection 428 to lock the machine against a succeeding operation, in the manner heretofore explained.

The operator, upon attempting the entry of another item is immediately advised that the entry of the last item exceeded the capacity of the machine.

A partial or complete operation of the subtraction lever 403 shifts the locking lever 434 laterally to displace the active arresting tooth 438 out of the path of the locking projection 428, whereupon the tensioned spring 432 snaps the locking projection past the point where it was arrested, see dotted lines in Fig. 61, as heretofore set forth.

The subtraction lever may be held in its fully operated position while the operator subtracts the amount of the item last entered to restore the former total on the totalizer, if desired, the machine being automatically locked at the end of such subtracting operation so long as the subtraction lever is held in its effective position, but upon release of such lever, the locking lever 434 is shifted to the right to disable the lock.

In this connection, it will be noted that in subtraction operations, the locking lever 434, when in latched position, arrests the main drive shaft and when tripped, permits succeeding subtraction operations, whereas in adding operations, the locking lever, when in latched position, permits successive cycles of the main shaft, and when tripped, locks the main drive shaft against rotation.

Operation of division

The performance of division, which as practiced on a calculating machine, is effected by repeatedly subtracting the divisor from the dividend, may be accomplished by at least two methods, the customary one being to first shift the totalizer carriage to its extreme left-hand position, and then enter the dividend on the totalizer.

The divisor may then be set up in the field of value-representing devices, and the totalizer carriage shifted to the right until the least number of wheels on which are registered the digits of higher orders of the dividend into which the divisor will "go", lie opposite the actuators 175 controlled by the set elements 77 representing the divisor.

Assuming a divisor of "123" and a dividend of "456,789", the totalizer wheels bearing the digits "456" would be located opposite the first three denominational actuators 175.

If the divisor be larger than the amount represented by an equal number of the higher digits of the dividend, then the totalizer carriage may be so positioned that the totalizer wheel bearing the digit of highest denomination of the dividend lies one step to the left of the digit of highest denomination represented in the field of elements.

Graduations on the sight plates associated with the totalizer wheels and the actuators facilitate the proper location of the totalizer carriage.

In either case, after the totalizer carriage is properly positioned, the operator shifts the subtraction lever 403 to condition the machine for subtraction, rocks the repeat key lever 356 to its rearward position, and proceeds to turn the main drive shaft.

In consequence, the true complement of the divisor is added to that portion or section of the dividend registered on the wheels located opposite the actuators controlled by the set elements representing the divisor, the remaining actuators of higher denominations operating their totalizer wheels which originally registered zeros, to add "9's" thereon, whereby to eliminate the excess "1" all as fully explained heretofore, in connection with the operation of subtraction.

As soon as the amount registered on the active totalizer wheels which originally displayed the higher digits of the dividend, becomes less than the divisor, the automatic lock becomes effective

to prevent further operation of the machine, whereupon the operator shifts the subtraction lever 403 to the "add" position, thereby releasing the lock, and operates the machine once to restore to the totalizer the last amount subtracted, (123 in the example given). He then shifts the totalizer carriage to the left one or more "places" or denominational steps to, in effect, increase that portion of the dividend under treatment, reconditions the machine for subtraction, and operates the machine until again arrested by the effective action of the automatic lock, which indicates, as before, that the amount remaining on the active totalizer wheels has been exhausted, whereupon he repeats the operations hitherto explained, until the dividend is entirely cleared from the totalizer wheels, or a remainder left which is less than the divisor.

An understanding of the above-explained operation of division may be facilitated by the following problem set forth step by step on a machine having a capacity of eleven places.

Dividing 456,789 by 123 gives a result of "3713" with a remainder of "90".

00000456789
99999877

00000333789 (1)
99999877

00000210789 (2)
99999877

00000087789 (3)
99999877

99999964789 (4) Machine locks.
00000123 Divisor added once to restore totalizer to previous reading.

00000087789 (3) Carriage shifted one step to left and subtraction resumed.

999999877

00000075489 (1)
999999877

00000063189 (2)
999999877

00000050889 (3)
999999877

00000038589 (4)
999999877

00000026289 (5)
999999877

00000013989 (6)
999999877

00000001689 (7)
999999877

99999989389 (8) Machine locks.
123 Divisor added once to restore totalizer to previous reading.

00000001689 (7) Carriage shifted another step to left and subtraction resumed.

999999877

00000000459 (1)
999999877

99999999229 (2) Machine locks.
123 Divisor added once to restore totalizer to previous reading.

99999999877
99999999877

and subtraction resumed.

00000000336 (1)
99999999877

00000000213 (2)
99999999877

00000000090 (3)
99999999877

99999999967 (4) Machine locks.
123 Divisor added once.

00000000090 (3)

The several series of figures in parentheses indicate the number of operations in each carriage adjustment and by taking the last number in each series, it is seen that "123" is contained in "456,789" 3713 times, leaving a remainder of "90" on the totalizer.

In the early practice of this method of division, and even on many of the present-day machines, it was and is necessary for the operator to closely watch the totalizer wheel dials so that he may cease turning the main drive shaft when the amount represented by the higher digits of the dividend under treatment is reduced below the actual divisor, and when this occurred, the operator had to set the complement of the divisor to the right one place.

Also, it was necessary for the operator to remember how many times he added the complement of the divisor to the dividend, in each of the several denominational positions occupied by such complement in order to obtain the correct quotient.

Later machines include means on which the present invention is an improvement, to not only indicate when the operator has exceeded the proper figure in the quotient, but also to indicate the quotient automatically.

In attaining the first result, the above described overdraft indicator means controlled by the effective wheel of highest order is utilized, such means, in the present instance, locking the machine against operation at the end of that stroke during which the quotient is exceeded; that is to say, the machine is locked at the end of that stroke during which the divisor has been subtracted from the dividend once too often.

This enables the operator to effect division in a most rapid and facile manner, since it is no longer necessary for him to watch the totalizer to know when to cease subtracting the divisor from the dividend, as the subtraction of the divisor once too often automatically effects a locking of the machine and prevents a continuance of the subtracting operations, whereupon the operator need only release the subtraction lever 403 to disable the lock and simultaneously condition the machine for addition, operate the main drive shaft once to accumulate on the totalizer the last amount subtracted, shift the totalizer carriage and totalizer one or more steps to the left until the wheels of highest denomination located opposite the set elements representing the divisor, register an amount greater than the divisor, set the subtraction lever to, and hold it in effective position, and resume the successive cycling of the main drive shaft until the latter is again locked by the exhaustion of that part of the dividend on the wheels last positioned opposite the set elements representing the divisor.

Repetition of the above operations will result

in the accurate division of the dividend by the divisor, leaving the wheels clear if the divisor is contained evenly in the dividend, or leaving a remainder on the totalizer less than the divisor.

It will be understood that, as commonly practiced, the repeat or multiplying key 356 (Figs. 1, 3, 4, 22, 27 and 28) will have been set to disable the index carriage return mechanism, so that the set elements 77 representing the divisor remain opposed to their actuators throughout the operation of division.

Restoration of incomplete carry

Reference has been made to the fact that the carrying mechanism controlled by whichever totalizer wheel is of highest denomination in any particular adjustment of the totalizer carriage except that farthest to the right, may be shifted to operative position, but will not be operated because its pawl-carrying lever 321 (Figs. 42, 43 and 52) lies beyond and to the left of the pawl-actuating cam 332 (Figs. 4-6) of highest denomination.

Obviously, adjustment of the totalizer carriage towards the right from its extreme left-hand position would bring such effectively-positioned carrying mechanism within the scope of operation of one or another of the carry-actuating cams 331, 332, depending upon the extent of such adjustment, and if no precaution was taken to prevent, an operation of the main drive shaft 206 with the totalizer carriage in its newly adjusted position, would result in a completion of the carry and the unintentional addition of "1" on a totalizer wheel, which would render erroneous the result of a new calculation.

To prevent the possibility of such objectionable occurrence there is provided means automatically effective whenever the totalizer carriage is shifted in either direction, to reset any shifted carrying mechanism to its normal ineffective position, one form of which means is as follows:

It will be remembered that the tails 351 (Figs. 42 and 43) at the rear lower corners of the guide and positioning plates 334 are accommodated in parallel guide slots 352 formed at an incline in the cross beam 317, which are in register with recesses 355 (Figs. 40, 42 and 43) formed in the rear edge of the cover plate 325.

A carry-restoring bar 490 rests upon the upper face of and lies parallel with the cover plate.

Headed studs 491 (Figs. 35 and 40) pass through transversely extending slots 492 in the carry-restoring bar 490 and into the fixed cover plate 325, the forward edge of the carry-restoring bar having teeth 493 formed therein which lie between the upturned ears 324 at the forward edge of the cover plate, and project therebeyond for guidance.

If desired, springs 494 anchored at their opposite ends to the carry-restoring bar and to ears 324 on the cover plate, may be provided to urge the carry-restoring bar forwardly as far as permitted by the rear end walls of the slots 492, which normally contact the upturned ears 324 fitting in the spaces between the teeth 493, to maintain the teeth projected beyond the forward edge of the cover plate 325 which, in turn, overhangs the beam 317, as shown in Figs. 42 and 43.

There are, preferably as many teeth 493 as there are carrying mechanisms, the teeth being offset laterally with relation to each of the guide and positioning plates 334 of the carrying mechanisms, additional teeth being provided at the opposite ends of the series to insure the operation

of the carry-restoring bar in any adjusted position of the totalizer carriage.

The outer ends of the teeth 493 are oppositely beveled (see Fig. 40) to co-act with the oppositely beveled faces of stationary cams 495 (Figs. 2, 22 and 54) mounted on the left side frame 52 and the partition 53 in line with the teeth 493, the beveled ends of such restoring cams 495 projecting into the space between those pairs of teeth which lie adjacent thereto in any adjusted position of the carriage.

The rear edge of the carry-restoring bar 490 is recessed, as at 497 (Fig. 40), the front wall of such recess normally lying transversely across and a little in front of the inclined front edges of the series of vertically-arranged guide and positioning plates 334 at points adjacent the lower front corners of such plates (see Figs. 42 and 43).

In the ordinary operation of the machine, the guide and positioning plates 334 rock clockwise and counter-clockwise, as heretofore explained, without interference from the carry-restoring bar 490, the forward edges of the guide and positioning plates, when at their clockwise limit, lying in substantial contact with the recessed edge of the carry-restoring bar (Fig. 43), but in the event that the capacity of the totalizer is exceeded, either additively or subtractively, as heretofore explained, the guide and positioning plate 334 controlling the effectiveness of the carrying pawl 326 associated with the totalizer wheel beyond and to the left of the pawl-actuating cam 332 of highest denomination, will be rocked to its clockwise limit of travel by the active totalizer wheel of highest denomination, thereby locating its carrying pawl in position to effect a carry on the wheel to the left of the active totalizer wheel of highest order.

However, in order to drive such set carrying mechanism, it would be necessary to shift the totalizer carriage to the right to bring the pawl-carrying lever 321 into operative relation with one or another of the pawl-actuating cams 331, 332, and during the first step of such travel the teeth 493 of the carry-restoring bar 490, which lie adjacent the cams 495, ride over the projecting beveled ends of their associated cams which force the carry-restoring bar rearwardly, causing its recessed rear edge to contact the forward edge of the tripped guide and positioning plate 334 to restore the plate and its carrying pawl 326 to their normal positions, wherein the pawl is ineffective.

Employment of a pair of restoring cams 495 spaced apart as shown insures an even motion of the carry-restoring bar 490 transversely of the cover plate without canting or binding on the guides 491.

After the active teeth 493 have escaped past the beveled ends of the restoring cams 495, the springs 494 may advance the carry-restoring bar to remove its rear edge from the paths of travel of the guide and positioning plates 334 when shifted in the ordinary operation of the machine, or the return springs 323 for the pawl-carrying levers 321 may be relied upon to effect this result.

Obviously, the totalizer carriage, when shifted to the left, will effect the same result, and the carry-restoring bar 490 being common to all the carrying mechanisms, serves to insure the restoration of any tripped carrying mechanism to normal whenever the totalizer carriage is shifted.

Quotient and multiplier indicators

It is common in the class of machines embodying the foregoing novel features, to provide an indicator to disclose the quotient, in operations of division, and also an indicator, to disclose the multiplier in multiplying operations.

To these ends, there are provided two separate indicators or counters, each comprising a series of numeral wheels 500 and 501, respectively, (Figs. 1, 3, 5, 6, 23 and 35), similar in general construction to the totalizer wheels 176, the two indicators being mounted in alignment on a single fluted indicator shaft 502 (Figs. 36 and 38), lying in front of and parallel with the totalizer shaft 255, the ends of the indicator shaft 502 being journaled in bearings in the forward ends of the totalizer carriage side frames 261, 262.

The respective indicators 500 and 501 are separated by a collar 503 (Fig. 35) located about centrally of the indicator shaft, and set collars 504 at the opposite outer ends of the series of indicators maintain the wheels in assembled position.

A drive pinion 505 is associated with each indicator wheel, and separate drive pawls 506 and 507 (Figs. 4-6, 23 and 58) for the respective indicators are actuated from a common source, to co-act with one or another of the drive pinions 505 of its related indicator, depending upon the particular adjustment of the totalizer carriage and its indicators relatively to the drive pawls.

The drive pawls 506 and 507 are longitudinally slotted, as at 508, to accommodate the transversely grooved guide rod 452 extending between and supported at its ends in the left side frame 52 and the partition wall 53, respectively. The lower end of each drive pawl is circularly apertured to snugly fit over its respective eccentric 509 fast on the jack shaft 465. The eccentrics are mounted near the respective opposite ends of the jack shaft, the drive pawls extending substantially vertically upwardly therefrom and each terminating at its upper end in a tooth adapted to engage and turn a drive pinion 505 and its indicator wheel one step, at each rotation of the jack shaft irrespective of the direction of rotation of the latter, it being obvious that the direction in which the drive pawls will turn the indicator wheels depends upon the direction of rotation of the jack shaft.

The drive pawls 506, 507 are separated on the jack shaft a distance equal to the distance between corresponding denominational wheels of the respective indicators, so that, for instance, when the totalizer carriage is in its extreme left-hand or normal adding position, the right-hand drive pawl 506 will engage the drive pinion 505, connected to the units wheel of the multiplier indicator 500 and the left-hand pawl 507 will engage the drive pinion 505 of the units wheel of the quotient indicator 501.

It will be noted that the numerals on each wheel of the multiplier indicator 500 at the right are arranged in progressive sequence about the wheels, in a direction opposite to the arrangement of the numerals on the wheels 501 of the quotient indicator at the left.

And in this connection, it will be recalled that provision is made through the twin clutch members 469, 470, 471 (Figs. 4 and 59) and the separate trains of drive gears 466, 467 and 473, 474 and 476 to reverse the direction of rotation of the jack shaft 465 under control of the subtraction

lever 403 with its bell crank 406, shifter rod 458 and fork 477.

The jack shaft, and its eccentrics 509, when rotated, will first simultaneously raise both drive 5 pawls 506, 507 to engage and turn the particular wheels of the respective indicators which lie opposite such pawls in any adjustment of the totalizer carriage, and will then withdraw the pawls simultaneously to their normal idle positions. 10

When the machine is conditioned for adding, which, in the form of invention herein illustrated, is its normal condition, the jack shaft 465 will be driven through the train of gears 473, 474 and 476, and the drive pawl 506 for the multiplier indicator will be raised and rocked to turn the opposed indicator wheel 500 counter-clockwise (Figs. 5 and 6) to bring successively higher digits of the wheel at the sight opening in the casing (Fig. 1). Meanwhile the drive pawl 507 will be operated to turn its opposed quotient indicator wheel 501 in the same direction, but owing to the reversal of progression of the numerals on the quotient indicator, the wheel will display 20 successively lower digits at the sight opening. 25

Conditioning the machine for subtraction by operation of the subtraction lever 403, shifts the clutch members 469, 470 to reverse the direction of rotation of the jack shaft 465, through the gears 466, 467 and consequently the throw of the drive pawls 506, 507 is reversed so that the pawl 507 actuates the particular quotient indicator wheel 501 in its path, step by step to present the numerals in ascending order at the sight opening, 35 whereas the drive pawl 506 for the multiplier indicator 500 reversely turns whichever wheel is in its path, to present the numerals one by one in descending order at the sight opening. 40

In multiplying operations, it will be recalled that with the machine conditioned for addition, the multiplicand is set up in the field of value-representing elements 77, the repeat key set, and the machine operated a number of times equal to the number of units in the units digit of the multiplier, after which the totalizer carriage may be moved to the right one step by operation of the carriage shifting handle 391, (Figs. 1 and 3), and the machine then operated a number of times equal to the number of digits in the tens figure of the multiplier, and so on until the multiplier is exhausted. 45 50

Assuming the machine to have been first operated with the totalizer carriage in its extreme left-hand position, the multiplier drive pawl 506 will actuate the units wheel of the multiplier indicator 500 step by step according to the number of operations of the machine with the totalizer carriage in the stated position, which results in registering on the multiplier indicator, the units digit of the multiplier. 55 60

Similarly, when the totalizer carriage is shifted one step to the right, and the machine repeatedly operated according to the number of units in the tens figure of the multiplier, the drive pawl 506 will turn the tens wheel of the multiplier indicator, which has been brought into line with the pawl by the shift of the carriage, to register thereon the "tens" figure of the multiplier, and so on until at the conclusion of the multiplying operation, the multiplier indicator 500 displays the multiplier used in the problem. 65 70

Meanwhile, the drive pawl 507 for the quotient indicator has turned the corresponding wheels of its indicator backwardly as regards the progres- 75

sion of numerals thereon, an equal number of steps.

In performing division, however, during which operation the divisor, which is set up in the value-representing field of elements, is repeatedly subtracted from the dividend registered on the totalizer, as heretofore explained, the direction of rotation of the jack shaft 465 is reversed, the totalizer carriage being first located to the right of its left-hand limit of travel, is adjusted as required towards the left and the drive pawl 507 for the quotient indicator actuates the respective wheels of its indicator from the higher to the lower wheels successively to register thereon the number of times the machine is operated with the totalizer carriage in each of its adjusted positions, so that at the end of the operation of division, the quotient is displayed on the indicator 501 with the remainder, if any, on the register, while the drive pawl 506 has stepped the corresponding wheels of the multiplier indicator reversely to their direction while adding and multiplying. 80 85 90 95

Arranging the numerals around the wheels of the quotient indicator in a direction opposite to that in which the numerals progress around the wheels of the multiplier indicator, and reversing the operation of the drive pawls, enables the machine to be used in short-cut methods of calculation, as in figuring percentage, for instance. 100

Transfer mechanism for multiplier indicator

The multiplier indicator 500 is useful as a stroke or item counter in listing a large number of amounts, and to facilitate such use, as well as others, a transfer mechanism embodying novel features is provided for such indicator. 105 110

Parallel posts 515 (Figs. 3-5, 22 and 23) project upwardly from the machine side frame 52 and the partition wall 53, respectively, and support a cross rod 516 parallel with and in front of the indicator shaft 502. The indicator shaft travels with the totalizer carriage relatively to the cross rod 516. 115

Hangers 517 journaled at their upper ends on the cross rod 516 sustain a supporting bar 518, rectangular in cross-section and secured at its ends to the depending portions of the hangers, the rear edge of the guide and supporting bar being transversely slotted as at 519, to accommodate carrying pinions 520 journaled on a rod 521 seated in a groove 522 (Fig. 5) extending longitudinally of the supporting bar 518 intermediate the ends of the transverse slots 519. 120 125

The journal rod 521 may be suitably fastened to the supporting bar 518 and its ends mounted in the hangers 517. 130

The carrying pinions 520 are equidistantly spaced so as to lie opposite and normally out of mesh with the respective drive pinions 505 on the right-hand faces of the multiplier indicator wheels 500. 135

There is a carrying pinion 520 for each multiplier indicator wheel except the units wheel, and each carrying pinion may be so positioned relatively to its respective drive pinion 505 as to engage the latter throughout only a part of its width, but I prefer to use carrying pinions of greater width than the driving pinions so that the right-hand portion of each carrying pinion shall lie in the same plane with a carrying tooth 523, (Figs. 35 and 37) projecting radially from the periphery of a disk 524 fast on the left-hand end of the hub of the multiplier indicator wheel of next lower order. 140 145

A detent and over-rotation preventing member in the form of a rod 525, common to the sev- 150

eral carrying pinions 520 extends across the entire series of such pinions with its ends projecting through slots 526 formed in the opposite hangers 517. One or more springs 527 (Figs. 5 and 6) connected to the supporting bar 518 overlie the detent and over-rotating preventing member 525 to press the latter yieldingly against the teeth of the carrying pinions at all times.

The slots 526 are arranged radially to the carrying pinions 520, and as the carrying pinions or any of them, rotate, their teeth force the detent member outwardly along the slots 526, the spring 527 restoring the member to position between the teeth of the carrying pinions, to insure the completion of the step of movement thereof, and to maintain the proper alignment of the teeth of the carrying pinions so that they may readily engage with or disengage from their respective drive pinions 505 during the operation of the machine.

The engagement and disengagement of the series of carrying pinions 520 with the drive pinions 505 of the multiplier indicator, is conveniently effected as follows:

It will be recalled that the resetting lever 480 (Figs. 5, 6 and 23) for the overdraft indicating mechanism is positively rocked clockwise by the cam 478 on the jack shaft 465 at the beginning of the first half cycle of each operation of the main drive shaft, and that a spring 484 restores the resetting lever 480 and its pawl 482 counter-clockwise to their normal positions under control of operating cam 478. The spring 484 is anchored at one end to one of the pivoted hangers 517, and the substantially upright arm 488 fastened to the resetting lever 480 carries a stud 528 projecting laterally into an open slot 529 formed in the adjacent hanger 517.

Obviously, as the resetting lever 480 rocks clockwise, at the beginning of an operation, its arm 488, through the stud connection 528, rocks the hangers 517 and their associated parts counter-clockwise about the fulcrum rod 516 to mesh the carrying pinions 520 with the drive pinions 505 of the multiplier indicator wheels 500. Such engagement is maintained by the operation of the cam 478 on the lever 480 until the withdrawal of the drive pawl 506 from the drive pinion 505 on the opposed multiplier indicator wheel, whereupon the low point of the cam 478 is brought opposite the roll 479 on the rear arm of the resetting lever 480 to enable the restoring spring 484 to rock the hangers 517 clockwise to disengage the carrying pinions 520 from the multiplier indicator pinions 505.

Simultaneously with the disengagement of the carrying pinions and their indicator pinions, the hanger 517 having the pin and slot connection 528, 529 with the upright arm 488, rocks the latter to return the resetting lever 480 and its pawl 482 to their normal positions, the contact of the roll 479 with the resetting cam 478 controlling the time of such return and of the disengagement of the carrying pinions 520 from the multiplier indicators 500.

During the time of engagement of the carrying pinions with their indicator wheels 500, the eccentrics 509 on the jack shaft 465 have projected their respective drive pawls 506, 507 upwardly into engagement with the particular indicator wheels 500, and 501 opposed to the drive pawls at that time, and as the lobes of the eccentrics pass dead center, they rock their respective drive pawls about the guide rod 452 as a fulcrum, to turn their corresponding indicator wheels one step, after which the eccentrics with-

draw their drive pawls from engagement with their respective indicator wheels.

As a multiplier indicator wheel 500 turns from its "9" to its "0" position at the sight opening, the trip tooth 523 engages and rotates the carrying pinion 520 in line therewith through one step of movement, and the carrying pinion, in turn, being at that time in mesh with the drive pinion 505 of the indicator wheel of next higher denomination, imparts one step of rotation thereto, to effect the transfer of "1" from the wheel of lower denomination.

It will be noted that the power for turning the wheel of higher order is derived directly from the main drive shaft through the drive pawl 506 as it turns the indicator wheel in line therewith, in view of which construction, the carry may occur clear across the series of indicator wheels or any part thereof.

Clearing the quotient and multiplier indicators

As heretofore stated, the wheels of the respective indicators 500 and 501 are similar in construction to the totalizer wheels 176, each being provided with diametrically opposed spring-pressed detents 270 (Fig. 36) carried by and projecting inwardly through the hubs of the wheels to frictionally engage one or another of the appropriate series of equidistant seats arranged circularly about the indicator shaft 502.

Knobs 536 (Figs. 1, 3, 35 and 54) on the opposite ends of the indicator shaft 502 enable the operator to turn the shaft with the two sets of indicator wheels to align the "zeros" at the sight line in clearing operations.

To this end, each indicator wheel 500, and 501 is equipped with a stop 537 (Figs. 5, 6, 36, 37) projecting radially beyond the periphery thereof and adapted to contact and be arrested by a zero alignment bar 538 common to and extending across both series of indicators in rear thereof where it will not interfere with the inspection of the indicators.

The opposite ends of the zero alignment bar are journaled in the end wall or sides 261, 262 (see Figs. 5, 6, 68 and 69) of the totalizer carriage, the lower edge of the alignment bar extending parallel with the indicator shaft 502 and preferably beveled to lie against or closely adjacent the peripheries of the indicator wheels 500, 501 in the paths of the stops 537 projecting from the respective wheels.

Obviously, retention of the zero alignment bar 538 in its normal position would arrest the indicator wheels when turning in one direction under the influence of their driving pawls 506 and 507 during additive operations of the machine, with a consequent liability of damage to the machine, to avoid which, means is provided to displace the zero alignment bar during the operation of the indicator wheels, and since the totalizer carriage, in which the indicator wheels 500, 501 and the zero alignment bar 538 are mounted, is adjustable relatively to such disabling means, it is necessary to arrange a universal connection between the disabling means and the zero alignment bar to permit the latter to be disabled in any of its adjusted positions.

It will be remembered that the upright arm 488 (Figs. 5, 6 and 23) on the resetting lever 480 carries a stud or pin 528 projecting into a slot 529 in one of the hangers 517 to rock the transfer pinions 520 into and out of mesh with the multiplier indicator wheels 500 at each operation of the machine, and I contrive to utilize this mechanism to control the zero alignment bar 538.

A universal bail comprising a horizontal cross rod 540 is supported by its ends at the outer ends of angular arms 541, the inner ends of which arms are pivoted at 542 to the inner faces of the sides 261, 262 of the totalizer carriage, (see Figs. 68-70 and 74). This cross rod passes through the slot 529 in one of the hangers 517 and through a similar slot in the remaining hanger, the slots embracing the cross rod 540 at different points, as the latter moves with the totalizer carriage to one or another of its adjusted positions.

A link 544 is pivoted at its opposite ends to one of the arms 541 of the universal bail and to an arm 546 depending from one end of the zero alignment bar 538, respectively.

As the upright lever arm 488 oscillates back and forth during each operation of the machine, it rocks the hangers 517 rigidly connected by the rod 516. The hangers, in turn, rock the universal bail 540, 541 to first thrust the link 544 rearwardly to turn the zero alignment bar 538 on its pivots and swing the beveled lower edge thereof out of the paths of the zero stops 537 on the indicator wheels 500, 501.

As the upright lever arm 488 restores to its normal position subsequently to the actuation of the indicator wheels, to disengage the carrying pinions 520 from the multiplier indicator wheels 500, the hangers 517 rock the universal bail and draw the link 544 forwardly, to return the zero alignment bar to its normal effective position.

The clearing operation is performed in the identical manner heretofore explained in connection with resetting the totalizer to zero, and as in the case of the totalizer shaft, the tooth of a dog 545 (Fig. 70) supported on the left-hand pivot 542 is urged by a spring 547 into engagement with a ratchet 548 on the indicator shaft 502 to permit rotation of the shaft in one direction only, by twirling either knob 536.

Since the various operations of the machine have been fully referred to in connection with the various mechanisms heretofore described in detail, it is not thought necessary to repeat the description.

The machine illustrating the foregoing invention is customarily enclosed within a casing (see Fig. 1) to protect the parts from dirt and injury, such casing having an opening 549 formed therein beneath which the field of value-representing elements travels.

The cover plate for the totalizer carriage, as shown in Fig. 1, is provided with properly positioned openings to form reading lines through which a single series of figures on the totalizer and on the respective counters are exposed, and indicators mounted for adjustment lengthwise of the reading openings may be provided for the purpose of "pointing off" the amounts on the totalizer and the counters.

Conveniently, the upper ends of the value-representing elements 77 each bear a numeral indicating its value, which are exposed to the view of the operator when the upper ends of the elements are set or projected by the keys 54 when depressed to enable the operator to check the accuracy of the set up.

It will be noted that this invention differs from others in that depression of a numeral key sets a value-representing element to accord with the actual value of the key depressed and also the complemental value thereof.

In effect, therefore, each numeral key simultaneously sets a plurality of value-determining

media, one of which controls its actuator according to the actual value assigned to the key, and the other of which controls its actuator, according to the complement of the actual value assigned the key.

Changes may be made in the form and arrangement of the several parts set forth, and omissions and substitutions made, without departing from the spirit and scope of the invention as disclosed in the appended claims.

What is claimed as new, is:

1. In a machine of the class described, the combination with a keyboard, including a number of variously fulcrumed numeral key levers of graduated lengths: a corresponding number of setting levers arranged on a common axis at a substantial angle to the axes of the key levers and extending transversely over the inner ends of the graduated key levers, the setting levers being substantially equal in length and equidistantly spaced; means interposed between and bearing a predetermined relation to both the setting levers and the key levers, to enable the key levers to actuate their associated setting levers to equal extents; a shiftable indexing carriage having rows of value-representing elements mounted therein, the elements adapted to be effectively positioned directly by the setting levers; and a series of actuators relatively to which the indexing carriage shifts to bring the set elements into effective relation with the actuators.

2. The combination of a number of numeral key levers; a corresponding number of setting levers arranged progressively transversely of the key levers and operable by their respective key levers; the key levers being variously fulcrumed to compensate for the progressive transverse arrangement of the setting levers relatively to the key levers, whereby the setting levers are all actuated to like extents; and an indexing carriage having rows of value-representing elements mounted therein, means operable incident to the operation of a numeral key lever, to feed the carriage step by step relatively to the setting levers to bring the rows of elements successively to position to enable the setting of an element in any row.

3. The combination of a number of numeral key levers; a corresponding number of pivoted setting levers arranged progressively transversely of the key levers, to be operable by their respective key levers; the key levers being variously fulcrumed to compensate for the progressive transverse arrangement of the setting levers relatively to the key levers; means located intermediate the key levers and setting levers, and arranged with regard to the positioning of the respective key levers relatively to the fulcrum of the setting levers, and the fulcrums of the key levers, to enable the key levers to actuate their respective setting levers to like extents; an indexing carriage having rows of value-representing elements mounted therein; and means operable as an incident to the operation of the numeral key levers to feed the carriage step by step relatively to the setting levers to bring the rows of elements successively to position to enable the setting of an element in any row.

4. The combination of a number of numeral key levers; a corresponding number of setting levers arranged transversely of the key levers; fingers interposed between the key levers and setting levers, and arranged at graduated distances relatively to the lengths of the key levers and setting levers, respectively, to enable selec-

- tive operation of the setting levers to like extents; an indexing carriage having rows of value-representing elements mounted therein; and means controlled by the numeral key levers to feed the carriage step by step relatively to the group of setting levers to bring the rows of elements successively to position to enable the setting of any element in any row.
5. The combination of a group of variously fulcrumed numeral key levers; a group of progressively arranged setting levers arranged at a substantial angle to and adapted to overlie the free ends of the key levers; means located intermediate the key levers and setting levers, and arranged with regard to the positioning of the respective key levers relatively to the fulcrum of the setting levers, and the fulcrums of the key levers, to enable the key levers to actuate their respective setting levers to like extents; guides for the free ends of the setting levers; a shiftable indexing carriage; groups of value-representing elements mounted therein; and means controlled from the key levers to feed the carriage step by step in one direction relatively to the free ends of the setting levers to enable the latter to set the value-representing elements.
6. The combination with a plurality of substantially semi-circular actuators; of an indexing carriage having a rectilinear positioning movement into and out of the area circumscribed by the semi-circular actuators, and an oscillatory driving movement relatively to the actuators substantially tangential to the plane of its rectilinear travel; a stationary member; and means on the carriage adapted to engage the stationary member to prevent movement of the carriage in one of said directions until it has been restored to its starting position from the other of its directions of movement.
7. The combination of a series of denominationally arranged actuators adapted to rock about a common axis; of an indexing carriage shiftable differential distances within the arc traversed by the actuators and relatively thereto for effective cooperation with the actuators; denominational rows of elements mounted in the carriage and settable to positions to select the desired actuators for operation; an oscillatory support for the carriage and relatively to which the carriage is adjusted in its advance and return; and means to oscillate the support from one to the other limit of its travel, and return, subsequently to the location of the carriage in effective relation to the actuators, and prior to its restoration to position without the arc traversed by the actuators, to control the actuators.
8. The combination of a series of denominationally arranged annular actuators adapted to rock about a common axis; an indexing carriage oscillatory about the said axis and normally located adjacent one end of the series of actuators; a series of denominational rows of elements mounted in the carriage; means to set desired elements for operation and to advance the indexing carriage step by step within the area circumscribed by the annular actuators to bring the elements into effective position relatively to the corresponding actuators adjacent which the elements are positioned by the step by step advance of the indexing carriage; means to impart to the carriage a single complete vibration from and to the position to which the indexing carriage is finally advanced within the circum-circling actuators; and means to restore the indexing carriage to its normal home position subsequently to the conclusion of a complete vibration.
9. The combination with a series of actuators; an indexing carriage to control the differential advance of the actuators; and means to advance the indexing carriage in one path of movement to effective position relatively to the actuators, the indexing carriage being shiftable in another direction to cause it to operate the actuators; of an escapement to variously arrest the indexing carriage relatively to the actuators, including an abutment on the indexing carriage; a support relatively to which the carriage escapes; a series of normally effective displaceable stops on the support adapted to be successively contacted by the abutment to arrest the carriage in its step by step movement; and a manually operable device adapted to travel with the indexing carriage to displace the stops to enable the indexing carriage to advance step by step.
10. The combination with a series of actuators; an indexing carriage to control the actuators; and means to advance the indexing carriage in one path of movement to effective position relatively to the actuators, the indexing carriage being shiftable in another path of movement to cause it to operate the actuators; of a manually operated escapement to variously arrest the indexing carriage relatively to the actuators, including an abutment on the indexing carriage; a support relatively to which the carriage escapes; a series of normally effective displaceable stops on the support adapted to be successively contacted by the abutment to arrest the carriage in its step by step movement; and a manually operable device traveling with the carriage in both its paths of movement, to displace the stops to enable the indexing carriage to advance step by step.
11. The combination with a series of actuators; a supporting member associated with the actuators and shiftable in one path; and an indexing member mounted on the supporting member to travel thereon in another path relatively to the actuators, and to shift with the supporting member; of a manually controlled escapement for the indexing member, including means to advance the latter relatively to the actuators; a series of shiftable stops mounted on the supporting member to rock therewith, and adapted to successively arrest the carriage on its advance; and manually operated escapement controlling means mounted on the supporting member to travel therewith and with the indexing member, to successively displace the stops.
12. The combination with a series of actuators; a support adjacent the actuators; and an indexing carriage mounted on the support to travel thereon relatively to the actuators; of an escapement to control the feed of the carriage relative to the actuators, including means to advance the carriage relatively to the actuators; a series of shiftable stops adapted to successively arrest the carriage on its advance; a rotatable shaft; a finger mounted to rock with the shaft and slide thereon with the carriage to adjust the stops successively; and manually controlled means to rock the shaft.
13. The combination with a plurality of actuators; a shiftable indexing carriage; and means to advance the carriage relatively to the actuators; of a series of shiftable stops to arrest the carriage in its several successive positions; a rocking support relatively to which the carriage shifts in one plane of movement; a finger mounted to shift

on and rock with the support, and connected to travel with the carriage; and means to actuate the finger and support relatively to the carriage to adjust the stops successively to free the carriage to the action of its advancing means.

14. The combination with a series of actuators; a shiftable indexing carriage to control the actuators; and means to feed the carriage relatively to the actuators; of an escapement to control the carriage feed, including a series of stops and an abutment, relatively displaceable; an escapement control device to effect relative displacement of the abutment and the effective stop to enable the carriage to advance step by step; a rock shaft on which the escapement control device is mounted to turn therewith and slide thereon; manipulative devices; setting levers operated by their respective manipulative devices; a universal bail operable by any of the setting levers; a tappet slide to actuate the rock shaft; and an equalizing yoke interposed between and connecting the tappet slide and the universal bail.

15. The combination with a series of actuators; a shiftable indexing carriage to differentially control the excursions of the actuators; and means to feed the carriage relatively to the actuators; of an escapement to control the carriage feed, including a series of stops and an abutment, relatively displaceable; an escapement control device to effect relative displacement of the abutment and the effective stop to enable the carriage to advance step by step; manipulative devices; a universal member operable by any of the manipulative devices; a rectilinearly movable drive member for the escapement control device; and a three-point connection between the universal member and the drive member.

16. The combination with a series of actuators; a shiftable indexing carriage to differentially control the excursions of the actuators; and means to feed the carriage relatively to the actuators; of an escapement to control the carriage feed, including a series of stops and an abutment, relatively displaceable; an escapement control device to effect relative displacement of the abutment and the effective stop to enable the carriage to advance step by step; manipulative devices; a universal member operable by any of the manipulative devices; a drive member for the escapement control device; and an equalizing connection between the drive member and the universal member.

17. The combination of a main drive shaft having a single definite excursion, a series of actuators; an indexing carriage shiftable to and from in one direction transversely of the actuators to any of a number of effective positions relatively to the actuators, while the main drive shaft remains at rest and in another direction at a substantial right angle to the first-named direction, and under the influence of the main drive shaft, to differentially control the excursions of the actuators; and means operated by the main drive shaft to impart continuous movement to the carriage throughout the entire excursion of the main drive shaft.

18. In a machine of the class described, the combination with a series of actuators; an indexing carriage shiftable in one direction to any of its effective positions relatively to the actuators, and in another direction, to select the actuators which are to operate; of means to impart the last-named movement to the carriage, including an oscillatory support on which the carriage travels; a main drive shaft having a definite ex-

cursion to effect a complete operation of the machine; and connecting means between the shaft and support, including a disk on the main drive shaft and a link connecting the disk and oscillating support, so arranged as to decelerate the speed of travel of the oscillatory support at opposite ends of its oscillation, and to accelerate the speed of travel of the oscillating support between the limits of its oscillatory motion, the drive shaft and support movable synchronously and coincidentally.

19. In a machine of the class described, the combination with a series of actuators; an indexing carriage shiftable in one direction to any of its effective positions relatively to the actuators, and in another direction, to select the actuators; of means to impart the last-named movement to the carriage, including an oscillatory support on which the carriage travels; a drive shaft having a definite excursion to complete an operation of the machine; and connecting means between the shaft and support, including a shaft-driven disk and a link eccentrically connected to the disk, to rock the carriage support, the link normally lying substantially at dead center relatively to the disk and carriage support to impart a slow starting and stopping motion to the support at the opposite limits of oscillation, respectively, the support being continuously driven by the drive shaft throughout the entire excursion of the shaft.

20. The combination with a series of actuators; of a totalizer carriage shiftable laterally only relatively to the actuators; a totalizer frame mounted in the carriage to shift relatively thereto toward and from the actuators, and including a bar; a series of totalizer wheels mounted in the frame; a lever connected to the bar and relatively to which the bar may shift with the totalizer carriage during lateral adjustment thereof; means operable upon the lever to shift the totalizer frame and its wheels relatively to the carriage, and towards and from the actuators; and mechanical means to shift the totalizer carriage with its frame and wheels in a rectilinear direction laterally relatively to the actuators and the operating lever.

21. The combination with a group of actuators; and a shiftable totalizer carriage; of a combined feeding and locking member normally engaged with the carriage and mounted for movement in one direction relatively to the totalizer to adjust the carriage step by step in either direction, and in another direction away from the carriage to release the carriage for adjustment through longer distances.

22. The combination with a group of actuators; and a shiftable totalizer carriage; of a combined feed and locking member operable upon the totalizer carriage to shift the latter step by step and to hold it where adjusted, such member including a barrel; a support having a socket with which the barrel is aligned; yielding means to press the barrel of the feed and locking member to effective position, with provision for withdrawing the barrel into the socket out of effective position to enable the totalizer carriage to be freely adjusted.

23. The combination with a shiftable totalizer carriage; of a combined feed and locking member cooperable therewith to shift the totalizer carriage step by step in either direction, with provisions to withdraw the feed and locking member by a longitudinal movement from the total-

izer carriage to enable the latter to be shifted greater extents.

24. The combination with a shiftable totalizer carriage; of a combined feed and locking member cooperable therewith to shift the totalizer carriage step by step in either direction, with provisions to withdraw the feed and locking member by a longitudinal movement from the totalizer carriage to enable the latter to be shifted greater extents; and yielding means to return the feed and locking member to and maintain it in engagement with the totalizer carriage.

25. In a machine of the class described, the combination with a group of actuators; of a totalizer carriage shiftable relatively thereto, including a serrated rail; and toothed means directly facing the serrations to feed the carriage step by step, a tooth of which means enters a serration from either side of the rail, passes transversely across the rail, and leaves the serration at the opposite side of the rail.

26. The combination with a series of actuators; and an indexing carriage shiftable from home position in one direction to effective position relatively to the actuators, and shiftable from and to the position to which it is adjusted, in another direction to control the actuators; of normally idle carriage-restoring mechanism set to effective position as the indexing carriage is moved in the last-named direction, to return the indexing carriage to its home position.

27. The combination with a series of actuators; and an indexing carriage shiftable to effective position relatively to the actuators; of means to restore the indexing carriage to its home position, including a restoring device normally freely movable relatively to the indexing carriage to avoid obstruction to its travel; and means operable relatively to the restoring device and effective upon the restoring device to cause it to return the indexing carriage.

28. The combination with a shiftable indexing carriage; and means to advance the indexing carriage from its home position in one direction; of means to restore the indexing carriage to its home position, including a restoring device, normally freely movable relatively to the indexing carriage; operating means for the restoring device; means to cock the operating means; and means to retain the operating means ineffective during such cocking until it has attained an effective position relatively to the restoring device.

29. The combination with a shiftable indexing carriage; and means to advance the indexing carriage from its home position in one direction; of means to restore the indexing carriage to its home position, including a restoring device, normally freely movable relatively to the indexing carriage; operating means for the restoring device; means to cock the operating means; means to shift the operating means out of the path of the restoring device, and to retain it in the plane to which it is shifted during the cocking operation; and means to shift the operating means to effective position relatively to the restoring device after the cocking operation.

30. The combination with an indexing carriage; means to advance the carriage differentially; and a main drive shaft; of means to restore the indexing carriage to its home position against the influence of the means which advances the carriage, including a motor controlled by the main drive shaft; and a supplemental motor adapted to be energized by the main drive

shaft proportionally to the extent of advance of the indexing carriage, to assist the carriage-restoring motor to return the carriage.

31. The combination with an indexing carriage; means to advance the carriage differentially; and a main drive shaft; of means to restore the indexing carriage to its home position against the influence of the means which advances the carriage, including a motor controlled by the main drive shaft; and a supplemental motor spring, one end of which is given a constant excursion by the main drive shaft, and the opposite end of which is variously arrested according to the extent of advance of the indexing carriage, whereby the supplemental motor spring is proportionally tensioned, to assist the carriage restoring motor to return the carriage from various points in its advance at a substantially constant speed irrespective of the extent of such advance.

32. The combination with an indexing carriage; opposed springs to advance the carriage from and return it to home position, respectively; and means to differentially determine the extent of advance of the carriage; of a compensating spring to supplement the return spring in restoring the carriage to home position at a substantially uniform rate irrespective of the extent of advance of the carriage.

33. The combination with an indexing carriage; opposed springs to advance the carriage from and return it to home position, respectively; and means to differentially determine the extent of advance of the carriage; of a floating compensating spring to supplement the return spring in restoring the carriage to home position at a substantially uniform rate irrespective of the extent of advance of the carriage and the opposition of the advancing spring.

34. The combination with an indexing carriage; opposed springs to advance the carriage from and return it to home position, respectively; and means to differentially determine the extent of advance of the carriage; of a compensating spring to supplement the return spring in restoring the carriage to home position at a substantially uniform rate irrespective of the extent of advance of the carriage; and automatically releasable means controlled by the indexing carriage to arrest one end of the compensating spring, to enable the compensating spring to be variously tensioned according to the extent of advance of the carriage.

35. The combination with an indexing carriage; opposed springs to advance the carriage from and return it to home position, respectively; and means to differentially determine the extent of advance of the carriage; of a floating compensating spring to supplement the return spring in restoring the carriage to home position at a substantially uniform rate irrespective of the extent of advance of the carriage and the opposition of the advancing spring, the terminals of the compensating spring normally adapted to travel concentrically about a common center; and automatically releasable means controlled by the indexing carriage to arrest one end of the compensating spring, whereby to enable the compensating spring to be variously tensioned according to the extent of advance of the carriage.

36. The combination with an indexing carriage; opposed springs to advance the carriage from and return it to home position, respectively; and means to differentially determine the extent of advance of the carriage; of a floating com-

compensating spring to supplement the return spring in restoring the carriage to home position at a substantially uniform rate irrespective of the extent of advance of the carriage and the opposition of the advancing spring; a pivoted tensioning arm to which one terminal of the compensating spring is anchored; an opposed arm pivoted concentrically with the tensioning arm and having a constant excursion at each operation of the machine, to which the remaining terminal of the compensating spring is anchored; and automatically releasable means to arrest the tensioning arm to enable the opposed arm to tension the compensating spring and bring it nearer dead center, the tensioning arm, upon its release from its arresting means, adapted to rock the compensating spring away from its dead center position to enable the spring to apply its energy in an increasing leverage to return the carriage.

37. In a machine of the class described, the combination with a series of actuators adapted for differential advance; of a drive means having a fixed excursion; means operable by the drive means to determine the extent of advance to be imparted to selected actuators; and means to connect the drive means and selected actuators to prevent overthrow of the latter.

38. In a machine of the class described, the combination with a series of actuators adapted for differential advance; of a drive mechanism therefor, including a movable support and a carriage, the latter shiftable in one direction relatively to its support and the actuators, and in another direction with the support; differentially set elements mounted in the carriage to advance the actuators and overthrow preventing means for the actuators, operated by the drive means, the differentially set elements effective to connect the actuators with their overthrow preventing means.

39. In a machine of the class described, the combination with side frames; of a plurality of slitted guide bars mounted between the side frames, the slits in one of the guide bars having enlarged outer ends; slotted actuators mounted in the slits in the respective bars; certain of the bars having seats formed transversely of the slits therein; rods fitted in the seats, one of the rods passing through the slots in the actuators to form a stop common to all the actuators to limit their movement in one direction; and rolls mounted on one of the rods and occupying the enlarged outer ends of the slits in the associated guide bar to afford friction-reducing supports for the corresponding actuators.

40. In a machine of the class described, the combination with side frames; of a plurality of slitted guide bars mounted between the side frames; traveling actuators accommodated in the slits in the guide bars, the slits in one of the guide bars being enlarged at their outer ends; a rod extending across the enlargements; and rolls journaled on the rod in the enlargements to afford a support for the actuators.

41. The combination with a totalizer; actuating means therefor; and means to drive the actuating means; of arresting means to lock the drive means against operation, including a plurality of individual stops associated with the drive means; a detent shiftable into and out of the path of travel of either of the stops; means controlled by the totalizer to shift the detent into the path of either of the stops; and means operable at will to shift the detent out of the path of either

of the stops, and to determine with which stop the detent shall become effective.

42. The combination with a totalizer; actuating means therefor; and means to drive the actuating means; of means to lock the drive means against operation, including a stop connected with the drive means to afford a limited relative movement; resilient means interposed between the stop and drive means; and a detent controlled by the totalizer, to engage the stop and arrest the drive means.

43. In a machine of the class described adapted for addition and subtraction, the combination with a totalizer; and drive mechanism therefor; of means to lock the totalizer against operation, including a detent, and a plurality of stops, relatively adjustable, and mutually engageable to arrest the drive means, one of the stops for use during adding and another of the stops for use in subtracting operations; and means to effect the relative adjustment between the detent and the stops.

44. In a machine of the class described adapted for addition and subtraction, the combination with a totalizer; and drive mechanism therefor; of means to lock the totalizer against operation, including a detent, and a plurality of stops, relatively adjustable, and engageable and disengageable one of the stops for use during adding and another of the stops for use in subtracting operations; means to cushion the impact between the detent and the stops; and to effect a relative movement between the detent and stops subsequently to the disengagement thereof; and means to effect the relative adjustment between the detent and the stops.

45. In a machine of the class described adapted for addition and subtraction, the combination with a totalizer; and drive means therefor; of means to lock the totalizer against operation, including a detent, and a plurality of stops, and mutually engageable and disengageable, the detent and stops being relatively adjustable, one of the stops for use during adding and another of the stops for use in subtracting operations; the stops connected with and adapted for a limited movement relatively to the drive means; and means to effect the relative adjustment between the detent and the stops to select the proper stop.

46. In a machine of the class described adapted for addition and subtraction, the combination with a totalizer; and drive mechanism therefor; of means to lock the totalizer against operation, including a detent, and a plurality of stops, relatively adjustable, one of the stops for use during adding and another of the stops for use in subtracting operations, the stops being laterally spaced, and the detent being forked to provide an arm to co-act with its respective stop; and means to effect the relative adjustment between the detent and the stops.

47. In a machine of the class described, the combination with amount-determining manipulative devices; of a single field of denominationally arranged value-representing elements selectively set by the manipulative devices; denominational actuators, the excursions of which are controlled by the set elements; and means to adjust the field of elements bodily to enable the set elements to control the actuators in accordance with the actual values set up by the manipulative devices, and of the true complements of such values, respectively, depending upon the position to which the field of elements is adjusted.

48. The combination with amount-determin-

ing, manipulative devices; of a single field of value-representing elements selectively set by the manipulative devices; actuators, the excursions of which are controlled by the set value-representing elements; and means to bodily adjust the field of value-representing elements relatively to their actuators to enable the same set elements to control the actuators in accordance with the actual values represented by the manipulative devices, and of the complements thereof, respectively.

49. The combination with a totalizer; actuators therefor; and manipulative devices; of value-representing elements selectively set by the manipulative devices to control the excursions of the actuators, each element having at least two effective areas, one of which controls the excursions of its co-related actuator according to the actual value of the element, and the other of which controls its actuator according to the complementary value of the element, the setting of an element simultaneously presenting both areas for use; and means to effect relative adjustment between the elements and the actuators to render one area effective and the other ineffective accordingly as addition or complementary subtraction is desired.

50. The combination with a totalizer; actuators therefor; and manipulative devices; of value-representing elements selectively set to effective positions by the manipulative devices, to control the excursions of the actuators according to the actual and the complementary values of the element so set; a shiftable frame in which the value-representing elements are mounted; and means to bodily adjust the frame to vary the positions of all of the elements relatively to their co-related actuators to determine which value shall be accumulated on the totalizer.

51. The combination with a totalizer; actuators therefor; and manipulative devices; of value-representing elements selectively set by the manipulative devices, to control the excursions of the actuators according to the actual and the complementary values of the set elements; and means to adjust the elements bodily in a direction transverse to the planes of the actuators, to determine which value shall be accumulated on the totalizer.

52. The combination with amount-determining manipulative devices; of a series of value-representing elements arranged in denominational rows in a single field, and selectively set by the manipulative devices; actuators controlled by the set elements; and means operable at will prior to the advance of the actuators to variously adjust the field of elements relatively to the actuators to positions to enable the set elements to control the advance of the actuators according to the actual values set up, or to the complements of such values, respectively.

53. The combination with a totalizer; a series of denominationally arranged actuators therefor; and manipulative devices; of an indexing field of value-representing elements selectively set by the manipulative devices so that one end of each set element represents a digit of the actual amount to be registered and the opposite end represents the complementary value of such digit; and means to render either end of each of the elements effective to control the excursions of their actuators.

54. In a machine of the class described, a numeral wheel having a hub and a disk; a laterally extending annular flange mounted on the pe-

riphery of the disk and combining with the hub to form a housing; a click stud passing loosely through the hub radially thereof; a shaft on which the hub is journaled, the shaft having a plurality of recesses formed peripherally thereof equal in number to the predetermined number of positions the wheel is to assume relatively to the shaft, the nose of the stud adapted to seat in any of the recesses; and means housed between the flange and the hub to yieldingly retain the nose of the stud seated in any of the recesses.

55. In a machine of the class described, the combination of a numeral wheel shaft having a series of recesses arranged peripherally thereof; a numeral wheel, including a hub journaled on the recessed periphery of the shaft; a ring mounted on the outer end of the hub; a click stud passing loosely through the hub, the nose of the stud adapted to seat in any of the recesses; and a spring encircling the periphery of the hub between the wheel and the ring, to yieldingly retain the stud in and return it to effective position.

56. The combination with a plurality of rows of keys depressible to like extents; of a set of key levers of varying lengths actuated by their respective keys, and spaced apart laterally different distances, the key levers being variously fulcrumed; a series of setting levers arranged progressively relatively to the set of key levers; individual means interposed between the respective key levers and their corresponding setting levers so arranged with reference to the relations of the respective key levers with their corresponding setting levers as to enable the key levers to actuate their setting levers to like extents; a field of value-representing elements arranged in rows; and means controlled by the key levers to advance the field step by step to position the rows of value-representing elements successively in line with the row of setting levers, to enable the latter to selectively set the desired elements corresponding to the values of the keys depressed.

57. In a machine of the class described, including a base, the combination with a set of key levers; and manipulative devices for operating them; of a fulcrum block mounted on the base and slitted longitudinally to accommodate and guide the key levers, the fulcrum block having a plurality of grooves arranged transversely of the slits from front to rear of the block; fulcrum members seated in the grooves and on which the key levers are severally pivoted; a series of setting members arranged transversely relatively to the rear arms of the key levers; and value-representing elements arranged in rows to form a field, and shiftable step by step relatively to the setting members to enable the selection for operation of any value-representing element in one or more rows.

58. The combination of a series of denominationally arranged annular-like actuators adapted to rock about a common axis; oscillatory supporting means passing through the area circumscribed by the actuators; an indexing carriage mounted to travel on the supporting means to differential distances within the area circumscribed by the actuators; the indexing carriage normally lying outside such area; denominational rows of value-representing elements mounted in the carriage and settable to represent the actual value of the item to be added or subtracted, the value-representing elements adapted to determine the differential movement of the actuators; and means to impart a complete oscillation to

the oscillatory supporting means, from its normal position to its opposite limit of travel, and back, subsequently to the advance of the indexing carriage within the area circumscribed by the actuators and prior to its withdrawal from such area, to differentially control the advance and return movements of the actuators.

59. The combination with a support oscillatory about a horizontal axis; and an indexing carriage shiftable along the support in the direction of its axis, and having its normal position adjacent one end of the support; of a plurality of semicircular actuators circumscribing the support adjacent the normal position of the indexing carriage; means to advance the indexing carriage differentially within the orbits traversed by one or more of the actuators; and means to impart a complete oscillation to the carriage from and to the position to which it is finally adjusted within the orbits of the actuators, and to restore the indexing carriage to its normal position on the support subsequently to the completion of its said oscillatory movement.

60. The combination of a series of skeleton actuators adapted to enclose an area; a field of settable value-representing elements adapted for differential advance into the area enclosed by the actuators, set elements of the field adapted to control the excursions of the corresponding actuators; manipulative means to selectively set the elements and determine the extent of advance of the field of elements into the area enclosed by the actuators; actuator-driving means with which the actuators are normally out of engagement to advance the actuators according to the values of the set elements; and means to drive the field of elements to cause the set elements to advance their co-related actuators differentially into engagement with the actuator-driving means.

61. In a machine of the class described, a series of substantially annular actuators; an indexing device operable within the space circumscribed by the actuators, and including opposed arcuate heads conforming to the curvature and lying adjacent the inner peripheries of the opposite arcs of the actuators, settable value-representing elements mounted in the heads; and manipulative means to selectively set the value-representing elements to control the excursions of the actuators.

62. In a machine of the class described; a series of substantially semicircular rotatable actuators offset intermediate their ends; an indexing device operable within the space circumscribed by the actuators, and including a frame extending diametrically relatively to the actuators and having convex heads lying adjacent the inner peripheries of the actuators; value-representing elements extending between and slidably mounted in apertures in the respective heads, one end of each element normally projecting beyond its adjacent head; manipulative means to selectively project the remaining ends of the value-representing element beyond their adjacent head; and means to rotate the indexing device through a constant extent of travel to cause the projected value-representing elements to control the actuators.

63. In a machine of the class described, a series of substantially annular actuators; a field of value-representing elements operable within the area circumscribed and embraced by the actuators; means to selectively set desired value-representing elements; and means to impart a com-

plete forward and backward oscillation to the field while so embraced.

64. The combination of a series of denominationally arranged actuators, substantially annular in form; a field of settable value-representing elements rotatable within the area circumscribed by the annular actuators; an equal number of value-representing elements being positioned on opposite sides, respectively, of a vertical longitudinal plane extending through the axis of rotation of the field, the opposite ends of the value-representing elements extending, respectively above and below the horizontal plane of the axis of rotation of the field; and means to selectively set the elements to enable such set elements to render effective the corresponding actuators.

65. The combination with a series of actuators; a shiftable field of value-representing elements to control the actuators; and means to advance the field of elements relatively to the actuators; of an escapement to control the advance of the field of elements, including a series of stops and an abutment relatively displaceable; an escapement control device adapted for movement in two different angular directions to effect relative displacement of the effective stop and the abutment to enable a step by step advance of the field of elements; manipulative devices; a universal member operable by any of the manipulative devices; and connections between the universal member and the escapement control device to effect operation of the latter in one of its directions of movement and enable the escapement control device to move in the other of its directions.

66. The combination with a series of actuators; a field of settable value-representing elements; means to advance the field of elements relatively to the actuators in one direction; and means to drive the field of elements in another direction from and back to its advanced position; of a series of shiftable stops movable with the field of elements in the second-named direction, and adapted to arrest the field of elements in its several successive positions of advance relatively to the actuators; an escapement control device; and means to move the device relatively to the field of elements to adjust the stops successively whereby to free the field to the action of its advancing means, which positions the escapement control device relatively to the stops.

67. The combination with a series of actuators; of a support shiftable in one direction; a field of value-representing elements mounted on the support to shift therewith, and itself shiftable relatively to the support in another direction; and means to advance the field relatively to the actuators in the last-named direction; of a series of relatively displaceable stops and an abutment travelling with the field of elements and its support, respectively, to arrest the field of elements successively in its step by step advance and prevent its accidental advance in either position of the support; an escapement control device to effect relative displacement between the abutment and the effective stop to enable the step by step advance of the field of elements; and manipulative means to operate the escapement control device.

68. The combination with a series of actuators; a shiftable indexing carriage; a support therefor; and means to advance the carriage relatively to the actuators; of an escapement to control the advance of the carriage, including a series of stops and an abutment, relatively displaceable, and

- mounted on the carriage and the support, respectively; an escapement control device, including a finger travelling with the carriage; a rock shaft on which the finger is mounted; means to turn the shaft; manipulative devices; and means actuated thereby to coast with the turning means on the rock shaft, to effect an oscillation of the shaft.
69. The combination with a series of actuators; a support; an indexing carriage mounted to travel on the support; and means to advance the carriage in one direction; of an escapement to control the advance of the carriage, including a series of stops and an abutment, relatively displaceable, and mounted on the carriage and on the shiftable support, respectively; an escapement control device to effect such relative displacement between the abutment and an effective stop, the escapement control device including a rock shaft mounted in the support; a finger mounted on the shaft; a crank fast on the shaft; manipulative devices; a tappet actuated by any of the manipulative devices to operate the crank, its shaft, and the escapement finger; and means to restore the shaft, crank and finger to normal.
70. The combination with a series of actuators; a support; an indexing carriage mounted to travel on the support; and means to advance the carriage in one direction; of an escapement to control the advance of the carriage, including a shaft journaled in the support; a finger mounted to slide along and turn with the shaft; an abutment on the carriage; a series of stops mounted on the support in the path of the abutment, and successively displaceable by the finger to restrict the carriage to a step by step advance; a crank fast on the shaft; manipulative devices; and means operable thereby to rock the crank.
71. The combination with a series of actuators; a field of settable value-representing elements arranged in rows, to control the actuators; and means to advance the field of elements in one direction relatively to the actuators; of an escapement to constrain the advance of the field of elements to a step by step movement; a nest of setting members over which the field of elements travels to present the rows of elements successively to the contacting portions of the setting members; manipulative means to operate the setting members selectively to set the desired value-representing elements; the setting members being recessed; and an escapement tripping, universal member normally lying across the nest of setting members and accommodated in the recesses therein.
72. The combination with a totalizer carriage; of a combined feed and locking mechanism therefor, including a shaft, a locking and feeding barrel on the shaft engageable with and disengageable from the totalizer carriage; a bracket having a bearing in which the shaft is slidably and rotatably mounted, the bearing being chambered to accommodate the locking and feeding barrel to permit longitudinal movement thereof; and yielding means to retain the barrel engaged with the totalizer carriage.
73. In a machine of the class described, the combination with actuators; a totalizer carriage laterally shiftable relatively to the actuators, including a serrated rail; of a support relatively to which the rail and carriage travel, the support being grooved to provide a guide for the rail intermediate its ends to maintain the rail against flexing; and manually operable means mounted on the support and releasably engaged with the serrated rail to feed the carriage step by step in either direction, and lock the carriage against movement.
74. The combination with a shiftable carriage having a serrated rail mounted at its ends in the carriage, the carriage having fixed limits of travel; of a support located intermediate such limits of travel, the support being grooved to accommodate the rail and hold it against flexing, and having a chamber communicating with the groove; a toothed member seated in the chamber for rotatory and longitudinal movement therein relatively to the rail; means to impart either movement to the member; that end of the member distant from the rail being oppositely beveled; and a spring-pressed thrust element adapted to bear against the beveled faces of the toothed member to yieldingly hold the toothed member engaged with the rail against longitudinal movement, as well as to insure its proper positioning rotatively relatively to the rail at the end of its operation.
75. The combination with an indexing carriage; and means to advance the indexing carriage differentially from its home position toward its opposite limit of travel; of means to restore the indexing carriage to its home position, including a restoring device normally freely movable relatively to the indexing carriage to offer no opposition to the advance of the carriage; the carriage adapted to variously adjust the restoring device in accordance with the extent of advance of the carriage; an operating means for the restoring device; means to maintain the operating means ineffective during the adjustment of the restoring device by the carriage; means to impart a cocking movement to the operating means sufficient to enable it to actuate the restoring device in any of the positions to which the latter may be adjusted by the indexing carriage; and suitably timed means to render the operating means effective relatively to the restoring device.
76. The combination with an indexing carriage; and means to advance the indexing carriage differentially from its home position toward its opposite limit of travel; of means to restore the indexing carriage to its home position, including a restoring device normally freely movable relatively to the indexing carriage to offer no opposition to the advance of the carriage; the carriage adapted to variously adjust the restoring device in accordance with the extent of advance of the carriage; an operating means for the restoring device; and means to render the operating device effective.
77. The combination with an indexing carriage; means to advance the indexing carriage step by step in one direction; a main drive shaft; and means operable thereby to drive the indexing carriage in another direction from any position to which it may be adjusted, and return it to such adjusted position; of means to restore the indexing carriage to its home position, including a motor energized by the main drive shaft as it drives the indexing carriage from its adjusted position in the second named direction; and a booster motor adapted to be energized by the main drive shaft as it returns the indexing carriage to such adjusted position.
78. The combination with an indexing carriage; a motor to advance the carriage differentially in one direction; means to control such advance; and a main drive shaft; of means operable by the main drive shaft to shift the indexing carriage in another direction from and to

any of its differentially adjusted positions; and means to restore the indexing carriage to its home position, after its return to its adjusted position at the end of its travel in the last-named direction, including a motor energized by the main drive shaft, to overcome the first-named motor.

79. The combination with an indexing carriage; a motor to advance the carriage differentially in one direction; means to control such advance; and a main drive shaft; of means operable by the main drive shaft to shift the indexing carriage in another direction from and to any of its differentially adjusted positions; means to restore the indexing carriage to its home position, after its return to its adjusted position at the end of its travel in the last-named direction, including a motor energized by the main drive shaft as it shifts the indexing carriage from its adjusted position; and a restoring device actuated by this last-named motor.

80. The combination with an indexing carriage; a motor to advance the carriage differentially in one direction; means to control such advance; and a main drive shaft; of means operable by the main drive shaft to shift the indexing carriage in another direction from and to any of its differentially adjusted positions; means to restore the indexing carriage to its home position, after its return to its adjusted position at the end of its travel in the last-named direction, including a motor energized by the main drive shaft; and detaining means to lock the indexing carriage in the adjusted position to which it has been fed while enabling the carriage to shift in said last-named direction until it completes its return to its adjusted position.

81. The combination with an indexing carriage; means to feed the carriage differentially in one direction; and a main drive shaft; of means operable by the main drive shaft to shift the indexing carriage in another direction from and to any of its adjusted positions; and means to restore the indexing carriage to its home position subsequently to the completion of its travel in the last-named direction, including a normally ineffective motor, energized by the main drive shaft as it shifts the indexing carriage in the last-named direction; an operating lever actuated by the motor; and a restoring device driven by the operating lever.

82. The combination with an indexing carriage; means to feed the carriage differentially in one direction; and a main drive shaft; of means operable by the main drive shaft to shift the indexing carriage in another direction from and to any of its adjusted positions; and means to restore the indexing carriage to its home position subsequently to the completion of its travel in the last-named direction, including a normally ineffective motor, energized by the main drive shaft as it shifts the indexing carriage in the last-named direction; detaining means to lock the indexing carriage against movement in the first-named direction until the completion of its movement in the second-named direction; an operating lever actuated by the motor; and a restoring device driven by the operating lever.

83. The combination with an indexing carriage; means to feed the carriage differentially in one direction; and a main drive shaft; of means operable by the main drive shaft to shift the indexing carriage in another direction from and to any of its adjusted positions; and means to restore the indexing carriage to its home position

subsequently to the completion of its travel in the last-named direction, including a normally ineffective motor, energized by the main drive shaft as it shifts the indexing carriage in the last-named direction; an operating lever actuated by the motor; a restoring arm driven by the operating lever; and a shoe on the indexing carriage, of sufficient extent to enable the restoring arm to maintain contact therewith during the maximum extent of return travel of the carriage.

84. The combination with an indexing carriage; a normally energized motor to advance the carriage; and a main drive shaft; of means to restore the indexing carriage to its home position, including a motor adapted to be energized by the main drive shaft; a normally idle restoring device displaceable by the indexing carriage under the influence of the first-named motor; an operating lever actuated by the second-named motor, to cause the restoring device to return the carriage to home position; and automatic means to shift the operating lever clear of the restoring device and to return it to effective position relatively to the restoring device.

85. The combination with an indexing carriage; and means to advance the carriage from its home position; of means to restore the indexing carriage to its home position, including a motor; means to energize the motor; an operating lever actuated by the motor; a restoring device controllable by the operating lever to restore the indexing carriage to its home position; and automatic means to shift the operating lever bodily clear of the path of the restoring device, and to restore it to effective position relatively to the restoring device.

86. The combination with an indexing carriage; and means to advance the carriage from its home position; of means to restore the indexing carriage to its home position, including an operating lever adapted for movement in different planes; a restoring device actuated by the operating lever when travelling in one of its planes; and automatic means to shift the operating lever bodily to another of its planes of movement, out of the path of the restoring device.

87. The combination with an indexing carriage; and means to advance the carriage from its home position; of means to restore the indexing carriage to its home position, including an operating lever adapted for movement in different planes; a restoring device actuated by the operating lever when travelling in one of its planes; automatic means to shift the operating lever bodily to another of its planes of movement out of the path of the restoring device; and means to guide and retain the operating lever in either plane of travel.

88. The combination with an indexing carriage; and means to advance the carriage from its home position; of means to restore the indexing carriage to its home position, including an operating lever adapted for movement in different planes; a restoring device actuated by the operating lever when travelling in one of its planes; a guide to retain the operating lever in either plane of travel throughout the greater extent thereof; and automatic means to shift the lever bodily from one side to the other of the guide.

89. The combination with an indexing carriage; and means to advance the carriage from its home position; of means to restore the indexing carriage to its home position, including an

operating lever adapted for movement in different planes; a restoring device actuated by the operating lever when travelling in one of its planes; a guide to retain the operating lever in either plane throughout the greater extent of its travel; and spring-actuated deflectors to shift the lever from one side to the other of the guide.

90. The combination with an indexing carriage; and means to advance the carriage from its home position; of means to restore the indexing carriage to its home position, including an operating lever adapted for movement in different planes; a restoring device actuated by the operating lever when travelling in one of its planes; a guide to retain the operating lever in either plane of its travel throughout the greater extent thereof, the path of travel of the operating lever being longer than the guide; and switching means to shift the operating lever from one side to the other of the guide as the lever completes its travel in one direction or the other, and escapes the opposite ends of the guide, respectively.

91. The combination with an indexing carriage; means to advance the carriage differentially from its home position, including a normally energized motor; and a main drive shaft rotatable through successive cycles; of means to restore the carriage to its home position, including a restoring motor energized and de-energized by the operation of the main drive shaft, the last-named motor gradually decreasing in power as the main drive shaft approaches the end of a cycle of operation; and a booster motor to assist the restoring motor to return the indexing carriage, and adapted to be energized by the main drive shaft as it approaches the end of a cycle of operation, in proportion to the extent of advance of the carriage under the influence of the first-named motor.

92. The combination with actuators; an indexing carriage; rows of selectors mounted in the carriage to control the excursions of the actuators; means to advance the carriage step by step; and means to oscillate the carriage; of means to restore the carriage to home position, including a restoring device; a motor energized and de-energized by the means which oscillates the carriage, and adapted to actuate the restoring device; and means controlled by the oscillating means to restrain the motor against de-energization, until the carriage completes an oscillation.

93. The combination with an indexing carriage; means to advance the carriage differentially; and means to impart a complete vibration to the carriage in any of its advanced positions; of means to restore the carriage to its home position, including a motor, the tension of which varies in inverse order to the power exerted by the carriage-advancing means; and a supplemental motor controlled by the means which vibrates the carriage, to aid the carriage-restoring motor to overcome the influence of the carriage advancing means.

94. The combination with an indexing carriage; means to advance the carriage differentially; and means to impart a complete vibration to the carriage in any of its advanced positions; of means to restore the carriage to its home position, including a motor, the tension of which varies in inverse order to the power exerted by the carriage-advancing means; and a supplemental motor, the tension of which is automatically graduated according to the extent of advance of the indexing carriage, to aid the car-

riage-restoring motor to overcome the influence of the carriage advancing means.

95. The combination with an indexing carriage; and means to advance the carriage differentially; of means to restore the carriage to its home position, including a return motor; and a supplemental motor to assist the return motor to overcome the means which advances the carriage.

96. The combination with a main drive shaft; an indexing carriage; and means to advance the carriage differentially; of means to restore the carriage to its home position, including a return motor; a supplemental motor to assist the return motor; means to control the power exerted by the supplemental motor, according to the extent of advance of the carriage; and means to temporarily lock the carriage in any of its advanced positions to prevent premature return.

97. The combination with an indexing carriage; means to advance the carriage differentially; and a main drive shaft adapted for successive cycles of operation; of means to restore the carriage to its home position, including a motor energized by the main drive shaft and de-energized as the main drive shaft completes any of its cycles of operation; the tension of the motor when the main drive shaft is at the beginning of its cycle approximating the maximum power exerted by the carriage advancing means; and a supplemental motor, adapted to be energized by the main drive shaft, the amount of tension being automatically controlled by the indexing carriage according to the extent of advance of the carriage, to assist the carriage-restoring motor to return the carriage.

98. The combination with an indexing carriage; means to advance the carriage differentially; and a main drive shaft adapted for successive cycles of operation; of means to restore the carriage to its home position, including a motor energized by the main drive shaft and de-energized as the main drive shaft completes any of its cycles of operation; the tension of the motor when the main drive shaft is at the beginning of its cycle approximating the maximum power exerted by the carriage advancing means; and a supplemental motor, adapted to be energized by the main drive shaft proportionally to the extent of advance of the indexing carriage, to assist the carriage-restoring motor to return the carriage.

99. The combination with an indexing carriage adapted for differential advance from its home position; of means to restore the indexing carriage to its home position at a substantially constant speed irrespective of the extent of advance of the carriage, including motors to advance and to return the carriage, respectively, the power of the advancing motor increasing and the power of the returning motor decreasing as the carriage restores to its home position; and a booster motor tensioned proportionally to the extent of advance of the carriage, to assist the carriage restoring motor to return the carriage.

100. The combination with an indexing carriage adapted for differential advance from its home position; of means to restore the indexing carriage to its home position at a substantially uniform speed from any of its advanced positions, including motors to advance and to restore the carriage, respectively, the advancing motor de-energizing in proportion to the advance of the carriage and energizing in proportion to the return of the carriage; the restoring motor de-

energizing in proportion to the return of the carriage, the maximum power exerted by the restoring motor being sufficient to overcome the inertia of the carriage when in advanced position; and a compensating motor energized proportionally to the extent of advance of the carriage and adapted to apply its power in gradually increasing volume as the carriage progresses on such return, to assist in the return of the carriage.

101. The combination with an indexing carriage adapted for differential advance from its home position; of means to restore the indexing carriage to its home position at a substantially uniform speed from any of its advanced positions, including motors to advance and to restore the carriage, respectively, the energy of the motors being substantially balanced when the indexing carriage is about intermediate its limits of travel; a compensating motor to assist the carriage restoring motor, and energized proportionally to the extent of advance of the indexing carriage, the compensating motor being so arranged as to expend its energy in gradually increasing volume as the carriage approaches its home position to compensate for the progressive de-energization of the carriage-restoring motor.

102. The combination with an indexing carriage adapted to be differentially advanced from its home position, and returned thereto; and a motor to advance the carriage, which motor de-energizes proportionally to such advance and is energized as the carriage returns; of means to restore the indexing carriage to home position at a speed substantially uniform irrespective of the extent of advance of the carriage and the increasing energy of its advancing motor, including a restoring motor; means to energize the restoring motor, the energy of which decreases as the carriage returns; a normally idle compensating motor differentially energized according to the extent of travel of the indexing carriage from its home position, to assist the restoring motor in returning the carriage; said motor being shiftable relatively to a neutral point, as the carriage returns to enable the compensating motor to deliver its energy in increasing amount as the indexing carriage approaches its home position, to counterbalance the loss of power of the returning motor and the increase of power of the advancing motor.

103. The combination with an indexing carriage adapted to be differentially advanced from its home position, and returned to home position; and a motor to advance the carriage, the power of which motor decreases proportionally to the advance of the carriage and correspondingly increases as the carriage returns to home position; of means to restore the indexing carriage to its home position at a speed substantially uniform irrespective of the extent of advance of the carriage and the increasing power of its advancing motor, including a restoring motor; means to energize the restoring motor to enable it to apply its maximum power to the return of the indexing carriage at a time when the advancing motor is exerting its minimum power during the operation of the machine; and a compensating motor energized by the aforesaid energizing means under control of the carriage, whereby the degree of energy stored in the compensating motor varies according to the extent of advance of the indexing carriage.

104. The combination with an indexing carriage adapted to be differentially advanced from

its home position, and returned to home position; and a motor to advance the carriage, the power of which motor decreases proportionally to the advance of the carriage and correspondingly increases as the carriage returns to home position; of means to restore the indexing carriage to its home position at a speed substantially uniform irrespective of the extent of advance of the carriage and the increasing power of its advancing motor, including a restoring motor; means including a rocking tensioning member, to energize the restoring motor to enable it to apply its maximum power to the return of the indexing carriage at a time when the advancing motor is exerting its minimum power during any one operation of the machine; a compensating motor also energized by the rocking tensioning member, the terminals of the compensating motor adapted to travel concentrically; and means controlled by the indexing carriage to arrest the tensioning member differentially according to the extent of advance of the carriage, whereby to variously energize the compensating motor.

105. The combination with an indexing carriage adapted to be differentially advanced from its home position; and returned to home position; and a normally tensioned spring to advance the carriage, the energy of which spring decreases proportionally to the advance of the carriage, and correspondingly increases as the carriage returns to home position; of means to restore the indexing carriage to home position at a substantially uniform speed, irrespective of the extent of advance of the carriage, and the increasing power of the advancing spring, including a restoring spring; a rocking tensioning arm to which one end of the restoring spring is anchored; means to rock the tensioning arm from and permit it to return to its normal position, the restoring spring decreasing in energy as it restores the carriage to home position and tensions the advancing spring; a compensating spring, one end of which is connected to the rocking tensioning arm; a member normally traveling coincident and concentric with the arm, to which member the opposite end of the compensating spring is connected; and automatically releasable means controlled by the indexing carriage to arrest the tensioning arm at different points on its return according to the extent of advance of the carriage, whereby to enable the compensating spring to be variously tensioned commensurate with the varied resistance afforded by the carriage and the advancing spring.

106. The combination with an indexing carriage; means, including a spring, to advance the carriage differentially; and means, including a pivoted tensioning arm, and a second spring opposed to the first-named spring, to restore the carriage to home position, of compensatory means to supplement the return spring in restoring the indexing carriage to its home position at a substantially uniform speed irrespective of the extent of advance of the carriage, including a floating spring, one end of which is connected to the pivoted tensioning arm; a second arm opposed to the tensioning arm and concentrically pivoted therewith, to which the remaining end of the floating spring is connected; automatically releasable means controlled by the indexing carriage to differentially arrest the tensioning arm; the opposed arm having a constant excursion to locate the floating spring variously relatively to dead center, and differentially tension the floating spring according to the extent of advance of

the carriage; the tensioning arm, when released, adapted to swing the attached end of the spring away from dead center as the carriage returns, to enable the floating spring to exert its energy on an increasing leverage as the energy of such spring decreases.

107. The combination with an indexing carriage; and means, including a spring, to advance the indexing carriage differentially from its home position; of carriage-restoring means, including an arm and a spring opposed to the advancing spring, to return the carriage to home position and reenergize the carriage-advancing spring; of means to supplement the carriage-restoring spring to assist the return of the carriage to its home position at a substantially uniform speed irrespective of the extent of advance of the carriage, including a floating spring; connected at one end with the carriage-restoring arm; an opposed element movable relatively to the carriage-restoring arm and pivoted concentrically therewith, to which the opposite end of the floating spring is connected, the restoring arm and the element normally moving coincidentally about their common centre to avoid energizing the floating spring; and automatically releasable means to arrest the carriage-restoring arm to enable the opposed element to tension the floating spring and shift it towards a dead centre position relatively to the arrested arm; the arrested arm, when released, adapted to shift the floating spring away from dead centre to enable it to expend a substantially constant amount of energy upon the carriage-restoring arm as the tension of the floating spring relaxes.

108. The combination with an indexing carriage; means, including a spring, to advance the carriage differentially from its home position; and means, including a second spring opposed to the carriage-advancing spring, to restore the carriage to home position and re-energize the carriage-advancing spring; of means supplementing the action of the carriage-restoring spring to insure the return of the carriage to home position from any of its differential positions, at a substantially uniform speed irrespective of the extent of advance of such carriage, including a floating spring connected to the carriage-restoring means; means to tension the floating spring and incidentally shift it from its normal position to one wherein it applies its energy to the carriage-restoring means at a point near a line extending through the pivotal point of the restoring means; the restoring means operative to shift the point of application of power of the floating spring away from the dead centre position as the carriage returns to its home position, to enable the floating spring to more effectively apply its power as it de-energizes.

109. The combination with an indexing carriage; and a motor to advance the carriage from its home position; of a carriage-restoring element; operating means, including a return spring, normally uncoupled from the carriage-restoring element; and means controlled by the carriage to enable the return spring to be tensioned proportionately to the extent of advance of the carriage, to render the operating means potentially effective upon the carriage-restoring element.

110. In a machine of the class described, the combination with an indexing carriage; and a motor to variously advance the carriage from its normal position; of means to restore the carriage to its normal position, including a restoring element; operating mechanism for the restoring element

normally out of operative position relatively to the restoring element, and including a restoring spring; means to shift the operating mechanism to effective position relatively to the restoring element and tension the restoring spring; and carriage-controlled means to temporarily delay the actuation of the restoring element by its operating mechanism.

111. In a machine of the class described, the combination with a totalizer; a series of actuators therefor; an indexing carriage to control the excursions of the actuators; a motor to advance the carriage in one direction relatively to the actuators; carrying mechanism associated with the totalizer; and means to actuate the carrying mechanism subsequently to the excursions of the actuators; of an element to restore the indexing carriage to normal position; operating mechanism for the restoring element; means to automatically shift the operating mechanism into and out of effective position relatively to the restoring element; and means to restrain the operating mechanism from effective operation until the carry-actuating mechanism has completed its operation.

112. In a machine of the class described, the combination with a drive shaft operable through successive cycles; a series of actuators; an indexing carriage to control the excursions of the actuators; and a motor to advance the carriage relatively to the actuators; of a carriage-restoring element; operating mechanism for the carriage-restoring element; means to automatically shift the operating mechanism into and out of effective position relatively to the carriage-restoring element; carriage-controlled means to restrain the operating mechanism from actuating the carriage-restoring element until the main drive shaft has completed one of its cycles; and means controlled by the operating mechanism to prevent a succeeding operation of the main drive shaft until the carriage has returned to its home position.

113. The combination with an indexing carriage; and a motor to differentially advance the carriage in one direction; of a carriage-restoring element; operating means, including a return spring, for the carriage-restoring element; means to automatically shift the operating means into and out of effective position relatively to the carriage restoring element, as an incident to the operation of the machine; a compensating spring connected with the operating means; and carriage-controlled means to restrain the action of the operating means upon the carriage-restoring element to enable the tensioning of the compensating spring in proportion to the extent of advance of the carriage.

114. The combination with actuators; a travelling indexing carriage; a motor to advance the carriage in one direction; and manipulative means to determine the extent of advance of the carriage; of a carriage-restoring element, operating mechanism for the carriage-restoring element, including a return motor, and a compensating motor; a drive shaft and connections to energize the last-named motors; means operable incident to the operation of the machine to automatically shift the operating mechanism into and out of effective position relatively to the carriage-restoring element; and carriage-controlled means to restrain the action of the operating mechanism upon the carriage-restoring element after the operating mechanism is in effective position relatively thereto, to enable the drive shaft to

energize the compensating motor proportionally to the extent of advance of the carriage.

115. The combination with a series of actuators; of overthrow preventing means therefor, including an oscillatory member; a power shaft; drive means connected with the power shaft; connections between the drive means and the overthrow preventer to oscillate the latter; selective indexing means shiftable relatively to and operable by the drive means to select and engage corresponding actuators with the overthrow preventing means.

116. The combination with a series of actuators adapted for differential advance; of a support having an excursion of fixed extent in one direction; a carriage mounted to shift on the support relatively to the actuators in another direction; elements mounted in the carriage and adapted to be selectively set to advance the corresponding actuators when the support is moved in one direction; and an overthrow preventer, including a rotatable toothed member engageable by the actuators as they advance under the influence of the set elements in the carriage; and means to limit the rotation of the toothed member.

117. The combination with a series of actuators adapted for differential advance; of a support having an excursion of fixed extent in one direction; a carriage mounted to shift on the support relatively to the actuators in another direction; elements mounted in the carriage and adapted to be selectively set to advance the corresponding actuators when the support is moved in one direction; and an overthrow preventer, including a rotatable toothed member engageable by the actuators as they advance under the influence of the set elements in the carriage.

118. The combination with a series of actuators adapted for differential advance; of a support having an excursion of fixed extent in one direction; a carriage mounted to shift on the support relatively to the actuators in another direction; elements mounted in the carriage and adapted to be selectively set to advance the corresponding actuators when the support is moved in one direction; and an overthrow preventer, including a rotatable toothed member engageable by the actuators as they advance under the influence of the set elements in the carriage; and connections between the toothed member and the support to limit the rotation of the toothed member.

119. The combination with a series of actuators; of a drive means; settable means operated by the drive means to impart a preliminary advance to corresponding actuators; an overthrow preventer for the actuators, including a rotatable member common to the several actuators, and with which the actuators engage as an incident to their preliminary advance; and means to drive the rotatable member through an excursion of fixed extent.

120. The combination with a totalizer; actuating means therefor; and drive means for the actuating means; of means to lock the drive means against operation, including a stop having a loose connection with the drive means to enable limited relative movement between the stop and drive means; and a totalizer-controlled detent shiftable into the path of the stop to arrest the latter prior to the completion of that stroke on which the detent becomes effective, the connection between the stop and drive means affording sufficient relative movement to enable the drive means to

complete its stroke subsequently to the arrest of the stop by the detent.

121. In a totalizer-controlled lock; a stop; a detent shiftable into and out of effective position relatively to the stop; a latch to hold the detent in one of its positions; a trip member operable upon the latch to release the detent, to enable the latter to shift to its remaining position; and means controlled by the totalizer to actuate the trip member.

122. In a machine of the class described, the combination with a totalizer; and means to drive the totalizer differentially; of a lock for the drive means, including a detent controlled by the totalizer, and a stop means associated with the drive means, the stop means and detent being relatively adjustable in different planes; and means to condition the machine for addition and subtraction, and to effect such relative adjustment between the stop means and the detent to either of the planes, whereby to render the locking means operable in either condition of the machine.

123. The combination with a totalizer, and drive means to cause the totalizer to register different amounts; of a lock for the drive means, including a stop element connected with the drive means to travel in one plane, and a detent shiftable in the same plane to coact with the stop element to lock the drive means; the stop element and detent being relatively adjustable in a different plane to coact under different operating conditions; and means to adjust the relative positions of the detent and stop element, for coaction in either plane.

124. The combination with a totalizer; differential mechanism to determine the amounts to be registered thereon; and drive means to effect the registry of amounts on the totalizer; of means to prevent the registry of amounts on the totalizer, including a plurality of individual stops connected with the drive means, spaced apart from each other in the direction of travel of the drive means, and also laterally; and a detent relatively adjustable to become effective with a predetermined stop when the capacity of the totalizer is exceeded in adding and subtracting operations, respectively.

125. The combination with a totalizer; differential mechanism to determine the amounts to be registered thereon, and drive means to effect the registry of such amounts on the totalizer; of means to prevent the registry of amounts on the totalizer, including a plurality of individual stops, and a detent adjustable to become effective with a predetermined one or the other of the stops, when the capacity of the totalizer is exceeded in straight addition, and in subtraction operations, respectively.

126. The combination with a totalizer; and drive means therefor; of means to prevent operation of the drive means, including a stop element and a detent device, adapted for mutual engagement and disengagement and relatively adjustable, as the totalizer is operated for adding and for subtracting respectively; and means controlled by the totalizer to effect engagement of the detent device and the stop element, in either of their relative adjustments.

127. The combination with a totalizer; and drive means therefor; of means to lock the totalizer against operation, including a plurality of stops and a detent, relatively adjustable to enable the detent to coact with one or another of the

stops; and means to effect relative adjustment between the detent and stops.

128. The combination with a totalizer; and drive means therefor; of means to lock the totalizer against operation, including a plurality of stops and a detent, relatively adjustable to enable the detent to coact with one or another of the stops; the drive means having a limited movement relatively to the stops upon the impact of the stops and detent; and means to effect relative adjustment between the detent and stops.

129. The combination with a totalizer; and drive means therefor; of means to lock the totalizer against operation, including a plurality of stops operable in parallel planes; and a detent engageable with, and adjustable into one or another of the planes to coact with the stop operating in such plane; detaining means to hold the detent ineffective; means controlled by the totalizer to disable the detaining means; and means to restore the detent to position to enable the detaining means to become effective.

130. The combination with a totalizer; and drive means therefor, of means to lock the totalizer against operation, including a stop element and a detent for mutual cooperation, adjustable relatively in parallel planes; detaining means to hold the detent normally ineffective; means controlled by the totalizer to disable the detainer; and means to restore the detent to its ineffective position.

131. The combination with a totalizer; and drive means therefor, of means to lock the totalizer against operation, including a stop element having a limited movement relatively to the drive means, and a detent to coact therewith, the stop and detent being relatively adjustable to one or another parallel plane; resilient means tending to hold the stop in its advanced limit of movement relatively to the drive means; means controlled by the totalizer to shift the detent into the path of the stop whereby to lock the totalizer against operation and cause a relative movement of the stop element and drive means to tension the resilient means; and means to displace the detent relatively to the stop to enable the resilient means to advance the stop to its normal position relatively to the drive means.

132. The combination with a totalizer; and drive means therefor; of means to lock the totalizer against operation, including a stop, and a detent; means controlled by the totalizer to detain the detent in ineffective position; means to disengage the detent and stop after an effective operation of the detent; and means to restore the detent to its ineffective position, including a resetting member; a resetting dog carried thereby and normally in position to contact the detent and restore it to ineffective position upon operation of the resetting member; and means engaged by the resetting dog to disengage the dog from the detent upon the return of the detent to ineffective position and to thereafter restore the dog to its normal position.

133. The combination with a totalizer, and drive means therefor; of means to lock the totalizer against operation, including a stop, and a detent; means controlled by the totalizer to retain the detent in ineffective position; means to disengage the detent and stop after an effective operation of the detent; and means to restore the detent to its ineffective position on the succeeding operation of the drive means, including a rocking member operated by the drive means;

a resetting dog actuated by the rocking member to engage the detent and restore it to ineffective position, the dog having a pair of lugs; and a stationary member successively engaged by the lugs to alternately shift the dog to ineffective and effective positions, respectively, relatively to the detent.

134. In a machine of the class described, adapted for addition and subtraction; the combination with a totalizer; actuators therefor; and means to drive the actuators; of means to lock the machine against operation, including a stop element connected with the drive means, and a detent to cooperate with the stop element, the stop element and detent being relatively adjustable; means to condition the machine for addition and subtraction and to effect relative adjustment between the detent and stop element, whereby the detent is normally ineffective in one adjustment and normally effective in another adjustment; totalizer-controlled means to render the detent effective in the first mentioned of said adjustments; and means to restore the detent to its normal position.

135. In a machine of the class described adapted for addition and subtraction, the combination with a totalizer; actuators therefor; and drive means for the actuators; of means to lock the machine against operation, including a stop element connected with the drive means, and a detent shiftable in different planes relatively to the stop element; means to condition the machine for addition and subtraction, and to adjust the detent in one plane of its adjustment relatively to the stop element; a latch to maintain the detent normally ineffective in one of its adjusted positions and normally effective in the other of its adjusted positions; totalizer-controlled means to trip the latch and render the detent effective in one of its adjusted positions; and means to restore the detent to its latched position.

136. In a machine of the class described, the combination with a totalizer; actuators therefor; and a main drive shaft; of an exceeded capacity and negative balance indicator; means, including a switch member, operable from the totalizer wheel of highest denomination to render the indicator effective; zero-resetting means for the totalizer, operable in conjunction with the switch member when the latter is substantially in normal position; and a spring to return the switch member towards its normal position to arrest the totalizer wheel in a zero-resetting operation.

137. In a machine of the class described, the combination with a totalizer; actuators therefor; and a main drive shaft; of means to lock the machine against operation; control means operable by the effective totalizer wheel of highest denomination to effect actuation of the locking means; zero-resetting means for the totalizer, cooperable with the control means to restore the effective totalizer wheel of highest order to zero; and means to restore the control means to position to arrest its totalizer wheel in zero position upon a zero-resetting operation.

138. The combination of a series of value-representing elements shiftable in three different directions; a series of actuators controlled thereby; selective means to shift the selected elements in one direction to set position; means to shift the elements bodily in a second direction to position them relatively to the actuators; a second means to adjust the elements in said second direction relatively to the actuators to enable them to con-

trol the actuators according to their actual or their complemental values; and means to shift the elements in a third direction to cause them to advance the actuators.

5 139. The combination with a series of actuators; of a series of value-representing elements to control the excursions of the actuators; selective means to shift selected elements in one direction to their set positions; means to adjust
10 the elements in another direction relatively to the actuators and incident to the setting of the elements; and a second means to impart another adjustment to the elements relatively to the actuators and in the last-named direction of travel
15 to enable the set elements to control the actuators according to their actual or their complemental values, respectively.

140. The combination with amount-determining devices; of an indexing carriage, including
20 value-representing elements settable by the amount-determining devices; actuators, the excursions of which are controlled by the set elements; means to feed the carriage in one direction relatively to the actuators and the amount-determining devices; means to effect relative
25 movement of the carriage and the actuators in another direction during which the set elements control the actuators; and means to adjust the carriage relatively to the actuators to enable the set elements to control the actuators according
30 to the actual or to the complemental values of the amount-determining devices, respectively.

141. The combination with a series of actuators; of an indexing carriage; normally idle
35 value-representing elements mounted in the carriage and adapted to control the excursions of the actuators; amount-determining devices to set the desired elements for operation; means to effect a relative adjustment between the carriage
40 and the actuators to enable the selected elements to control the excursions of their corresponding actuators according to the actual values of the amount-determining devices, and of the complemental values thereof, respectively; and means
45 to feed the carriage and its elements step by step relatively to the actuators, in either adjustment.

142. The combination with a totalizer; actuators therefor; and amount-determining devices; of suitably supported denominational rows of
50 value-representing elements settable by the amount-determining devices; means to feed the rows of value-representing elements step by step relatively to the actuators to locate the set elements in position to control the excursions of the
55 actuators; and means to adjust the positions of the set elements relatively to their actuators to determine whether the elements shall control their actuators according to the actual values of the manipulative devices or the complemental
60 values thereof; the step by step feeding means remaining operative in either adjustment of the set elements.

143. The combination with a series of actuators; of a carriage support; an indexing carriage
65 mounted to travel thereon relatively to the actuators in one direction; value-representing elements mounted in the carriage and adapted to control the excursions of the actuators; amount-determining devices to select the elements to
70 represent the amount desired; and means operable upon the carriage support to adjust the carriage relatively to the actuators; to enable the selected elements to control the actuators according to the actual or the complemental values, respectively, of the amount determining devices.

144. The combination with a series of actuators; of a carriage support; an indexing carriage
mounted to travel thereon relatively to the actuators, in one direction; value-representing elements
80 mounted in the carriage and adapted to control the excursions of the actuators; amount-determining devices to select the elements to represent the amount desired; means to adjust the carriage support and carriage relatively to
85 the actuators, to enable the selected elements to control the actuators according to the actual values or the complemental values, respectively, of the amount-determining devices; and means operable in either adjustment of the carriage to feed the latter relatively to the actuators.

145. In a machine of the class described, adapted for addition and subtraction, the combination with a totalizer, and a series of actuators
therefor; of an indexing mechanism adapted to advance step by step in one direction relatively
95 to the actuators, to control the excursions of the actuators, and means to vary the starting position of the indexing mechanism, whereby the steps taken from one starting position alternate with the steps taken from another starting position, to
100 enable the indexing mechanism to control the actuators according to the actual or the complemental value, respectively, of the amount to be registered.

146. The combination with a totalizer; and a
105 series of actuators therefor; of an indexing carriage, including settable elements; amount-determining devices to set the elements; means to advance the carriage in one direction relatively to the actuators, to position the set elements
110 effectively to control the excursions of the actuators; means to restore the carriage to its starting point; and means to vary the position from which the carriage starts its advance, including a carriage-shifting member, and a state-determining
115 device to control the member by varying the relative positions of the settable elements and their actuators accordingly as addition or subtraction is to be performed.

147. The combination with a totalizer; and a
120 series of actuators therefor; of an indexing carriage, including settable elements; means to set desired elements; means to feed the carriage in one direction relatively to the actuators, to position the set elements in the indexing carriage
125 effectively to control the excursions of the actuators; and means to vary the position of the carriage relatively to the actuators, including a cam member connected with the carriage, and a shifting lever coacting with the cam member to
130 shift the carriage in the same plane in which it is fed.

148. The combination with a totalizer; and a series of actuators therefor; of an indexing carriage, including settable elements; means to set
135 desired elements; means to feed the carriage in one direction relatively to the actuators, to position the set elements in the indexing carriage effectively to control the excursions of the actuators; and means to vary the position of the
140 carriage relatively to the actuators, including cooperating cam members, one of which is effective upon the carriage, to shift the carriage in the same plane in which it is fed.

149. The combination with a totalizer; and a series of actuators therefor; of an indexing carriage, including settable elements to control the
excursions of the actuators; and an escapement mechanism for the indexing carriage, including
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stops shiftable relatively to the actuators, and adapted, when in one position, to arrest the travel of the carriage step by step, and in another position to both arrest the carriage and control the excursions of those actuators beyond the control of the settable elements.

150. The combination with a totalizer; denominationally arranged actuators therefor; and amount-determining devices; of a travelling field of value-representing elements arranged in denominational rows, and settable by the amount-determining means according to the actual value of the item to be registered, to control the excursions of the corresponding actuators; means to effect relative adjustment between the field of elements and the actuators, to enable the set elements to control the actuators according to the complement of the actual value of the set elements; and a series of normally effective members individually displaceable according to the extent of travel of the carriage, to control the excursions of such actuators as lie beyond the point to which the carriage has travelled.

151. The combination with a totalizer; actuators therefor; and amount-determining devices; of a travelling carriage; denominational groups of value-representing elements mounted in the carriage, and settable by the amount-determining devices according to the actual value of the amount to be registered; means to variously advance the carriage relatively to the actuators according to the number of denominations in the amount set up, including individually displaceable, normally effective denominational stops; and means to adjust the travelling carriage with its denominational groups of elements together with the denominational stops, relatively to their co-related actuators, to enable the set elements to control the actuators according to the complementary values of the elements, and to enable those denominational stops which remain effective to control those actuators lying beyond the farthest advance of the travelling carriage to introduce the complementary digits into the totalizer beyond the digit of highest value set up by the amount-determining devices.

152. The combination with a totalizer; actuators therefor; and amount-determining devices; of a field of value-representing elements settable by the amount-determining devices; means to differentially advance the field of elements denominationally relatively to the actuators according to the denominational values set up by the amount-determining devices, the field-advancing means including normally effective denominational stops displaceable from the path of the field as the latter advances; and means to adjust the field of elements and the denominational stops relatively to the actuators to enable the set elements to control their actuators according to the complementary values of the set elements, and to render the stops effective to control the excursions of such actuators as lie beyond the point to which the field is advanced, to supply the full complement of the amount set up.

153. The combination with a totalizer; a series of denominational actuators therefor; and amount-determining devices; of a field of value-representing elements arranged in denominational rows, the value-representing elements being settable according to the amount to be registered; means to effect relative adjustments between the actuators and the field of elements to enable the set elements to control the excursions of the actuators according to the actual values set up,

or to the complements of such values, respectively; and means shiftable with the field of value-representing elements, and adapted under one adjustment thereof, to control the excursions of those actuators beyond the set element of highest denominational value.

154. The combination with a totalizer; a series of denominationally arranged actuators therefor; and amount-determining devices; of a field of value-representing elements settable by the amount-determining devices according to the amount to be registered to control the excursions of their corresponding actuators; means to effect relative adjustment between the field of elements as a whole and the actuators to cause the set elements to control the actuators according to the actual values of the set elements, or according to the complementary values thereof, respectively; and means rendered effective by one of such adjustments to control the excursions of those actuators beyond the control of the set elements.

155. The combination with a totalizer; a series of denominationally arranged actuators therefor; and amount-determining devices; of a field of value-representing elements settable by the amount-determining devices; each element having a plurality of contact faces, one of which controls the excursions of its corresponding actuator according to the actual value set up and another of which controls the corresponding actuator according to the complement of such value; and means to effect relative adjustment between the field of elements and the actuators to render one or the other of the contact faces of the set elements effective.

156. The combination with a totalizer; a series of denominationally arranged actuators therefor; and amount-determining devices; of a field of value-representing elements settable by the amount-determining devices; means to impart a driving stroke to the field of elements to cause the set elements to advance the actuators; each element having a plurality of contact faces, one of which advances its corresponding actuator according to the actual value set up, and another of which advances the actuator according to the complement of such value; means to select one or the other set of contact faces for operation; and means automatically rendered effective by the selection of the complementary set of contact faces to advance throughout their normal travel, those actuators in denominations higher than the set element of highest value.

157. The combination with a totalizer; actuators therefor; and amount-determining devices; of value-representing elements settable by the amount-determining devices to control the excursions of the actuators; each element having a surface to represent the actual value of the element, and a surface offset relatively to the first-named surface, to represent the complementary value thereof; and means to effect relative adjustment between the elements and the actuators, whereby one surface or the other of each of the set elements lies out of line with its actuator.

158. The combination with a totalizer; and a series of arcuate actuators therefor; of an indexing carriage adapted to enter and be withdrawn from the area circumscribed by the arcuate actuators; settable elements mounted in the carriage and extending substantially diametrically relatively to the path of travel of the actuators; means to rotate the carriage when encircled by the actuators to enable the set elements to advance their

associated actuators; and means to adjust the carriage relatively to the actuators to enable one end of each set element to control its corresponding actuator according to the actual value of the digit to be registered, and the opposite end of each set element to control such actuator according to the complemental value of the digit to be registered.

159. The combination with a totalizer; a series of actuators therefor; and a series of amount-determining devices; of an indexing carriage, including elements settable by the amount-determining devices to control the excursions of the actuators; means to position the carriage effectively relatively to the actuators; and means to adjust the carriage and the set elements relatively to the actuators to enable one end of each set element to control its associated actuator according to the actual value set up by the manipulative devices, and the opposite end of each set element to control its associated actuator according to the complemental value of the amount set up.

160. The combination with a totalizer; a series of actuators; and a series of amount-determining devices; of groups of offset, value-representing elements settable by the amount-determining devices to control the excursions of the actuators, the elements being offset laterally in parallel planes; and means to bring one or another of the offsets to effective position relatively to the corresponding actuators to enable the elements to control the excursions of the actuators according to the actual values of the elements, and according to their complemental values, respectively.

161. The combination with a totalizer; a series of actuators; and amount-determining devices; of double-ended value representing elements settable by the amount-determining devices to control the excursions of the actuators, one end of each element adapted to control its corresponding actuator according to the actual value of the element, and the other end of the set element adapted to control the actuator according to the complemental value of the element.

162. The combination with a totalizer; a series of actuators; and amount-determining devices; of a travelling carriage shiftable denominationally relatively to the actuators; value-representing elements mounted transversely of the carriage and settable by the amount-determining devices to control the excursions of the actuators; and means to adjust the carriage relatively to the actuators, in addition to the denominational travel of the carriage to enable identical set elements to variously control the excursions of their corresponding actuators.

163. The combination with a totalizer; actuators therefor; and amount-determining devices; of a single field comprising a plurality of denominational rows of value-representing elements settable by the amount-determining devices to control the excursions of their corresponding actuators according to the actual value of the amount to be registered, the same element, set according to its actual value, also adapted to control its corresponding actuator according to the complemental value of the element; and means to adjust the field of elements bodily to effect either addition or complemental subtraction on the totalizer.

164. The combination with a totalizer; actuators therefor; and amount-determining devices; of an adjustable support, value-representing elements mounted in the support and settable by the amount-determining devices to represent the

actual values of the amounts to be added, the set elements adapted to control the excursions of the actuators; and means to variously adjust the support and its settable elements to locate the corresponding ends of the set elements in positions to control the excursions of the actuators according to the actual values of such elements, and to locate the other corresponding ends of the set elements in positions to control the excursions of the actuators according to the complemental values of the set elements, respectively.

165. In a machine of the class described, a series of traveling actuators; a field of value-representing elements adapted for advance differentially along a path extending across the actuators; each actuator having opposed contact members lying on opposite sides of the field of elements; amount-determining devices to set the value-representing elements according to the actual amount desired; means to impart movement to the set elements in the line of travel of the actuators to control the excursions of the actuators; and means to effect relative adjustment between the field of elements and their respective series of contact members, whereby to enable the set elements to coact with either series of contact members to the exclusion of the other.

166. In a machine of the class described, a series of actuators having a plurality of series of contact members; a field of normally idle value-representing elements, to coact with either series of contact members to control the excursions of the actuators; the elements being recessed to clear one series of contact members; amount-determining devices to set the value-representing elements to effective positions relatively to one series of contact members; and means to adjust the field of value-representing elements to enable the set elements to coact with another series of contact members, the recesses in the value-representing elements enabling the last-named series of contact members to clear the unset elements intervening between the set element and the coacting contact member.

167. In a machine of the class described, a series of actuators, each having a projection; a field of value-representing elements to coact with the actuators, the elements arranged in rows and each element being recessed to afford a clearance for the projection on its associated actuator; and amount-determining devices to set the elements to locate unrecessed portions thereof in positions to coact with the projections on their associated actuators.

168. The combination with a totalizer; actuators therefor; and amount-determining devices; of a field of value-representing elements settable by the amount-determining devices according to the amount to be registered; spaced contact faces on the respective elements; spaced contact faces on the actuators with which the respective sets of contact faces on the elements coact to enable the set elements to control the excursions of the actuators according to the actual values of the set elements, or according to the complements of such values, respectively; means to select the sets of coacting contact faces for operation; a further set of contact faces on the actuators; and means selected for operation by the selection of the complementary coacting contact faces to cooperate with said last-named set of contact faces on those actuators which lie beyond the control of the set element of highest denomination to insure the registration of the complete complement.

169. In a machine adapted for addition and complementary subtraction; the combination with a totalizer; and amount-determining devices; of a series of denominational actuators for the totalizer, each actuator having a contact member thereon, the contact member on the units actuator lying one step in advance of the remaining contact members; a field of value-representing elements settable by the amount-determining devices to coact with the corresponding contact members and control the excursions of the actuators; a set of normally effective controllers corresponding in number to the actuators and individually displaceable according to the number of denominations in the amount set up; a second set of contact members on the actuators with which the controllers are adapted to coact when in effective position to operate those actuators of denominations higher than the set element of highest denomination, to insure the registration of the complete complement of the amount set up.

170. In machine of the class described, the combination with a totalizer; and amount-determining devices; of a series of denominationally arranged actuators, each having spaced contact members thereon, forming a plurality of sets; a single field of value-representing elements settable by the amount-determining devices to control the excursions of the actuators; each element having spaced contact faces, each of which is adapted to coact with its respective set of contact members; means to effect relative adjustment between the single field of elements and the actuators to enable the elements set in accordance with their actual values to control the excursions of the actuators according to such actual values, or according to the complemental values thereof, respectively, another set of contact members on the actuators; and means normally out of line with the last-named contact members, rendered effective by the adjustment of the complementary set of contact faces and members for operation, to coact with such last-named set of contact members on those actuators of higher denominational value than the set element of highest denominational value, to effect the registry of the complete complement.

171. The combination with amount-determining devices; of actuators, each having a plurality of contact members; a field of value-representing elements settable by the amount-determining devices to represent an item; each element having a plurality of series of driving faces; means to move the field of elements through a path of constant extent to cause one series of driving faces on the set elements to coact with its corresponding series of contact members and advance their associated actuators differentially according to the actual value represented by the set elements; and means to effect a relative adjustment between the field of elements and the actuators to enable another series of driving faces on the set elements to coact with another series of contact members on the actuators and advance the associated actuators differentially according to the complement of the actual amount represented by the set elements.

172. The combination with a totalizer; denominationally arranged actuators therefor; and amount-determining devices; of a field of value-representing elements adapted to travel differentially in one direction relatively to the actuators, the elements being set by the amount-determining devices to represent the actual value of the

amount to be registered; means to shift the field of elements in another direction through a path of constant extent to cause the set elements to advance the actuators; means to effect relative adjustment between the field of elements and the actuators to enable the set elements to advance the corresponding actuators according to the actual values of the elements set, or according to the complemental values thereof respectively; and a series of members individually displaceable as the carriage travels differentially relatively to the actuators, in the first-named direction, to advance those actuators beyond the control of the set stops under the last-mentioned adjustment, to complete the complement of the amount set up.

173. The combination with a totalizer; denominationally arranged actuators therefor; amount-determining devices; and a travelling field of value-representing elements selectively set by the amount-determining devices to represent the actual value of an amount to be registered; of means, including individually displaceable stops, to differentially advance the field step by step in one direction relatively to the actuators according to the number of denominations in the amount set up; means to impart a driving stroke in another direction to the field of elements to enable the set elements to advance the corresponding actuators according to the actual values of the elements set; and means to effect relative adjustment between the field of elements and the actuators prior to the driving stroke, to enable the same set elements, upon the driving stroke, to advance the actuators according to the complement of the amount represented by such set elements, the stops corresponding denominationally with those actuators beyond the control of the set elements, effective upon such adjustment to advance their actuators to complete the registry of the full complement of the amount set up.

174. The combination with a totalizer; a series of denominationally arranged actuators therefor; and amount-determining devices; of an indexing field of value-representing elements settable by the amount-determining devices according to the actual value of the amount to be registered; each element having a plurality of contact faces; means to differentially advance the field of elements relatively to the denominationally arranged actuators to effectively position the set elements relatively to their corresponding actuators; means to impart a driving stroke in one direction to the field of elements to cause the set element to advance the actuators; and means to effect relative adjustment between the actuators and the field of elements to enable one series of the contact faces to advance the actuators according to the actual value set up and the other series of contact faces to advance the actuators according to the complement of such value.

175. The combination with a set of actuators; of a field of settable, double-ended value-representing elements shiftable relatively to the actuators, one end of each element adapted to control its co-related actuator additively and the remaining end of each element adapted to control its co-related actuator subtractively.

176. The combination with a set of actuators; of a field of double-ended value-representing elements shiftable differentially in one plane relatively to the actuators, and in another direction through a constant path of travel from and toward its normal position to render the actuators

effective; one end of each element adapted to control its co-related actuator for direct addition, and the remaining end adapted to control its co-related actuator for complementary addition; and means to adjust the relative positions of the field of elements and actuators to determine which kind of addition shall be effected.

nation to trip the locking means; and means to restore the control member towards its normal position to coact with the zero-resetting means to arrest the effective wheel of highest denomination.

177. In a calculating machine the combination with a series of differentially and independently operable actuators adapted to enclose an area; of a field of settable, value-representing elements laterally shiftable differentially in one direction into the area enclosed by the actuators; and means to impart a to-and-return movement to the field in another direction after its entry into the area enclosed by the actuators and prior to its return to normal home position adjacent one end of the series of actuators, to control the actuators according to the values of the set value-representing elements.

178. The combination with a totalizer; a series of differential and independently operable actuators therefor; and a series of manipulative, amount-determining devices; of means controlled by the amount-determining devices to determine the extent of differential travel of the actuators, including a single field of settable, value-representing elements adapted for advance from its home position in one direction through differential distances to locate the set value-representing elements effectively relatively to the actuators to be operated; and operating means to impart a to-and-fro movement in another direction to the field of value-representing elements from and back to its advanced position, and prior to its return to home position to cause the value-representing elements to advance their corresponding actuators.

179. The combination with a series of actuators; a field of settable value-representing elements; and means to advance the field in one direction transversely of the actuators; of means to shift the field of elements in another direction from and back to its advanced position; a series of displaceable stops movable with the field of elements in the second-named direction and adapted to arrest the field of elements in its successive positions of advance in the first-named direction; and an escapement control device connected with the field of elements to travel therewith in both directions of movement of the latter, and also movable relatively to the field of elements to successively displace the stops to free the field to the action of its advancing means.

180. In a machine of the class described, the combination with a totalizer; actuators therefor; and a main drive shaft; of an indicator; means, including a switch member, operable from its normal position by the effective totalizer wheel of highest denomination to render the indicator effective; zero-resetting means for the totalizer, adapted to cooperate with the switch member associated with the effective wheel of highest denomination when such switch member is substantially in normal position; and means to restore said switch member towards its normal position after its operation upon the indicator.

181. In a machine of the class set forth; the combination with a totalizer; and means to effect accumulation of amounts thereon; and zero-resetting means to clear the totalizer wheels; of means to lock the totalizer against operation; a control member displaceable from its normal position by the effective wheel of highest denomination

182. In a machine of the class described, the combination with a totalizer; and a drive means; of means to lock the drive means against operation, including a detent device having a plurality of arresting members; and a plurality of stops to coact, respectively, with the respective arresting members of the detent device and lock the drive means; and means to effect a relative adjustment between the detent device and the stop element to render the locking means effective when the machine is conditioned to add and to subtract, respectively.

183. In a machine of the class described, the combination with a totalizer; and a drive means; of means to lock the drive means against operation, including a detent device having a plurality of arresting members, and a plurality of stops with which the respective arresting members of the detent device coact to lock the drive means; and means to impart relative movement to the detent device and stops in one direction to inter-relate the proper arresting members of the detent device and the respective stops; the stops also having limited movement relatively to the drive means in another direction, to thereby enable the drive means to complete its stroke subsequently to the engagement of either arresting member and its stop.

184. In combination, a series of skeleton actuators enclosing an area, and shiftable about such area without encroaching thereon; a field of settable, value-representing elements shiftable into and out of such area circumscribed by the actuators, and adapted to rock within such area to advance the actuators; and means to set selected value-representing elements to effective position and to retain them effective to advance the actuators as the field rocks, the axis about which the field turns being encompassed within the area enclosed by the actuators.

185. In combination, a series of skeleton actuators enclosing an area, and shiftable about such area without encroaching thereon; a field of settable, value-representing elements shiftable into and out of such area circumscribed by the actuators, and adapted to rock within such area to advance the actuators; and means to set selected value-representing elements to effective position and to retain them effective to advance the actuators as the field rocks, the axis about which the field turns being encompassed within the area enclosed by the actuators; and means located wholly exteriorly of the area enclosed by the actuators, to support the latter.

186. In combination, a series of skeleton actuators enclosing an area; a field of settable, value-representing elements operable within said enclosed area, the field of value-representing elements and the series of skeleton actuators being relatively telescopic; means to selectively set the value-representing elements, each of which elements, when set, adapted to define both the actual and the complemental value assigned thereto, at opposed points in the field; opposed contacts on the actuators with which the set elements co-act; and means to relatively offset the field of elements and the actuators to enable the set elements to control the differential advance of the actuators for addition and subtraction, respectively.

187. The combination, with amount-determining, manipulative devices; of a single field of value-representing elements selectively set by the manipulative devices; actuators, the excursions of which are controlled by the set value-representing elements; and means to cause the identical value-representing elements set by the manip-

ulative devices in any single operation of the machine, to control the actuators to register on the totalizer, amounts according to the actual values, or according to the complementary values represented by the set elements.

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