

Sept. 22, 1959

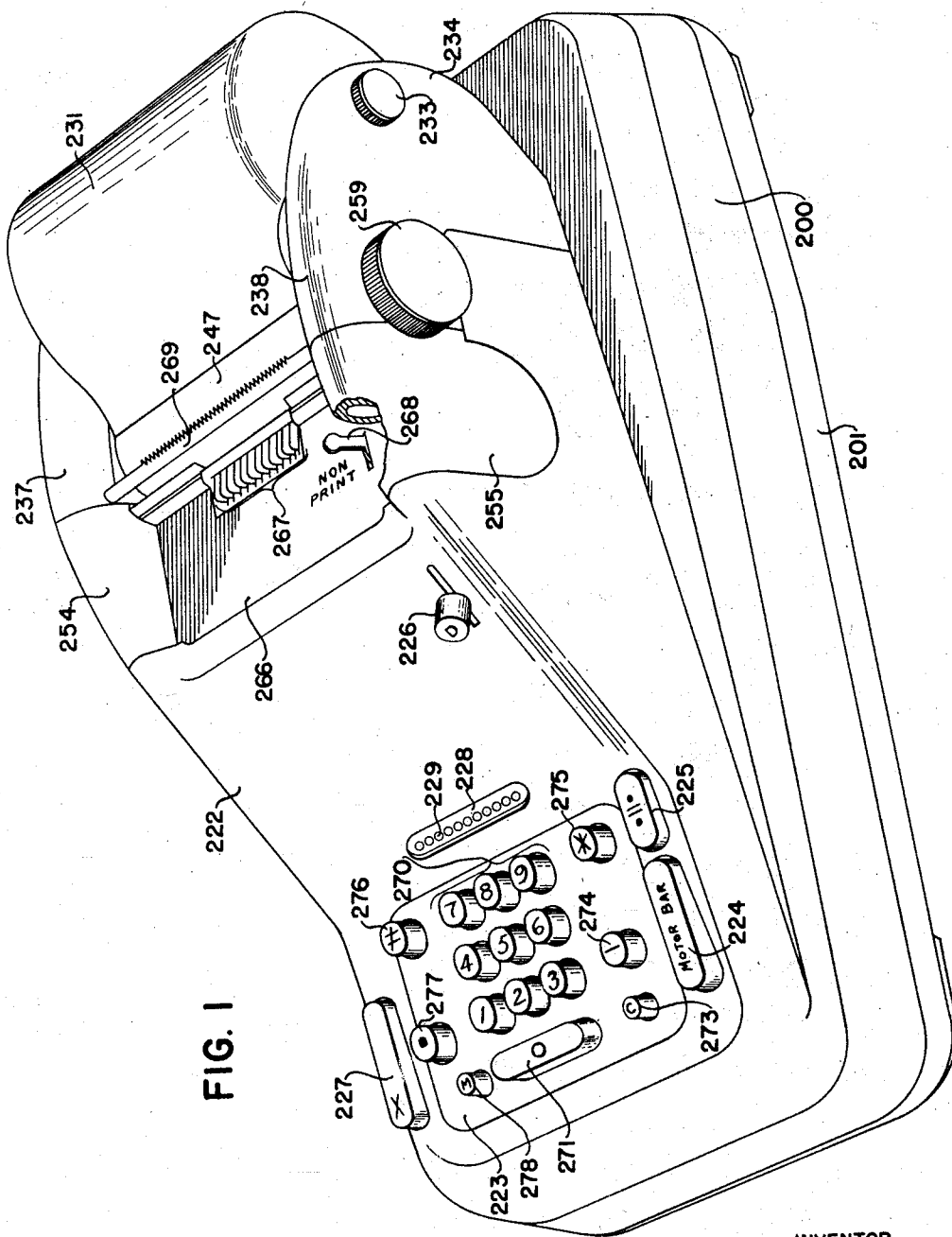
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2,905,382

TEN-KEY PRINTING MULTIPLYING AND DIVIDING MACHINE

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INVENTOR
GUIDO CARNACINA

BY

BY *Karl Benst*
Justin S. Remington
HIS ATTORNEYS

Sept. 22, 1959

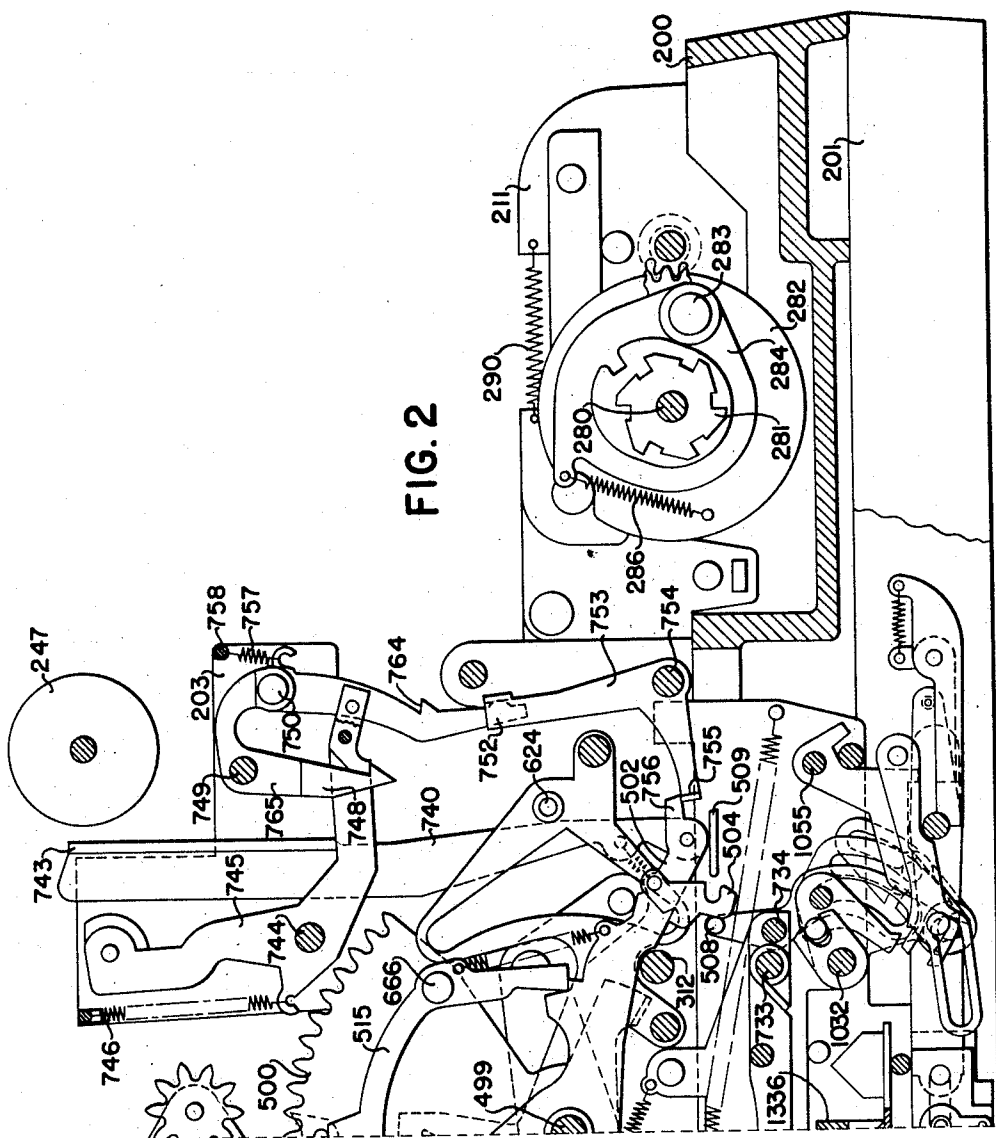
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INVENTOR
GUIDO CARNACINA

BY

Karl Beust
Justin K. Kuntz

HIS ATTORNEYS

Sept. 22, 1959

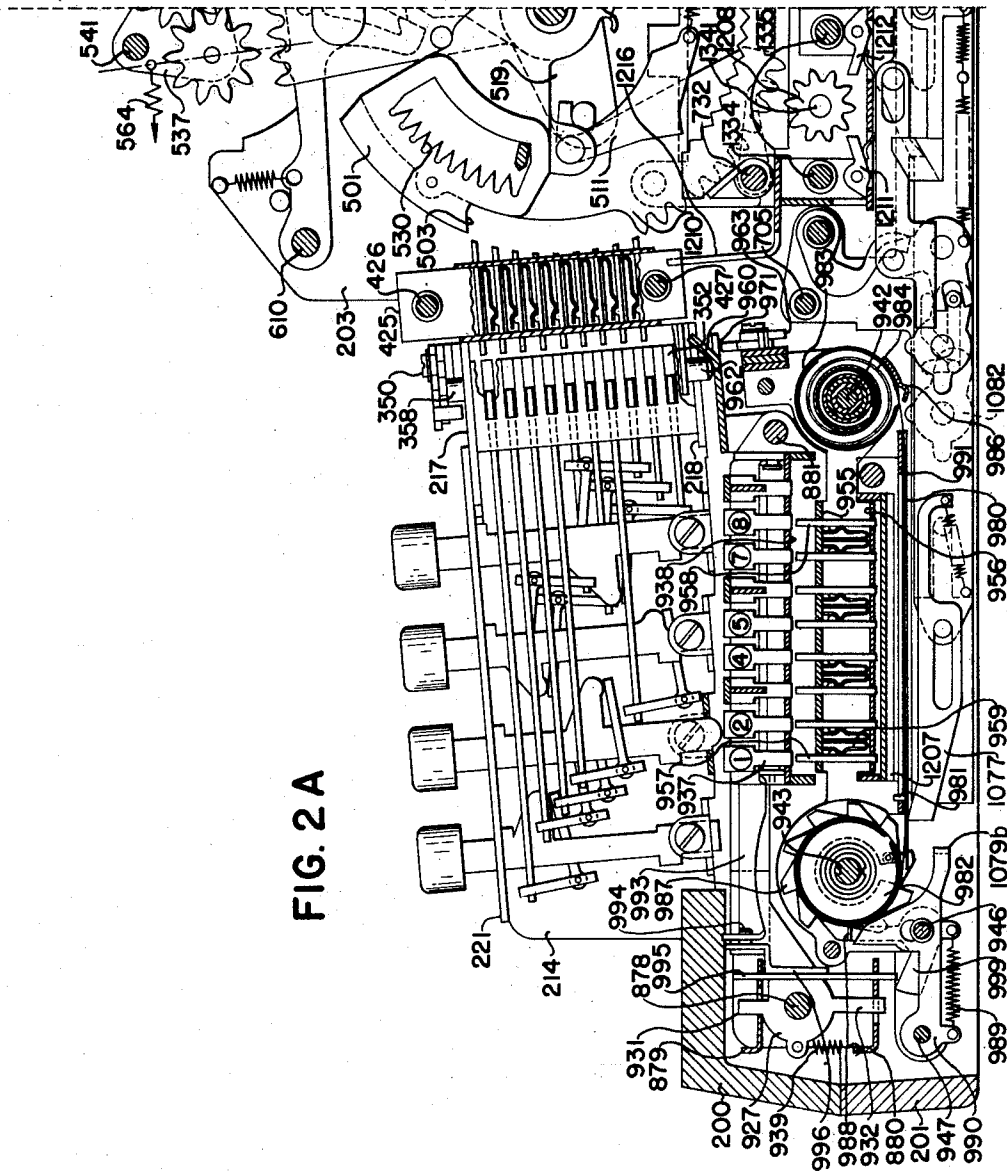
G. CARNACINA

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INVENTOR
GUIDO CARNACINA

BY *Karl Berst*
Justin K. Smith

HIS ATTORNEYS

Sept. 22, 1959

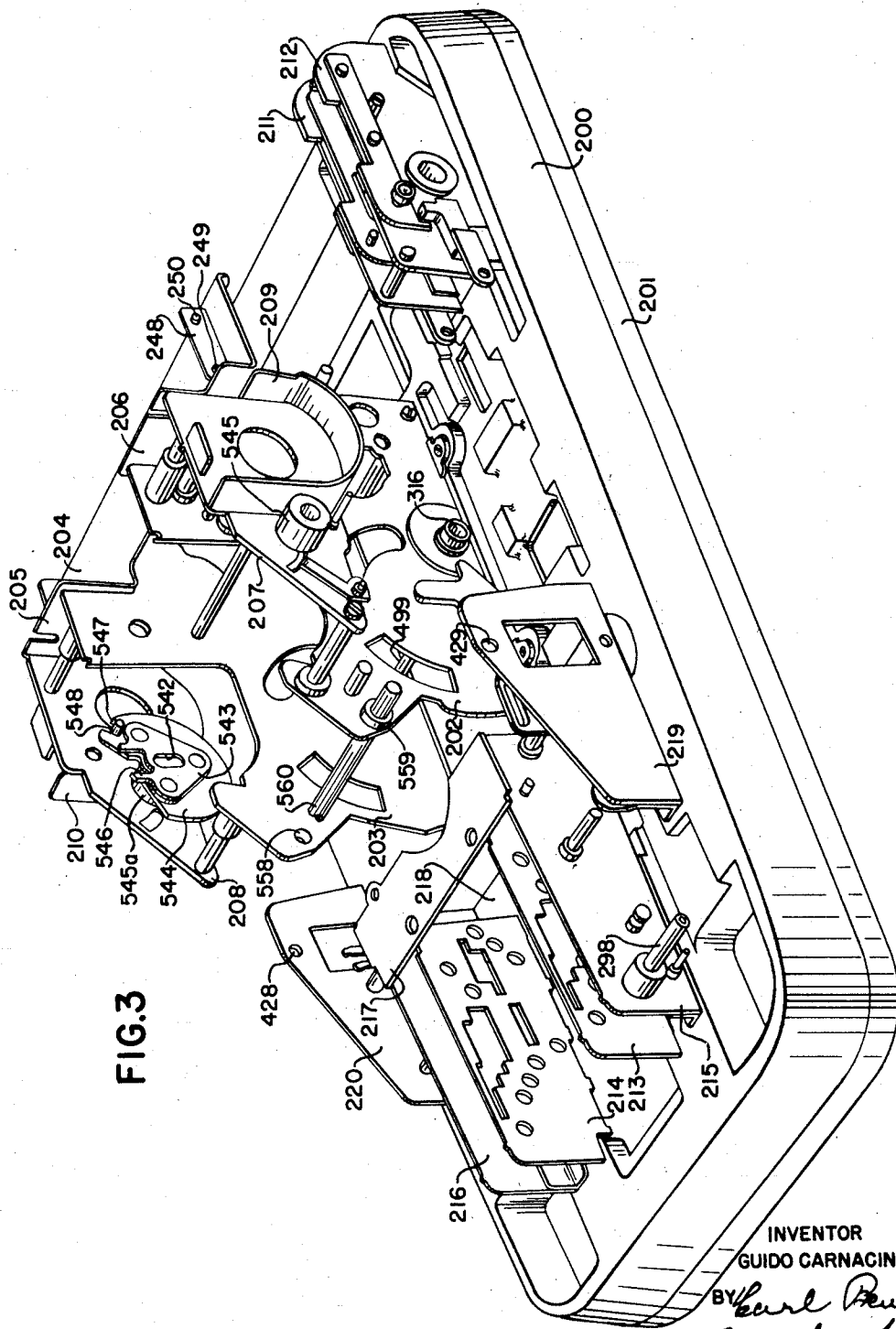
G. CARNACINA

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INVENTOR
GUIDO CARNACINA

BY *Karl Rust*

Justin K. Rust
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Sept. 22, 1959

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FIG. 4

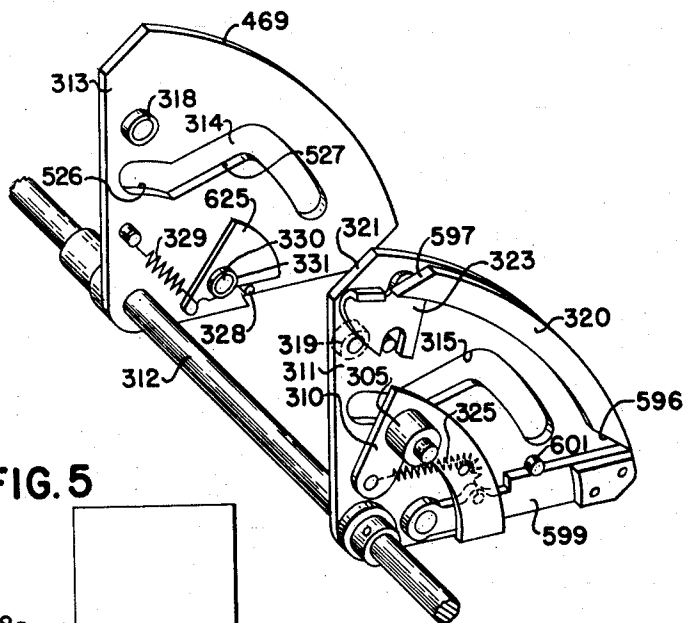
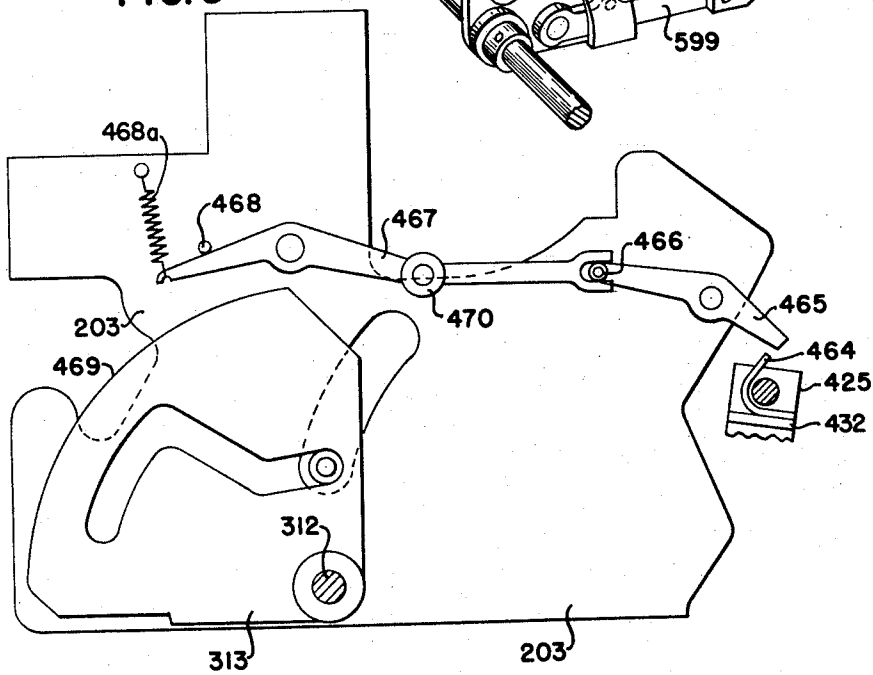


FIG. 5



INVENTOR
GUIDO CARNACINA

BY

Karl Benst
Justin S. Benst

HIS ATTORNEYS

Sept. 22, 1959

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FIG. 6

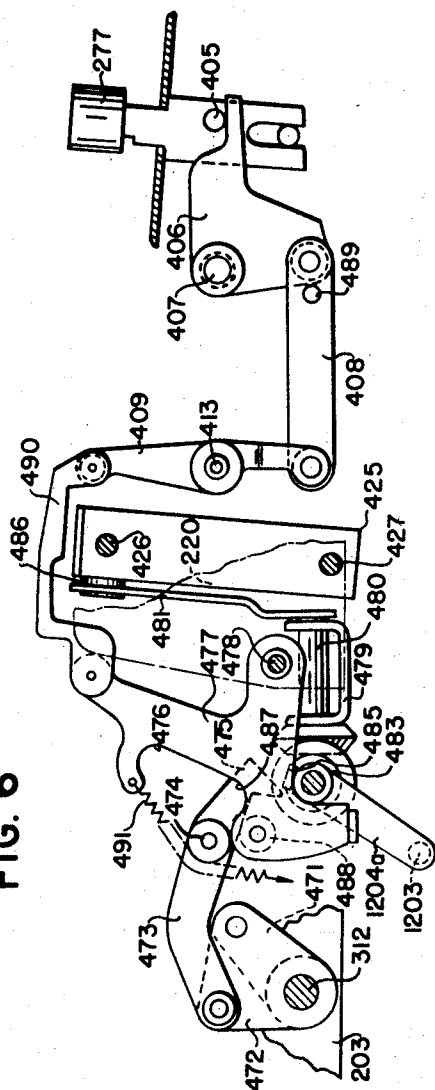
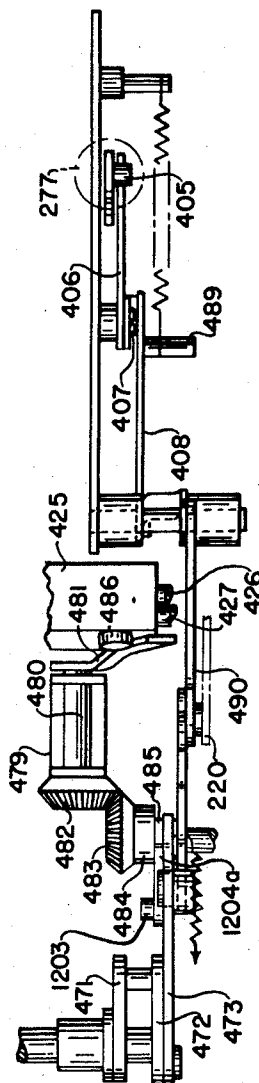


FIG. 7



INVENTOR
GUIDO CARNACINA

BY

Carl Rust
Justin L. Compton

HIS ATTORNEYS

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FIG. 8

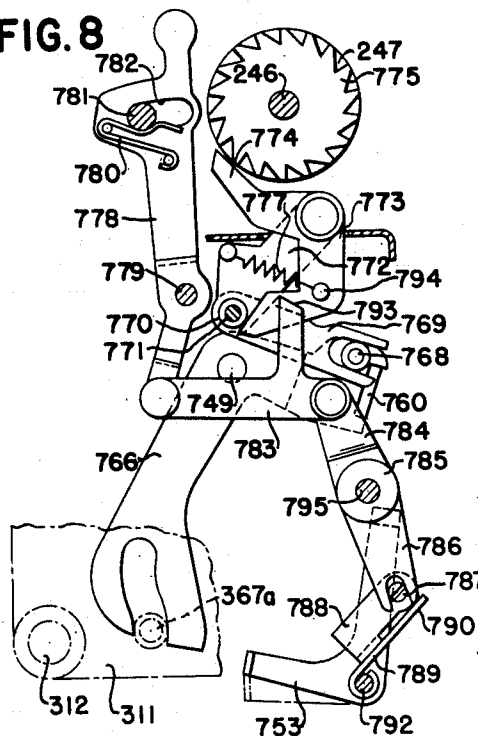
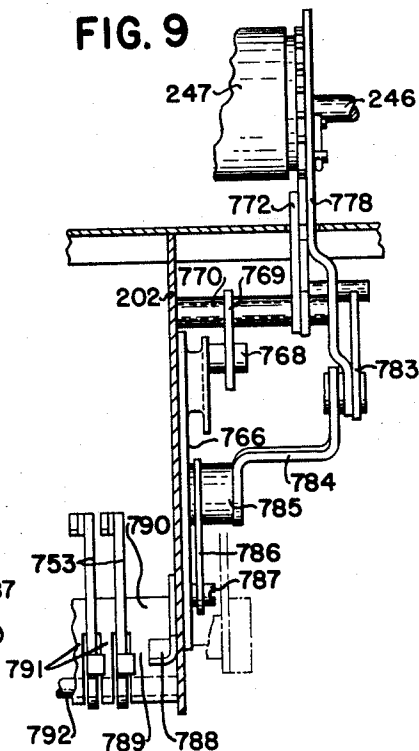


FIG. 9



INVENTOR
GUIDO CARNACINA
BY *Harold Bernt*
Justin K. ...
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FIG. 10

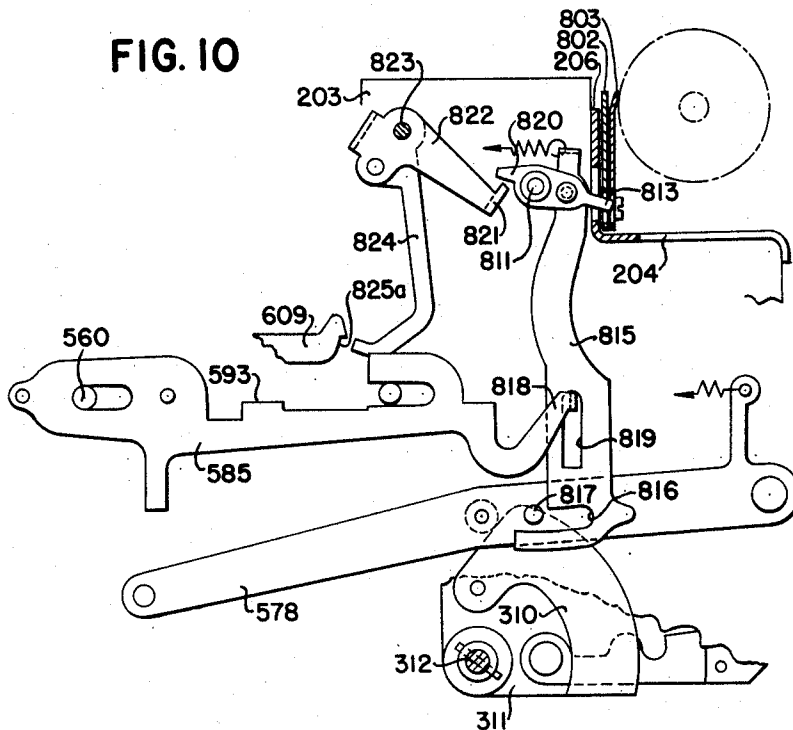
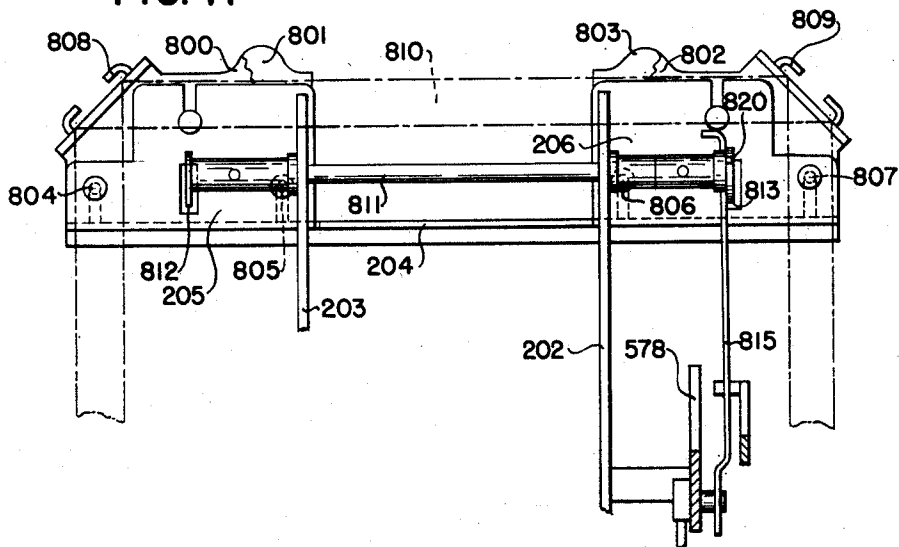


FIG. 11



INVENTOR
GUIDO CARNACINA

BY

Karl Bernt
Justin S. Sampson

HIS ATTORNEYS

Sept. 22, 1959

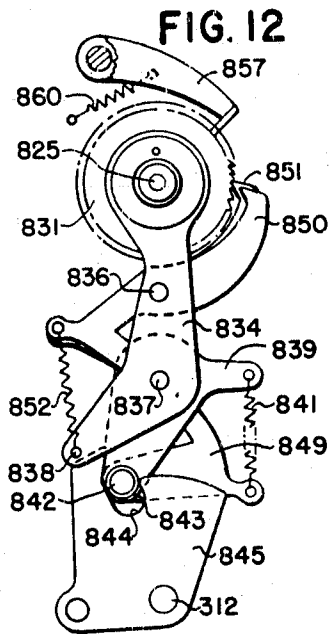
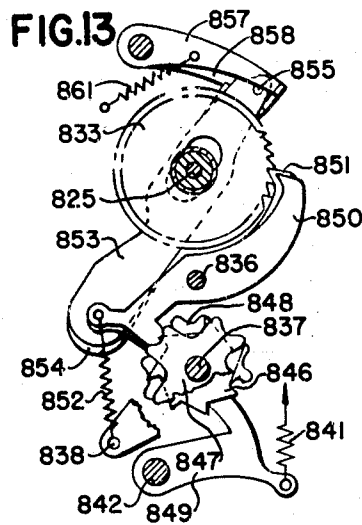
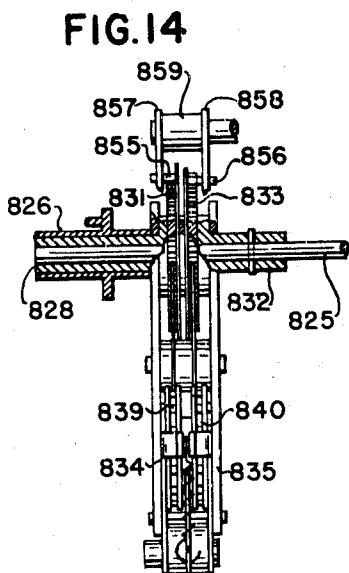
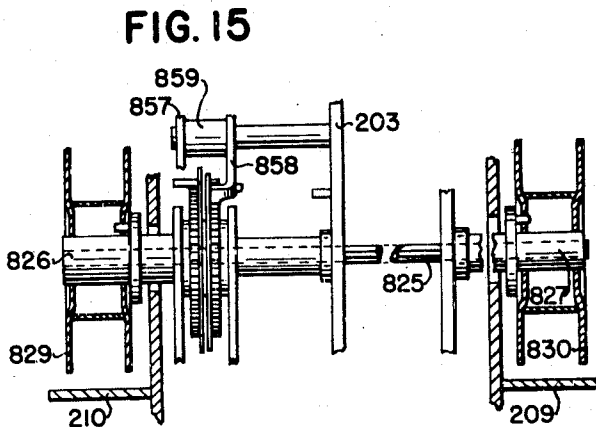
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INVENTOR
GUIDO CARNACINA

BY

Carl Berst
Justin S. [Signature]

HIS ATTORNEYS

Sept. 22, 1959

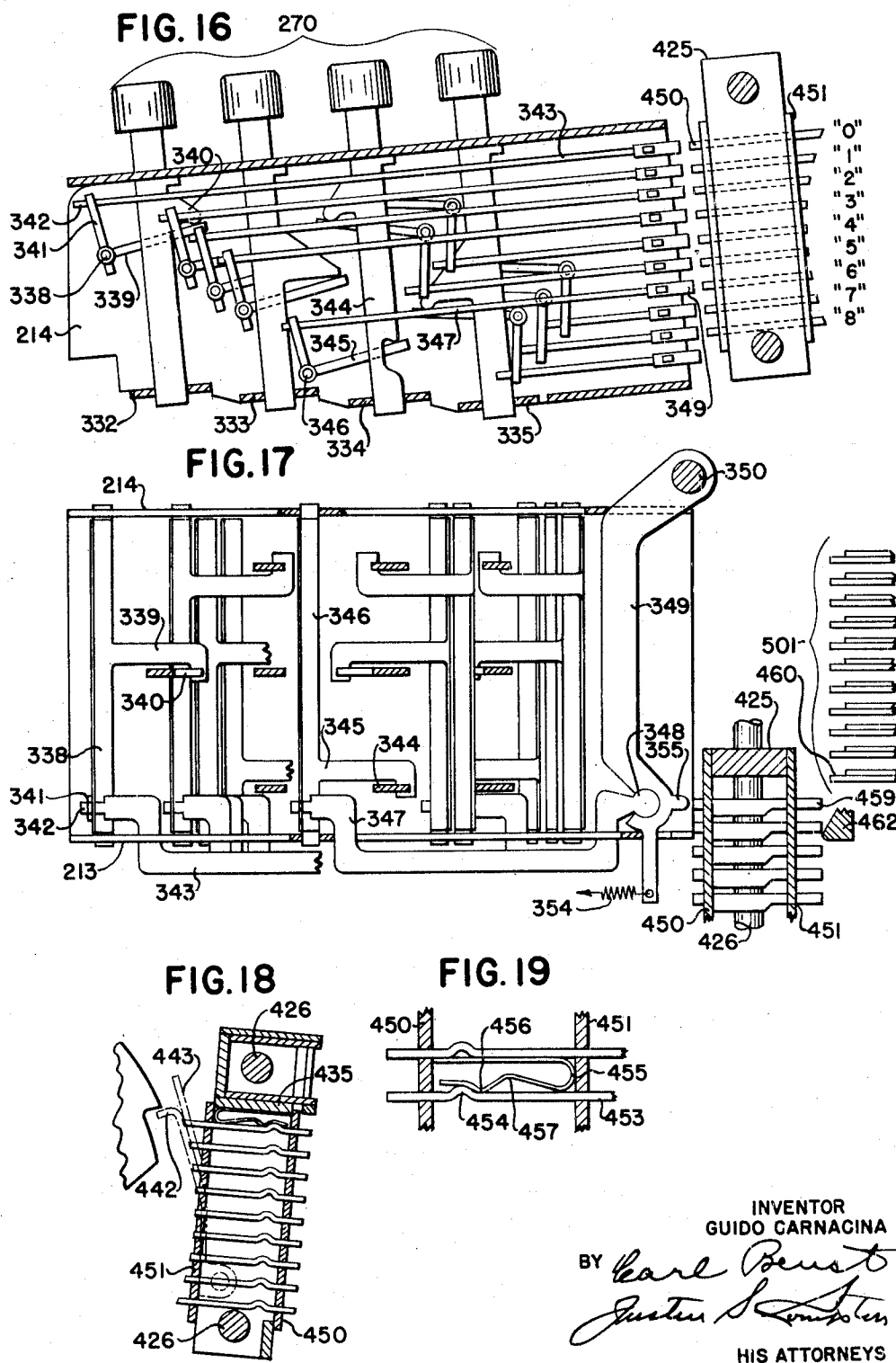
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FIG. 20

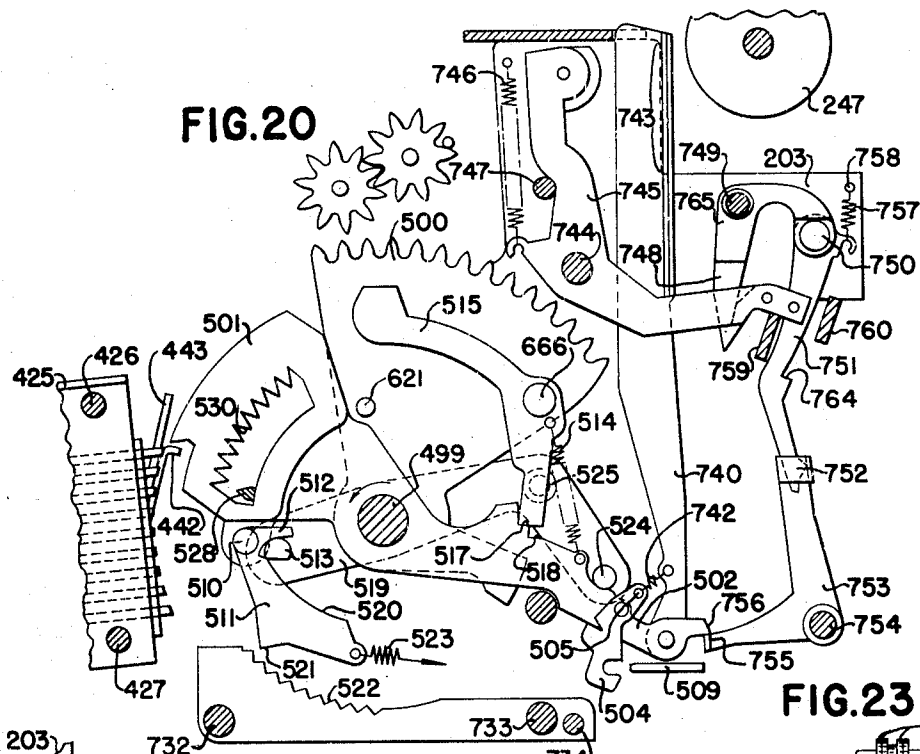


FIG. 21

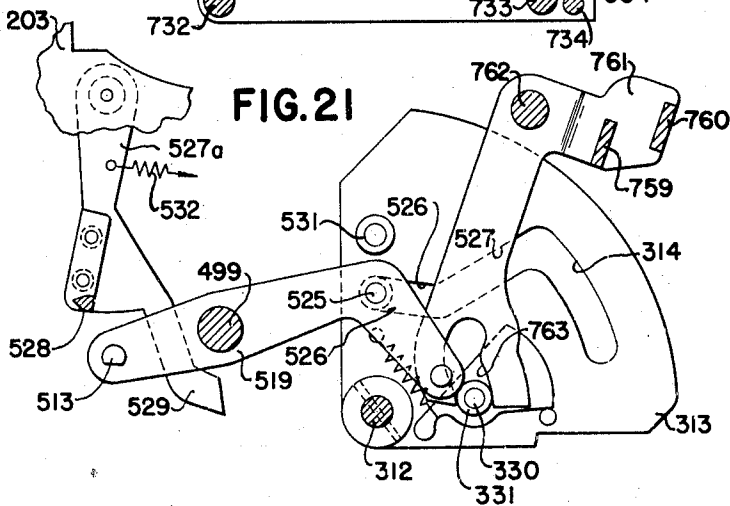


FIG. 22

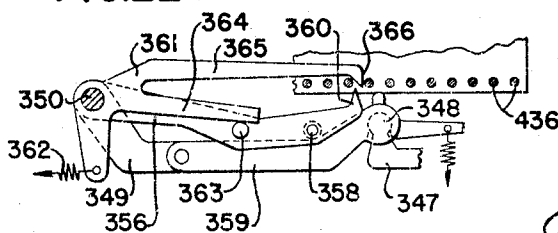
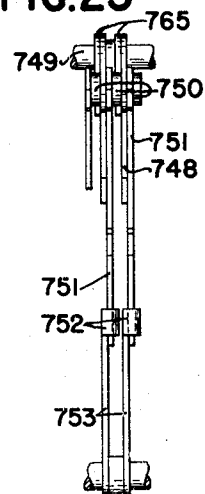


FIG. 23



INVENTOR
GUIDO CARNACINA

BY

Karl Benst
Justus K. Kuxton

HIS ATTORNEYS

Sept. 22, 1959

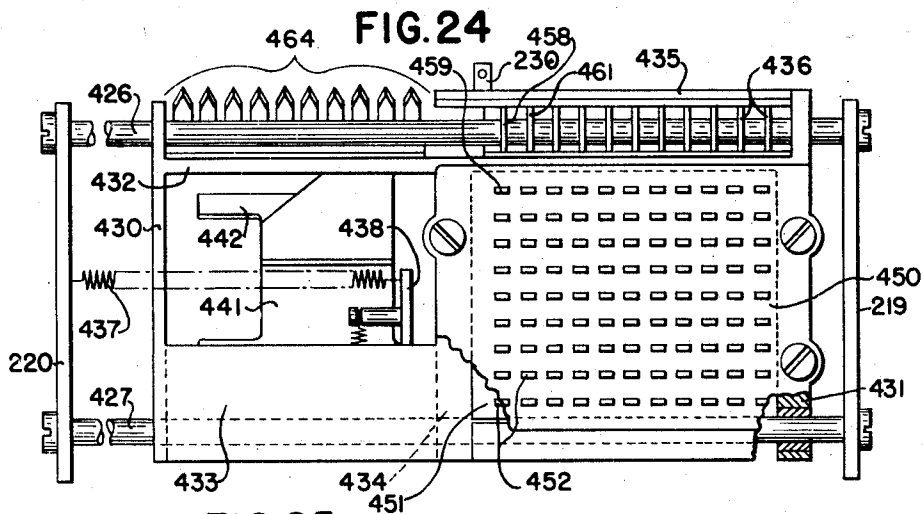
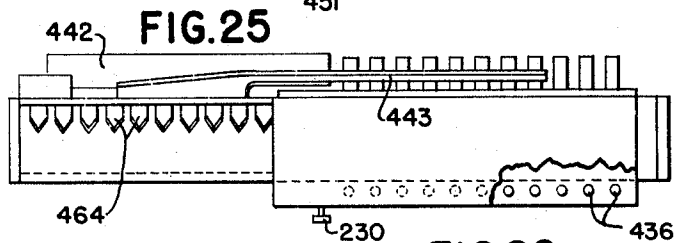
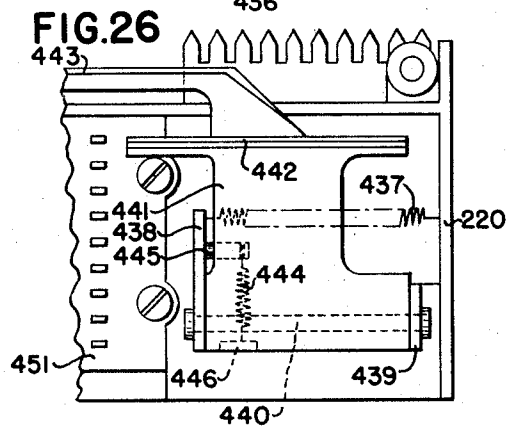
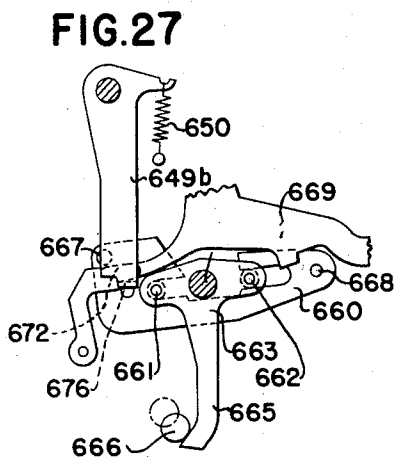
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INVENTORS
GUIDO CARNACINA

BY

*Heard Bernt
Justin R. Ransom*

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FIG. 30

INVENTOR
GUIDO CARNAC

BY *Earl Berst*
Justin Livingston
HIS ATTORNEYS

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FIG.31

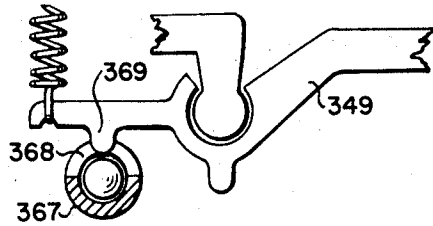


FIG.32

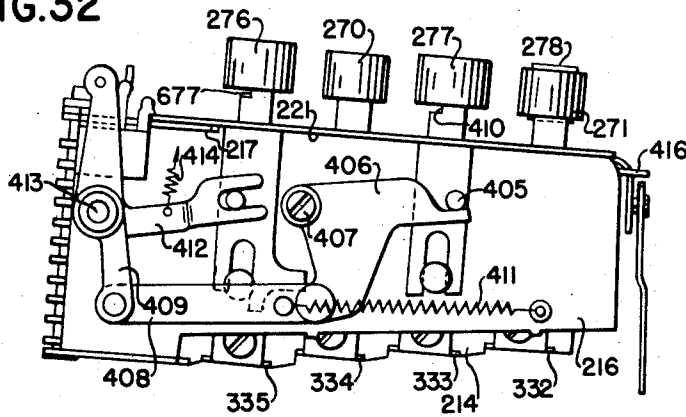
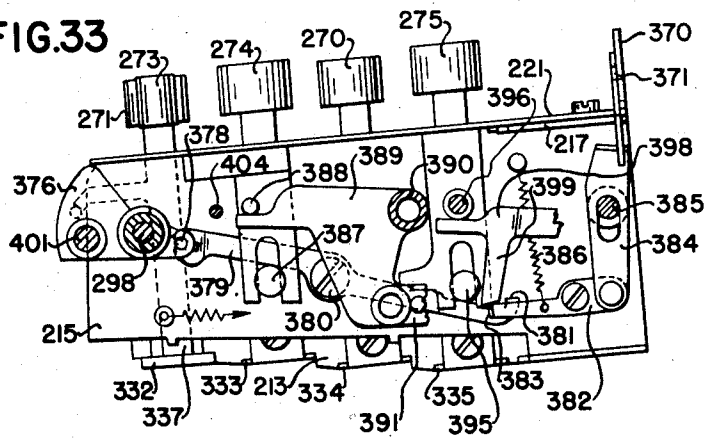


FIG.33



INVENTOR
GUIDO CARNACINA

BY

Carl Ernst
Justin S. Livingston

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FIG. 35

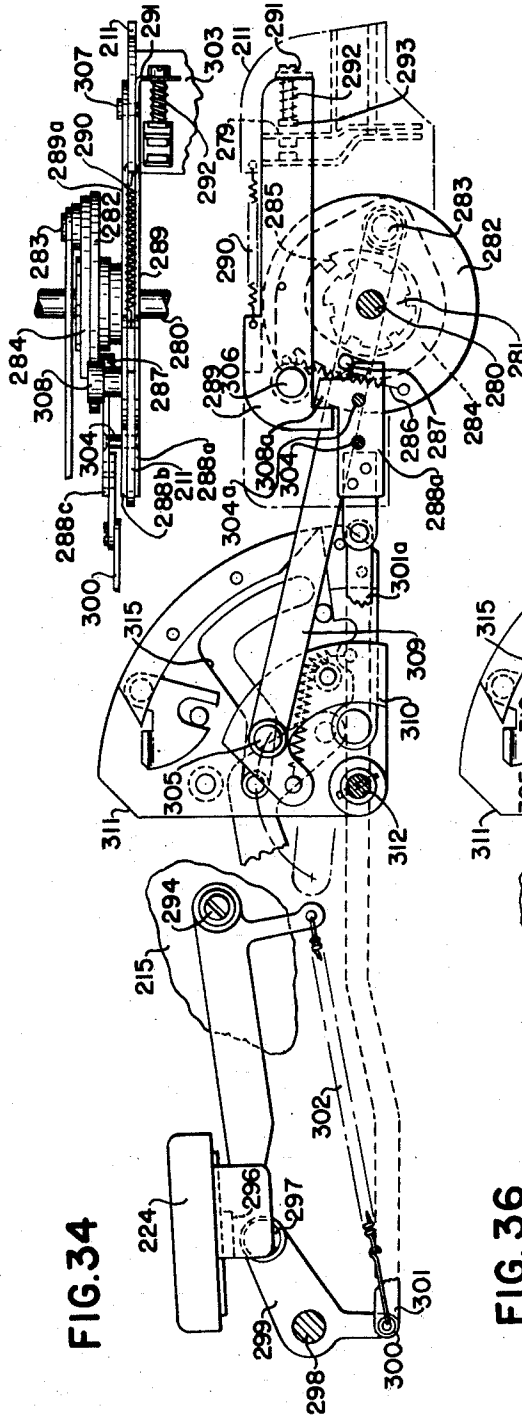
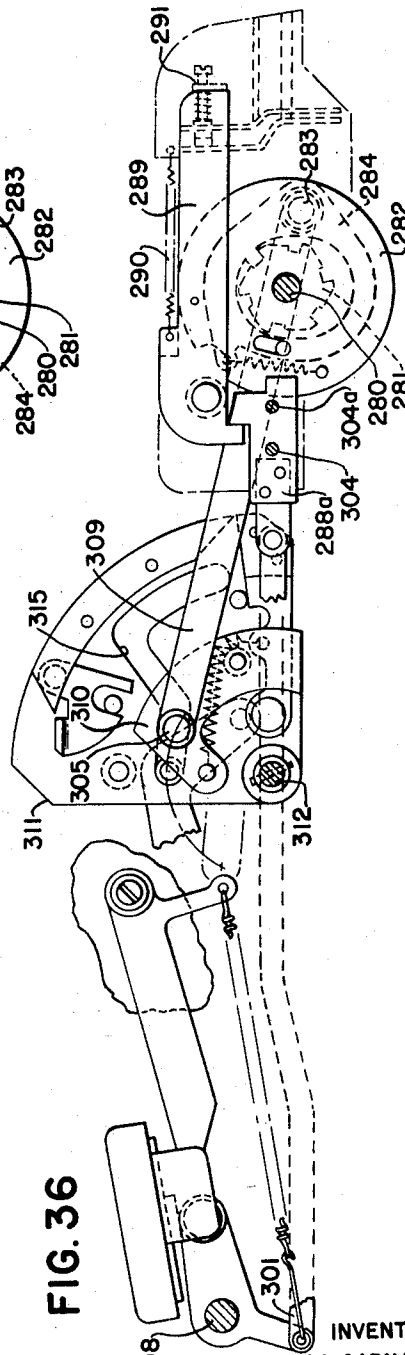


FIG. 36



INVENTOR
GUIDO CARNACINA
BY *Karl Benst*
Justin S. Supton
HIS ATTORNEYS

Sept. 22, 1959

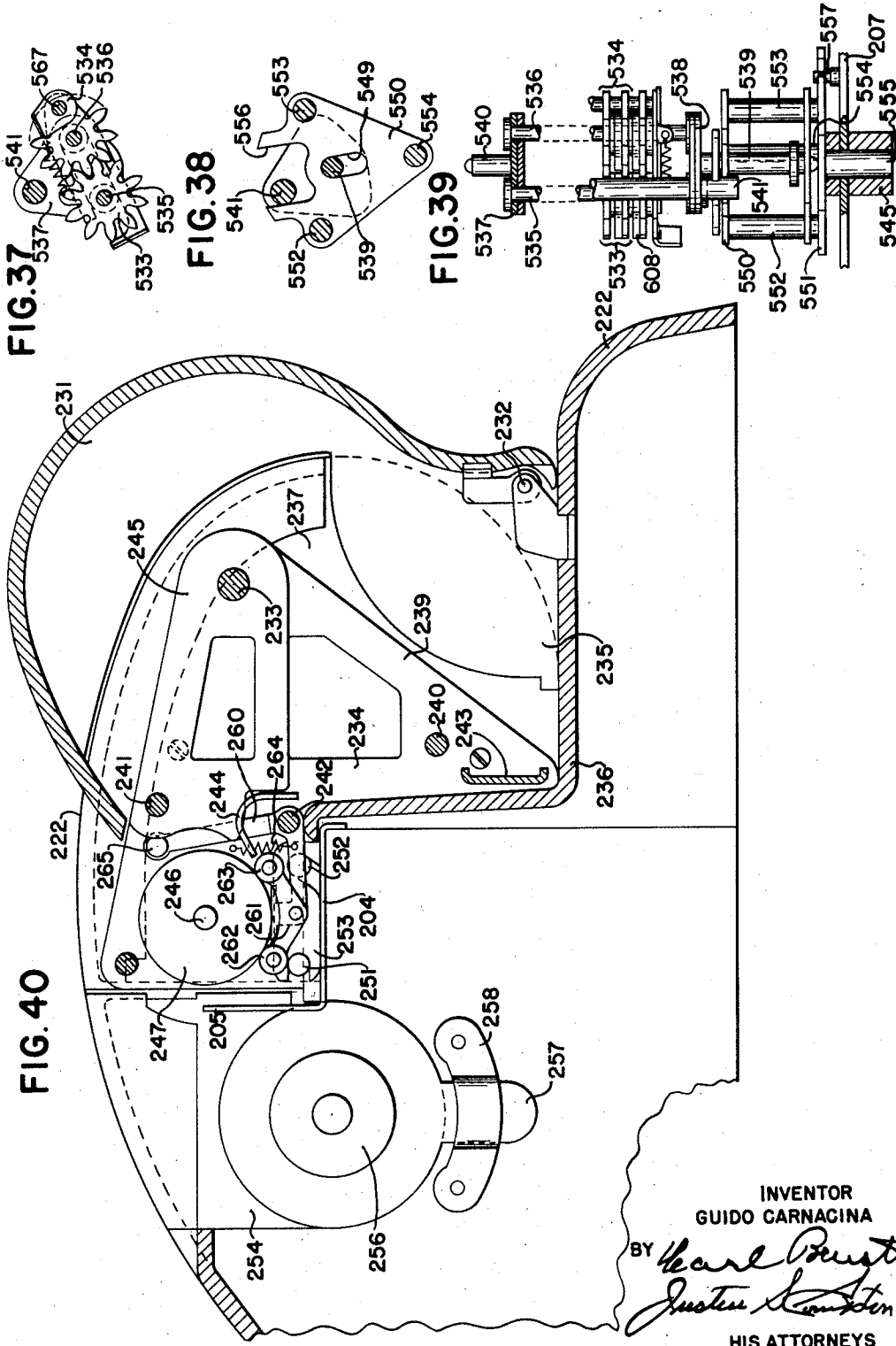
G. CARNACINA

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INVENTOR
GUIDO CARNACINA

BY *Harold B. Smith*
Justin L. Smith
HIS ATTORNEYS

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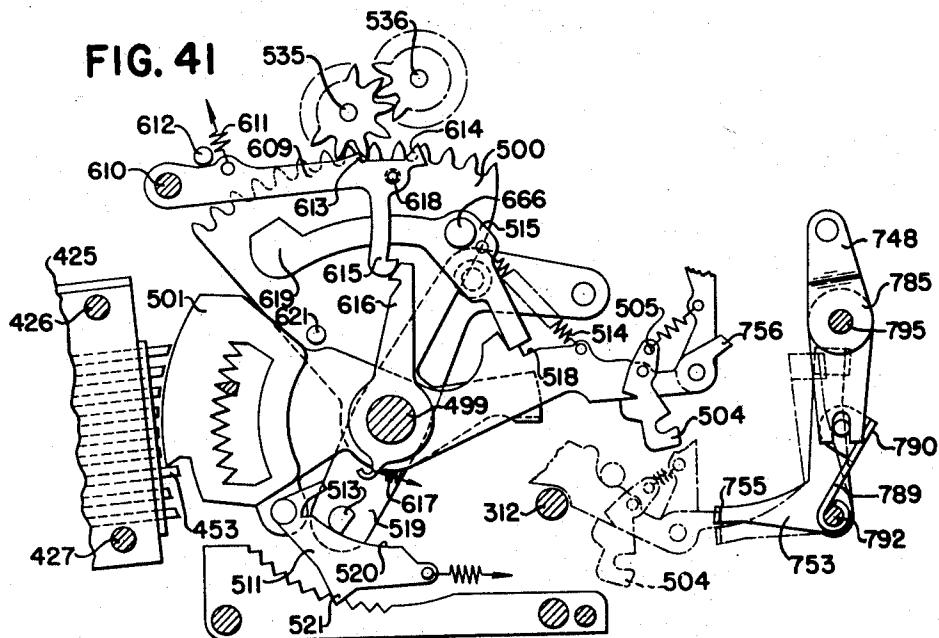


FIG. 42

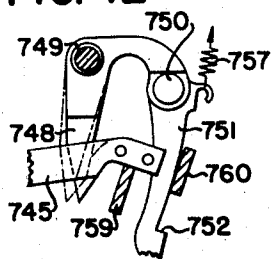


FIG. 43

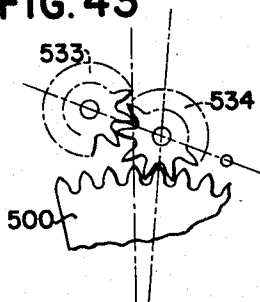


FIG. 44

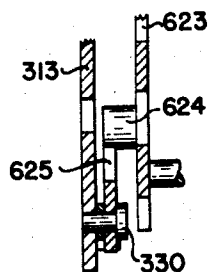
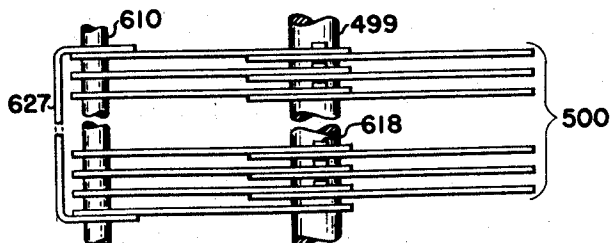


FIG. 45



INVENTOR
GUIDO CARNACINA

BY *Kearl Smith*
Justin L. Smith
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FIG. 46

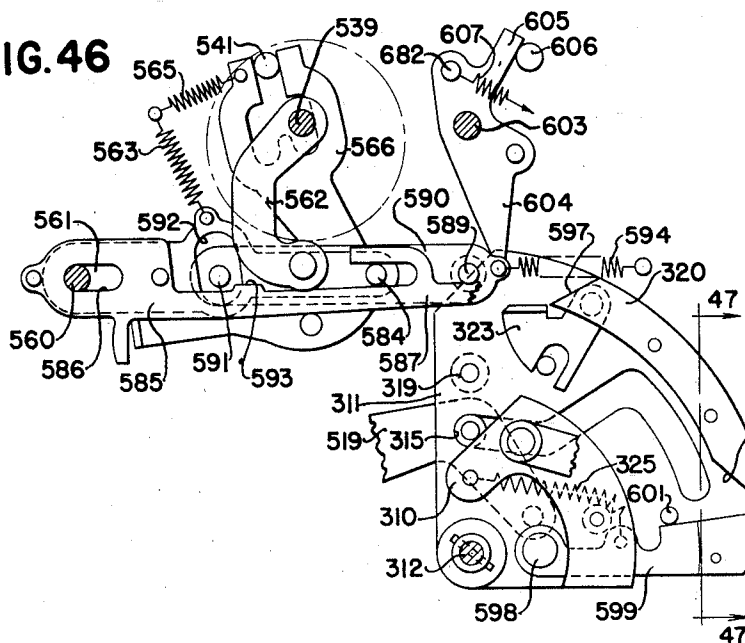


FIG. 47

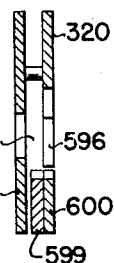


FIG. 48

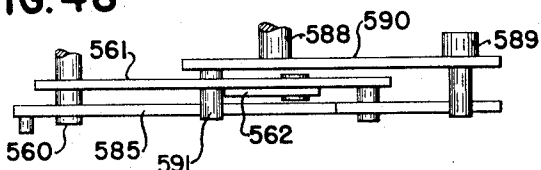


FIG. 49

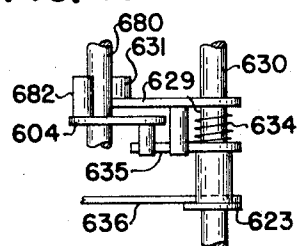
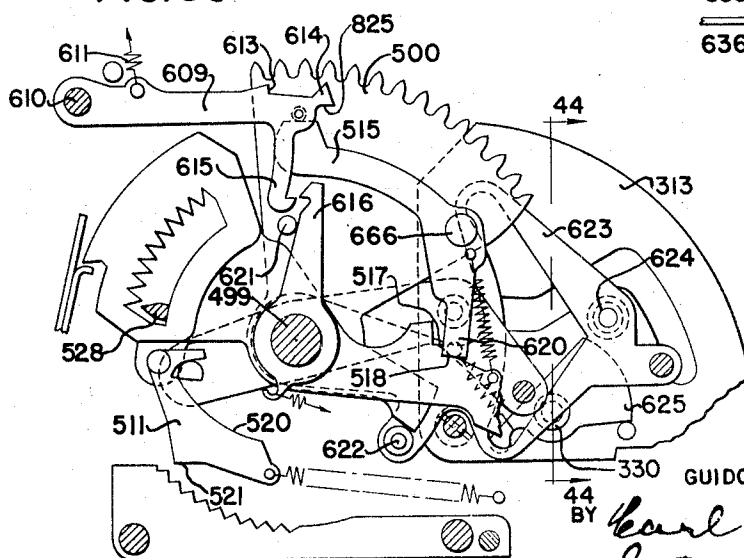


FIG. 50

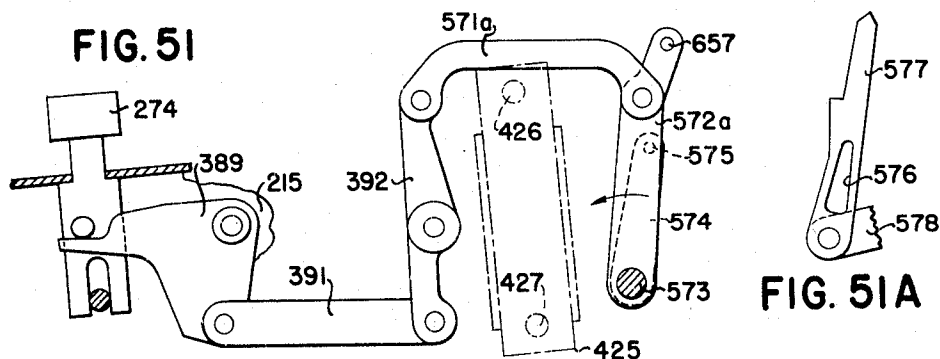
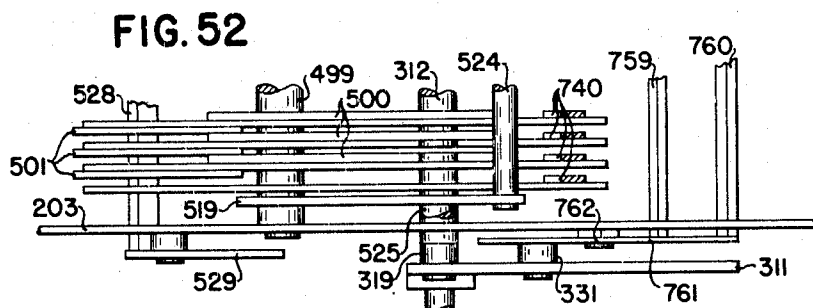
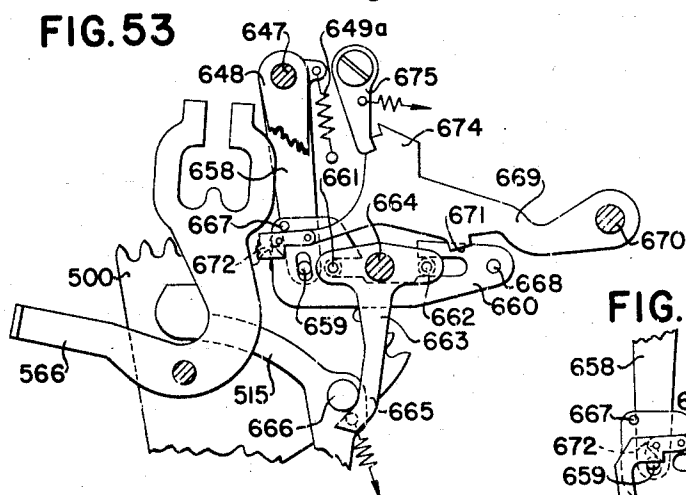
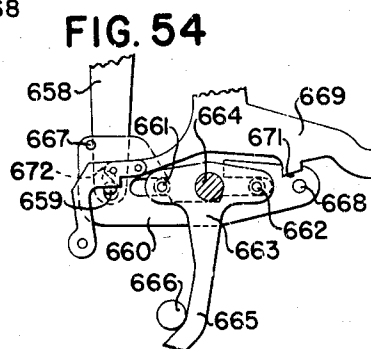


INVENTOR
GUIDO CARNACINA
BY *Karl Bernt*
Justin S. Simpson
HIS ATTORNEYS

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BY

HIS ATTORNEYS

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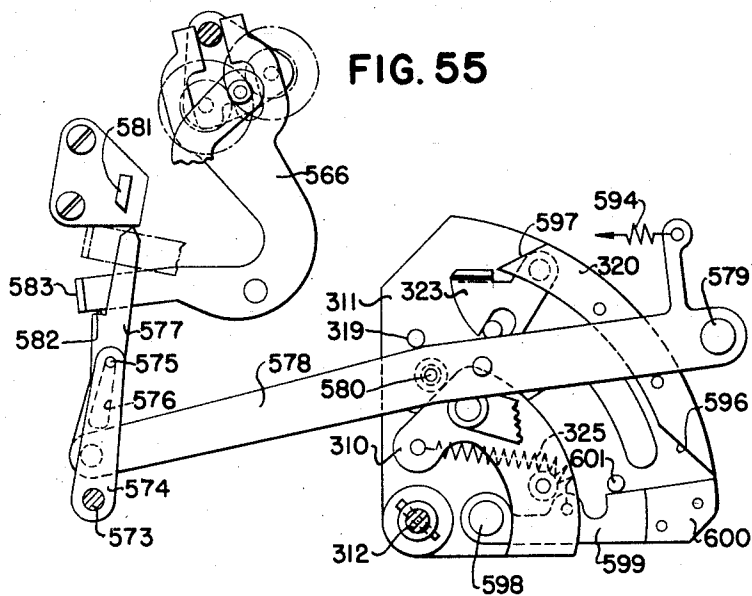
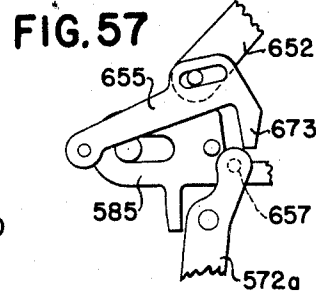
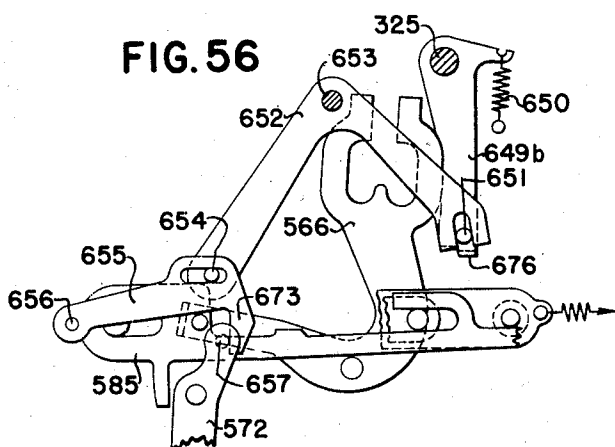
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INVENTOR
GUIDO CARNACINA
BY *Karl Fertig*
Justin L. Landon
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G. CARNACINA

2,905,382

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FIG. 58

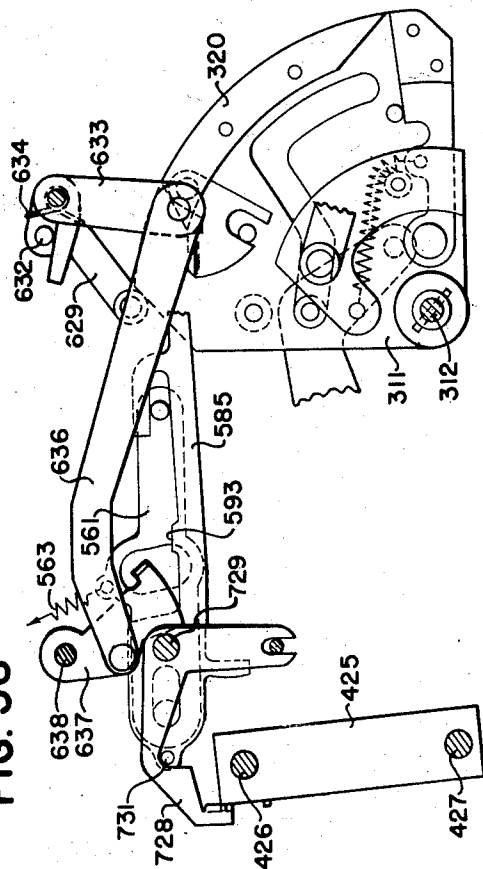


FIG. 60

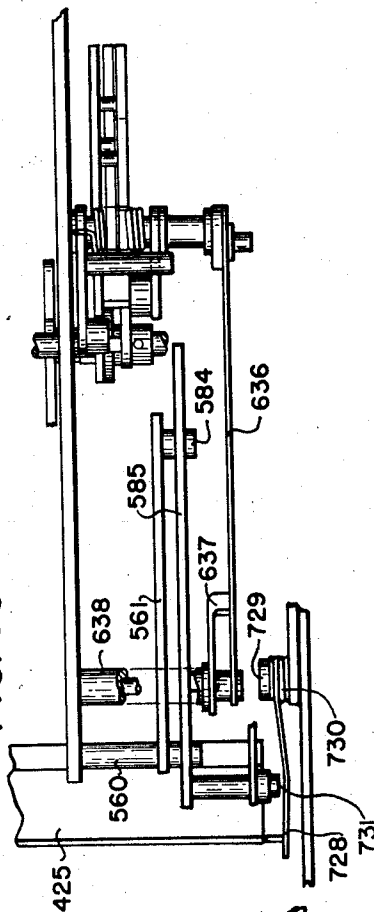
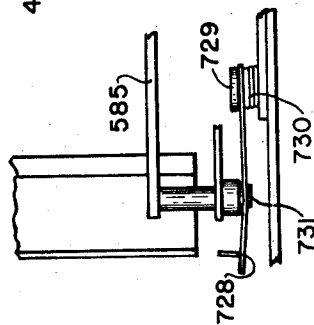


FIG. 59



INVENTOR
GUIDO CARNACINA

BY

Heard Bergt
Justin S. ...

HIS ATTORNEYS

2,905,382

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FIG. 61

BY

BY *Karl Ernst*
Justin K. Kumbsten
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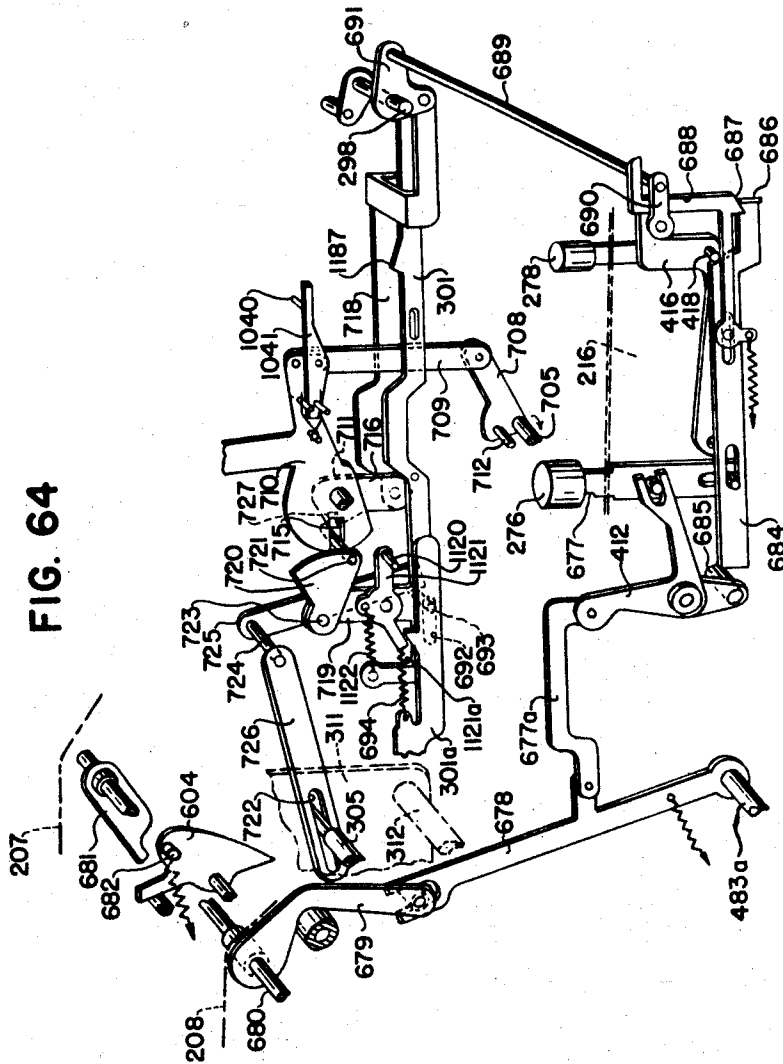
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FIG. 64



INVENTOR
GUIDO CARNACINA

BY

Heard Ernst
Justus S. S. S. S. S.

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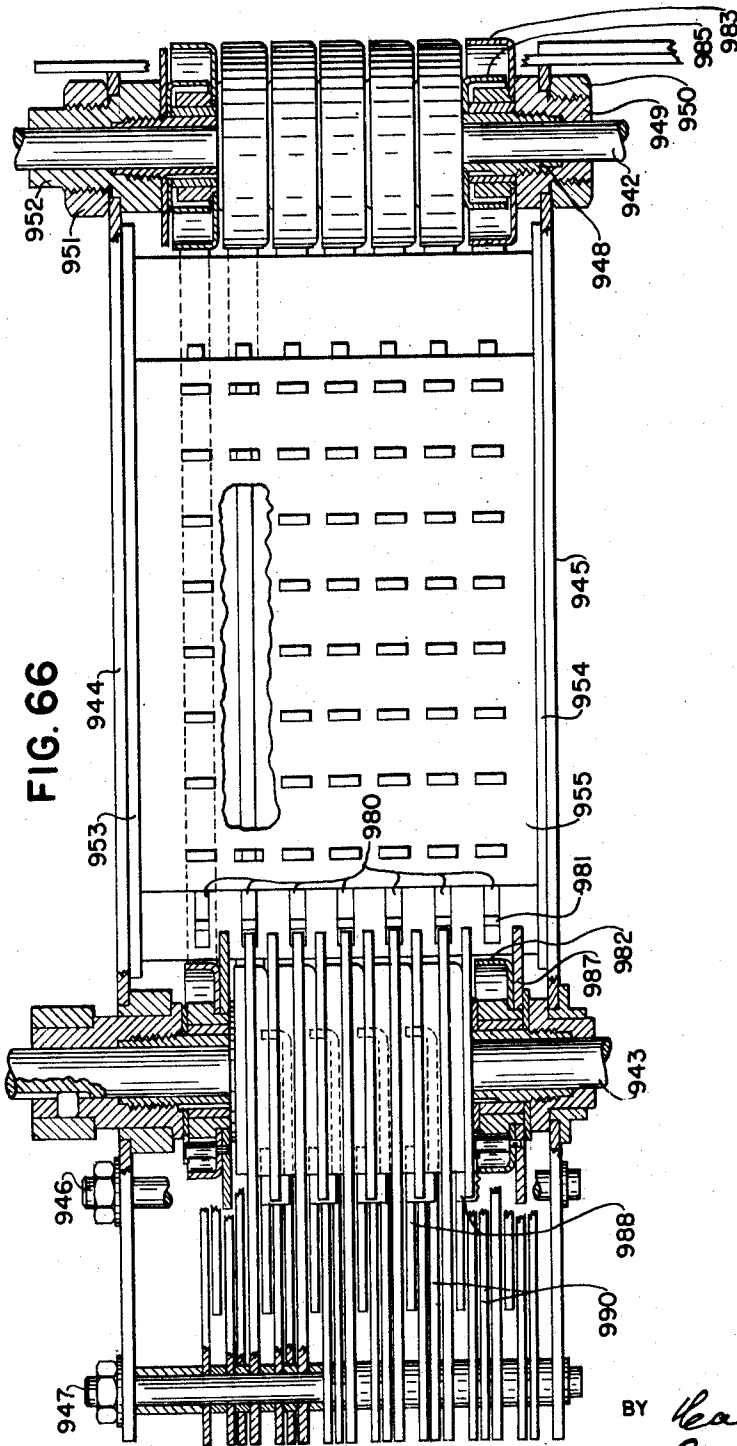
G. CARNACINA

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INVENTOR
GUIDO CARNACINA

BY

Karl Beust
Justin S. Thompson

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Sept. 22, 1959

G. CARNACINA

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FIG. 67

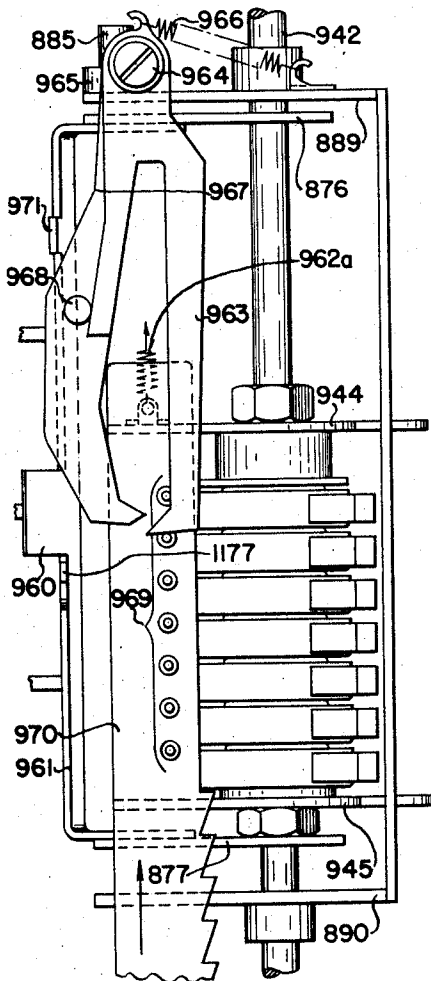


FIG. 68

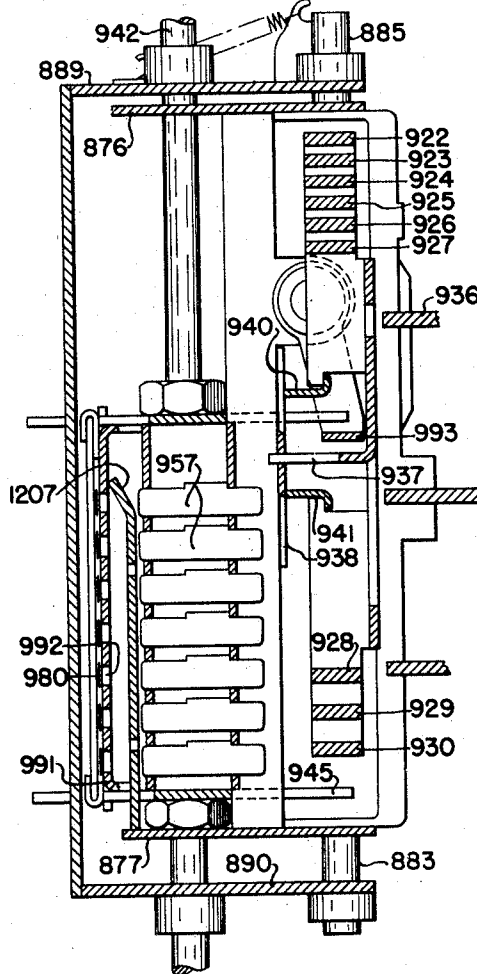
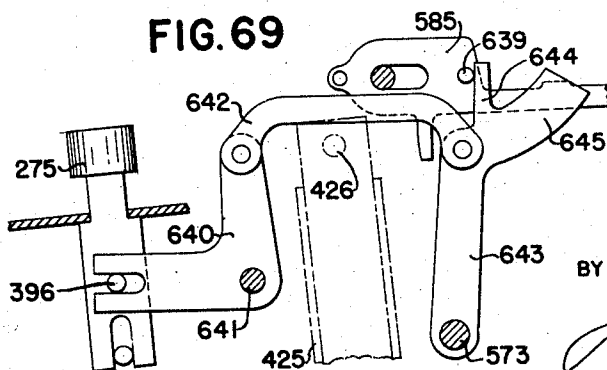


FIG. 69



INVENTOR
GUIDO CARNACINA

BY

Earl Burt
Justin K. Smith
HIS ATTORNEYS

Sept. 22, 1959

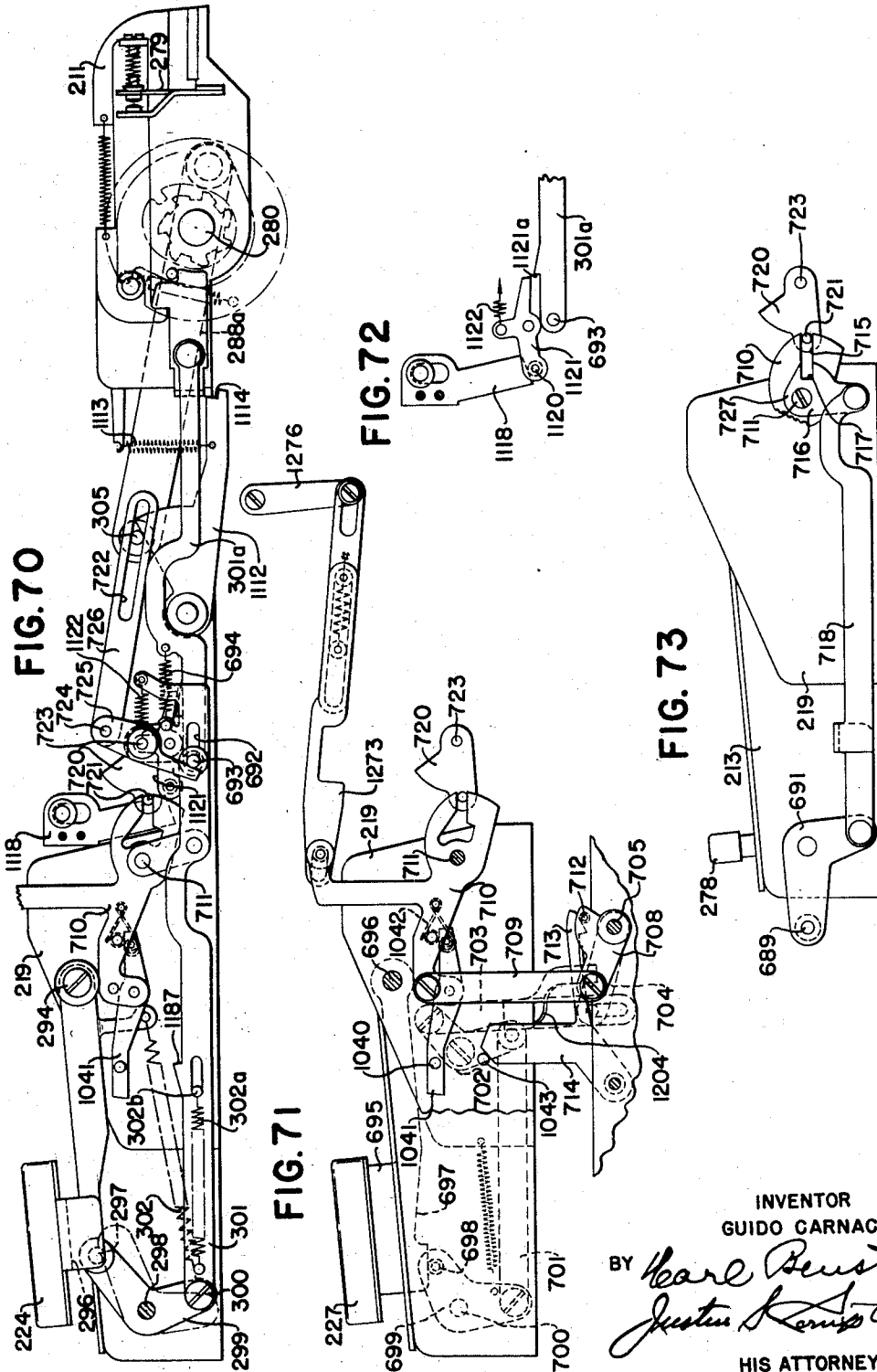
G. CARNACINA

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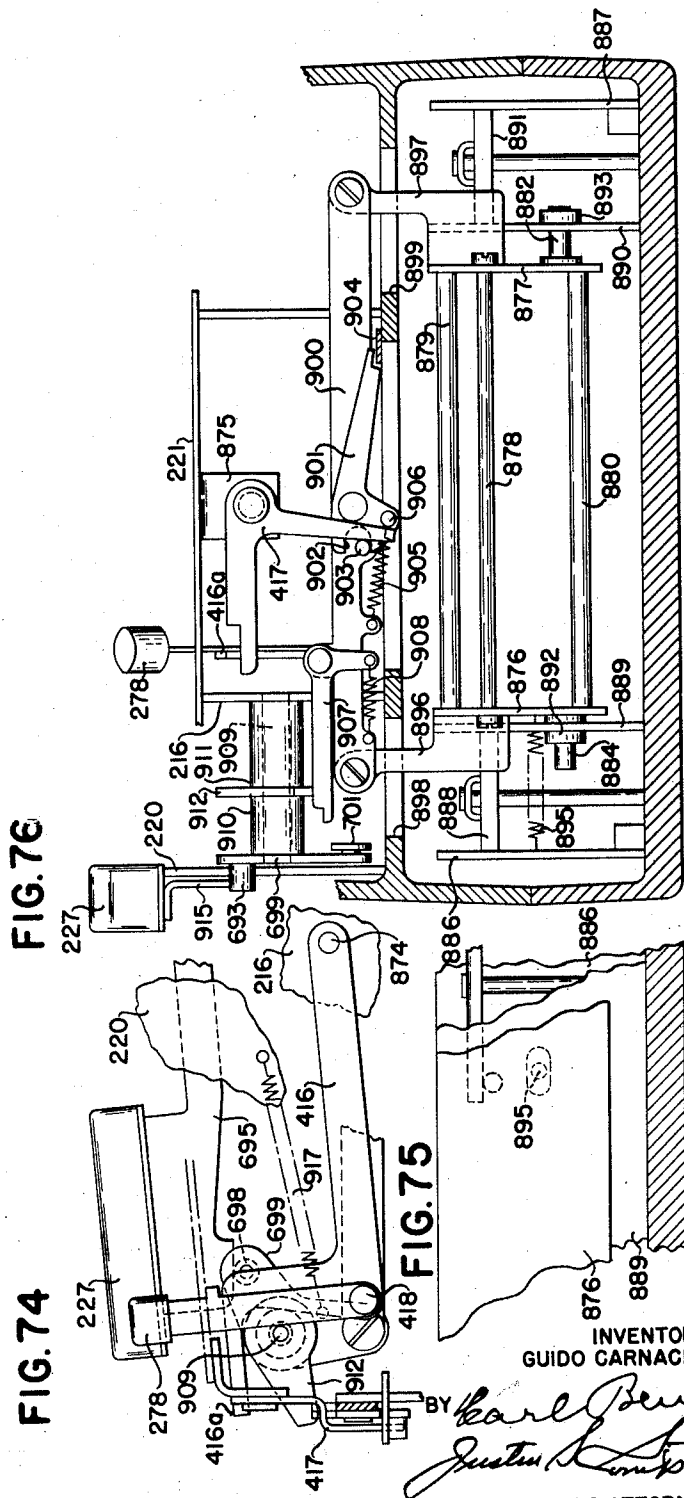


INVENTOR
GUIDO CARNACINA
BY *Heare Rust*
Justin Karpis
HIS ATTORNEYS

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INVENTOR
GUIDO CARNACINA

BY *Karl Beust*
Justin Livingston

Sept. 22, 1959

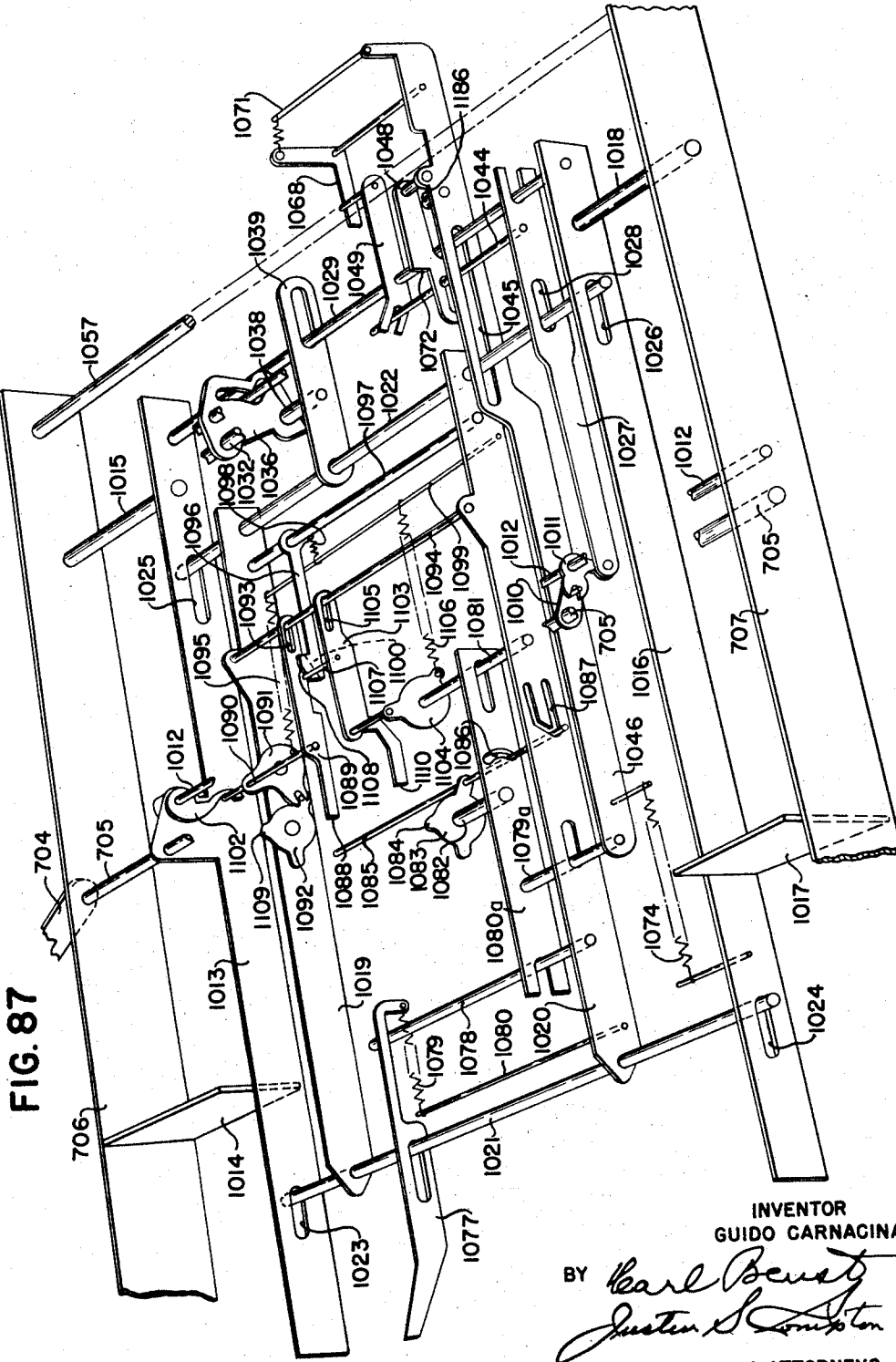
G. CARNACINA

2,905,382

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INVENTOR
GUIDO CARNACINA

BY *Karl Benat*
Justin S. Thompson
HIS ATTORNEYS

Sept. 22, 1959

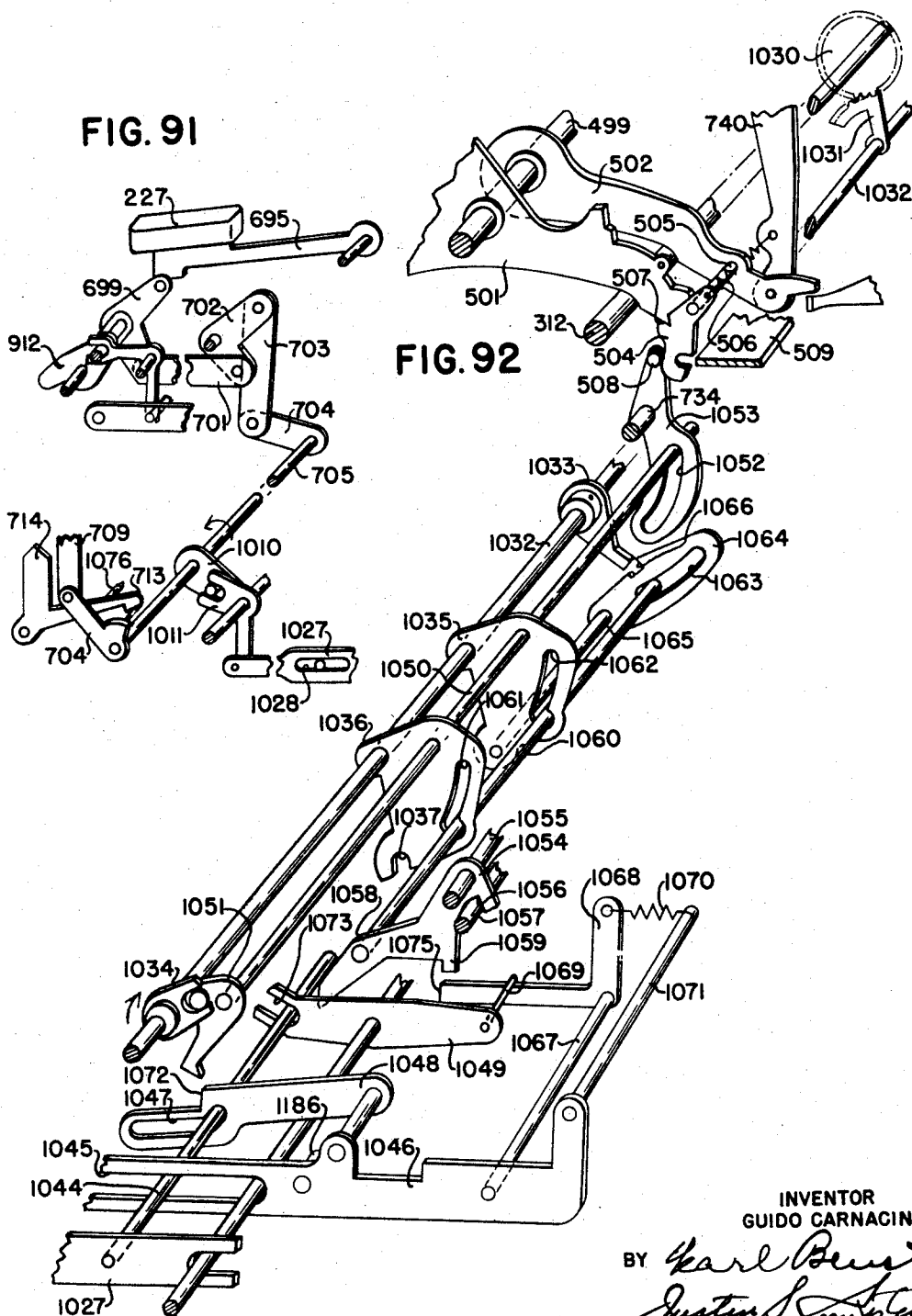
G. CARNACINA

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INVENTOR
GUIDO CARNACINA

BY

Karl Benz
Justin S. Smith

HIS ATTORNEYS

Sept. 22, 1959

G. CARNACINA

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FIG. 93

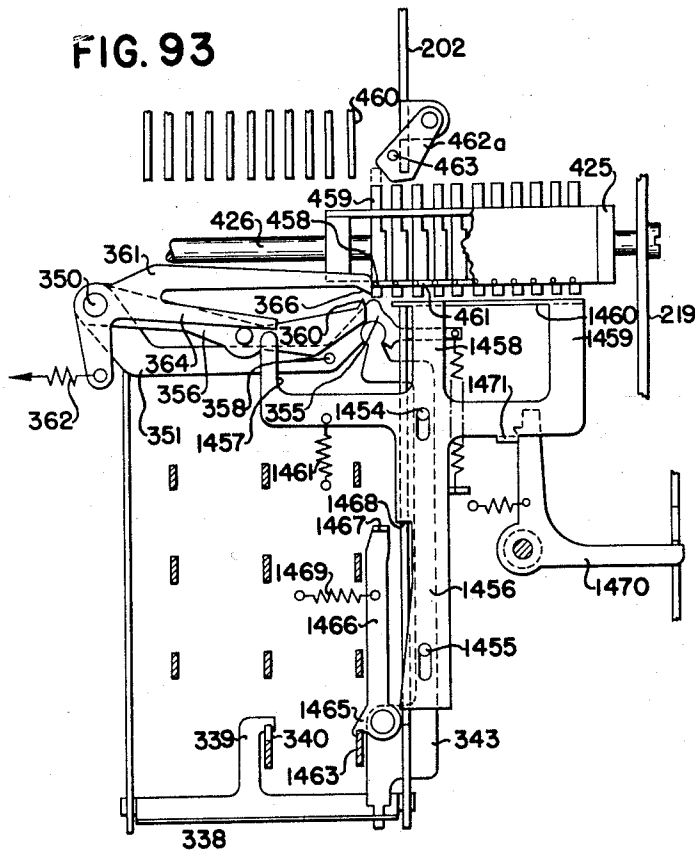
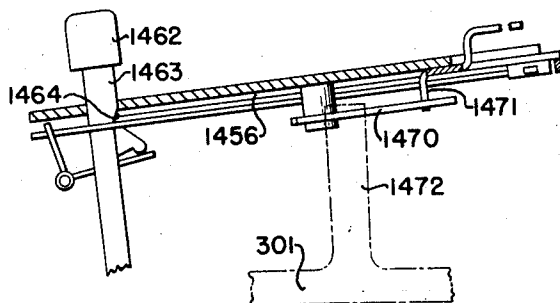


FIG. 94



INVENTOR
GUIDO CARNACINA

BY

Karl Benoit
Justin S. Smith
HIS ATTORNEYS

Sept. 22, 1959

G. CARNACINA

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FIG. 95

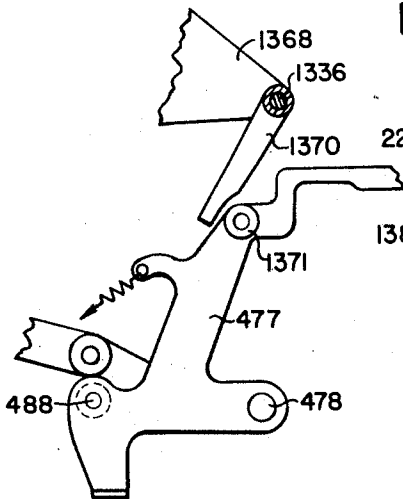


FIG. 96

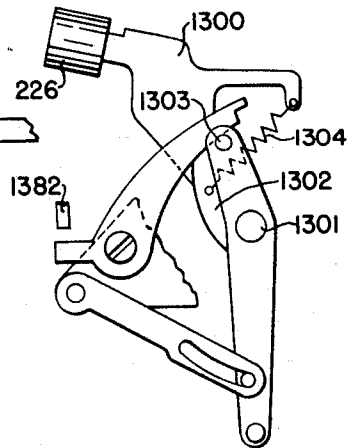
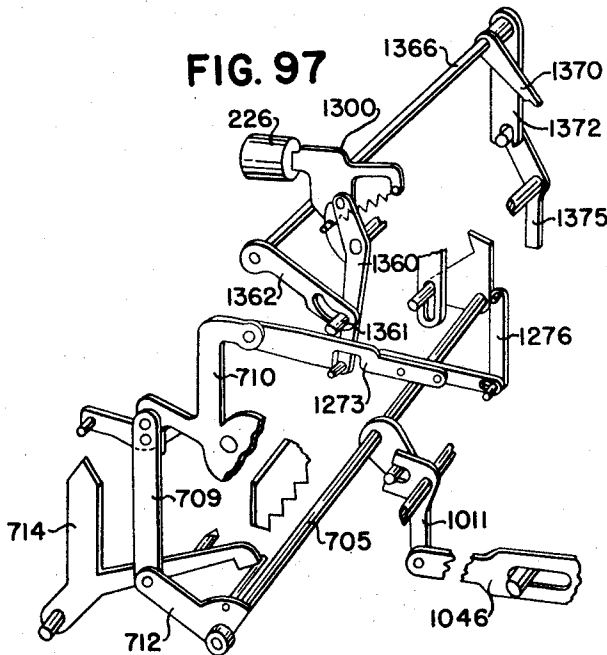


FIG. 97



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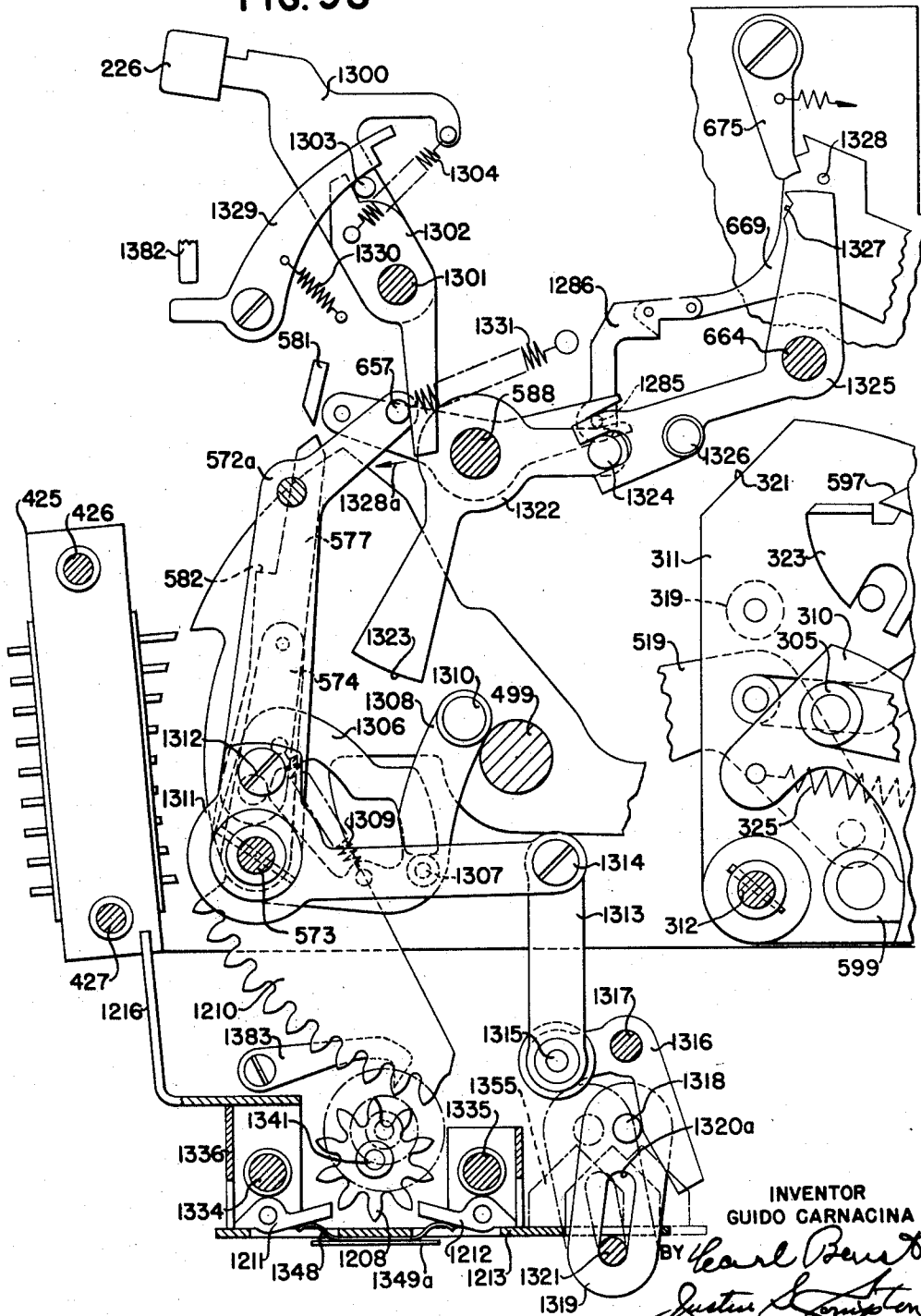
2,905,382

TEN-KEY PRINTING MULTIPLYING AND DIVIDING MACHINE

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43 Sheets-Sheet 35

FIG. 98



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TEN-KEY PRINTING MULTIPLYING AND DIVIDING MACHINE

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43 Sheets-Sheet 36

FIG. 99

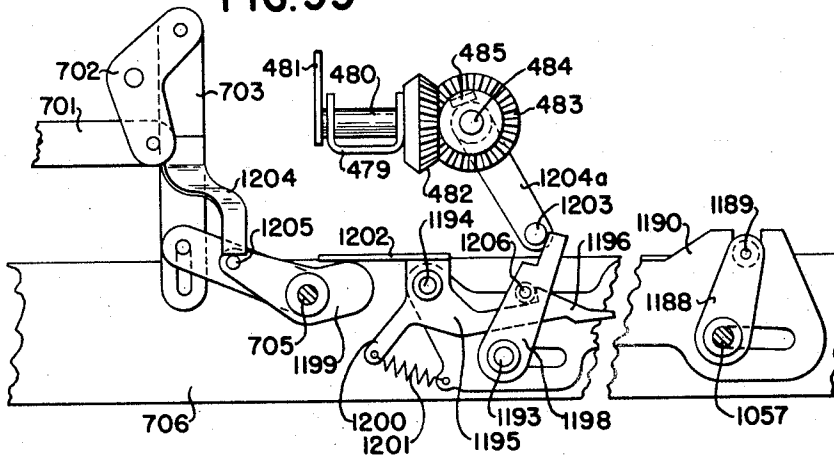


FIG. 100

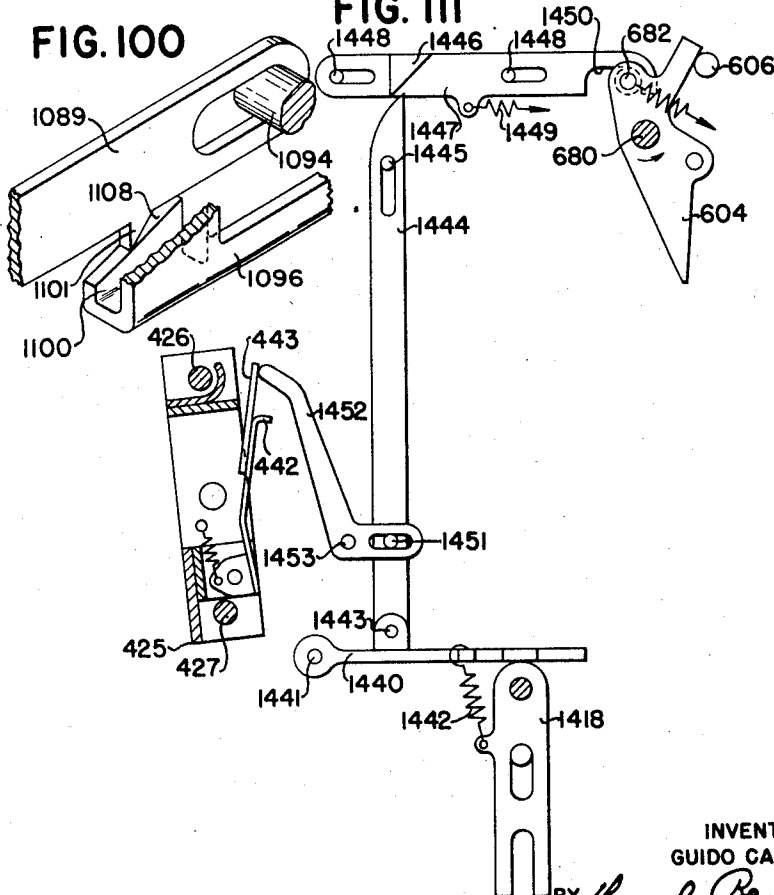


FIG. 101

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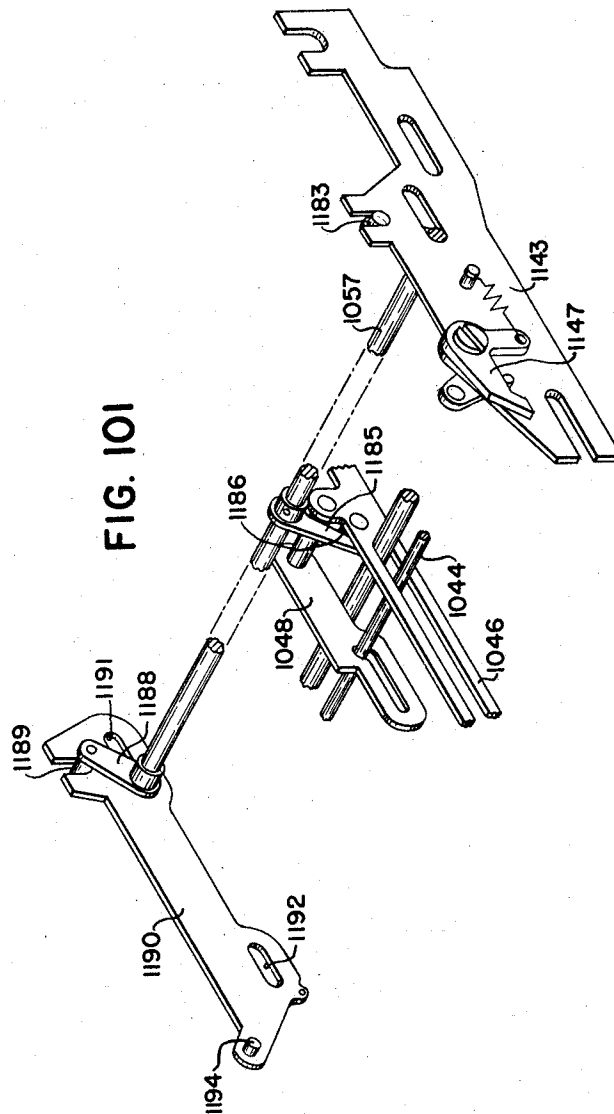
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TEN-KEY PRINTING MULTIPLYING AND DIVIDING MACHINE

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43 Sheets-Sheet 37



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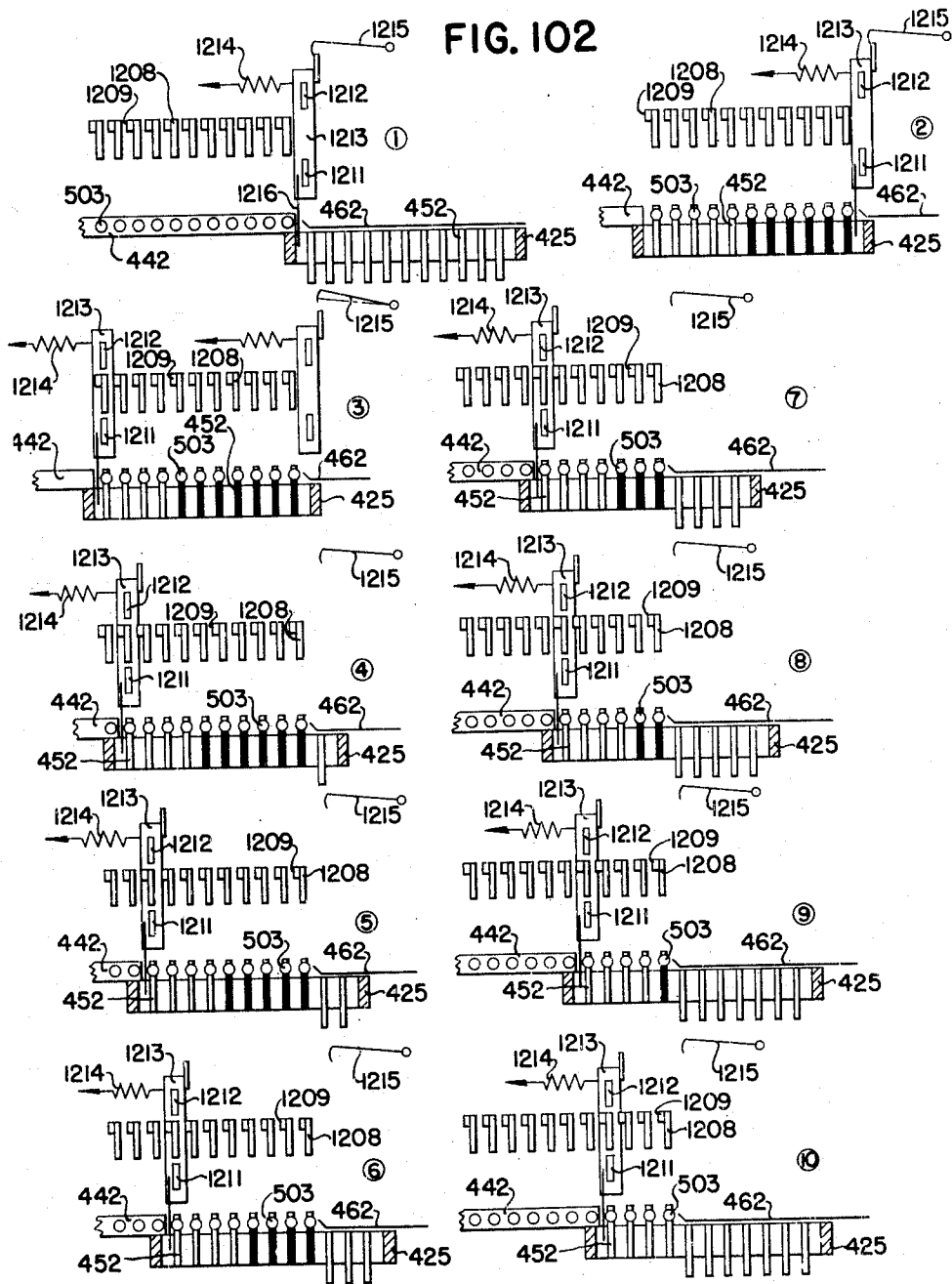
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FIG. 102



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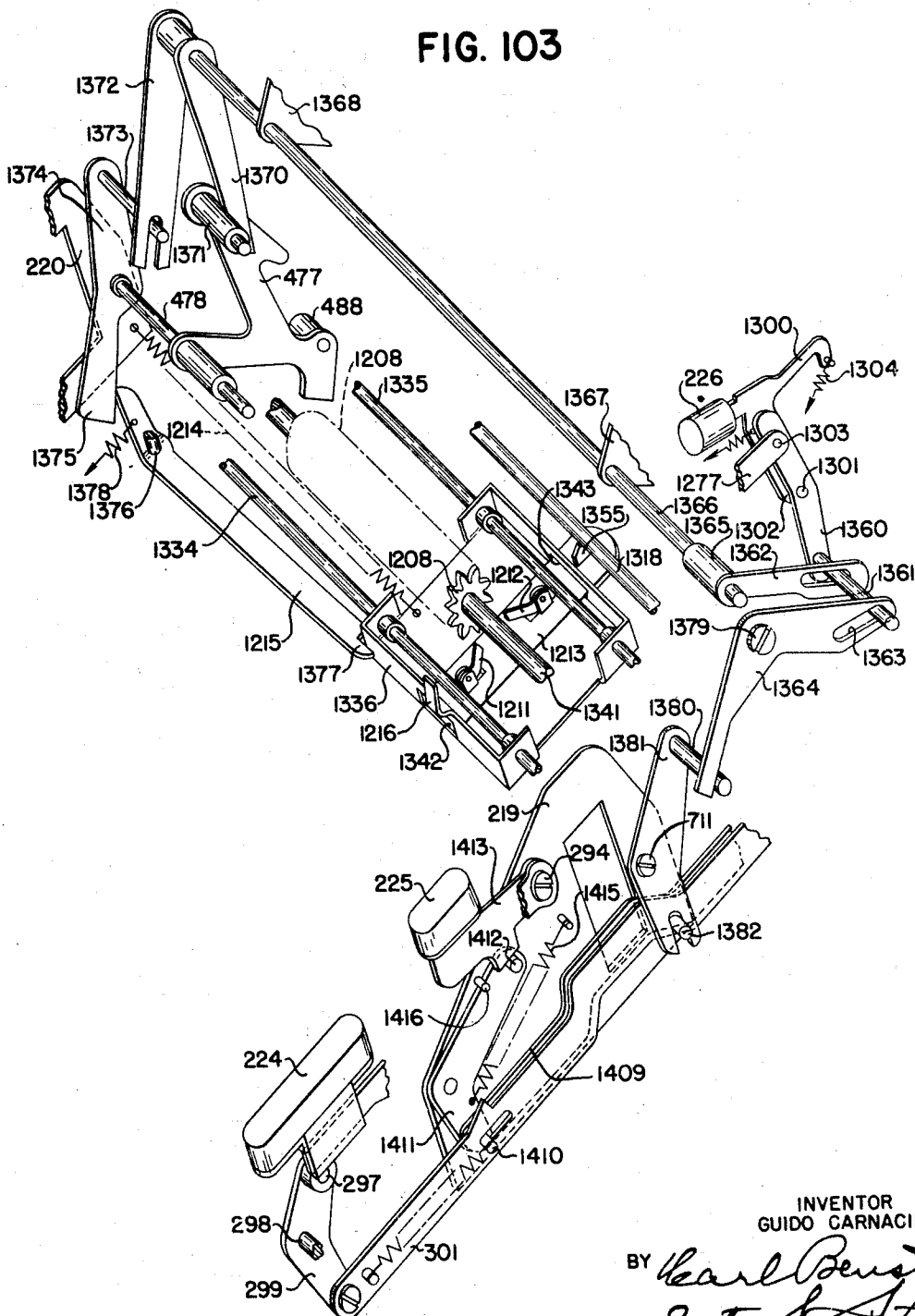
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TEN-KEY PRINTING MULTIPLYING AND DIVIDING MACHINE

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FIG. 103



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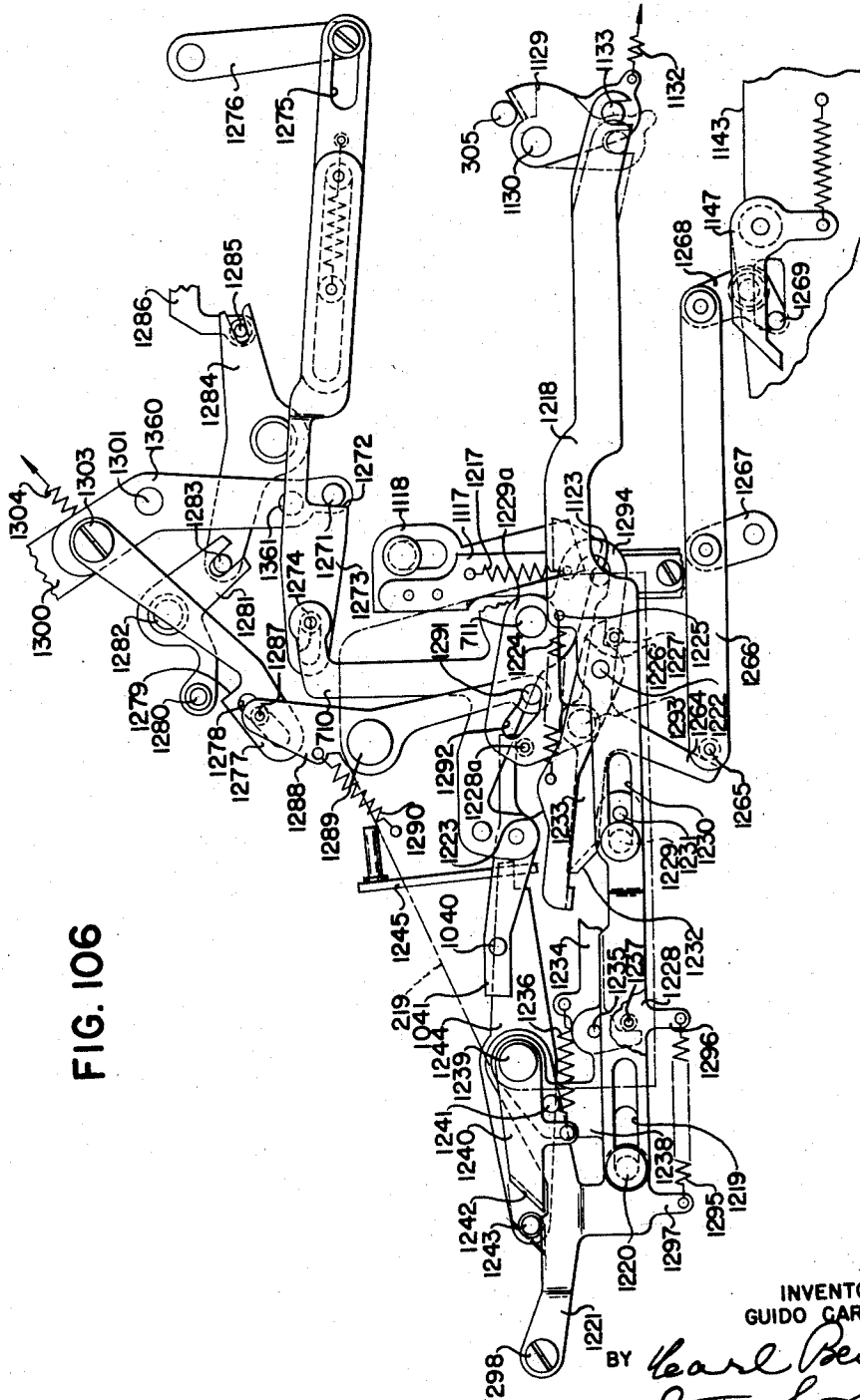
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43 Sheets-Sheet 41



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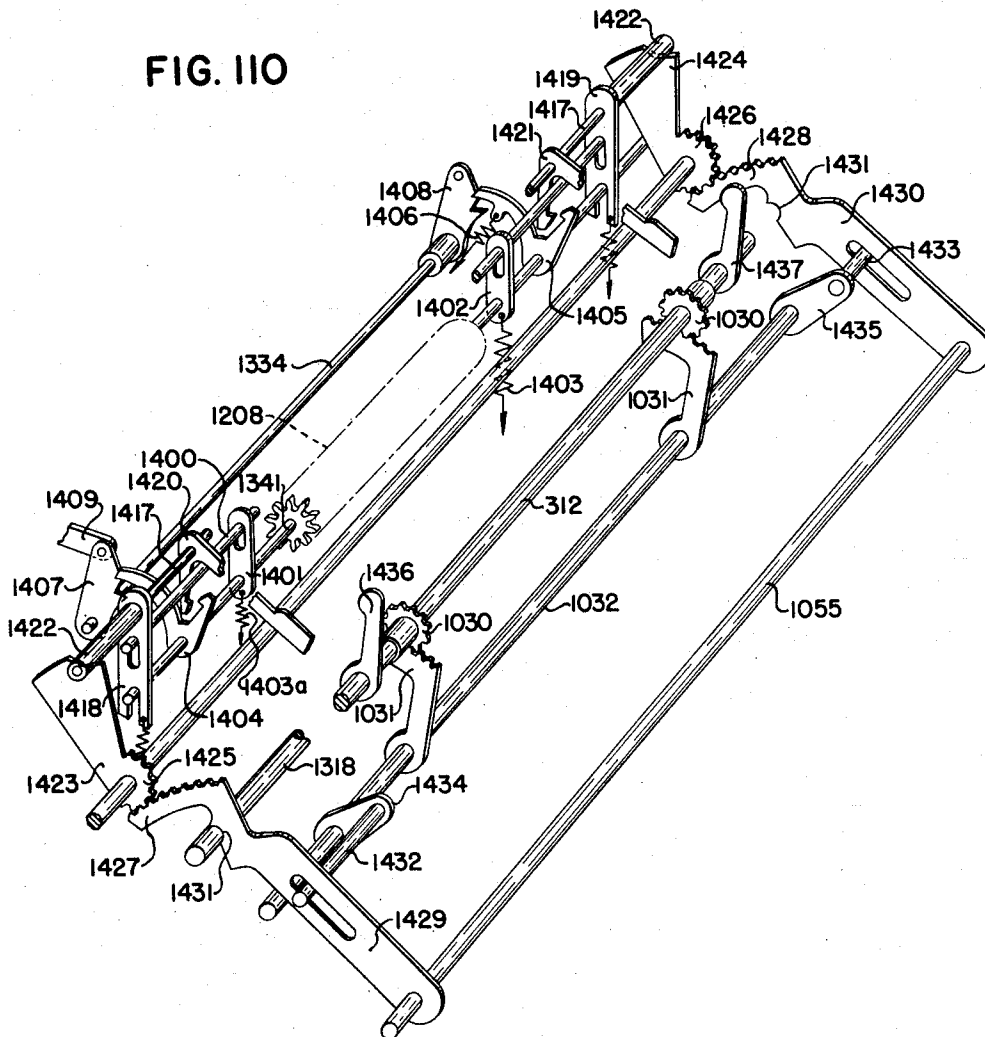
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TEN-KEY PRINTING MULTIPLYING AND DIVIDING MACHINE

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FIG. 110



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2,905,382

TEN-KEY PRINTING MULTIPLYING AND DIVIDING MACHINE

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Application August 5, 1955, Serial No. 526,670

9 Claims. (Cl. 235—60)

This invention relates to a printing-calculating machine which carries out the four fundamental operations of addition, subtraction, multiplication, and division, and in which the various factors are set up on a single digit keyboard having but ten digit keys. The machine has suitable mechanism for printing the add and subtract entries and their totals and the various factors and results of multiplying and dividing operations, the calculations being automatically performed by the machine without any activity on the part of the operator after he sets up the problem and sets the machine into operation. The results, either positive or negative, are obtained and printed by one or more working cycles of the mechanism. Moreover, the differential mechanism moves in the same direction for the various operations, whether negative or positive, so that the main operating means is never required to reverse motion.

This application is a continuation-in-part of my application for United States Letters Patent Serial No. 335,320, filed February 5, 1953 (now abandoned).

The machine has a single rotary oscillating differential mechanism, which is utilized for the four types of mathematical calculations noted above. This differential mechanism is adapted to cooperate with a tumbling type of totalizer which has in each denominational order an add pinion meshing with a subtract pinion.

In general, the upper part of the machine contains an add-subtract totalizer and differential mechanism which performs the operations of addition and subtraction, while the lower part of the machine, which may be easily detached therefrom, controls the multiple-cycle operations of multiplication and division, the same electric motor drive means being used to operate both sections of the machine, there being a main clutch for operating the adding and subtracting portions of the mechanism in the upper part of the machine, and an auxiliary clutch for operating certain of the multiple-cycle controls in conjunction with the control keys.

One of the principal novel features of the machine is that the ten digit keys can be used, not only to set up add and subtract items, but also to set up both the multiplier and the multiplicand factors in a multiplying operation, and the dividend and the divisor factors in a division operation, as the case may be. There is a main pin carriage for controlling the differential mechanism and an auxiliary storage unit in which a multiplier factor may be stored, the same digit keys being used for setting up both.

Another feature of the invention is that, after the factors have been set up for multiplication or division, the problem is automatically carried out by the machine, without anything more being done by the operator than to press the particular control key which sets the machine into operation. Multiplication results and division results are printed by further operation of the control keys. The product of a multiplication operation is obtained by taking a total. The quotient of a division operation is obtained by operating a special quotient key,

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while the remainder is obtained by taking a total of what is left in the totalizer.

A further feature of the invention is that, although ordinarily the printing mechanism is operated on each cycle, if numerical data is being set on the differential, the printing mechanism is disconnected during the repeated cycles of the main operating mechanism during multiplication and division, whereby the speed of the machine is increased by relieving the motor of the task of driving the printing mechanism, the repeated additions or subtractions not being printed.

The machine also is unique in that a rotary type of differential is used in combination with the differential-controlling pin carriage, in which the pins are parallel, with the ends arranged in an arc by reason of the differences in length, said arc having as its center the center of rotation of the differential members.

The machine is provided with mechanism by which a sub-total is taken and printed whenever the motor bar is used without any digit key having been operated.

Novel means is provided for latching the various differential members in set position, as determined by the differential-controlling pin carriage at mid-cycle, while the printing operation is being performed.

The machine is further characterized by a totalizer having two meshed totalizer wheels for each denominational order, one being engaged with the differential mechanism during positive operations and the other being engaged with the differential mechanism during negative operations, the positive wheels normally being conditioned to be engaged with the differential mechanism.

Novel printing hammer actuating and disabling mechanism is provided.

There is also provided novel totalizer-engaging control means adjustable to engage and disengage the totalizer in the various timings necessary to bring about positive and negative entries and for taking totals and sub-totals.

Means is provided for automatically selecting the positive or negative wheels of the totalizer for engagement with the differential, on sub-total and total taking operations, so that true positive or negative totals or sub-totals are printed automatically.

It is another object of this invention to provide, in the multiplier storage unit, mechanism which controls the multiple-cycle operations of the machine in multiplication, consisting of a denominational series of metal bands, each wound on two spaced associated scroll drums, and said bands each having a stop positioned against the pins of a multiplier pin carriage as determined by the digit keys, to control the number of cycles of operation in each denominational order. This will be called the multiplier factor storage unit.

Novel controls are provided for shifting the multiplicand factor and the multiplier factor denominationally and stopping the multiple operations of the machine in multiplying operations at the end of the problem, including formations on said scroll drums and associated cooperating mechanism.

Further, there is provided novel shuttle mechanism which is operated each cycle of machine operation, in multiplying problems, to control the cycling of the machine.

It is also the intention to provide novel mechanism for controlling the entry of a dividend and a divisor into the mechanism, and cooperating mechanism for successively controlling the machine for successively subtracting the divisor from the dividend in the various stages of the problem, and finally causing the operation to cease at the conclusion of the dividing action.

There are provided various interlocks and controls of novel construction.

Mechanism is provided for disabling the differential-

controlling pin carriage return mechanism in multiple-cycle operations.

Further features of the invention will appear from the following description, referring to the accompanying drawings, which show, merely by way of example, a preferred embodiment thereof.

Of the drawings:

Fig. 1 is a perspective view of the machine.

Figs. 2 and 2a, together, form a sectional view, from front to rear, through a typical denominational order of the machine, some of the parts being in section and others not.

Fig. 3 is a perspective view of the base and frame plates of the machine, with the casing and most of the mechanisms removed therefrom. Reference will be made to this view from time to time to show the location of the parts shown in detail in other figures.

Fig. 4 is a perspective view of the main drive shaft and the associated pair of drive sector cam plates, which are oscillated back and forth once each entry cycle of operation.

Fig. 5 is a detail of the alining and locking mechanism for the differential-controlling pin carriage, as seen from the left side of the machine.

Fig. 6 is a side elevation of the automatic differential-controlling pin carriage return mechanism and associated repeat key mechanism.

Fig. 7 is a plan view of the mechanism shown in Fig. 6.

Fig. 8 is a right side elevation of the platen feed mechanism and the non-print mechanism.

Fig. 9 is a front elevation of the mechanism shown in Fig. 8, only the right-hand part being shown.

Fig. 10 is a right side elevation of the ink ribbon guide and shifting mechanism.

Fig. 11 is a front elevation of the mechanism shown in Fig. 10.

Fig. 12 is a side elevation of a part of the ribbon-feeding mechanism.

Fig. 13 is a side elevation of another part of the ribbon-feeding mechanism and the means for reversing the direction of the feed.

Fig. 14 is a cross section through a portion of the ribbon-feeding and reversing mechanism, as viewed from the front of the machine.

Fig. 15 is a broken elevation, partly in section, of the ribbon-feeding mechanism.

Fig. 16 is a right side view of the digit keyboard unit with the right side plate of the keyboard removed, diagrammatically showing its relation to the cooperating pin carriage associated with the differential mechanism.

Fig. 17 is a plan view of the substance of Fig. 16 with the top plate of the key bank unit removed, and the stems of the keys shown in section. The relation of the differential sectors and the differential-controlling pin carriage is shown diagrammatically.

Fig. 18 is a vertical section through the pin-carrying portion of the differential-controlling pin carriage, showing the zero stop bail and its relation to the pin-controlled differential sectors, the view being taken from the left side of the machine, looking toward the right.

Fig. 19 is a detail view of the pin detent mechanism for the pins in the differential-controlling carriage of Fig. 18.

Fig. 20 is a right elevation of a typical denominational order of the differential mechanism and associated printing mechanism, in relation to the pin carriage associated with and controlling the differential mechanism, and to the pair of totalizer wheels associated therewith.

Fig. 21 shows the drive sector cam plate attached to the left end of the main drive shaft, the bail for controlling the movement of the differential sectors, and the means for alining and locking the differential sectors at mid-cycle.

Fig. 22 is a top plan view of the escapement for the

pin carriage associated with the differential mechanism, with the mechanism for reverse movement of the pin carriage in dividing operations removed.

Fig. 23 is a rear elevation of the printing hammer control mechanism for two typical denominational orders.

Fig. 24 is a front elevation, partly broken away, of the differential-controlling pin carriage.

Fig. 25 is a top plan view of the pin carriage of Fig. 24.

Fig. 26 is a rear elevation of the left end of the pin carriage, showing the zero stop bail and associated mechanism.

Fig. 27 shows a portion of the totalizer-sensing mechanism which determines the negative or positive position of the totalizer, said view showing the mechanism in one of its operating positions.

Fig. 28 is an enlarged view of a portion of Fig. 33, which relates to keyboard interlock mechanism on the right side of the machine.

Fig. 29 shows mechanism operated by the control keys on the right side of the keyboard, and interlocks therebetween.

Fig. 30 is a rear elevation of the digit keyboard, partly broken away, looking from the rear thereof toward the front, showing the crowding key lock mechanism and the levers for setting up the pins of the pin carriage.

Fig. 31 is a top plan view of the crowding key lock mechanism, being a detail of the left end of one of the pin-setting levers and its actuating rod.

Fig. 32 is a left side elevation of the control key mechanism on the left side of the digit key bank unit.

Fig. 33 is an elevation of the right side of the keyboard unit, showing the interlocks operated by the control keys.

Fig. 34 is a right side elevation of the motor bar, the main clutch, and the drive mechanism, the linkage 301 and 301a in broken lines being shown in detail in Fig. 70.

Fig. 35 is a top plan view of the main clutch mechanism shown in Fig. 34.

Fig. 36 shows the mechanism of Fig. 34 in the condition in which it is immediately after the motor bar has been depressed.

Fig. 37 is a section through the totalizer unit, showing the left supporting plate and the totalizer wheel alining rod.

Fig. 38 shows the right support plate for the totalizer unit and the guide slots for limiting the movement thereof in tumbling and engaging action.

Fig. 39 is a top plan view of the totalizer unit with the center portion broken away.

Fig. 40 is a sectional elevation of the rear part of the machine casing, showing how it is secured to the machine framework.

Fig. 41 shows a typical differential denominational order in moved position against a protruding pin of the differential-controlling pin carriage denomination associated therewith, showing the transfer mechanism, and showing the printing hammer latch control mechanism in normal position in dotted lines and in the moved position in full lines.

Fig. 42 is a detail view of part of the mechanism for tripping the printing hammer latches.

Fig. 43 is a view from the right side, showing the totalizer tumbled to its negative position with relation to the differential sectors, the totalizer wheels of this order being shown diagrammatically.

Fig. 44 is a section on the line 44-44 of Fig. 50, looking in the direction of the arrows.

Fig. 45 shows the connections between the highest denominational order transfer lever and the lowest order transfer lever whereby the "fugitive 1" is entered into the lowest order of the totalizer as the totalizer passes through zero condition.

Fig. 46 shows the totalizer-engaging control mechanism in right side elevation.

Fig. 47 is a section of Fig. 46 on the line 47—47, looking in the direction of the arrows.

Fig. 48 is a top plan view of the slide mechanism of Fig. 46, for selecting the type of totalizer engagement.

Fig. 49 is a top plan view of the right end of Fig. 61, which relates to the sub-total-taking mechanism.

Fig. 50 shows a typical denominational order of the differential mechanism, with the transfer mechanism tripped, and the means for restoring the transfer mechanism by the main operating means, the view being in right side elevation.

Fig. 51 is a right side elevation of the linkage from the subtract key to the control means, which determines whether the totalizer shall be tumbled to the negative position during the ensuing machine operation.

Fig. 51a is a detail of part of the subtract control mechanism.

Fig. 52 is a plan view of the mechanism shown in Fig. 21, this being of the right end only.

Fig. 53 is a right side elevation of the means for sensing the negative or positive condition of the totalizer whereby to control the taking of a true total, whether it be positive or negative.

Fig. 54 shows a portion of the substance of Fig. 53 in one of the two possible operated positions.

Fig. 55 shows the means for actuating the totalizer tumbling means, as determined by the subtract control finger shown in Fig. 51a.

Fig. 56 is a view of that part of the totalizer sensing mechanism which is linked with the totalizer tumbling mechanism.

Fig. 57 is a detail of the left end of Fig. 56, showing the parts moved from normal position.

Fig. 58 is a right side elevation of a portion of the sub-total control mechanism.

Figs. 59 and 60 are plan views of portions of the mechanism shown in Fig. 58.

Fig. 61 is a view of more of the sub-total control mechanism as it affects the totalizer-engaging control slide.

Fig. 62 shows how the zero stop mechanism is disabled during total-taking operations by reason of the differential-controlling pin carriage associated with the differential sectors being in home position.

Fig. 63 shows the mechanism by which the totalizer wheel alining bail is moved into engagement with the totalizer wheels when they are not in engagement with the differential sectors.

Fig. 64 is a perspective view of the non-add mechanism, the non-add key controls therefor, and the latching mechanism which is operative in the first cycle of multiplying operations, the view being in more or less diagrammatical form to make the operation clear.

Fig. 65 is a plan view of the multiplier factor storage unit, having superimposed thereover the auxiliary interponent digit keyboard means by which the storage unit is operated by the digit keys, and also shows the mounting whereby the interponent means is moved out of the way of the digit key stems during ordinary single-cycle adding and subtracting operations, and in division operations, so that the digit keys will not operate said multiplier storage unit.

Fig. 66 is a plan view of the multiplier pin carriage storage device without the superimposed auxiliary interponent keyboard mechanism being shown thereover, as is the case in Fig. 65.

Fig. 67 is a view of the rear end of the mechanism shown in Fig. 65, the rear end of Fig. 65, as it is in the machine, being at the top of the sheet.

Fig. 68 is a view taken on the line 68—68 of Fig. 65. In this Fig. 68, the bottom of the view is that portion nearest Fig. 67.

Fig. 69 is a right side elevation of the total key and its linkage with the totalizer-engaging mechanism.

Fig. 70 is a right side elevation of the main motor bar and its linkage with the main drive clutch mechanism, together with associated mechanism used in multiple-cycle operations.

Fig. 71 is a right side elevation of the linkage operated upon depression of the multiplicand bar, and this may be connected up with the shuttle mechanism shown in Fig. 87.

Fig. 72 is a detail of part of the mechanism shown in Fig. 70 which is partially obscured in that figure, this detail being concerned with the mechanism for latching the main operating clutch controls in certain operations concerning multiple-cycle calculations.

Fig. 73 shows interlocking mechanism between the multiplier control key and the non-add mechanism.

Fig. 74 is a right side elevation of part of the mechanism shown in Fig. 76.

Fig. 75 is a detail of part of the mechanism of Fig. 76, showing how clearance is made for spring 895.

Fig. 76 is a front view of the mechanism for shifting the auxiliary interponent keyboard so that the multiplier may be set up in the multiplier storage unit.

Figs. 77, 78, 79, 80, 81, 82, 83, 84, 85, and 86 are parts of the shuttle mechanism used in multiplying operations to step back the various denominational control units of the multiplier storage unit to zero, to shift the multiplier units from stage to stage during the multiplying operation, and to initiate auxiliary cycles of machine operation for actuation of the pin-carriage-shifting mechanism. The components shown in these figures are more clearly set forth in diagrammatic form in the exploded views of Figs. 87 and 92.

Fig. 87 is an exploded perspective view, partly diagrammatic, of the shuttle mechanism whereby the multiplier storage unit denominational bands are returned step by step to zero position, and the means for sensing the zero condition of any of such denominations of the multiplier factor storage unit.

Fig. 88 is a right side elevation of the mechanism for shifting the multiplier storage unit denomination by denomination, and shows means for entering zeros in the differential-controlling pin carriage, when necessary, during a multiplying operation, and the auxiliary cycle control mechanism and associated clutch.

Fig. 89 is a plan view of that portion of Fig. 88 which pertains to the shifting of the multiplier storage unit and the entry of the zeros into the differential-controlling pin carriage.

Fig. 90 is a detail plan view of the ratchet and pawl mechanism for shifting the multiplier storage unit, step by step, toward home position, this view looking from the front toward the rear of the machine.

Fig. 91 is a broken perspective view of the linkage operated by the multiplicand key to condition the shuttle-actuating mechanism for operation during multiplication.

Fig. 92 similarly shows the shuttle drive and also shows the mechanism whereby the printer is disabled during successive entries in multiple-cycle calculating operations.

Fig. 93 is a plan view of the means for entering zeros into the differential-controlling pin carriage to the right of the lowest significant digit of the dividend.

Fig. 94 shows a side elevation of part of the mechanism of Fig. 93.

Fig. 95 is a view of the left-hand part of the mechanism shown in Fig. 103, as viewed from the left of the machine looking toward the right, which is the mechanism by which the pin carriage return mechanism is disabled during division operations.

Fig. 96 is a view of the Division key and its latching mechanism.

Fig. 97 is a perspective view of the mechanism for operating the printing suppression mechanism during division operations.

Fig. 98 is a vertical section from front to rear of the Division key mechanism with its relation to the differential-controlling pin carriage and a typical denominational order of the differential mechanism and the quotient counter, there also being shown linkage to the totalizer-sensing mechanism and the quotient slide controlling mechanism.

Fig. 99 is a view of the mechanism for returning the differential-controlling pin carriage to home position at the conclusion of a multiplying operation.

Fig. 100 is a detail view of the latch mechanism for holding the auxiliary cycle mechanism in activated condition.

Fig. 101 is a perspective view of the slide mechanism for operating the multiplier storage unit return mechanism, and the associated slide on the left side, which operates the differential-controlling pin carriage return mechanism at the close of a multiplying operation.

Fig. 102 is a diagrammatic view showing the relative positions of the differential-controlling pin carriage, the differential sectors, and the quotient slide during various stages of a typical division operation.

Fig. 103 is a perspective view of the mechanism whereby operation of the Division key initiates a division operation and disables the mechanism for returning the pin carriage to home position at the end of each machine cycle.

Fig. 104 is a sectional view of the mechanism shown in Fig. 105 on the line X—X thereof.

Fig. 105 is a plan view of the mechanism for actuating the quotient counter on each cycle of operation during division.

Fig. 106 is a right elevation of the mechanism controlling the machine cycling during division.

Fig. 107 is a top plan view of the mechanism of Fig. 106.

Fig. 108 is a plan view of the top of the differential-controlling pin carriage and the mechanism for reversely tabulating it in various stages of division.

Fig. 109 is an elevation of the right end of the mechanism shown in Fig. 108.

Fig. 110 is a perspective view, from the right rear, of the mechanism for engaging the quotient counter with the differential sectors.

Fig. 111 shows the mechanism for disabling the zero stop mechanism in quotient-taking operations.

Main framework

Referring to Figs. 1, 2, 2a, and 3, the machine is built upon a main base 200, which supports the keyboard, the differential and totalizer mechanisms, and the printer and power-driving mechanism, and upon an auxiliary base 201, which supports mechanism for performing multiple-cycle operations required in multiplication and division, the stage control mechanism for the multiplier factor storage unit, and certain division control mechanism. Referring to Fig. 3, there are a number of vertical frame plates and cross frame plates secured to the base 200. Vertical frame plates 202 and 203 support the differential mechanism, the main drive shaft, and closely associated mechanism. Across the rear end, on steps of the frame plates 202 and 203, is a horizontal plate 204, which supports a cylindrical platen for holding the record material and affords means for supporting and locking the casing onto the base of the machine. Vertical portions 205 and 206 of the horizontal plate 204 support the ribbon guides, as will be described. Laterally mounted from the vertical frame plates 202 and 203, by supporting studs, are auxiliary plates 207 and 208, which support the totalizer and the ribbon guards 209 and 210. On the right rear of the base 200 are a vertical support 211, on which the main clutch is mounted, and the like plate 212, on which the auxiliary clutch used in multiple-cycle auxiliary operations is mounted. The electric drive motor is supported on the left rear of the base 200, but, as it

is not necessary to an understanding of the invention, it is not shown in the drawings.

At the front of the base 200 are two inner vertical support plates 213 and 214, for supporting the digit key mechanism, and outer vertical frame plates 215 and 216, for supporting the control key mechanism. To plates 215 and 216 are secured a top cross plate 217 and a bottom cross plate 218. A cover plate 221 for the key bank unit is shown in Fig. 29.

Outer vertical frame plates 219 and 220, on either side of the key bank unit, are provided for supporting other mechanism to be described. These frame plates are secured to the base and to each other by means of brackets, tongue-and-slot connections, screws, and similar methods of fastening, which are not pertinent to an understanding of the invention.

Machine casing

The main part of the casing 222 (Fig. 1) covers approximately the front two-thirds of the machine and has in its forward part a large aperture, into which projects the digit keyboard unit, designated generally at 223, and other apertures, through which project the main motor bar 224, a quotient key 225, a division key 226, both on the right-hand side, and a multiplicand bar 227, on the left-hand side. Above the keyboard is a recessed plate 228, having therein eleven apertures, such as aperture 229, through which the position of the differential-controlling pin carriage may be seen, there being an index signal 230 (see Figs. 24 and 25), which moves with the differential-controlling pin carriage, being attached to a bracket thereon. There are eleven denominational orders in the machine, as shown, although this number may be increased or decreased, as desired, without departing from the principles of the invention.

Projecting through the keyboard unit top cover plate, in addition to the nine digit keys, are a "0" key 271, for introducing zeros into the pin carriage; a correction key 273; a subtract key 274; a total key 275; a non-add key 276; a repeat key 277; and a multiplier key 278. There also may project through this plate a "multiple zero" key 1462, as seen in Fig. 94. The functions and associated mechanism pertaining to these keys will be explained in detail at the proper time.

Hinged at 232 (Fig. 40) to the rear part of the main casing 222 is a paper roll cover 231, which may be rocked clockwise around its hinge 232, as seen in Fig. 40, to give access to the paper roll supported on arbor 233 mounted in the platen support unit 234, next to be described. As the hinge cover 231 is rocked counter-clockwise to cover the paper roll, it is stopped by foot 235 striking on portion 236 of the casing 222.

The platen unit consists of a left support member 237 (Figs. 1 and 40) and a similar right support member 238, which, respectively, support the left plate 239 (Fig. 40) and a similar right plate (not shown). Extending between and supported by said left frame 239 and its counterpart right frame are rods 240, 241, and 242. A cross brace 243 is provided for additional structural support. Also supported between said left frame plate 239 and its right counterpart frame plate is a rear paper guide 244. The paper roll arbor 233 extends through the left frame plate 239 and its right counterpart, and also between spacer plates, the left one, 245, of which is shown in the drawing. The rear end of said spacer plates are slidably mounted on rods 233 and 241, so as to be adjustably movable according to the width of the paper roll. Mounted in the said frame 239 and its right-hand counterpart is a platen arbor 246, on which is securely mounted the platen 247, which is rotated by turning the arbor 246 by a knob 259 or by machine operation in the manner to be described in connection with the paper-feeding mechanism. The plate 204 (see also Fig. 3) has supported thereon a right vertical

piece 248, having studs 249 and 250. A similar piece on the left side of the plate 204 has studs 251 (see Figs. 40) and 252. As seen in Fig. 40, the forward end of the plate 239 has notches which may engage the studs 251 and 252. The right-hand counterpart of the plate 239 has similar notches, which cooperate with the studs 249 and 250 (shown in Fig. 3). Inasmuch as the part 253 of the plate 239 rests on the plate 204 and becomes interlocked because of engagement therewith of the studs 251 and 252, and inasmuch as a similar interlocking occurs on the right end of the platen unit, the case 222 is locked onto the base 200, which supports the frame plate 204. Engagement of the platen unit with the studs, as described, is accomplished by causing the forward studs to be engaged first, while the rear end of the platen unit is elevated; then, if the rear end of the platen unit is pushed down, the rear studs are engaged. To prevent the unlocking of the platen unit from the frame, and hence to prevent the casing from being accidentally removed, there are provided ribbon guard covers 254 and 255 (see also Fig. 1), which conform to the exterior surface of the casing 222, each of said covers having, on the side which faces the machine, a spring-mounted ribbon retainer disk, like disk 256, associated with ribbon cover 254. When the ribbon covers, like the cover 254 (Fig. 40), are in place, an ear, like ear 257, mounted thereon, passes between a strap 258 and the side of the casing 222 to hold said covers in place. In this position, the disk 256 bears against the left ribbon spool in the ribbon guard 210 (Fig. 3), and the right-hand counterpart of the ribbon guard cover 254 acts in the same manner. Because the ribbon guard cover 254 fills the space between the casing 222 and the front end of the platen unit on the left side, and the ribbon cover 255 on the right side acts in the same manner, the platen unit cannot be removed until the ribbon guard covers have been removed.

This novel interlocking mechanism makes it possible to remove the casing of the machine by pulling off the ribbon guard covers 254 and 255, throwing back the cover 231, lifting upwardly and outwardly on the rear of the platen unit, and removing it. Thereupon the casing 222 can be lifted bodily off the base 200.

Referring to Fig. 1, it will be seen that the right end of the platen arbor extends through the platen unit right support plate 238 and ends in the knurled knob 259, by which the platen may be rotated from without the casing.

Referring to Fig. 40, mounted on the cross rod 242 is a bell crank lever 260, having pivoted on its front end a cradle 261, having pressure rolls 262 and 263 mounted therein, which rolls are spring-pressed against the platen by a spring 264 urging the bell crank lever 260 clockwise. The upper end of the bell crank lever 260 ends in a finger knob 265, which may be pulled forward to release the pressure rolls from the platen, so that the paper inserted over the paper guide 244 and around the platen may be adjusted for either horizontal or vertical alinement.

Secured to the ears on top of the ribbon guards 209 and 210 (Fig. 3) is a flat plate 266 (Fig. 1), the rear end of which is slotted to act as a guide comb for printer bars 267, which are selectively differentially raised opposite the platen 247, on machine operations, to present at the printing station the type representing the entered item or the total taken.

A non-print control lever 268, the function of which will be described in connection with the non-print mechanism, also extends through the plate 266.

A serrated cut-off bar 269 is supported by the platen unit, between the frame plates thereof, under which bar the paper wound around the platen from the rear passes, and against which bar the paper which extends beyond it may be torn off in the usual manner.

Functions of the control keys and the digit keys

In add operations, the number is set up on the pin carriage by successive depression of the digit keys corresponding to the digits of the multi-digit number, beginning with the highest order thereof. This is followed by depression of the motor bar 224, which initiates a machine operation, the number being entered into the totalizer and printed.

In subtract operations, the number is set up, as before described with reference to add operations, but, before the motor bar 224 is depressed, the subtract key 274 is depressed, which causes the totalizer to tumble, upon the ensuing machine operation, to the negative position, so that the number will be entered into the totalizer negatively instead of positively.

In non-add operations, the key 276 is depressed before the motor bar 224 is depressed. The number set up on the digit keys will be printed when the motor bar is depressed, but will not be entered into the totalizer.

In repeat operations, the key 277 is depressed, the number to be repeatedly added or subtracted is set up on the keys, and the motor bar is operated the number of times it is desired to enter the number into the totalizer; or the motor bar may be held down for the selected number of cycles.

In sub-total-taking operations, the motor bar 224 is depressed without any item being set up on the keys. This causes an operation of the machine in which the engagement of the totalizer with the differential elements is in sub-total timing, resulting in the setting of the amount in the totalizer on the printer bars, and in the printing of the sub-total. The amount is returned into the totalizer in the last half of the sub-total-taking operation.

In taking the total, the total key 275 is depressed, and in the ensuing machine cycle the amount in the totalizer will be transferred to the differential elements and printed, but will not be returned to the totalizer in the second half of the cycle.

In multiplying, the multiplier key 278 is depressed, the multiplier is set up on the digit keys, and the motor bar 224 is depressed. This sets up the amount of the multiplier in the multiplier storage unit in the base 201 and prints the multiplier but does not enter it into the totalizer. The multiplicand key 227 then is depressed, which causes the multiplier key 278 to be restored. The multiplicand then is set up on the digit keys 270 and 271, and the motor bar 224 is depressed. The multiplicand is then printed, and there follows a series of machine cycles in which the multiplicand is entered into the totalizer in various stages of multiplication, without being printed. The final product is obtained by depression of the total key as in taking a total, followed by an operation of the motor bar 224.

In division, the dividend is set up on the digit keys, ciphers are introduced to carry the pin carriage completely to the left, and the motor bar is then depressed, causing an operation in which the amount of the dividend, as increased by the ciphers, is entered into the totalizer and printed. The divisor is next set up on the digit keys 270 and 271, and ciphers are introduced to cause the pin carriage to be moved to its leftmost position. The division key 226 then is operated, and the machine enters into a series of successive subtract operations, in which the divisor is successively subtracted from the dividend until the diminished dividend is less than what remains of the divisor, whereupon the machine ceases to cycle. By operation of the quotient key 225, the quotient is withdrawn from a special quotient totalizer and printed. The remainder is in the totalizer and may be printed by taking a total thereof; that is to say, by depression of the total key 275, followed by depression of the motor bar 224.

The machine is electrically driven in entry cycles and totaling operations by a motor energized upon the closing of a normally open switch 279 (Figs. 34 and 35), mounted on a bracket 303, extending between the clutch support plates 211 and 212 (see also Fig. 3). The switch 279 is in the supply circuit of the motor (not shown), which motor, when energized, turns a shaft 280 counter-clockwise, through intermediate gearing (not shown). Secured to the shaft 280, journaled in the plates 211 and 212, is a notched drive wheel 281. Rotatably mounted on the shaft 280 is a drive disk 282 having a stud 283, to which is pivoted a clutch ring 284 having an inwardly projecting tooth 285 adapted to engage one of the teeth on the notched drive wheel 281 when the clutch ring 284 is rocked counter-clockwise, as seen in Fig. 36. The clutch ring 284 is held in the position shown in Fig. 35, when the machine is at rest, against the urge of a spring 286, by reason of a stud 287 on the clutch ring resting on a shoulder on the rear end of a slide plate 288c.

Slide plates 288a, 288b, and 288c are fastened together in spaced relation, to form the machine release slide unit, by pins 304 and 304a, which pass through a guide slot in the plate 211, allowing the machine release slide a limited back-and-forth movement.

A switch-operating slide unit is formed of slide plates 289 and 289a, held in spaced relation by pins 306 and 307 (Fig. 35), which slide in the slots in the plate 211, allowing limited back-and-forth movement thereof. The switch-operating slide unit is urged rearwardly by a spring 290. The enlarged left end 308 of the pin 306 engages a notch in the periphery of the drive disk 282, when the drive mechanism is in home position. The slide plate 288a has, on its rear end, an upwardly-extending ear 308a, engaging a downwardly-extending ear on the forward end of the slide plate 289. The rear end of the slide plate 289 has an ear 291, supporting a screw stud on which is mounted a coil spring 292, tipped with a head 293, adapted to bear against the switch plate 279 to close the switch and start the motor as the slide plate 289 moves forward.

Forward movement of the machine release slide unit moves the rear end of the plate 288c from under the stud 287, causing the clutch ring 284 to rock, so that the tooth 285 engages the notched drive wheel 281. Simultaneously, the switch-closing slide unit, composed of the slide plates 289 and 289a, is pulled forward, so that the end 308 of the pin 306 comes out of the notch in the drive disk 282, and the switch closes, starting the drive disk 282 to start rotating counter-clockwise, as seen in Figs. 34 and 36. The end 308 of the pin 306 rides the periphery of the disk 282, holding the motor switch closed during one rotation, after which the switch-closing slide unit may return to home position unless retained in the position shown in Fig. 36 by the machine release slide unit 288a, 288b, and 288c being held in moved position. After the drive disk 282 completes one rotation, the stud 287 strikes the rear end of the plate 288c, declutching the notched wheel 281 from the drive disk 282.

If the slide unit 288a to 288c is not permitted to return to normal position, shown, the drive disk 282 will continue to rotate. One rotation of the drive disk 282 is equal to one machine cycle.

Pivoted to the vertical side frame plate 215 (Figs. 34 and 70), on a stud 294, is the motor bar 224, having a surface 296, which bears on a stud 297 on a bell crank lever 299, pivoted on a frame-supported stud 298. The lower arm of the lever 299 has a stud 300, to which is pivoted a link 301, which in turn is coupled to a link 301a (Fig. 70), which is pivoted at its rear end to the machine release slide unit 288a to 288c. A spring 302 resiliently holds the motor bar 224 in contact with the stud 297. A spring 302a resiliently holds the link 301 in its

rearmost position, as determined by the frame-supported stud 302b.

The coupling between the link 301 and the link 301a, shown in Fig. 70, consists of a stud 693 on the link 301a, riding in the longitudinal slot 692 in the link 301. The two links are resiliently held in the position shown by a spring 694, extending between the forward end of the link 301a and a lug on the rear end of the link 301, so that the two links work as a unit unless prevented, as will be explained with regard to multiple-cycle operations.

Pivoted to the stud 283 of the disk 282 (Figs. 34 and 36) is a drive link 309, which is pivoted at its forward end to a stud 305 on a bracket 310, secured to and spaced from the right side of a right drive sector plate 311, pinned to a cross shaft 312 (see also Fig. 4) journaled in the vertical frame plates 202 and 203, the right bearing hole 316 in the plate 202 being shown in Fig. 3. Pinned to the left end of the shaft 312 is a left drive sector plate 313, similar in contour to the right drive plate 311.

The drive plates 311 and 313 have aligned cam slots 314 and 315, to control the movement of the differential members, which will be described later. During a machine cycle, the plates 311 and 313 are rocked first counter-clockwise and then clockwise, as seen in Fig. 4, to home position.

The forward and trailing portions of the cam slots 314 and 315 are arcuate to the shaft 312, but the mid-portion of these cam slots are not, and they act, as will be described, to control the differential mechanism.

A cam member 320, secured to the outside surface of the plate 311, but spaced outwardly therefrom, has a centrifugal leading edge 597 and a centripetal trailing edge 596. This cam member controls the timing of the engagement and disengagement of the totalizer and the differential members. A rockable guide bracket 323 guides a roller on the totalizer engaging control mechanism, to be described, onto the cam 320 as the drive plates 311 and 313 oscillate.

A blocking lever 599, pivoted to the outside of the drive plate 311 and held against a stud 601 by a spring 325, has a wide outer end, which covers the trailing end 596 of the cam 320 and the space between said end 596 and the drive plate 311. The lever 599 is rocked clockwise to give access to the inner arcuate edge of the cam member 320 for certain types of totalizer control to be described.

The arcuate outer edge of the bracket 310 actuates the subtract control mechanism shown in Fig. 55.

On the inside of the drive plate 313 (Fig. 4) is a cam pawl 625, pivoted thereto at 330 and urged clockwise against a stud 328 by a spring 329. A similar cam pawl is mounted on the inside of the drive plate 311. These restore any tripped transfer pawls at the beginning of a machine cycle.

The pivot stud 330 has mounted thereon a roller 331 for tripping printing hammers that are conditioned for tripping.

The keyboard

Referring to Figs. 29 and 32, there are four straps, 332, 333, 334, and 335, extending between the bottom edges of the plates 213 and 214 (see also Fig. 3) and secured to their outside surfaces by means of upwardly-extending ears. The right end of the strap 332 has an extension to receive the bottom end of the correction key stem 337 (Fig. 33).

The digit key stems 270 and 271 are mounted in aligned slots cut in the top plate 221 and in the straps 332, 333, 334, and 335.

Extending between and journaled in the inner key bank vertical plates 213 and 214 (Figs. 16 and 17) are a plurality of bails, there being one for each digit key. Each bail cooperates with a formation on the key stem of its associated key and also with an associated rod for actuating the differential-controlling pin carriage, to be de-

scribed. As an example, the "0" key bail 338 has a tongue 339, which lies under a formation 340 on the "0" key stem, and a tongue 341, having a hole which receives the forward reduced end 342 of the associated actuating rod 343. In a like manner, the "6" key stem 344 has a formation which rests on the tongue 345 of a bail 346, coupled to a rod 347, having a disk-like rear end 348, which engages in an embracing formation in a lever 349, pivoted on a vertical post 350, mounted between the plates 217 and 218 (see also Figs. 3 and 30).

Each of the keys "0" through "9" has its own rod and lever. The ten levers corresponding to the levers 349 (Fig. 30) are stacked in numerical order vertically on the post 350, with the "0" lever 351 at the top and the "9" lever 352 at the bottom. These levers are spaced by collars on the post, like collar 353.

Referring to Fig. 17, each of the levers, like lever 349, has a spring attached to its left end, like spring 354, associated with the "6" key, holding the right end forward, which, through the linkage of the associated rod and bail, keeps the associated key in the "up," or restored condition, subject to be depressed by the operator.

Each of the digit key levers, like lever 349, except the "9" lever, has a rearwardly-extending projection 355 (Figs. 17 and 30) for actuating the associated pins in the pin carriage for controlling the differential mechanism, to be described. Depression of a digit key causes counter-clockwise movement of the associated pin-setting lever, as seen in Fig. 17, so that the projection 355 will make contact with the associated pin of the pin carriage 425, moving it from inoperative position to operative position.

Also mounted on the post 350 (Fig. 30) is a bail consisting of an upper support arm 356 and a lower support arm 357, both pivoted on the post 350, and a rod 358, extending between and supported by the outer ends of said arms. The lower end 962 of the rod 358 will be referred to in connection with multiplication. As seen in Figs. 22 and 30, depression of a digit key moves the associated lever, such as the lever 349 of the "6" key, against the rod 358, rocking it counter-clockwise with respect to the post 350, as seen in Fig. 22, to actuate the differential-controlling pin carriage escapement.

A spring leaf 359, attached to the top of the lever 349, has its right end over the coupling between the disk-like end 348 of the rod 347 (also see Fig. 17). A similar spring leaf is attached to the bottom of the lever 349, the two leaves being provided to secure the coupling.

Point 360 on the arm 356 (Fig. 22) is one tooth of the pin carriage escapement mechanism. A lever 361, pivoted on the post 350, is urged clockwise by a spring 362 until the arm 364 strikes the stud 363, has another arm, 365, with a tooth 366, which is the opposing tooth of the pin carriage escapement mechanism. The depression and release of a digit key oscillates the arm 356 and the lever 361 together, to cause a step of movement of the differential-controlling pin carriage 425, to be described later.

Digit key interlocks

Secured between the plates 217 and 218 (Fig. 30) is a tube 367, having a horizontal slot, like the slot 368, for each digit representing the lever mounted on post 350. These slots are aligned with their associated levers. Each of the levers has a nose 369 (see Fig. 31), which enters its associated slot when the associated key is depressed.

Within the tube 367 is a column of balls of such diameter that adjacent balls meet opposite a slot.

On the left end of the plate 217, as seen in Fig. 30, is secured a right-angle bracket 370, to which is pivoted a bell crank lever 371, with its horizontal limb having a lobe 372, which rests on top of the column of balls. The other limb of the bell crank lever 371 hangs over the edge of the plate 217 and has a shoulder 373 in its end. Referring to Figs. 28 and 33, the correction key 273 has a forwardly-extending arm 374, which overlies a pin 375,

projecting from a fan-shaped member 376, pivoted on the stud 298 (see also Fig. 3), secured in the plate 215. Referring to Fig. 33, the member 376 has a laterally-extending pin 378, resting in the bifurcated forward end of a lever 379, pivoted by a stud 380 to the plate 215. The rear end of the lever 379 is bent over laterally to form a lug 381, which overlies one end of a lever 382, pivoted to the plate 215. The forward extremity of the lever 382 is bent outwardly at right angles to form a lug 383. The rear end of the lever 382 is pivoted to the lower end of a slide 384, having a slot by which it is mounted on a stud 385, secured in the plate 215.

The upper end of the slide 384 is adapted to cooperate with the lower end of the depending arm of the bell crank lever 371. A spring 386 is tensioned between the stud on the plate 215 (Fig. 33) and the forward end of the lever 382, tending to rock it clockwise to hold it in contact with the lug 381, which, through the linkage 379 and 376, resiliently holds the key 273 in raised position. Said spring 386 also holds the slide 384 in the down position, shown in Fig. 33. The subtract key 274 has a bifurcated end to its stem, which rides a guide stud 387.

The stem of the key 274 has a stud 388, which bears against the forwardly-extending arm of a bell crank lever 389, pivoted to the plate 215 by a stud 390. Pivoted to the bottom of the bell crank lever 389 is a link 391 (see Fig. 29), which is pivoted to a lever 392, which is pivoted on the stud 385. A spring 393 (Fig. 28) pulls forwardly on the link 391, holding the subtract key 274 in raised position. The link 391 has secured to its inner face a cam block 394 (see Fig. 28), adapted to cooperate with the lug 383.

The stem of the total key 275 is bifurcated and rides a stud 395 on the plate 215. On the stem of the total key is a stud 396, which overlies the forwardly-extending arm of a bell crank lever 398, pivoted on the stud 385. The lever 398 has a downwardly-extending arm 399, the end of which is slanted and overlies the lug 383 of the lever 382.

As a digit key is depressed, the associated lever, like the lever 349 (Fig. 31), moves between two of the balls in the tube 367, pushing up the balls on top and rocking the bell crank lever 371 counter-clockwise, as seen in Fig. 30. The balls above and below the nose 369 of the moved lever 349 are thus crowded together, so that no other digit key can be operated. This forms a crowding key lock for the digit keys, so that two cannot be depressed at the same time.

As the upper balls are raised and the bell crank lever 371 is rocked from normal position, the shoulder 373 engages the upper end of the slide 384, so that it cannot move. This locks the keys 273, 274, and 275 against depression until the depressed digit key is released. The key 273, when depressed, raises the slide 384 through the linkage 376, 378, 379, 381, and 382. Obviously, if the slide 384 cannot move, neither can the key 273. On the other hand, if the key 273 is depressed and the slide 384 is raised, a digit key cannot be depressed, because the bell crank lever 371 (Fig. 30) is rocked clockwise and holds the balls together.

When the subtract key 274 is depressed alone, the stud 388 (Fig. 33) on its stem rotates the bell crank lever 389 counter-clockwise, which moves the link 391 toward the rear, whereupon the cam block 394 strikes the lug 383 to move the lever 382 and the slide 384 to lock the digit keys.

When the total key is depressed, its stud 396 rocks the lever 398 to effect the same locking of the digit keys.

These keys 273, 274, and 275 are all locked when the slide 384 is prevented from rising because of a digit key's being depressed, because the members 376, 379, and 389 and the lever 399 are prevented from moving.

Pivoted to the stud 298 (Fig. 29) is a bell crank lever 400, having a bifurcated forwardly-extending arm embracing a screw stud 401 in the fan-shaped member 376.

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The lower arm 402a of the bell crank lever 400 actuates motor-driven pin carriage return mechanism, not shown, thereby clearing from the differential-controlling pin carriage any number erroneously set up therein.

Pivoted to the inner, lower arm of the bell crank 299 (Fig. 29), which is operated ordinarily by the motor bar 224, is a link 402, which is pivoted at its rear end to a pendulum lever 403, pivoted at 390 to the plate 215. As the total key 275 is depressed, the stud 396 strikes a shoulder on the lever 403, rocking it clockwise, which, in turn, rocks the bell crank lever 299 to set the machine in operation to take a total.

Extending laterally from the bell crank lever 299 is a pin 404 (Figs. 29 and 33). If the correction key is depressed, the lever 379 rocks clockwise to meet the pin 404, which will prevent the bell crank 299 and the motor bar from being operated. Conversely, if the motor bar is operated, the pin 404 makes contact with the lever 379 in its home position and prevents the correction key 273 from being operated.

The link 391 (Fig. 29), moved rearwardly when the subtract key 274 is operated, is pivotally connected to the lever 392, which, thus, is rocked counter-clockwise when the subtract key 274 is operated. To the top end of the lever 392 is pivotally connected the linkage for controlling subtract operations, as will be described.

The bell crank lever 398 is connected to mechanism for controlling total-making, which will be taken up in that part of the specification.

Referring to Fig. 32, the repeat key 277 has on its stem a stud 405, which bears on an arm of a bell crank lever 406, pivoted at 407 to the frame plate 216. Downward movement of the repeat key will rock the lever 406 clockwise and move rearwardly a link 408, pivoted thereto. The rear end of the link 408 is pivoted to a lever 409, pivoted to the plate 216. The lever 409 is, therefore, rocked clockwise when the repeat key is depressed to actuate the repeat mechanism, to be described later. The repeat key stem has a notch 410, by which it may be locked down by pushing rearwardly on the key to engage the notch with the plate 221. A spring 411 is provided to hold the repeat key in raised position unless held depressed, or depressed and latched down.

The stem of the non-add key 276 has a stud engaged by the bifurcated end of an arm of a bell crank lever 412, pivoted on a stud 413, on the plate 216. The other arm of the lever 412 lies directly behind the upper portion of the lever 409 and is connected to the non-add mechanism, to be described. The non-add key normally is kept in the raised position by a spring 414 but may be latched down by engaging a notch 677 in its stem with the plate 221.

The stem end of the multiplier key 278 (Figs. 32 and 74) is pivoted by a stud 418 to a bell crank lever 416, pivoted at 874 to the plate 216, the forward arm of which bell crank lever 416 overlies a leftwardly-extending arm of a bell crank lever 417 (Fig. 76), pivoted to a bracket secured to the under side of the plate 221. The downwardly-extending arm of the lever 417 operates to move to effective position the auxiliary keyboard, by which the multiplier is set up in the multiplier storage unit, in the manner to be described in connection with the multiplication section of the specification.

The differential-controlling pin carriage

The pin carriage 425 (Fig. 2a), for controlling the differential mechanism, is slidably mounted on rods 426 and 427, rod 426 being supported in holes 428 and 429 (Fig. 3) in outer frame plates 219 and 220, directly behind the keyboard unit, and rod 427 being supported in other holes in said plates.

In general, the differential-controlling pin carriage, movable in a substantially vertical plane, contains a number of vertical columns and horizontal rows of pins, each movable toward the rear from a retracted position, to control the differential sector members 501.

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The number of vertical columns represents the number of denominational orders in the machine, which is eleven, and there are nine pins in each column, representing the digits "0" to "8" inclusive, there being no need for a pin for the "9" digit, as it is represented by the full movement of a differential member 501. The "0" pin is at the top of a column, and the other pins of the column are arranged in order, downwardly. The pin carriage consists of a left side plate 430 (Fig. 24), a right side plate 431, a top plate 432, a front plate 433, a vertical mid-rib 434, and an auxiliary top plate member 435, fabricated of two single plates, the top one having secured thereto the index signal 230, and the bottom one acting as the top support for a series of vertical posts 436, one extending above each column of pins extending upwardly from the plate 432. These posts cooperate with the escapement pawls, mounted on the vertical post 350 (see also Figs. 2a, 22, and 30). A spring 437, attached to the plate 220, at the left end, and to an arm 438, at the right end, tends to move the pin carriage toward the left. The arm 438 is in the upper extension of a bracket 439 (Fig. 26), which supports a pin 440, which has mounted thereon a zero stop plate 441, which has a zero stop bail 442 and a rightwardly-extending arm 443.

A spring 444, tensioned between a stud 445 on the arm 438 (Fig. 26) and an ear 446 on the plate 441, holds the plate 441, its bail 442, and the arm 443 in the dotted-line position shown in Fig. 62.

Referring to Figs. 18, 19, 24, 25, and 26, there are provided a front pin plate 450, attached to the right plate 431 and the vertical mid-rib 434, and a rear pin plate 451, also attached to the plate 431 and the mid-rib 434. As seen in Fig. 24, the plates 450 and 451 have aligned pin slots 452 of rectangular shape, arranged in columns and rows, as before mentioned.

As seen in Fig. 19, each pin 453 is provided with a hump 454, which, with the pin in normal position, lies just to the rear of the front pin plate 450. A U-shaped spring 455 is positioned between each two pins of a column, each having a formation 456, which cooperates with the hump 454 to hold the lower pin in normal position, and a formation 457 to hold the lower pin in moved position. The U-shaped springs serving the top pins bear against the top plate 435 (Fig. 18) of the pin carriage. With this construction, each pin is resiliently held in either normal position or moved position. A pin 453 (Fig. 41) is shown in moved position, where it is effective to stop the movement of the associated differential sector 501.

Each pin projects beyond the pin plates 450 and 451, the forward ends of the pins of a column being in alignment and the rear ends of the pins of the columns being in arcuate alinement with the concavity facing the rear of the machine, so that they may cooperate with the associated differential sector member 501, which has a rotary movement, as will be described. To bring about the concave arcuate array of the pins in a column, the pins in the center column are shortest, and the intermediate and end pins are longer.

The selected pin in each column, for a given entry, is projected rearwardly by the projections 355 (Figs. 17 and 30) on the key-actuated levers, like the lever 349. As seen in Fig. 2a, there is no pin for the "9" lever 352, as none is necessary, for, if a "9" key is operated, a "9" will be entered in that order by a full throw of the associated differential member 501.

The pin carriage normally is kept in its right-most position, when the machine is at rest, by means of the tooth 366 (Fig. 22) of the escapement mechanism bearing against a post 458 (Fig. 24).

In the right-most position of the differential-controlling pin carriage, to which it is automatically returned after a cycle of machine operation unless otherwise prevented, the first column of pins, represented by the "0" pin 459, is one denominational order interval to the right of

the lowest denominational order differential sector member, represented by the line 460 (Fig. 17). If a digit key is depressed, the universal rod 358 (see Fig. 22) will rock the lever 356 counter-clockwise around the post 350, freeing the post 458 from the tooth 360 and allowing the pin carriage movement equivalent to a part of the denominational interval distance, against the tooth 360, which has moved into the path of the post 458. As the key is released, the arm 356 returns to home position under influence of the spring 362. On return movement of the lever 361, the tooth 366 enters the space between the posts 458 and the next post 461 (Fig. 24), permitting the pin carriage to move until the post 461 bears against the tooth, stopping the pin carriage with the projected pin aligned with the differential member of the lowest order, represented by the line 460. The next digit key depressed positions the pin in the next pin column and allows a step of movement to the pin carriage. Of course, operation of the "9" key only causes a step of movement of the pin carriage. This step-by-step movement of the pin carriage is repeated until the desired number has been set up. Thereafter, in an add, subtract, or non-add operation, the proper control keys or key are operated, and the machine goes through a cycle of operation, at the end of which the differential-controlling pin carriage is automatically returned to the right, slightly past home position. On the movement of the pin carriage to home position, the projected pins are returned to normal position by contact with a restoring cam 462 (Fig. 17) secured to the frame plate 202. The cam 462 extends arcuately downward in front of all the keys, conforming in shape to the arcuate array presented by the pins.

A locking comb 464 (Fig. 24) is attached to the plate 432 to hold the pin carriage in set position during a machine operation. A lever 465 (Fig. 5), pivoted to the frame plate 203 (see Fig. 3), has on its rear end a stud 466, which is engaged by the bifurcated forward end of a lever 467, also pivoted to the plate 203. A spring 468a, pulling up on the rear end of the lever 467, normally holds the rear end against the stop stud 468, and in this position the forward end of the lever 465 is held out of the comb 464. As the machine begins to operate, the right drive sector plate 313 moves clockwise, as seen in Fig. 5, and its peripheral edge rolls under a roller 470, mounted on the lever 467, rocking the lever 467 counter-clockwise, which lowers the forward end of the lever 465 into the comb 464, locking the pin carriage in set position until near the end of the machine cycle, when the sector plate 313 nears home position.

Differential-controlling pin carriage return mechanism and repeat key

Secured to the left end of the shaft 312, on the outside of the frame plate 203, is an arm 471, secured to a plate 472, having pivoted thereto a pawl 473, having a roller 474 and a tooth 475. The roller 474 rides the camming periphery 476 of a member 477, pivoted at 478 to the frame plate 220, and is held in contact therewith by a spring 491, extending from an arm of the member 477, over the roller 474, and fastened to a frame-supported bracket (not shown).

Attached to the machine base 200 is a bracket 479, in which is journaled a spindle 480, having secured to its forward end a lever 481, and having secured to its rear end a beveled gear 482, in mesh with another beveled gear 483, journaled in a base-supported bracket, not shown. On the hub 484 of the gear 483 is a rectangular stud 485. The upper end of the lever 481 rests against a roller stud 486, mounted on the differential-controlling pin carriage 425. The pin carriage is shown in its extreme left position in Figs. 6 and 7, and with the gears 482 and 483 and the stud 485 in its extreme moved position clockwise, as seen in Fig. 6. As the machine commences to operate, the shaft 312 rocks clockwise, as seen in Fig. 6, and the roller 474 rides into a depression 487 in

the member 477, while the tooth 475 rides over the stud 485 and catches it. On the return movement of the shaft 312 to home position, the gear 483 is turned counter-clockwise, which in turn rotates the gear 482, the spindle 480, and the lever 481, to force the pin carriage to the right, to home position.

By the time the pin carriage is forced to the right, the lever 465 (Fig. 5) has disengaged from the comb 464. As the pin carriage moves to home position, the projected pins wipe against the restoring cam 462 (Fig. 17), which returns them to home position.

Referring back to Fig. 6, if the repeat key 277 is depressed, the lever 409 is rocked clockwise, which, through a link 490, in turn rocks the member 477 clockwise, so that a roller 488 thereon rocks the pawl 473 counter-clockwise, so that the tooth 475 does not catch the stud 485, preventing return of the pin carriage, thus leaving the amount set up in the pin carriage to remain for a subsequent machine cycle.

Other repeat control mechanism will be described in connection with multiplication and division.

The differential and associated mechanism

Each denominational order has differential mechanism including a toothed totalizer-actuating sector 500 (Figs. 2 and 2a), a pin-controlled sector 501, and a type-bar-controlling lever 502 (see Fig. 92), rotatable on a cross shaft 499, these members being coupled together, as will be described, and rocking together first counter-clockwise and then clockwise in a machine cycle, the amount of rocking being controlled by the pins in the differential-controlling pin carriage 425. The sector 501 (Fig. 2a) has a formation 503, which cooperates with the pins in the differential-controlling pin carriage, so that the sector will come to rest against any pin that is in its rearwardly-projected effective position, thus controlling the extent of movement of both sectors 500 and 501 and the lever 502, except under the circumstances to be described, when no entry in that order is to be made or when no printing is to be done. The formation 503 makes an arcuate excursion past whatever column of pins is in line with it during a machine cycle, and because of such arcuate movement the pins in the vertical column, as has been said, are of different lengths, the pins being in parallel alinement, but the rear portions of the pins being arranged on a concave arc, so that the formation 503 can move past them closely without hitting any pin that is not in its rearwardly-projected position.

Each lever 502 is latched to its sector 500 by a latch 504 (see Fig. 92), pivoted on a stud 505 in the corresponding lever 502. Each latch normally is held in the position shown in Fig. 92 by a spring 506, so that a notch 507 therein is held against the saw-tooth point on the rear bottom edge of its sector 501. During repeated addition in multiplying operations, or during repeated subtractions in dividing operations, a rod 508 (Figs. 2 and 92) rocks against the forward edges of said latches until they are moved to engage a cross member 509 to hold levers, like the lever 502, against movement, under circumstances to be described.

The sectors 500 and 501 normally are held in the position shown in Fig. 20 by a spring 514, extending between the rearwardly-extending portion of the sector 501 and a bell crank lever 515, pivoted to the sector 500 and having its downwardly-extending arm 516 resting on a step 517 of the sector 501.

As will be explained, to cause a transfer of a carry-over from a lower denomination to a higher denomination, the lever 515 is rocked slightly counter-clockwise, so that the lever slips off of the step 517 onto a step 518, causing a relative movement of the sector 500 with respect to the sector 501, representing one digital unit.

Pivoted to each sector 501 by a stud 510 is a latch member 511 having an arm 512 embracing a bail 513,

extending between a supporting left arm 519, rotatable on the shaft 499, just inside the plate 203 (see Fig. 3), and a similar supporting right arm, rotatable on the shaft 499 just inside the plate 202. Each latch member 511 has an arcuate upper edge 520 and a lower edge with a point 521 adapted to cooperate with a serrated alining member 522, secured on cross rods 732 and 733 in the framework. A spring 523, attached to the rear end of each latch member 511, constantly urges the sectors 500 and 501 and the lever 502 counter-clockwise, as seen in Fig. 20.

The rear end of the bail support arm 519 and the rear end of its corresponding right counterpart are tied together by a rod 524, and each has a roller stud (see also Fig. 21), which normally rides in the forward end of the slot of its associated drive sector plate, the stud 525 for the arm 519 being shown in Fig. 21, riding in its slot 314. As the machine cycle commences, the drive sector plates 311 and 313 rock counter-clockwise (see also Figs. 4 and 34), rocking the leading frame, comprising the bail 513, the arm 519, the tie rod 524, and the right arm corresponding to the arm 519, counter-clockwise after the studs corresponding to the stud 525 move along the arcuate portion 526 and meet the camming portion 527. The transfer mechanism is reset during the travel of the studs in the forward arcuate section of the cam slots. As the leading frame allows the sectors 500 and 501 to rock counter-clockwise, the sectors of the various denominational orders are stopped either by the zero stop bail 442 or by one of the pins in the pin carriage. It will be understood that the movement of the pin carriage to the left carries the zero stop bail 442 with it, uncovering the denominational orders of the differential members one by one, as pins are set in those orders.

Referring to Fig. 41, the sector 501 is shown in moved position, as stopped by the "6" pin 453. The leading frame has gone ahead to complete its full counter-clockwise movement, and the bail 513 has ridden down the arcuate edge 520 of the latch 511, forcing the point 521 into the serrated edge of the alining member 522. This is a temporary latching of the various sectors 501, pending a complete movement of the leading frame, it being understood that each sector 501 has its own latch member.

A positive locking takes place after the sectors have completed their movement, to hold the sectors and the printing bars, to be described, in set position while the totalizer engages and the printing takes place. Referring to Fig. 21, pivotally mounted in the frame plate 203 is an arm 527a, supporting the left end of an alining bail 528 and ending in a rearwardly and downwardly extending portion 529. The bail extends through apertures in the sectors 501 (as seen in Fig. 20), having alining teeth 530, and is supported on its right end by a right arm, like the arm 527a, pivoted in the right frame plate 202 (see Fig. 3). As the sector drive plate 313 nears its half-cycle position, a roller stud 531 thereon strikes the upper edge of the portion 529 of the arm 527a, driving the alining bail 528 into the teeth 530. Similar action occurs on the right side. On the return movement of the drive sectors, the alining bail 528 is allowed to restore under the urge of a spring 532, and the tie rod 524 (Fig. 20) returns the sectors 500 and 501 and the lever 502 to home position after the bail 513 has struck the arm 512 and unlatched the member 511. The full movement of the leading frame from home position determines the "9" digit position, and that is the reason no "9" pin need be provided in the pin carriage.

The totalizer

The totalizer, which is of the tumbling type, has a set of add pinions 533, which mesh with a set of subtract pinions 534 (Figs. 37 and 39), mounted, respectively, on shafts 535 and 536, mounted in end plates 537 and 538. A stud 539, with a ball in the end, extends from the plate 538, and a similar stud 540 extends from the plate 537.

These studs are located half-way between the shafts 535 and 536 and form the axis about which the totalizer tumbles from normal add position to subtract position. A rod 541, running between the plates 537 and 538 and extending beyond, is used for tumbling the totalizer from one position to the other. The stud 540 extends into a vertical slot 542 (Fig. 3) in a plate 543, secured to a plate 544, which has on its left side a stud which extends into a bushing 545a in the frame plate 208. The right counterpart bushing 545 is shown on the plate 207. The plate 543 has a U-shaped cut-out 546, in which the left end of the rod 541 plays as the totalizer tumbles. The plate 544 has an ear with a bifurcation 547 straddling a stud 548 in the plate 208. Thus the unit consisting of the plates 543 and 544 can wobble slightly, as determined by the stud 548 playing in the bifurcation 547, and the totalizer can tumble the distance determined by the play of the rod 541 in the U-shaped cut-out 546 plus the wobble. The right end of the totalizer is similarly supported, the right end of the stud 539 extending through a slot 549 (Fig. 38) in a plate 550, secured to a plate 551 by studs 552, 553, and 554. The plate 551 has a stud 555, extending into the bushing 545 of the frame plate 207. The plate 550 has a U-shaped cut-out 556, in which the right end of the rod 541 plays, and the unit formed of the plates 550 and 551 and the studs 552, 553, and 554 is allowed to wobble slightly, as controlled by a stud 557 playing in a bifurcation in the plate 550 to control the tumbling of the totalizer from the right side. The extents of the tumbling of the totalizer from the left-hand side and from the right-hand side are thus correlated. The slots 542 and 549 allow for movement of the totalizer into and out of engagement with the racks, and the wobble of these slots as the totalizer tumbles from add position to subtract position provides for proper directional motion of the wheels with the racks, as shown by the dot-and-dash lines in Fig. 43.

Referring to Figs. 3 and 46, journaled in bushings 558 and 559 in the frame plates 203 and 202 is a shaft 560 (Fig. 46), which extends beyond the plates. On the right end of the shaft 560 is secured a lever 561, to which is pivoted a support link 562, pivoted at its upper end to the right support stud 539 of the totalizer. A left lever, corresponding to the lever 561, is secured to the left end of the shaft 560 and has a link, similar to the link 562, pivoted to the left totalizer support stud 540. A right spring 563, tensioned between the lever 561 and a frame-supported stud, and a similarly-tensioned spring on the left side normally keep the totalizer in the "up" position in the slots 542 and 549 in the tumble control plates 543 and 550 (Figs. 3 and 38). The totalizer is engaged with the sectors 500 by the rocking of the lever 561 (Fig. 46) clockwise against the tension of the spring 563.

A spring 564 (Fig. 2a), tensioned between the left plate 537 of the totalizer unit and the machine frame, normally keeps the totalizer tumbled, as shown, to add position. The spring 564 is assisted by a spring 565 (Fig. 46) tending to rock the add-subtract bell crank lever 566, pivoted to the frame plate 202, counter-clockwise. The upwardly-extending arm of the bell crank lever 566 is bifurcated and embraces the rod 541 of the totalizer unit, by which it is tumbled. The rocking of said bell crank lever 566 clockwise tumbles the totalizer unit so that the pinions are positioned for engagement with the sectors 500. The actuation of the bell crank lever 566 will be described later in connection with subtraction and negative total-taking.

To hold the totalizer wheels from turning when they are disengaged from the sectors 500, an alining rod is provided for the totalizer unit, to engage the teeth of the subtract totalizer pinions when the totalizer is disengaged. The alining rod 567 (Fig. 63) is held at the left end in a clip 568, which rides on the shafts 535 and 536 (Fig. 39) to the left of the totalizer pinions. A spring 569,

tensioned between an ear on the rear of the clip 568 and a spring anchor on the shaft 536, normally holds the left end of the rod 567 in pinion-engaging position. A similar spring-urged clip on the right side normally holds the right end of the rod 567 in pinion-engaging position.

To provide for the disengagement of the alining rod 567 as the totalizer goes into engagement with the sectors 500, two levers have been secured to the shaft 560, which is described in connection with Fig. 46, one lever 570 (Fig. 63) being alined with the left clip 568, and the other, not shown, but of the same shape, being alined with the right clip, before mentioned. The lever 570 has a formation engaging one arm of a bell crank lever 571, pivoted to the machine frame, and another formation engaging an arm of a bell crank lever 572 also pivoted to the machine frame. As the lever 561 (Fig. 46) rocks clockwise, the shaft 560 does likewise, which rocks the bell crank levers 571 and 572 in the same direction. If the totalizer is in the add position, the upper arm of the bell crank 572 will bear against and move the clip 568 and the rod 567 backward to ineffective position. If the totalizer is in subtract position, the upper arm of the bell crank 571 will move the clip 568 backward. The right-hand clip is moved backward by identical mechanism.

Subtract control

As before mentioned in connection with Fig. 29, depression of the subtract key 274 (Fig. 51) rocks the bell crank lever 389 counter-clockwise, forcing the link 391 to the rear and rocking the lever 392 counter-clockwise.

Pivoted to the top of the lever 392 is a link 571a, pivoted at its rear end to a lever 572a secured on a shaft 573 journaled in the frame plates 202 and 219. Also secured on the shaft 573 is a lever 574, with a stud 575 (also see Fig. 55) playing in a slot 576 (also see Fig. 51a) in a finger 577 pivoted to the forward end of a lever 578, which is pivoted to the frame plate 202, by a stud 579. A roller 580 on the lever 578 rides the periphery of the bracket 310 on the right drive sector plate 313. As the machine cycle commences, the lever 578 is immediately moved clockwise, causing the finger 577 to rise. Under normal conditions, without the subtract key being depressed, the finger 577 passes to the right of a guide stud 581, secured to the frame plate 202, with no effect. However, as the subtract key is depressed, the finger 577 will rock counter-clockwise, and, upon commencement of a machine operation, the finger 577, in rising, passes to the left of the guide stud 581, while a shoulder 582 catches under an ear 583 of the add-subtract bell crank lever 566, rocking it clockwise to tumble the totalizer to subtract position. The parts will return to normal add position at the close of the machine operation.

In division operations, requiring repeated subtraction, the totalizer is tumbled under different key control, to be described. The totalizer tumbling also occurs in taking a negative total or sub-total.

Totalizer-engaging mechanism

Referring to Fig. 46, the lever 561, to which the link 562 is pivoted, carries at its rear end a stud 584, engaged by a forwardly-opening slot in the rear end of a slide 585, having a forward slot 586, elongated from front to rear, which embraces the shaft 560. The slide 585, therefore, is capable of forward and backward movement within the limits imposed by the elongated slot 586. There is an extension 587, on the rear end of the slide 585, on which rests a stud 589 of a beam 590 pivoted on a frame-supported stud 588 (see Fig. 48), the forward end of said beam 590 having a stud 591, which passes through a slot 592 in the lever 561 and is adapted to rest on the upper edge of the slide 585. The stud 591 is positioned relatively to a raised portion 593 of the slide 585, so that, when the slide 585 is in the rearmost posi-

tion, shown in Fig. 46, the stud 591 has a slight freedom of movement downwardly, so that the beam 590 may rock slightly counter-clockwise, whereas, if the slide 585 is in its forward position, the raised portion 593 will be under the stud 591, preventing any such counter-clockwise movement. A spring 594 is attached to the rear end of the beam 590 into a frame-supported spring anchor to resiliently hold the beam 590 in horizontal position, as shown in Fig. 46.

On the drive cam plate 311, as can be seen in Figs. 46 and 47, is fastened the arcuate cam 320, spaced apart from the cam plate by studs, leaving the clearance 595. As seen in Fig. 46, the arcuate cam 320 has at its most clockwise end the centripetal gradient 596 and at its most counter-clockwise end the centrifugal gradient 597. Pivoted to the drive cam plate 311 at 598 is the lever 599, having on its free end a plate 600, which makes it wide enough to make contact with the lower end of the arcuate cam 320, and to cover, substantially, the clearance space 595. The lever 599 is held resiliently against the stop stud 601 by the spring 325, connecting the lever 599 and the drive cam plate 311. Pivoted on a frame-supported stud 603 is a pawl 604, normally held in the position shown in Fig. 46 by a spring 607, so that an upper arm 605 rests against a stop stud 606, the pawl being free to move counter-clockwise against the tension of the spring 607. The lower pointed end of the pawl is in vertical alignment with the clearance 595 between the cam plate 311 and the arcuate cam 320, and normally rides in said clearance as the drive plate 311 rocks clockwise until it makes contact with the free end of the lever 599 in the manner to be described. The parts shown in Fig. 46 are at rest position, with the machine conditioned for adding. As the machine operation commences, the drive cam plate 311 rocks counter-clockwise, and the gradient 597 of the cam 320 makes contact with the stud 589 on the beam 590 and rotates the beam 590 counter-clockwise. Because the slide 585 is in the rearward position shown, such movement is without effect because the stud 591 is free to move a sufficient distance in the slot 592. As the cam drive plate 311 reaches the end of its counter-clockwise movement, the lower end of the pawl 604 strikes the free end of the lever 599, moving it clockwise from the position shown, and, as the trailing end of the arcuate cam 320 passes the stud 589, the beam 590 straightens out because of the spring 594, and the roller passes over the gradient 596 on the return movement of the cam drive plate 311.

By this time, the differential sectors 500 and 501 have completed their forward movement and have been positioned at "0" or at any digital position up to "9," as controlled by the pins in the differential-controlling pin carriage 425. On the second half of movement of the cam plate 311, the stud 589, passing over the gradient 596, rocks the beam 590 clockwise past its horizontal position, which, through linkage to be described, pulls down on the link 562, pulling the totalizer into engagement with the sectors 500, in which position the totalizer stays until the cam plate 311 is almost at home position, whereupon the beam 590 becomes free to move to its horizontal position, which, under the influence of the spring 594, causes the totalizer to be disengaged in response to the action of the springs 563 and 564. The action of the stud 589, supported by the beam 590, is on the slide 585, which is rocked clockwise and which in turn, through the stud 584, carries the lever 561 with it, causing the downward movement of the link 562. As the totalizer is in engagement with the tooth sectors 500, the sectors are returned to home position, registering the selected amount into the totalizer wheels. As the lever 561 turns the shaft 560, the alining rod 567 (see Fig. 37) moves out of mesh with the wheels to allow them to rotate with the sectors.

The transfer of carry-over units from a given totalizer wheel to the wheel of the next higher denomination is ef-

fectured by means of the transfer teeth 608 (Fig. 39), one being provided on the left side of the zero-representing tooth of a totalizer pinion. Each transfer tooth operates on an associated transfer lever 609 (Fig. 41), situated in the plane of the path of the associated transfer tooth 608 and pivoted on a shaft 610, extending between the frame plates 202 and 203.

Each of the transfer levers 609 is urged upwardly by its spring 611 against a stud rod 612, and each is provided with two projections 613 and 614, which are pressed downwardly by the transfer tooth, depending on whether the entry is positive or negative, as it passes through "9" to its "0" position. Projections, like the projection 613, are associated with the add pinions, and projections, like the projection 614, are associated with the subtract pinions. Each lever 609 is provided with a hook 615, adapted to engage a hook 616, pivoted to the shaft 499 and urged toward the hook 615 by a spring 617. The lever 609 is provided with a laterally-extending pin 618, which is adapted to press downwardly the end 619 of the lever 515 associated with the sector 500 of the next higher denominational order. As the transfer tooth 613 or 614 presses the lever 609 downwardly, the hook 615 on the lever 609 engages the hook 616, and, on backward movement of the sector 500 of the next higher order, the end 619 of its lever 515 makes contact with the pin 618 of the next lower order, and the lever 515 is rocked counter-clockwise, as seen in Fig. 50. The lower extending arm 620 of the lever 515 moves to the lower step 518 of the sector 501, allowing the sector 500 to rotate by one tooth, effecting the transfer of one unit to said next higher order. Shortly thereafter, a stud 621, secured on the sector plate 500, releases the hook 615, which in turn releases the lever 609, which returns to its initial position. In order to reestablish the position of the levers 515 which have been operated during a machine cycle, so that the arms 620 are replaced on the steps 517, there is provided a resetting bar 622, extending underneath all the extensions of the sectors 500.

The bar 622 is carried by two arms pivoted to the shaft 499, the left arm, 623, being shown in Fig. 50. These arms carry near their free ends rollers, like the roller 624, associated with the left arm. As the drive sector plates start their forward movement, the last-named rollers are pushed upwardly by the profiles of by-pass pawls, like the left by-pass pawl 625, pivoted to the cam plate 313 (Fig. 4), to restore the levers 515 and their associated sectors 500. The by-pass pawl for the right sector plate 311 is a counterpart of the by-pass pawl 625. On each return movement of the drive sector cam plates, the rollers rock and by-pass the pawls. This resetting of the transfer mechanism occurs during that part of the cycle before the drive sector plates 311 and 313 start the differential sectors moving.

In subtract operations, the subtract totalizer pinions 534 act on the teeth 614 on the levers 609, giving the transfer of negative "1" to the next higher order negative denominational totalizer wheel. When the totalizer as a whole passes through zero, the totalizer pinion associated with the highest order enters a unit into the totalizer wheels lowest order to take care of the fugitive "1." The connection between the highest order transfer lever 609 (see Fig. 45) and the lowest order transfer lever 609 is by means of the strap 627, which causes operation of the lowest order transfer lever whenever the highest transfer lever is operated. This transfer lever of lowest order is utilized for automatically obtaining negative or positive totals and will be dealt with in the further course of the specification.

Sub-total mechanism

A sub-total is obtained by operation of the motor bar 224 without previous operation of any of the digit keys. Referring to Figs. 24, 25, and 26, on the zero stop mem-

ber 441 is a rightwardly-extending arm 443 (see also Fig. 62), which, when the pin carriage is in home position, extends in front of a leg 628 of the slide 585, so that, if the slide 585 is pushed forwardly as shown in Fig. 62, the zero stop plate will be rocked on the pin 440 by the leg 628 out from under all of the formations 503 on the sectors 501, this not occurring when the digit has been set up in the pin carriage, as the pin carriage then will have moved one step or more to the left, in which event the right end of the arm 443 is no longer in front of the leg 628. Referring to Fig. 61, an arm 629 is pivoted to the frame-supported pivot 630 and has at its end a roller 631, which rides the edge of the cam sector drive plate 311, so that, when the cam sector drive plate 311 commences its cycle of operation, the arm 629 is rocked clockwise. The arm 629 has a laterally-extending pin 632. Also pivoted on the stud 630 is a lever 635, held in contact with the pin 632 by a spring 634. Attached to the lever 635 is a lever 633, pivoted to a link 636, pivoted in turn to a member 637, rotatable on a frame-supported pivot 638 and shaped to abut a pin 639, laterally projecting from the before-described slide member 585 (see also Fig. 46), which tends to move the slide member 585 to the left from the position shown in Fig. 61, in which event the member 604, mentioned before in connection with Fig. 46, will be rocked in the direction of the arrow, as seen in Fig. 61, so that its pointed end will be out of the path of the lever 599 (Fig. 46) when the middle of the cycle occurs, so that the stud 589 will ride the outside of the cam 320 on both half cycles of operation, which results in the engagement of the totalizer during both cycles of operation, during which, at mid-cycle, the total standing on the totalizer is printed, the total then being transferred back into the totalizer.

This occurs because, upon leftward movement of the slide 585, the step 593 has come under the stud 591, and, as the stud 589 rides on the gradient 597, the slide 585 is rocked downwardly, coupling the totalizer wheels with the sector 500 and decoupling them at the end of the cycle.

Total-taking

In taking a total, the total key 275 (Fig. 69) is depressed, and the stud 396 on its key stem rides in a forked end of a bell crank lever 640, pivoted to the frame at 641, turning the bell crank lever 640 counter-clockwise. The upper end of the bell crank lever 640 is pivoted to a link 642, which in turn is pivoted to the frame at 573. The upper end of the lever 643 has a finger 644, which bears against the pin 639 on the slide 585, so that, upon operation of said total key by depression of it, the slide 585 is moved forwardly. At the same time, an arm 645, on the upper end of the lever 643, moves under a formation 649 on the member 637 (Fig. 61), preventing movement of it, and consequently permitting the member 604 to act upon the lever 599 (Fig. 46), so that the totalizer is engaged on the first half cycle, setting the sectors 500 and 501 under control of the totalizer pinions, causing the total to be printed, followed by disengagement of the pinions in the last half cycle, because the stud 589 is allowed to ride over the gradient 596 on the cam sector plate 311 and ride along the under side of the member 320 until the end of the cycle. In total taking or sub-total taking, the totalizer pinions are stopped in zero position as the wide teeth 613 or 614, depending on which way the totalizer tumbles, strike the stop formations on the transfer levers 609. The transfer levers 609 are kept from moving during total taking and sub-total taking by means to be described in connection with Fig. 10, which deals with the ribbon shifting.

To prevent a sub-total from being taken by depression of the motor bar while the pin carriage is not in home position, a hook 728 (Figs. 58, 59, and 60), mounted on a stud 729, is provided, the forward end being held

toward the pin carriage by a spring 730. When the pin carriage is out of home position, it springs to the position shown in Fig. 59, to embrace a stud 731, so that the slide 585 cannot move forwardly. Thus the totalizer is engaged only in the last half of the machine cycle. When the pin carriage is in the home position, the hook 728 is pushed back to the position shown in Fig. 60, where it is ineffective.

Automatic selection for positive or negative total

Means is provided to take a positive or negative total or sub-total automatically, with but one machine cycle, there being means which senses the negative or positive condition of the totalizer. This sensing means retains such indication until the totalizer changes again to the opposite algebraic sign, the totalizer tumbling movement being governed by said sensing means in the taking of totals or sub-totals.

Referring to Figs. 53, 54, and 56, there are two arms pivoted on frame-supported pivots 647. These are the arm 648 (shown in Fig. 53) and the arm 649b (shown in Fig. 56), both of said arms being held against the profile of the bell crank lever 566 by their respective springs 649a and 650. The lower end of the arm 649b has a stud 651, which rides in a bifurcation in an arm of a bell crank 652, pivoted to a frame-supported stud 653. The other arm of the bell crank lever 652 has a stud 654, which rides in the slot of a hook member 655, pivoted to the slide 585 at 656. The rearwardly and downwardly projecting finger 673 of the member 655 engages a stud 657 of the lever 574 (see also Fig. 51), which controls the movement of the add-subtract bell crank lever 566. The arm 648 (Fig. 53) has fixedly connected thereto a further arm 658, which, by means of the pin 659 on its lower end, moves forward and backward a member 660, slidable on two pins 661 and 662. The movement of the slide member 660, therefore, follows the movement of the forked bell crank lever 566.

The pins 661 and 662 are carried by a beam 663, rockable on a frame-supported pivot 664. The beam 663 has a leg 665, engaging the rear edge of a pivot 666 on the lowest denominational order tooth sector plate 500. The slide member 660 is provided with two pins 667 and 668 (see Figs. 53 and 54) cooperating with an overlying arm 669, pivoted to the frame at 670. When the member 660 is moved forward—that is, to the left as seen in Figs. 53 and 54 (which is the positive position)—the pin 668 thereon is in line with the projection 671 on the arm 669. When the member 660 is fully to the right (which is the negative position), as shown in Fig. 53, the pin 667 is over a hook-shaped edge 672 of the arm 669. On the other hand (Figs. 56 and 57), the arm 649b, when in the positive position, rocks the finger 673 out of the way of the stud 657, and, when the arm 649 is in the negative position (Fig. 57), the finger 673 is in effective position.

In order for the totalizer to change from a positive balance to a negative balance, the forked bell crank lever 566 must move at least once clockwise, which is in a subtract direction, and the sector 500 of the lowermost order unit must move one step clockwise for the "fugitive 1" transfer, which carries along with it the pivot 666 (Fig. 27). The subtract movement of the bell crank lever 566 (Fig. 53) moves the member 660 to the right through the pin 659, and the movement of the pivot 666 rotates the member 660 counter-clockwise, so that its pin 667 has moved the hook 672 downwardly. At the same time, the bell crank 652 (Figs. 56 and 57) has been actuated, and the finger 673 has been lowered to embrace the stud 657. An ear 676 on the arm 649b is caught by the hook 672 on the arm 669, retaining the arm 649b in the subtract position. The unit just described is, therefore, retained in the position shown in Fig. 27 when the balance in the totalizer has changed from positive to negative.

In this condition of the mechanism, when a total or a

sub-total is to be taken, the slide member 585 (Fig. 57) is moved to the left, and the finger 673 has moved the lever 574 (Fig. 51) to the negative position, so that, upon machine operation, the totalizer will be tumbled to subtract position, whereby the negative wheels will be meshed with the sectors 500. This selection of the negative side of the totalizer will occur on either total taking or sub-total taking. At the end of either operation, the totalizer will return to positive condition. The arm 649b (Fig. 27) will be retained by the hook 672 until the next positive entry, including a "fugitive 1" entry, occurs. At such time, the pivot 666 strikes the leg 665 of the beam 663, causing it to rock counter-clockwise, whereupon the pin 662 strikes the projection 671, and, because the slide 660 is in the leftmost, positive, position, the hook 672 is released from the ear 676.

Non-add mechanism

When it is desired to print an amount without entering it into the totalizer, the amount is entered into the differential-controlling pin carriage by use of the amount keys, and the non-add key 276 (Figs. 32 and 64) is depressed and latched down by moving the top end of the key rearwardly, so that the notch 677 catches on the top plate 221 of the key bank unit. This rocks the bell crank lever 412 clockwise, as before explained.

Referring to Fig. 64, a link 677a, pivoted to the upwardly-extending arm of the bell crank lever 412, is drawn forwardly, which in turn rocks the lever 678, pivoted on a frame-supported stud 483a (see also Fig. 6). The bifurcated upper end of the lever 678 engages a stud on the end of a lever 679, secured on a shaft 680, journaled in the frame plates 207 and 208. On the right end of the shaft 680 is secured a finger 681, which, through the linkage just described, strikes a stud 682 on the pawl 604 (see also Fig. 46), rocking it counter-clockwise, as seen in Fig. 46, to ineffective position, where it will not strike the lever 599 during the machine operation, thus causing the totalizer to remain disengaged during a machine cycle. The non-add key may be released and returned to normal whenever desired. At this time it will be explained how the non-add mechanism operates during the preliminary cycles of a multiplying operation.

During the setting up of the multiplier and multiplicand factors into the machine, these factors are printed but are not entered into the totalizer. In setting up the multiplier, the key 278 is depressed, which positions an auxiliary keyboard over the multiplier storage unit under the digit keys, the amount of the multiplier is set up in the auxiliary multiplier storage mechanism by the digit keys, and the motor bar 224 is depressed to set the machine in operation. Operation of the multiplier key 278 also brings about a non-add condition of the machine in the following manner:

Referring to Figs. 74 and 76, as before stated, the stem of the key 278 is pivoted to the bell crank lever 416 by the stud 418. The stud 418 projects leftwardly (Fig. 64) and bears on the slanting edge of a slide 684, mounted on pins in the frame plate 216 (Fig. 3) for forward and backward movement. The rear end of the slide 684 abuts on a stud 685 on the lower extension of the lever 412. Depression of the multiplier key 278 will force the slide 684 rearwardly and rock the lever 412 clockwise, as seen in Fig. 64, to condition the machine for non-adding, as described in connection with the key 276. The forward end of the slide 684 has an ear 686, by which it is caught, and it is held in rear most position by a spring latch 687, pivotally mounted on one of the pins on which the slide 684 is mounted.

The latch 687 has an upwardly and forwardly extending arm 688, the forward end of which overlies a rod 689 held on its left end by an arm 690, pivoted to the frame plate 216, and held on its right end in a forwardly extending arm of the bell crank lever 691,

pivotaly mounted on the stud 298, secured in the frame plate 215 (see Fig. 34), which also supports the bell crank lever 299, which is actuated by the motor bar 224 to draw forward the link 301. It was stated in connection with Fig. 34 that the link 301 is a broken link, and its construction will now be described. The rear end of the link 301 (Fig. 64) has the slot 692, in which plays the stud 693, secured on the rear section, which, as has been said, will be designated 301a. A spring 694, extending between an ear of the section 301a and the section 300, normally holds them together, so that the stud 693 is in the forward end of the slot 692 and the two sections move forward as a unit when the motor bar is operated. The construction is shown from the other side in Fig. 70.

The latch 687 is rendered ineffective, by operation of the multiplicand bar 227 and the motor bar 224, in the following manner:

Referring to Fig. 71, as the multiplicand bar 227 is depressed, its supporting lever 695, pivoted to the frame at 696, through an edge 697, which abuts a stud 698, rocks a bell crank lever 699, pivoted to the left frame plate 216 by a stud 700, clockwise.

A link 701 connects the bell crank lever 699 with the front arm of a bell crank lever 702, pivoted to the frame plate 220. The upwardly and rearwardly extending arm of the bell crank lever 702 is pivoted to a link 703, pivotally connected to a lever 704 (also see Fig. 87) secured to a shaft 705, extending between and journaled in frame plates 706 and 707. Near the right end of the shaft 705 is secured a plate 708 (see also Fig. 64), to which is pivoted a link 709, pivoted at its upper end to a plate 710, pivoted to the frame plate 219 by a pivot stud 711. Through the linkage 699, 701, 703, 708 (Fig. 71), and 709 (Figs. 64 and 71), whenever the multiplicand bar 227 is operated, the plate 710 is rocked clockwise, as seen in Fig. 64, or counter-clockwise, as seen in Fig. 71.

As the plate 708 rocks, a pin 712 thereon is caught by a hook 713 of a latch pawl 714, pivoted to the machine framework. This holds the multiplicand key 227 and associated mechanism in operated condition until the end of a multiplying operation.

The plate 710 (Fig. 64) has a slot 715, normally coincident with a slot 717 in a cam lever 716 pivoted on the stud 711 (see also Fig. 73). The depending arm of the cam lever 716 is pivoted to a link 718, pivoted to the bell crank lever 691 at its forward end.

The link 301 (Fig. 64) has an upstanding arm 719, on which is pivoted, by a stud 723, a segment 720, supporting a pin 721, normally resting in the mouth of the slot in the plate 710, but not reaching the mouth of the coincident slot in the cam lever 716. See Fig. 73. On the right drive sector plate 311, as before mentioned, is the stud 305, by which the sector plate is driven. The stud 305 plays in the slot 722 in a link 726, coupled by a pin 724 to a lever 725, pivoted on the stud 723. At half cycle, the stud 305, on the drive sector plate 311, reaches the forward end of the slot 722 and nudges the link 726 forwardly, which is to the right, as seen in Fig. 64.

Ordinarily—that is to say, in adding and subtracting operations—the nudging forward of the link 726 causes the pin 721 to make an excursion into the slots 715 and 717 (see also Fig. 73), which are under such circumstances coincident, as best seen in Fig. 73. However, when the multiplicand key 227 is operated, followed by a machine operation, the non-add mechanism, which has been latched in effective position by the latch 687, is unlatched at mid-cycle, after the multiplicand has been printed without being entered into the totalizer. Because the operation of the multiplicand key has rocked the plate 710 (Fig. 71) counter-clockwise, the segment 720 is rocked clockwise, as seen in Fig. 71, or counter-clockwise as seen in Fig. 64.

Upon the nudging forward of the link 726, the pin 724 will make contact with and ride along the upper

edge of the segment 720 just after the multiplicand is printed, rocking the segment clockwise, and the pin 721 of the segment 720 (Fig. 73) will push against a surface 727 of the cam lever 716 instead of entering the slot 717, rocking the cam lever 716 clockwise, as seen in Fig. 73, moving forward the link 718, rocking the bell crank lever 691 clockwise, and raising the rod 689 (see Fig. 64), which will raise the latch 687, allowing the non-add mechanism to move to normal, ineffective, position.

This non-add operation, under control of the multiplier key and the multiplicand key, will be referred to again under the part of the specification on multiplying.

Printing

As seen in Figs. 20 and 91, there is pivoted to the rear of each type bar controlling lever a type bar 740, the top ends of which are indicated by the bracket 267 (Fig. 1). A comb plate 266, as has been said, keeps the top ends of the type bars in alinement, and a spring 742 (Fig. 20), extending between each type bar and the stud 505 on its associated lever 502, holds the type bars in the comb unless they are projected against the platen 247 by the printing hammer associated therewith. Each type bar has spaced along its upper rear edge raised type 743, representing denominational digital data. The type bars each move with their associated levers 502, and the type, positioned by such movement to the printing station opposite the platen 247, represents the value of the digits set up or entered in that order.

Pivoted on a shaft 744 are a series of printing hammer levers, like the lever 745, there being one for each type bar, in line therewith. A spring, like the spring 746, is provided for each lever, to constantly urge the levers clockwise, so that the top end will strike the associated type bar to print the selected data, but each is normally latched in a retracted position against the common stop bar 747 by an individual latch 748, swung from a common supporting bar 749, extending between the frame plates 202 and 203. Pivoted at 750 to each latch is a leg 751, the lower end of which is engaged by a cuff on an upwardly-extending arm of a bell crank lever 753, pivoted to a cross rod 754, said rod being common to all the denominations and supported by the frame plates 202 and 203. The forwardly-extending arm of each bell crank lever 753 has an ear 755, engaged by a tooth 756 on the rear of its associated lever 502 when the sector 501 has not been moved past "0" position.

If a sector 501 and its lever 502 have moved past "0" position, as shown in full lines in Fig. 41, the bell crank lever 753 normally is free to rock clockwise through the action of its spring 757 (Fig. 20), tensioned between a rod 758, extending between the frame plates 202 and 203, and a hook on the leg 751. A double bail, consisting of rods 759 and 760 (see also Fig. 21), is supported by a left arm 761, mounted on a rod 762, and a corresponding right arm 766 (see also Fig. 8), also mounted on the rod 762, is rocked clockwise from the position shown in Fig. 21 at the end of the first half of a machine cycle, and counter-clockwise to normal during the first part of the second half of a machine cycle, by the roller 331, on the left drive sector plate 313, working in a cam slot 763 of the arm 761. The right arm 766 (Fig. 8), corresponding to the arm 761, is moved in unison with the arm 761 by a similar roller 367a on the right drive sector plate 311.

As the double bail member including the rods 759 and 760 (Fig. 20) is rocked clockwise, the bottom end of the rod 760 hits the shoulder of all those legs 751 which have been rocked counter-clockwise, by reason of the associated sector 501 having been moved past zero position (see also Fig. 42), and unhooks the associated latch 748 to allow the associated printing hammer to be projected toward the platen. On return movement of the drive sector plates, the triggered hammer bell crank levers 745 are moved to home position by the rod

759, to be related by the latches 748 as urged by the springs 747. When any of the legs 751 are in the position shown in Fig. 20, the rod 760 will miss the shoulder 764, and the associated printing hammers will remain latched in position. However, to insure the printing of zeros to the right of the leftmost significant digit, to make a complete printing of a multi-digit number, means is provided whereby the release of a printing hammer of a higher order causes release of the printing hammers of all the next lower orders, regardless of whether the corresponding sectors 501 are moved out of zero position. Attached to the right side of each hook member 748 is a plate 765, the edge view of which is seen in Fig. 23, each plate extending over the top of the extended pivot 750 of the latch hook of next lowest order, so that, as the latch 748, shown in Fig. 23, rocks to release its associated printing hammer, the next lower order latch also is rocked, and so on, to the lowest order.

Platen feed and manual non-print control

The platen feed is actuated by the drive sector plate 311 (Figs. 8 and 9) through the stud 367a riding in the bifurcated end of the right support arm 766 of the printing bail. The arm 766, pivoted on the bar 749, is thus rocked counter-clockwise near the end of the first half cycle of a machine operation, and clockwise during the first part of the second half cycle of a machine operation. A stud 768 on the arm 766 is engaged in the bifurcated end of a lever 769, secured on a sleeve 770, mounted on a stud 771, secured in the frame 202. Secured on the outer end of the sleeve 770 is a lever 772, on the outer end of which is loosely mounted a feed pawl 773, having a tooth 774, adapted to cooperate with a ratchet wheel 775, secured on the platen shaft 246, on which the platen 247 is mounted. The feed pawl normally is held in the position shown in Fig. 8, with its downwardly and forwardly extending arm resting against the sleeve 770 under the urge of a spring 777, tensioned between the lever 772 and the pawl 773. As the arm 766 rocks clockwise and counter-clockwise, the pawl 773 is given a feeding movement to advance the platen rotatively a step. A non-print manual lever 778 is pivoted to a stud 779 in the plate 207 (see also Fig. 3) and is shown in Fig. 8 in print position, where it is retained by a spring 780, secured on the lever 778 and bearing against a limit stud 781. By rocking the lever 778 counter-clockwise, so that the limit stud 781 is in the rear of a slot 782 in said lever, a link 783, pivoted to the bottom of the lever 778 and to the top of a lever 784, is moved rearwardly. The link 783 is pivoted to the top of the lever 784, secured to a hub 785, pivoted on a stud 795. As the manual lever 778 is rocked to non-print position, the link 783 is shifted to the right, as seen in Fig. 8, bringing a surface 793 under a stud 794 to render the feed pawl 773 inoperative. Secured on the hub 785 is another lever 786, having a bifurcated end engaging a stud 787, secured in a bracket 788 of a comb 789, having a yoke 790 and teeth 791. The comb 789 is wound around a supporting rod 792, extending between and supported by the frame plates 202 and 203 (see Fig. 3). The comb 789 extends behind all of the bell crank levers 753, and movement of the bell crank levers 753 to the full-line position shown in Fig. 8 causes their upwardly-extending arms to enter the spaces between the teeth of the comb. But, if the lever 778 is rocked counter-clockwise to non-print position, the comb, through the linkage 783, 784, and 786, will be rocked counter-clockwise until the yoke 790 strikes the upstanding arms of the levers 753, preventing them from rocking to print position even though their associated sectors 501 and levers 502 have moved from zero position. Thus, printing is prevented as long as the lever 778 is in the non-print position. Therefore, operation of the non-print lever 778 to non-print position will also disable the platen feed mechanism.

Ink ribbon shift, feed, and reverse mechanism

A left ribbon guide, consisting of plates 800 and 801 (Fig. 11), and a right ribbon guide, consisting of plates 802 and 803, are mounted for up-and-down movement on studs 804, 805, 806, and 807, mounted on the rear side of the frame plates 205 and 206 (see Fig. 3), extending upwardly from the horizontal plate 204. On the outer beveled corners of the plates 800 and 802 are ribbon brackets 808 and 809. The ribbon 810 slides between the guides and the brackets and is wound on spools 829 and 830 (Fig. 15), mounted on collars 826 and 827 within the ribbon spool guards 209 and 210 (Fig. 3).

To shift the ribbon on total and sub-total operations from a black lane to a red lane, which runs along the lower half of the ribbon, there is provided a shaft 811 (Figs. 11 and 12) journaled in the frame plates 202 and 203 and having two lifting fingers 812 and 813 extending through holes in the plates 205 and 206 and engaging in holes in the pairs of plates 800 and 801, and 802 and 803. Pivoted to the finger 813 is a link 815, having a hook 816, normally held from engagement with a stud 817 on the lever 578, which is rocked clockwise and back each machine operation, as was described in connection with Fig. 55.

When the total slide 585 is moved to the left in total taking and sub-total taking operations, the hook 816 latches on to the stud 817, the tail 818 of the slide 585 being engaged in a slot 819. In the ensuing machine operation, the fingers 812 and 813 are rocked counter-clockwise, as seen in Fig. 10, to shift the ribbon so that the lower lane is presented at the printing station.

An additional function of the ribbon-shifting mechanism is to hold the transfer levers from moving during a total or sub-total taking operation, and this is accomplished by having a forwardly-projecting finger on the shaft 811 bear down on an ear 821 on a yoke 822 secured to a shaft 823 journaled in the plates 202 and 203. For each denominational order there is secured to the shaft 823 a latch pawl 824, which, when the shaft 823 is rocked clockwise by a hook 816, will catch under the end 825a of its associated transfer lever to keep it from moving. The tooth projections 613 and 614 (see also Fig. 50) on the transfer levers will then stop the totalizer wheels at zero during total or sub-total taking operations.

Extending through aligned holes in the upper rear of the plates 202 and 203, and through coaxial holes in the ribbon guards 209 and 210 (Fig. 3), is a spindle 825 (Figs. 12, 13, 14, and 15), on which is a left bushing, on which the ribbon spool collar 826 is secured, and a similar right bushing, to which the ribbon spool collar 827 is secured. Secured to a bushing 828 is a ratchet wheel 831 for driving the left ribbon spool, and secured to a bushing 832, pinned to the spindle 825, is a ratchet wheel 833 for driving the right ribbon spool. Free on the bushings 828 and 832 are depending arms 834 and 835, respectively, which are secured together in spaced relationship and at different points along their lengths by space pins 836, 837, and 838.

On the pin 837 is freely mounted, in spaced relationship, a pair of depending arms 839 and 840, having lateral lugs which are stepped inwardly to come together as one, and to which one end of the spring 841 is anchored. A pin 842 is secured between the interior ends of the arms and has its end projecting beyond the arm 839 to support a roller 843. This roller engages in a cam slot 844 in a cam plate 845 secured on the end of the main shaft 312. Also on the pin 837, between the arms 839 and 840, is freely mounted a unitary assembly of three tooth wheels, the middle wheel, 846, being a regular toothed ratchet wheel, whereas the two outside wheels, 847 and 848, each have alternate deep notches and shallow notched teeth, the wheels being secured in the assembly relatively to one another so that the shallow notched teeth in one outside wheel coincide with the deep notches of the other. The

regular ratchet wheel 846 is engaged by the nose of a ratchet pawl 849, freely mounted on the pin 842 and maintained located at the middle thereof by spacing washers. The other end of the spring 841 is secured into a projecting lobe of the pawl, whereby the nose of the latter is maintained in engagement with the wheel 846.

On the pin 836 are mounted two pawls, 850 and 851, these pawls being suitably spaced by washers, so that the former is located to cooperate with the ratchet wheel 831 and the latter with the ratchet wheel 833. These pawls have tail pieces, respectively, adapted to engage the wheels 847 and 848.

The engagement of the pawls with respect to the ratchet wheels is urged by means of springs, such as the spring 852, tensioned between lobes of the pawls and the pin 838.

It is to be seen from Fig. 13 that the tail of the pawl 850 is engaging within a tooth of the wheel 847, so that the nose of the pawl is tilted out of engagement with the ratchet wheel 831. On the contrary, the tail of the pawl 851 will be engaging a deep notch of the wheel 848, so that its nose is permitted to engage its associated ratchet wheel 833.

A pair of slides 853 and 854 is located between the ratchet wheels 831 and 833, the spindle 825 passing through longitudinal apertures in the slides, so that the latter are slidable with respect to one another. The slide 853 at its inferior end is pivoted to the lobe of the pawl 850, and, similarly, the inferior end of the slide 854 is pivoted to the lobe of the pawl 851. The ends of the spring, such as the spring 852, are anchored over projecting ends of the pivot studs. The upper ends of the slides 853 and 854 have pins 855 and 856, respectively, projecting therefrom, which underlie the operative ends of back-stroke pawls 857 and 858, pivoted on a pin 859, secured in the side frame 203, and which are urged to engage their ratchet wheels by means of springs 860 and 861, secured between them and a pin 862, projecting from the frame 203.

As the slides 853 and 854 are connected to the lobes of the pawls 850 and 851, respectively, they will occupy an upper position or a lower position, depending on whether the tails of the pawls engage a shallow tooth or a deep tooth of the wheels 847 and 848. When a slide occupies the upper position, the pin at its upper end lifts the back stop pawl out of engagement with the ratchet wheel, and, when the slide is lowered, it releases the pawl to engage its ratchet wheel.

In Fig. 13, the slide 853 is shown in the elevated position, wherein its pin 855 holds the pawl 857 out of engagement with the wheel 831. At the same time, the slide 854 will be in its lower position, wherein the pawl 858 will be permitted to engage the ratchet wheel 833. Also, it will be noted that the back stop pawl, together with the associated ratchet pawl, is disengaged at the same time the ratchet wheel associated therewith is entirely unconstrained.

Assume that the various components are in the positions indicated in Figs. 12 and 13. During the machine operation, the main shaft 312 makes a clockwise movement through approximately 90 degrees and carries the cam plate 845 therewith. Through the roller 843 on the pin 842, the lower ends of the arms 839 and 840, and therefore the pawl 849, are forced to move toward the right. If the ribbon is freely movable, the load imposed from the ribbon toward the ratchet wheel 846 is less than the tension applied to the pawl 849 by the spring 841, so that, in effect, the pawl is locked to the ratchet wheel. In this event, therefore, the arms 839 and 840, through the pawl 849 and the ratchet wheel 846, become locked with the arms 834 and 835, so that the lower ends of the latter move toward the right, whereby they execute a counter-clockwise movement about the spindle 825, as seen in Figs. 12 and 13. The pin 836 and, therefore, the pawls 850 and 851 are thus caused to make a similar

movement, which is transmitted through the pawl 851 to the ratchet wheel 833. The latter, through the bushing 832, rotates the spindle 825 and, therefore, the right ribbon spool 830. The left ribbon spool is completely free to rotate, as the ratchet wheel 831 is not restrained by either of its pawls 850 or 857.

The end of the ribbon is secured to the hub of its spool, so that, when the ribbon becomes exhausted from the spool, it will hold the spool immovable, which, in turn, will prevent movement of the ratchet wheel 833, which will lock the pawl 851 and the arms 834 and 835.

Thus, as the system just described is immovable, on the next operation of the machine the arms 839 and 840 are forced to follow the cam plate 845 and thereby rotate counter-clockwise about the pin 836, carrying with them the pawl 849, which ratchets over and engages the next tooth of the wheel 846. On the return movement of the cam plate 845, the arms 839 and 840 and the pawl 849 are restored, and the latter rotates the wheel 846 by one step. The wheel 846, being fast with the wheels 847 and 848, causes the latter to take one step, whereby the tails of the pawls 850 and 851, which previously engaged in deep notches and shallow notched teeth of the wheels, respectively, ratchet into shallow notched teeth and deep notches. Thus, the pawl 851 is disengaged from its ratchet wheel 833, and the slide 854 is moved upwardly to disengage the back stop pawl 858 so that the wheel 833 is completely released for free rotation. On the tail of the pawl 850, moving into a deep notch, the pawl rotates about the pin 836 to engage its ratchet wheel 831, and, at the same time, the slide 853 is lowered to permit the back stop pawl 857 to engage the wheel. Thus, the wheel 833 and the spool 830 are rendered free to rotate, whereas the wheel 831 and the spool 829 have become coupled to the ribbon-stepping mechanism. Thus, on the next operation of the machine, the ribbon will be fed in a reverse direction to that previously obtaining.

Multiplication

The machine is equipped to multiply factors which will give a product of eleven digits. Multiplication is carried out by successive addition of the multiplicand into the totalizer under control of the multiplier storage unit in the bottom of the machine. Under the digit keyboard is a mechanism in which the amount of the multiplier is set by use of the digit keys as it is being set up for printing. The multiplicand is set into the differential-controlling pin carriage and is thereafter printed, and the machine is thereafter controlled automatically until the product is entered by successive additions into the totalizer.

As before mentioned in connection with the general explanation of the functions of the machine, the depression of the multiplier key 278 (Figs. 74 and 76) causes the shift of an auxiliary interponent or blind keyboard to a position of alinement with the digit key stems beneath the main digit keyboard unit. This auxiliary keyboard is illustrated in plan view, partly broken away, in Fig. 65. When the key 278 is operated by being depressed, it stays in such position until the multiplicand bar 227 is depressed, and the auxiliary keyboard assembly is locked in alined position with the digit key stems during that time. The depression of the digit keys in accordance with the multiplier factor causes a similar operation of the key-operated levers of the auxiliary keyboard, which in turn control the setting of the multiplier factor into the multiplier storage unit, which is located beneath the auxiliary keyboard. The multiplier factor is set up in the differential-controlling pin carriage by the same digit key action. The motor bar is then depressed to cycle the machine, whereby the differential mechanisms are operated to set the type bars and print the factor on the tally roll, the amount, however, being prevented from entering into the totalizer by the conditioning of the non-add mechanism, as has been explained.

When the multiplier entry has been effected, the multiplicand bar 227 is depressed, which causes the elevation of the multiplier key 278 and the restoration of the auxiliary keyboard, in preparation for the entry of the multiplicand factor of the calculation.

The stem of the bar 227 passes through the top plate 221 (Figs. 74 and 76) and at its inferior end is pivotally connected at 418 to the lever 416, which at its rear end, or right-hand end (Fig. 74), is pivoted on the stud 874, secured in the frame plate 216. The lever 416, adjacent to the key stem, takes an upward bend to lie adjacent to the key stem and is then bent forwardly to form a projecting finger 416a. This finger overlies the end of a horizontal arm of a bell crank lever 417, which, at the angle thereof, is pivoted on a stud in a right-angled bracket 875, secured by its horizontal limb to the under side of the plate 221.

The auxiliary keyboard is carried in a framework consisting of two side plates 876 and 877 (Figs. 64 and 76), which are secured together in spaced relationship at their front ends by a rod 878 and plates 879 and 880, and at their rear ends by a rod 881, shown in Fig. 2a. The rod 878 and the plates 879 and 880 serve other support purposes, as will be described elsewhere. To the exterior side of the plate 877 are secured two spaced pins 882 and 883 (Fig. 65), and a similar pair of pins, 884 and 885, are secured to the plate 876.

In general, the multiplying mechanism contained in the base is supported from two side plates 886 and 887 (Fig. 76), which are secured by brackets in the machine base.

To the front end of the plate 886, through the medium of two spacing rods, only one of which is shown at 888, is secured an auxiliary plate 889, and a corresponding plate 890 is similarly secured to the plate 887 by a rod 891.

The auxiliary keyboard is located between the two plates 889 and 890, which are spaced apart a distance greater than the width of the auxiliary keyboard framework by an amount equal to the movement of the keyboard from its normal position, shown in Figs. 65 and 76, to its position of alinement with the main digit keyboard, which is to the right. Each of the plates 889 and 890 has a pair of hollow bushings, indicated at 892, 893, 894, and 895a, secured therein, the centers of which bushings correspond to the centers of the pins 884, 885, 883, and 882, so that said pins register with and are slidable in said bushings. A spring 895 (Fig. 76) is tensioned between the plate 876 and the plate 886, the spring passing through a clearance aperture in the plate 889 (see Fig. 75), whereby the auxiliary keyboard assembly is normally maintained in a leftward position with respect to the digit keyboard.

Attached to the front ends of the plates 876 and 877 are arms 896 and 897 (Fig. 76), which extend upwardly to corresponding apertures 898 and 899 in the base. Bridging the two arms 896 and 897, and secured thereto by screws, is a bar 900, which is thus located in front of the lower part of the digit keyboard unit.

At approximately the middle of the bar 900 is pivoted a latch piece 901, which, on one side of the pivot, has therein a bifurcation 902, which engages a stud 903, secured in the bar 900, the bifurcation being sufficiently wide to allow a limited lifting of the right end of the latch piece. The right end of the latch piece has therein a notch, which is adapted to engage a stop plate 904, secured to the base, thereby to maintain the auxiliary keyboard assembly in its leftward, ineffective, position, as shown in Fig. 76, where it is out of alinement with the digit keyboard. A spring 905, anchored between the shank of a stud 906 projecting from the latch piece 901 and a lug of the bar 900, exerts a clockwise tension on the latch, tending to maintain the notch in the latter in engagement with the stop plate 904, thus normally to lock the auxiliary keyboard assembly against movement

toward the right. The depending arm of the bell crank lever 417 cooperates with the stud 906 projecting forward from the latch piece 901.

On a lug projecting from the top edge of the bar 900 is pivoted a further latch piece 907, to which a clockwise tension is applied by a spring 908, secured between the tail of the latch and the bar 900.

Projecting leftwardly from the plate 216 is a pin 909, on which is pivoted an integral assembly, consisting of two bushings 910 and 911, between which is clamped a latch plate 912 (see also Fig. 74) and at the end of which, on the pin 909, is secured the bell crank lever 699. The forward end of the latch plate 912 overlies and cooperates with the notched left end of the horizontal arm of the latch piece 907. The upper arm of the bell crank lever 699 carries the stud 698, which underlies the forward end of the lever 695, to which the multiplicand bar 227 is secured and which is pivoted at its other end to the plate 220. The lower arm of the bell crank lever 699 has pivotally attached thereto the link 701 (Figs. 74 and 76), which will be referred to in operative detail in connection with Fig. 91. A spring 917 (Fig. 74) is tensioned between the lower arm of the bell crank lever 699 and a stud in the plate 220, which spring, therefore, applies counter-clockwise tension to the bell crank lever 699 and also to the latch plate 912, the latter thereby being caused to bear down on the end of the latch piece 907.

When the multiplier key 278 is depressed, it causes the front projecting finger of the lever 416 to depress the end of the horizontal arm of the bell crank lever 417, causing the latter to rotate counter-clockwise (Fig. 76) about its pivot. The end of the depending arm of the bell crank lever 417 thus moves to the right and, through its cooperation with the stud 906, causes the latch piece 901 to rotate about its pivot to cause the notch in its nose to disengage the stop plate 904. Immediately following this disengagement, the upper edge of the bifurcation 902 therein contacts the stud 903, whereby, in effect, the latch piece 901 becomes solid with the bar 900 and, therefore, with the auxiliary keyboard assembly, whereby further movement of the bell crank lever 417 causes the said assembly to move to the right (Fig. 76) against the tension of the spring 895. When the auxiliary keyboard assembly reaches the position of alinement beneath the digit keyboard unit, the notch in the nose of the latch piece 907, under the urgency of the spring 908, is caused to engage behind the latch plate 912, thereby locking the auxiliary keyboard assembly in its rightward, effective, position. The mechanism is now ready to have the multiplier set up on the digit keys, which, through the auxiliary keyboard, transfers it to the multiplier storage unit pin carriage. The machine is then cycled to print the multiplier under non-add conditions set up by the key 278, as before explained. The multiplicand bar 227 is now depressed, which, apart from operating the link 701 for purposes to be described in connection with Fig. 91, causes the bell crank lever 699 and, therefore, the latch plate 912, to rotate clockwise (Fig. 74). The latter disengages itself from the latch piece 907, and the whole of the auxiliary keyboard assembly, which thus becomes unrestrained, returns to its normal position under the urgency of the spring 895. This latter movement restores the bell crank lever 417 and, therefore, the lever 416 and the key 278.

Mounted in the framework, sliding from ineffective position to effective position in the bushings 892, 893, 894, and 895a and in the plates 889 and 890 (see Fig. 65), are a series of nine levers, 922, 923, 924, 925, 926, 927, 928, 929, and 930, pivoted on the rod 878 (see also Fig. 2a), each having an ear, like the ear 931, for the lever 927 (Fig. 2a), playing in a slot in the plate 879, and an ear, like the ear 932, playing in a slot in the plate 880. Taking the lever 927 as an example, because it shows in both Figs. 2a and 65, the rearwardly-extending portion has a portion 933 (seen in Fig. 65),

to which is attached a plate 934, having an extension 935, which is under the end of the stem 936 of the "1" representing digit key when said framework is moved by the multiplier key 278 to effective position. The outer end of the plate 934 is bent down and narrowed to form an auxiliary key stem 937 (seen best in Fig. 2a), which enters a guide slot in a guide plate 938, supported on cross members held by the side plates 876 and 877. The other levers, 922 to 926 and 928 to 930, are arranged with various conformations and plates, the digit values being shown in circles in Fig. 65, so as to be positioned under the keys "2" to "9", the corresponding dependent auxiliary key stems being arranged in guide slots in the guide plate 938 (Fig. 2a), the guide slots being arranged along the center of the guide plate in a line which is the setting-up station for the auxiliary pin carriage, to be described. The levers 922 to 930 and associated auxiliary key stems each are kept in "up" position, as determined by the slots in the plates 879 and 880, by an individual spring, such as the spring 939 (Fig. 2a) serving the arm 927, and as determined by rails 940 and 941 on the guide plate 938 (Fig. 68). In Fig. 68, the left-hand side of the mechanism is to the top of the sheet, and the top of the mechanism is to the right of the sheet, as indicated by the "1" digit key stem 936.

The auxiliary pin carriage and associated multiplier storage unit mechanism is mounted for sliding movement, horizontally crosswise in the machine, on two rods 942 and 943 (Figs. 2a, 65, and 66) supported in bushings in the plates 889 and 890 (Fig. 65). The pin carriage and storage unit has vertical side plates 944 and 945, held spaced apart by bolts 946 and 947 (Fig. 66), by a sleeve 948, and by retention nuts 949, 950, 951, and 952. Fastened to the interior sides of the plates 944 and 945 are pin carriage support plates 953 and 954, across which are secured an upper slotted guide plate 955 and a lower slotted guide plate 956 (Fig. 2a), the slots in the lower guide plate being in vertical alinement with those in the upper guide plate, and the slots forming seven denominational rows of eight pairs of alined slots each.

A pin 957, for the denominational order of pins shown in Fig. 2a, represents the digit "1," and a pin 958 represents the digit "8." There is no need for a "0" or a "9" pin in the multiplier storage unit, as will be seen. The pins have a normal "up" position, shown in Fig. 2a, where they are spring-retained by springs, like the spring 959, cooperating with a formation on the associated pin. The pins may be moved downwardly when in the pin-setting station by the pin-setting levers 922 to 930, operated by the digit keys. Normally, the pin carriage is in the position shown in Fig. 65, and, if the multiplier key 278 is operated, the auxiliary key stems will be brought directly over the left-hand denominational row of pins in the auxiliary pin carriage. In so doing, a cam formation 960 (Figs. 65 and 67) on a plate 961, pivotally mounted between the plates 876 and 877, is brought under the extended bottom 962 (Fig. 2a) of the rod 358 (see also Figs. 30 and 88), which is moved rearwardly each time a digit key is operated. Referring to Fig. 67, the auxiliary pin carriage and multiplier storage unit is constantly urged to the left by a spring 962a but is normally held in its rightmost position, shown, by a pawl 963 of an escapement mechanism pivoted on a stud 964 secured in a bracket 965 on the plate 889. The pawl 963 is urged to its effective restraining position by a spring 966. A companion escapement pawl 967, also pivoted on the stud 964, has a stud 968, which bears on the upper edge of an arm of the pawl 963. The two pawls 963 and 967 cooperate with pins 969 on a plate 970, secured to the rear ends of the plates 944 and 945. The pins 969 are spaced at denominational row intervals, so that the oscillation of the pawls 963 and 967 first counter-clockwise and then clockwise, as seen in Fig. 67, will cause the auxiliary pin carriage and multiplier

storage unit to move one step in the direction of the arrow, as seen in Fig. 67, to bring the second row of pins to the pin-setting station. The rocking of the plate 961, by the extension 962 moving over the cam formation 960, on operation of a digit key, is transmitted to the escapement pawls by a finger 971 striking the top edge of the pawl 967 when the auxiliary keyboard is shifted to multiplying position. By this mechanism, the pin carriage is carried step by step past the multiplier factor setting-up station.

The multiplier storage unit consists of seven denominational-representing steel bands 980 (Figs. 2a, 66, and 68), each stretched lengthwise beneath the associated denominational row of pins in the auxiliary pin carriage, the ends of each band being wound, like a scroll, on a pair of drums, to be described. Each steel band is provided with a stop stud 981 (Fig. 2a), normally standing in zero position, as shown in Figs. 2a and 66, and adapted, as it moves rearwardly, to strike a depressed pin, thereby to stop the band, which stores, by its position, the associated digit of the set-up multiplier factor. The forward end of each band is wrapped around an associated drum 982, secured to a saw-toothed ratchet wheel 987 mounted on a bushing rotatable on the rod 943. The mechanism of only one denominational order will be described. The rear end of each band is secured to an associated take-up drum 983, rotatable on bushings on the rod 942. Each drum 983 is constantly urged counter-clockwise, as seen in Fig. 2a, by a coil spring 984, secured to a stationary cup 985 (see especially Fig. 66), secured through bushings to the rod 942.

Referring to Fig. 2a, each drum has a zero-representing formation 986, which moves away from the shown zero position as the associated band is wound on the drum 983. A spring-urged pawl 988 is provided for each ratchet wheel 987 normally to hold it in zero position. The pawls 988 are mounted on the cross rod 946, and each is provided with a spring 989, connecting it to an ear of an associated latch 990, pivoted on the cross rod 947. Each of the pawls has a tail 999, which, if pushed down, rocks the associated pawl 988 out of engagement with the toothed ratchet wheel 987, allowing the rear drum to wind up the associated band until the stop stud 981 strikes a depressed auxiliary pin, or until the stop stud reaches the end of the run in the associated slot in a guide plate 991. There is a slot 992 in the guide plate 991 for the stop stud of each band 980 (Fig. 68), and the bands run under the guide plate, with the stop stud of a band projecting up through the associated slot. Each of the slots represents a run from "0" to "9" in digital value, the home position being with a stud in the front end of the associated slot in the "0" position. The rear end of the slot represents the "9" position, and the intermediate digit positions are represented by the auxiliary pins "1" to "8" of a denominational order.

Referring to Figs. 2a and 65, there is slidably mounted in the plates 879 and 880 a trip member 995, having secured thereto a bracket 996, having a pivot 994, to which is pivoted the front end of a universal bar 993, which is pivoted at its rear end at 997 to a plate 998, joining the plates 876 and 877. A spring, not shown, holds the trip member 995 in its "up" position under normal conditions. The intermediate portion of the universal bar runs immediately to the left of the auxiliary key stems. Whenever one of the levers 922 to 930 is operated, it bears down on the universal bar, rocking it so as to lower the trip member 995, which strikes the tail 999 of the pawl 988 associated with that denominational order of the auxiliary pin carriage and multiplier unit then at the setting station. As soon as the pawl 988 is rocked to ineffective position, the nose of its associated latch 990 rises behind it in response to its spring 989 and holds the pawl ineffective. Meanwhile, the associated band is wound up on its rear drum 983 until the stop stud strikes a pin in the

auxiliary pin carriage or the end of its guide slot to represent "9."

It should now be obvious how the multiplier factor is set up on the machine. Suppose the multiplier to be "607." First, the multiplier key 278 is operated, which moves the auxiliary keyboard to the right to effective position, where the auxiliary key stems are in line with the pin-setting station. Through the mechanism shown in Fig. 64, the non-add mechanism is set in effective position, as has been explained. The operator now depresses the "6" digit key, which sets a "6" in the differential-controlling pin carriage and sets the first, or leftmost, band in the multiplier storage unit to the "6" position. The downward movement of the digit key has caused the multiplier unit and pin carriage to move slightly to the left to where the pawl 967 (Fig. 67) has caught it. As the operator releases the "6" digit key, the auxiliary pin carriage and multiplier storage unit complete the movement of one denomination to the left. The operator then depresses the "0" key and releases it. A "0" pin is set in the second column of the differential-controlling pin carriage. As there is no "0" auxiliary key or pin, the universal bar 993 is not rocked, and the second band in the multiplier storage unit is left retained in home position. However, both the differential-controlling pin carriage and the auxiliary pin carriage in the multiplier storage unit move to the third denominational order, where the "7" is set up, just as the "6" was set up. The motor bar is now operated to cause "607" to be printed but non-added, while the multiplier factor remains stored for future use. The differential-controlling pin carriage has been cleared.

The multiplicand bar 227 now is depressed, which causes the auxiliary keyboard to return to ineffective position, as has been explained.

As the multiplicand factor must stay in the differential-controlling pin carriage during the entire process of multiplying, the pin carriage return mechanism is disabled as in repeat operations, there being a linkage, not shown, between the bell crank lever 699 (Fig. 71) and the link 490 (Fig. 6) whereby the movement of the bell crank lever 699 as the multiplicand bar 227 is depressed causes forward movement of the link 490 (Fig. 6), which is the same movement that it has when the repeat key 277 is depressed to disable the pin carriage return mechanism. Also, as has been explained in connection with Fig. 71, when the multiplicand bar 227 is operated, the shaft 705 is turned counter-clockwise. Referring to the exploded view (Fig. 87) of the shuttle mechanism and its drive, the shaft 705 has secured thereto a lever 1010, having a stud engaged in a bifurcated forwardly-extending arm of a bell crank lever 1011, mounted on a shaft 1012, having bearing in the plate 707 and an upward extension on an auxiliary plate 1013, secured to the plate 706 by a plate 1014 and a rod 1015. On the right side, there is a companion auxiliary plate 1016, secured to the plate 707 by a plate 1017 and a rod 1018. The shuttle proper includes a left member 1019 and a right member 1020, joined at the forward end by a rod 1021 and at the rear end by a rod 1022. The ends of the rod 1021 ride in slots 1023 and 1024 in the plates 1013 and 1016, respectively, and the ends of the rod 1022 ride in slots 1025 and 1026 in the plates 1013 and 1016, respectively, so that the shuttle can move back and forth as limited by said slots. Normally, the shuttle is in the rear position, shown.

Pivoted to the downwardly-extending arm of the bell crank lever 1011 is a slide 1027, having near its rear end a slot 1028 to afford passage of the rod 1022, and a bifurcated rear end riding a rod 1029, secured in the plates 1013 and 1016. When the shaft 705 is rocked counter-clockwise, as seen in Figs. 71 and 87, as the multiplicand bar 227 is depressed, the slide 1027 (Fig. 87) is drawn forward to condition the mechanism, next to be described, to cause entry operations of the machine to move the shuttle back and forth for each machine

operation until it is automatically stopped at the end of the multiplying operation.

Referring to Fig. 92, which includes mechanism at the rear of Fig. 87, there is a toothed wheel 1030 secured to the left end of the main drive shaft 312 (see Fig. 4 also), which drives the right and left drive sector plates 311 and 313, and which meshes with the toothed sector plate 1031, secured on a shaft 1032, which is journaled in downward extensions of the frame plates 202 and 203 (see also Fig. 3). A similar wheel and sector are driven by the right end of the shaft 312, as seen in Fig. 110. The shaft 1032 is rocked first clockwise (in the direction of the arrow in Fig. 92) in the first half of each machine cycle—that is, a machine cycle under control of the main clutch—and in the second half of this machine cycle is returned counter-clockwise to home position. This is so whether the operation is adding, subtracting, multiplying, or dividing. Pinned to the shaft 1032 are a tooth 1033 and a bifurcated lever 1034. Between the tooth 1033 and the lever 1034 are two cam plates 1035 and 1036, loosely mounted on the shaft 1032. The cam plate 1036 has a notch 1037, which straddles a stud 1038 (Fig. 87) in a link 1039, pivoted on the rod 1022 and having in its rear portion a slot which rides the rod 1029. When the plate 1036 is rocked around the shaft 1032, it drives the shuttle forward and backward. As the slide 1027 is moved forwardly by depression of the multiplicand bar 227, it is locked there by the hook 713 (Fig. 71) of the latch pawl 714, which has been cammed to effective position by a stud 1040 on a lever 1041, pivoted to the link 709. The lever 1041 is activated by a spring 1042, on the plate 710, before mentioned, so that, when the plate 710 rocks counter-clockwise, as seen in Fig. 71, the stud moves against the forward upper surface of the pawl 714, as indicated by the circle 1043. This latching of the slide 1027 in forward position persists until the pawl 714 is released at the end of the multiplying operation, as will be described.

Referring to Figs. 64 and 70, the forward end of the lever 1041 is adapted to bear down on a latching tooth 1187 on the link 301, as the plate 710 is rocked by the shaft 705, so that, when the motor bar is depressed, drawing the link 301 forward, the forward end of the lever 1041 will fall in back of the tooth 1187, holding the link 301 in its operated condition until the end of the multiplying operation, when the shaft 705 resumes its normal position.

As the slide 1027 (Fig. 92) moves forward, a stud 1044, extending leftwardly therefrom through a slot 1045 in a slide 1046, through a cam slot 1047 in a lever 1048, pivoted on a stud on the slide 1046, and through the bifurcated forward end of a beam 1049, pivoted on the rod 1029, rocks the forward end of the lever 1048 up and rocks the beam 1049 counter-clockwise, as seen in Fig. 92. Connecting the cam plates 1035 and 1036, and forming a frame rockable on the shaft 1032, is a rod 1050, having a lever 1051 pivoted on its right end, and its left end engaged in an arcuate slot 1052 in a lever 1053, pivoted on a cross rod 734 (see also Fig. 2). The cross rod 734 extends across the differential unit and has a companion lever to lever 1053 on its right end, which has been broken away so that it will not obstruct the perspective view in Fig. 92. The lever 1053 and its right companion support the rod 508, before mentioned in connection with Fig. 2 concerning the unlatching of pin control sectors 501 from the printer controlling levers 502. The clockwise rocking of the lever 1053 and its right companion, as seen in Fig. 92, will lock the printer bars against movement, as has been explained. A cam lever 1054 is pivotally mounted on a shaft 1055, extending between the frame plates, said lever 1054 having a hook 1056 engaging a shaft 1057 with some clearance, so that said lever 1054 may rock slightly clockwise as seen in Figs. 84 and 92. Said cam lever has a cam surface 1058, a downward extension 1059, and a left-

wardly-extending rod 1060, which passes through slots 1061 and 1062, in the plates 1036 and 1035, respectively, and through a slot 1063 in a drive link 1064, pivoted on a stud 1065, extending leftwardly from the plate 1035. The drive link 1064 has an opening 1066, adapted to be engaged by the tooth 1033. Extending leftwardly from the rear end of the slide 1046 is a stud 1067, having pivoted thereto a pawl 1068, the forwardly-extending arm of which is held against a stop stud 1069, secured in the beam 1049, by a spring 1070, anchored to a stud 1071, supported by the slide 1046.

The movements of the shaft 1032, the lever 1051, and the tooth 1033 are without effect unless the slide 1027 is drawn forward, causing the stud 1044 to ride forward in the slot 1047 in the lever 1048, raising its forward end, so that a shoulder 1072 thereof is in the path of movement of the end of the lever 1051. The stud 1044, riding forward in the bifurcation 1073 of the beam 1049, rocks it counter-clockwise, releasing the pawl 1068 to the action of the spring 1070, so that the forward end of the pawl strikes the bottom edge of the extension 1059.

The stud 1044 is raised off the top edge of the cam lever 1054, so that it may be rocked clockwise slightly, as will be explained. As the multiplicand is set up on the digit keys after the multiplicand bar 227 is operated, and the motor bar is next operated, the machine goes through a preliminary cycle of operation, in which the multiplicand is printed but not entered into the totalizer because the non-add mechanism, latched in effective position by the latch 687 (Fig. 64), as has been described, has not been released yet.

Returning to Fig. 92, on the first half of the preliminary cycle in which the multiplicand is printed, the end of the lever 1051 makes contact with the shoulder 1072 of the lever 1048 and pushes rearwardly on the assembly of the lever 1048 and the slide 1046 against the return action of a spring 1074 (Fig. 87), tensioned between the slide 1046 and a stud in the plate 1016. One of the functions of movement of the slide 1046, as will be explained, is to test for the possible zero condition of the particular denomination of the multiplier storage unit which is in controlling position at the moment. The pawl 1068 (Fig. 92) also is drawn rearwardly and rocks on the stud 1067 in response to the urge of the spring 1070, so that the forward end 1075 is behind the rear vertical edge of the extension 1059 of the cam lever 1054. The tooth 1033 is rocked counter-clockwise without effect. Now, on the second half of the preliminary cycle, the assembly of the slide 1046, the lever 1048, and the pawl 1068 moves forward, under the urge of the spring 1074, to home position. The pawl 1068 rocks the cam lever 1054 clockwise, which moves the rod 1060 from the radial portions of the slots 1061 and 1062 to the arcuate portions, and the drive link 1064 is rocked so that the tooth 1033 is engaged with the opening 1066 therein. This condition of affairs persists until the latch 714 (Fig. 91) is rocked counter-clockwise to ineffective position by the drum carriage of the multiplier storage unit as it is returned to initial position at the end of a multiplying operation, a portion of the drum unit striking a conical surface on a stud 1076 secured in the latch 714, rocking it counter-clockwise, as seen in Fig. 91.

With this construction, on each machine cycle of a multiplying operation, the shuttle, consisting of the members 1019 and 1020 (Fig. 87), the rods 1021 and 1022, and a toothed pawl 1077, is driven forward, which is to the left, as seen in Fig. 87, and returned. The pawl 1077 has a slot, through which the rod 1021 passes for support. The rear end of the pawl 1077 is held in contact with a stud 1078 secured to the member 1020 by a spring 1079, the forward end of which is secured to a stud 1080, also secured in the member 1020. The pawl 1077, at the commencement of the multiplying

operation, is in line with the ratchet wheel 987 (Fig. 2a) of the drum representing the lowest digit of the stored multiplier factor and will move the drum 982 reversely unless the multiplier digit is zero, in which event auxiliary mechanism, not involving the main shaft 312 in the differential mechanism, is brought into action, as will be described.

If the multiplier digit is not at "0," the multiplicand is entered into the totalizer once for each step of reverse movement of the particular drum in controlling position. As the band reaches its zero position on reverse movement, the auxiliary drive mechanism comes into play, moving the multiplier storage unit one further denomination toward home position. On each denominational movement of the multiplier storage unit toward home position, a "0" must be entered into the differential-controlling pin carriage to increase the multiplicand entry by a factor of 10, for the ensuing machine cycles in the next stage of the multiplying operation. In other words, as the multiplier storage unit advances one denomination to the right, the differential-controlling pin carriage is moved one denomination to the left.

The lower front edge of the pawl 1077 (Fig. 2a), as it advances, rides up on an ear 1079b of the latch 990, rocking it into ineffective position, so that the pawl 988 again becomes effective in response to the urge of the spring 989. The pawl 988 thus remains effective during the reverse movement of the associated band, and will continue to remain effective until unlatched by a digit key as another multiplier factor is set up.

In order to explain this mechanism, it is desirable at this point to describe the multiple cycle and auxiliary drive mechanism in connection with a sample problem in multiplying. It is to be assumed that the multiplicand factor is "647" and the multiplier factor is "103." The "103" factor is set up in the multiplier storage unit, and the "647" factor is set up in the differential-controlling pin carriage, in the described manner. The band of the multiplier unit representing the units digit "3" of the multiplier factor will be in line with the pawl 1077 of the shuttle mechanism. The motor bar is depressed, and the main machine drive mechanism, the operation of which has been explained with reference to Figs. 34 and 36, begins to function to perform a preliminary cycle, in which the multiplicand factor is printed but is non-added. Because the multiplicand bar had previously been operated, as explained with reference to Figs. 87, 91, and 92, the linkage 699, 701, 702, 703, 704, 705, 1010, 1011, and 1027 has been adjusted to multiplying position and will remain that way, as has been said, until the latch 714 (Figs. 71 and 91) is disabled at the end of the multiplying operation, as the multiplier storage unit is returned to home position. In the first half of the preliminary cycle, the lever 1051 (Fig. 87) moves lever 1048 (Figs. 87 and 92) and the slide 1046 rearwardly. The beam 1049 is rocked counter-clockwise, as seen in Fig. 92, releasing the pawl 1068, so that it can rise in back of the extension 1059, as before explained. On the last half of the machine cycle, the forward movement of the slide 1046 under the influence of the spring 1074, causes the cam lever 1054 (Fig. 92) to be rocked clockwise by the pawl 1068, bringing the rod 1060 forward into the arcuate portion of the slots 1061 and 1062, and throws the drive link 1064 toward the tooth 1033 to engage the opening 1066 at the end of the preliminary machine cycle. The amount of the multiplicand has been printed at mid-cycle but is non-added because the non-add mechanism of Fig. 64 is still latched in effective position by the latch 687.

Another important thing occurs during this preliminary cycle, and that is the sensing of the position of the drum 983 (Fig. 2a) to see if it is in "0" position, representing the lowest digit of the multiplier factor. In Fig. 2a, the particular band shown is in "0" position and not in the "3" position of the problem, with the stop formation

986 in the down position. If there were any digits stored in this denomination, the drum would have moved counter-clockwise one or more steps, up to nine steps, so that the stop formation would not be in a position to be sensed, as will be described. As the mechanism for sensing for a "0" in the preliminary cycle is closely interrelated with the mechanism for sensing the return of a drum to zero position, through the action of the pawl 1077, the construction of both will be explained at this point, before going on with the sample problem. Figure 87 is, as has been said, an exploded view with respect to the crosswise dimensions of the machine. Members 1017 and 1020 are close together, as are the elements between them. Secured to the slide 1046 by a stud 1079a is a slide 1080a, which has a bifurcated forward end, which rides the stud 1078, and a slot in its rear end, which slot engages a stud 1081, secured in the member 1020.

Pivoted on a stud 1082, secured in the slide 1080a, is a lever 1083, having a sensing tip 1084 and a stud 1085, which projects through an arcuate slot 1086 in the slide 1080a and normally rests in the forward end of a U-shaped slot 1087 in the member 1020, as shown in Fig. 87. The slide 1080a and the lever 1083 move with the slide 1046 on each cycle of operation of the machine during multiplying, including auxiliary cycles to be described, and the sensing tip 1084 will strike the stop formation 986 (Fig. 2a) if the drum of the particular denomination in control is at zero position. This will occur on the rearward movement of the slide 1046. If a zero is sensed, the lever 1083 will be rocked counter-clockwise, as viewed in Fig. 87, elevating the stud 1085, so that it will follow the upper leg of the slot 1087 and be in line with the nose 1088 of a member 1089 pivoted on a stud 1090, secured on a lever 1091, pivoted on a stud in the member 1019. Under such circumstances, as the slide 1046 is moved rearwardly, the lever 1091 will be rocked clockwise, which will rock a companion sensing lever 1092 clockwise. The lever 1092 is pivoted on the member 1019 and is articulated with the lever 1091. The rear end of the member 1089 has a slot 1093 embracing across rod 1094, extending between and supported by the members 1019 and 1020. A spring 1095 resiliently holds the member 1089 and the levers 1091 and 1092 in the position shown. As the member 1089 is pushed rearwardly, it is latched by a latch member 1096, pivoted on a cross rod 1097 extending in between and supported by the members 1019 and 1020. A spring 1098, extending between the downwardly-extending tail of the latch 1096 and a cross rod 1099, resiliently holds the latch in the position shown, with its upper edge against the rod 1094. The forward end of the latch 1096 has a tooth 1100 (see also Fig. 100), which normally rests behind a tooth 1101 on the member 1089. As the member 1089 is pushed rearwardly, the tooth 1100 rides over the tooth 1101, coming up in front of it to latch the member 1089 in moved position. The left end of the stud 1090 rocks a lever 1102, secured on the shaft 1012, counter-clockwise as the member 1089 is pushed rearwardly. This means that the shaft 1012 is held rocked counter-clockwise until the latch 1096 is rendered ineffective.

The release of the member 1089 is brought about by the rearward movement of a member 1103, pivoted on a lever 1104, which in turn is pivoted on the stud 1081. The member 1103 has a slot 1105, by which it rides the rod 1094. The member 1103 is resiliently held in the position shown by a spring 1106, extending between the lever 1104 and the cross rod 1099. Extending leftwardly from the member 1103 is a stud 1107, which rests on a sloping surface 1108 on the latch 1096. Rearward movement of the member 1103 will, therefore, rock the latch 1096 counter-clockwise to ineffective position, allowing the lever 1102 and the shaft 1012 to return to normal position under the influence of the spring 1095. The lever 1092 has a tip 1109, which normally is in the shown

position but which may be rocked counter-clockwise by the stop formation 986 (Fig. 2a) of a drum on the return portion of the shuttle excursion which has just brought the drum to zero position, in the forward portion of the shuttle excursion. Such counter-clockwise movement of the lever 1092, thus, will accomplish the same purpose of rocking the shaft 1012 as was accomplished by the stud 1085 striking the nose 1088 of the member 1089.

Thus, the lever 1083 is rocked on rearward movement of the slide 1046 during the first half of a preliminary cycle, if there is a zero in the denominational order drum in line with it. On an entry cycle, in which a drum is returned to zero by the shuttle mechanism, the lever 1092 is rocked on the return of the shuttle mechanism. If, on an excursion of the slide 1046, there is no zero in the drum, in line with the lever 1083, said lever will not be rocked, and the stud 1085 will move along the lower branch of the U-shaped slot 1087, holding the left end of the stud 1085 in line with the nose 1110 and causing the member 1103, riding the stud 1107, to move backward over the slope 1108 to release the member 1089, if at that time it is latched in moved position. The lever 1083 makes a sensing excursion in auxiliary cycles, also, as will be explained.

The presence of a zero in a denominational order of the multiplier storage unit demands that the multiplier storage unit be moved one denomination to the right, toward home position, to bring the next higher denominational order of the multiplier storage unit into control position. At the same time, the "0" must be entered into the differential-controlling pin carriage to increase the multiplicand by a power of ten. The rocking of the shaft 1012 causes these things to be brought about.

Considering, again, the proposed multiplication problem of "103" $\times$ "647," the drum and band representing "3," the unit digit of the multiplier factor, is in line with the shuttle mechanism. The operation is commenced by depression of the motor bar 224, which draws forward the resiliently connected links 301 and 301a (Fig. 70). The link 301 stays drawn forward until the latch 714 (Fig. 71) is moved to ineffective position at the end of the multiplying operation. It will be remembered in connected with the explanation of the non-add mechanism, shown in Fig. 64, that the stud 305 nudges the link 726 forward near the end of the first half cycle of an operation under control of the main clutch. Pivoted on the stud 723 is the lever 725, having its top pivoted to the pin 724 and a dependent finger located in front of the stud 693 (Figs. 64 and 70) on the link 301a. As the link 726 is nudged forward at half cycle, the lever 725 pushes the link 301a rearwardly, allowing a latch 1112, pivoted to the frame, to swing counter-clockwise under the influence of a spring 1113 to bring its toe 1114 in front of the slide plate 288a, to latch it in place until the end of the machine cycle, when the stud 305 will rock the latch 1112 clockwise to ineffective position.

Referring to Fig. 88, secured to the shaft 1012, which, as has been said, is rocked counter-clockwise when a zero is sensed, is a lever 1115, having pivoted thereto an upstanding link 1116, the other end of which is coupled to an extension link 1117 by a screw and a stud-in-fork arrangement. Riveted to the extension 1117 is a finger member 1118, having in its upper end a slot which engages a frame-supported stud 1119, so that the linkage has limited up-and-down movement. The slanting lower end of the finger 1118 normally bears down on a stud 1120 (Figs. 64, 70, and 72) on a latch pawl 1121 pivoted on the arm 719 (see Fig. 64) of the link 301, as the link 301 is pulled forward, leaving the rear end of the latch pawl raised, so that it is ineffective to engage a tooth 1121a on the link 301a (as seen in Fig. 72) as it is pushed rearwardly at mid-cycle. However, if the shaft 1012 has been rocked counter-clockwise, the finger 1118 rises out of effective position, and the pawl is rocked clockwise by a spring 1122 (Figs. 64 and 70), so as to be in front of

the tooth 1121a, keeping the link 301a in its rear position, preventing the main clutch, as shown in Fig. 70, from engaging at the end of the cycle. A stud 1123 (Fig. 88) is engaged by the bifurcated forward end of a lever 1124, pivoted to the forward end of a link 1125, having its forward end supported by means of a slot 1126, riding a frame-supported stud.

The rear end of the link 1125 is pivoted to the clutch block unit 1127 of an auxiliary drive clutch unit, which is a duplicate of the main drive clutch unit shown in Figs. 34 and 36, there being in common the drive shaft 280. The link 1125 normally is resiliently held in its rearmost position by a spring 1128. The stud 305 (Figs. 4 and 88), on the right drive sector plate 311, is in the position shown in Fig. 88 when the machine is at rest, bearing on an ear of a plate 1129, pivoted at 1130 on a bracket 1131, secured to the frame. A spring 1132 urges the plate 1129 counter-clockwise, and it will follow the stud 305 in the direction of the arrow as the machine is put into an entry operation. If, while the plate 1129 is away from home position, the lever 1124 is rocked clockwise, its rear end will lower and be in the return path of a stud 1133 on the plate 1129, as the stud 305 and the plate 1129 are returned home. When the stud 1133 strikes the end of the lever 1124, the link 1125 is forced forwardly to cause engagement of a clutch ring 1134 with a notched drive wheel 1135, and to close the switch of an auxiliary energizing circuit for the motor, which is in parallel with the energizing circuit associated with the main clutch switch. This auxiliary drive will keep operating until the end of its cycle, at which the link 1125 is returned to blocking position by its spring. As the main clutch and the auxiliary clutch are not running together, the main entry cycle may be running while one of the auxiliary cycles is running, as will be seen. Also, if the lever 1124 is not moved to home position by the shaft 1012, another auxiliary cycle will be started by the stud 305.

Pivoted to a frame plate 1144 (Fig. 88) is a bifurcated fork 1140, said fork embracing a stud 1141 on the auxiliary clutch ring 1134. The clutch ring 1134 makes one complete rotation in an auxiliary cycle, as was the case with the main clutch ring 284 of Fig. 34. The fork 1140, therefore, rocks counter-clockwise on the first half of an auxiliary cycle and back on the second half of the cycle. A stud 1142, on the fork 1140, rests in an upwardly-opening notch of a slide 1143, mounted by a stud-and-slot connection to the plate 1144 for forward and backward movement. The forward end of the slide 1143 is bifurcated and rides a stud shaft 1145 (see also Fig. 89) journaled in the frame plate 707. The right end of the stud shaft 1145 has secured to it an eight-tooth ratchet wheel 1146, adapted to be moved rotatively a distance equivalent to the distance between adjacent teeth in one auxiliary cycle by an advancing pawl 1147, pivoted to the slide 1143, as the slide moves forward and then back. The pawl 1147 is kept from rocking counter-clockwise from the position shown in Fig. 88 by a stud 1269, against which it is held by a spring 1269a. The stud 1269 is secured on a bell crank lever 1268, to be referred to in connection with Fig. 106. This ratchet pawl 1147 is rocked clockwise by the stud 1269 during auxiliary cycles of a division operation, as will be explained in connection with the section on division, to make it inoperative to turn the ratchet wheel 1146. On the left end of the shaft 1145 is pinned a four-toothed camming wheel 1148, adapted to cooperate with a roller 1149, pivoted on a vertical portion of a camming plate 1150, which has a horizontal portion of the cam slot 1151. The vertical portion of the cam plate 1150 is supported for sliding movement, forward and backward, on studs 1152 and 1153, and is resiliently held in its rearmost position by a spring 1154, as the roller 1149 rests in a low spot between teeth on the camming wheel 1148. On the forward movement of the slide 1143, the ratchet

wheel 1146 is moved counter-clockwise, one tooth, which moves the camming plate 1150 forward, the roller 1149 coming to rest on a high tooth of the camming wheel 1148. As seen in Fig. 89, there is a stud 1155 playing in the cam slot 1151 in the horizontal portion of the plate 1150. The stud 1155 extends downwardly from the base plate 1156 of a slide having vertical support plates 1157 and 1159 sliding on the shafts 705 and 1012. The base plate 1156 has on its forward edge (see especially Figs. 88 and 90) an upturned flange 1158, on which is pivoted a ratchet pawl 1160, urged by a spring 1161 toward the toothed edge of the plate 970 (see Fig. 67) secured to the rear end of the totalizer storage unit. Under normal conditions, the pawl 1160 is in the dotted-line position but is moved to the full-line position as the lug 1177 strikes it when the multiplier key is depressed and the auxiliary key carriage is moved to multiplying position (Figs. 65, 88, 89, and 90). As the camming plate 1150 moves forward, the base plate 1156 and its flange are pulled to the right a distance equal to and a little more than that between the adjacent denominational orders of the multiplier storage unit, the pawl 1160 becoming engaged with a tooth of the plate 970 as the leg 1176 leaves the lug 1177, carrying the multiplier storage unit with it to bring the next denominational drum unit into controlling position.

The escapement pawls 967 and 963 (Fig. 67) will bypass one of the pins 969 and will hold the storage unit against complete return movement as the pawl 1160 (Fig. 90) moves back to home position, which occurs during the first half of the next auxiliary slide as the slide 1143 (Fig. 88) is next moved forward, and the ratchet wheel 1146 is moved one step to permit the roller 1149 to move into a low spot on the camming wheel 1148.

During this first auxiliary cycle, in which the multiplier unit is moved homeward one step to bring the drum unit storing the next higher multiplier digit into controlling position, a "0" must be entered into the pin carriage controlling the differential, so as to increase the multiplicand by a factor of ten. Referring to Fig. 88, the "0" key rod 343, for setting the differential-controlling pin carriage (see for reference Fig. 16), is actuated by a lever 1162 secured on a frame-supported shaft 1163. The right end of the shaft 1163 has a lever 1164 secured to it, said lever having a stud 1165 in the line of movement of the upstanding forward end 1166 of a slide 1167 supported in slots in cross frame members 1017 and 1168 (Fig. 89) for forward and backward movement.

The slide 1167 has a flange 1169, to which is pivoted a cammable pawl plate 1170, having a cam slot 1171 and a pawl finger 1172, the rear end of which is notched, so that, if the plate 1170 is rotated clockwise, as seen in Fig. 89, it will engage an upwardly-extending finger 1173 of a slide 1174, supported for forward and backward movement, like the slide 1167. The frame member 707 provides outside lateral support for the slides 1167 and 1174. The rear end of the slide 1174 is held in contact with the forward bifurcated end of the camming plate 1150 by a spring 1176a, and the slide 1167 is held with its shoulder 1177 against the cross frame plate 1168 by a spring 1175 (Fig. 89). With the multiplier storage unit in home position, the forward movement of the slide 1174 will not be communicated to the slide 1167, and no "0" will be entered into the differential-controlling pin carriage during an auxiliary cycle. A sensing lever 1178 is provided, pivoted to a vertical post 1179 supported on a horizontal frame member 1180, and it is urged counter-clockwise, as seen in Fig. 89, by a spring 1181, while its movement is determined by the rear end resting on the rod 942, which moves with the multiplier storage unit (see also Fig. 65).

In the home position of the multiplier storage unit, the sensing lever 1178 is held in the position shown, and a pin 1182, riding in the slot 1171, holds the pawl plate

1170 in the position shown. However, if the multiplier unit has a number stored in it, it has moved to the left, causing the sensing lever 1178 to rotate counter-clockwise, which rocks the pawl plate 1170 clockwise far enough so that the end of the pawl finger 1172 gets in front of the finger 1173, so that, if, now, the camming plate 1150 is moved forward on the first auxiliary cycle, the slide 1167 will be moved forward with the slide 1174 and the pawl plate 1170. This means that a zero will be entered in the differential-controlling pin carriage in the first of any two auxiliary cycles caused by the sensing of a zero in the multiplier storage unit, except when such sensing occurs while the multiplier storage unit is in home position.

In each auxiliary cycle, the zero sensing unit, including a lever 1083 (Fig. 87) and the slides 1080a and 1046, is actuated by the rocking of the shaft 1057 (see also Fig. 92) in the following manner. Pinned to the right end of the shaft 1057 (Fig. 88) is a lever 1183, which has a stud riding in an upwardly-opening notch 1184 in the slide 1143. As the slide 1143 moves forward and back, the shaft 1057 is rocked first counter-clockwise and then clockwise to home position. The shaft 1057 is journaled in the frame plates 706 and 707 (Fig. 87) and has secured at its midportion a finger 1185 (see Fig. 101), which engages the front edge of a stud 1186 on the slide 1046. It will be obvious, then, that on the first half of each auxiliary cycle the lever 1083 (Fig. 87) will be given a sensing excursion, as the slides 1046 and 1080a are drawn rearwardly.

It is now time to consider the actual proposed multiplying problem of "103" × "64." After the factors are entered into the machine, as has been explained, the motor bar is depressed, initiating the multiplication cycles. The operation of the multiplicand bar 227 has turned the shaft 705 (Fig. 87) to condition the shuttle mechanism for operation each cycle of operation under control of the main clutch. This shaft 705 is held in multiplying position by the latch 714, as has been explained, until the end of the multiplying operation. The plate 710 (Fig. 71) has rocked to multiplying position, preparing for the return of the non-add mechanism in the preliminary multiplying cycle, conditioning the lever 1041 to latch the link 301 in operated condition when the motor bar is depressed. The operation of the motor bar draws forward the link 301, which is automatically latched in forward position, by the lever 1041, until the end of the multiplying operation. This draws forward the link 301a, resiliently coupled to the link 301, releasing the main operating clutch, which causes the preliminary machine cycle, in which the number "647" is printed but non-added. The differential-controlling pin carriage return has been disabled, so that the number "647" is retained in said pin carriage. The sensing lever 1083 has made a sensing excursion, finding no zero, so the machine commences an adding cycle, as the non-add mechanism of Fig. 64 has been restored to ineffective position in the middle of the preliminary cycle. In this first adding cycle, the sensing lever 1083 makes a sensing excursion and, finding no zero as the controlling drum (units order of the multiplier factor) stands at "3." The number "647" is entered into the totalizer while the shuttle mechanism, now enabled by the pawl 1068, moves the controlling drum and band of the multiplier storage unit to the "2" position.

On return movement of the shuttle mechanism, the sensing lever 1092 has found that the drum is not in zero position, so the machine automatically commences a second entry cycle, in which a second "647" is entered into the totalizer. Neither of the sensing levers 1083 or 1092 will sense a zero, because the drum has merely been moved from the "2" position to the "1" position. A third adding cycle automatically commences, in which a third "647" is entered into the totalizer. The sensing lever 1083, moving in the early part of the cycle, 75

senses no zero, as the drum has not yet been moved, but it has moved to zero by the beginning of the return movement of the shuttle. The sensing lever 1092 is rocked by the drum, which has returned to zero, and the shaft 1012, therefore, is rocked, setting the auxiliary cycle mechanism into operation near the end of the third entry cycle, as the stud 1133 (Fig. 88) strikes the lever 1124. At the middle of the third entry cycle, the main clutch mechanism link 301a, when moved rearwardly by the lever 725 (Figs. 70 and 72), is latched in position, by the pawl 1121, to stop any more entry cycles until the latch member 1096 (Fig. 87) is moved to ineffective position. As the first auxiliary cycle starts, the sensing lever 1083 is given a sensing movement by the rocking of the shaft 1057 (Fig. 88), sensing a zero, with no result, as the shaft 1012 is already in rocked position. During the first half of this first auxiliary cycle, the multiplier storage unit is shifted homeward by one denomination, and the "0" is entered into the differential-controlling pin carriage, making the number standing therein "6470." As the shuttle mechanism does not operate on auxiliary cycles, the sensing lever 1092 makes no sensing movement. In the last half of the first auxiliary cycle, the parts operated by the ratchet pawl 1147 remain as they are at the end of the first half of the cycle, but the slide 1143 returns to home position, as does the shaft 1057. A second auxiliary cycle commences automatically, and the sensing lever 1083 is given a sensing excursion only to find a zero, leaving the latch 1096 effective and, thus, leaving the shaft 1012 rocked counter-clockwise. In this first half of the second auxiliary cycle, the ratchet wheel 1146 is advanced one step, which permits the roller stud 1149 to fall into a low spot in the camming wheel 1143, allowing the mechanism operated thereby to return to normal position under spring actuation. Because a zero is sensed, by the lever 1083, on this second auxiliary cycle, indicating that no entry of the multiplicand is to be made under control of the tens denominational order of the multiplier storage unit, the multiplier storage unit must be moved to bring the drum representing the hundreds order of the multiplier factor into controlling position. A third auxiliary cycle automatically commences, causing a denominational shift of the multiplier storage unit and the entry of a "0" in the differential controlling pin carriage to make the amount set therein "64700." In the third cycle, the sensing lever 1083 senses a zero because it moves early in the first half of the cycle, making its sensing occur before the drum with the "1" on it has been moved to sensing position. On the second half of the third auxiliary cycle, parts moved by the slide 1143 are returned to home position, except those under control of the ratchet wheel 1146. A fourth auxiliary cycle commences, and, as now the hundreds multiplier digit factor drum is in position to be sensed, the lever 1083 will not be rocked, as it senses no zero positioning of the drum, and the stud 1085 will strike the nose 1110 of the member 1103 to unlatch the member 1089 to restore the shaft 1012 to its normal position, which sets the main operating clutch free to cause an entry cycle operation in which the hundreds drum is returned to zero, and, on the return of the lever 1092 in the last half of that cycle, the lever meets the zero stop formation 986 on the hundreds denomination of the drum of the multiplier unit, and the shaft 1012 will again be turned to perform an auxiliary cycle after the amount "64700" has been entered into the totalizer. This is the last entry cycle, and the following entries have been made into the totalizer:

647
647
647
64,700
66,641 = 103 × 647

As the first auxiliary cycle following the last entry cycle commences, the multiplier storage unit is moved to home position, and, in so moving, the slight overthrow which is made necessary to insure that the escapement mechanism of Fig. 97 takes hold causes the rod 942 (Fig. 89) to strike the conical surface 1076 (Fig. 91) on the latch 714, rocking it to ineffective position, which allows all the linkage shown in Fig. 91 to be restored to normal condition.

The lever 1178 (Fig. 89) has been moved to home position so as to disable the automatic "0" entry mechanism.

As the multiplier storage unit moves step by step homeward from the position in which it was after the multiplier was first set therein, the pins 957 in the multiplier storage unit are returned to normal position by a cam plate 1207 (Fig. 68) positioned beneath them.

All this has occurred by mid-cycle, as it is apparent that the ratchet pawl 1147 (Fig. 88) has by that time completed its movement forward. On the first half of this auxiliary cycle, the lever 1083 has sensed a zero, and the machine will go through a second, and final, auxiliary cycle.

As will be remembered, the shaft 1057 is rocked on each excursion of the slide 1143 (Figs. 88 and 101). Referring now to Figs. 99 and 101, the left end of the shaft 1057 has secured thereto an arm 1188, having a stud 1189 resting in an upwardly-opening notch in a slide 1190, having a rear slot 1191, by which it is supported on the shaft 1057, and a forward slot 1192, which engages a left-frame-supported stud 1193 (Fig. 99), so that the slide 1143 moves the slide 1190 first forwardly and then rearwardly on each auxiliary machine cycle.

On the forward end of the slide 1190 (Fig. 99) is a stud 1194, on which is pivoted a three-armed lever 1195, having a hook 1196, engaging a stud 1206 on a lever 1198 pivoted on the stud 1193, an ear 1202 resting on the rearwardly-extending arm of a bell crank lever 1199 pivoted on the shaft 705, and a spring-anchor arm 1200, to which is secured one end of a spring 1201, the other end of which is anchored to the forward end of the slide 1190. The end of the lever 1198 rests against a stud 1203 on a lever 1204a secured to the stud on which the hub 484 (see also Fig. 7) of the gear 483 is secured. As seen in Fig. 99, counter-clockwise movement of the lever 1198 will turn the gears 485 and 482, the spindle 480, and the lever 481 to throw the differential-controlling pin carriage to home position, just as in an add or subtract operation, explained in connection with Figs. 6 and 7. The link 703 (see also Fig. 71) is shown in normal position in Fig. 99; that is to say, in the position in which the parts are positioned as they are when the multiplicand bar 227 has not been operated. If the multiplicand bar is depressed, the link 703 moves downwardly, and a sidewardly and downwardly extending arm 1204 thereof bears down on a stud 1205 of the bell crank lever 1199, rocking it counter-clockwise, which in turn rocks the lever 1195 clockwise, unhooking the hook 1196 from the stud 1206, so that the forward movement of the slide 1190 will not return the differential-controlling pin carriage during those auxiliary cycles in which the multiplicand bar is depressed.

As has been explained, in the first half of the last auxiliary cycle, the multiplicand key linkage is returned home, and the hook 1196 will again hook over the stud 1206, and in the last and final auxiliary cycle the differential-controlling pin carriage will be returned home.

As the lever 710 (Fig. 70) has returned to home position, the lever 1041 will release the link 301, and it returns to home position. The levers 1092 and 1083 (Fig. 87) sense nothing, as no drum is in line with them during the last auxiliary cycle, and the shaft 1012 returns to normal, and no more cycles of operation will be initiated. The mechanism of Fig. 92 has been re-

stored in the next-to-last auxiliary cycle as the multiplicand key was restored. Now, by taking a total, the product is withdrawn from the totalizer and printed.

Division

In order to assist in the understanding of the mechanism of the machine which is involved in division operations, the general consideration will first be made of the manner in which division is effected. In this machine, division is carried out by a continuous process of successive subtractions. The dividend is entered into the differential-controlling pin carriage, followed by ciphers, to cause the pin carriage to travel to the extreme left. The divisor is then set in the pin carriage, followed by ciphers, to cause it to travel to the extreme left. The division key is then operated, which sets the machine operating to cause the amount in the pin carriage to be subtracted successively from the amount in the totalizer until an overdraft occurs, whereupon the amount in the pin carriage is added back into the totalizer. Next, the pin carriage is automatically stepped back toward the right one denomination, and subtract operations begin until another overdraft occurs. This process continues until the balance in the totalizer is diminished until only the remainder is left. A quotient totalizer is provided to count the number of subtractions minus those which caused overdrafts. The quotient may be printed through operation of the quotient key, and the remainder is printed by use of the regular total-taking key.

The sequence of operations involved in division is best explained in association with the diagrammatic showing of Fig. 102, in which the various components of the machine referred to in the previous description are similarly designated; that is, the differential-controlling pin carriage and its pins are designated 425 and 452, respectively, the pin-restoring cam 462, the zero stop bail 442, and the formations 503 on the differential sectors 501. Beneath the differential members is located a quotient counter having a number of denominational wheels 1208, each having a wide tooth 1209, one wheel for, and located beneath, each differential sector 501, the latter having dependent rack extensions 1210 (Fig. 2a) adapted to cooperate with the wheels of the quotient counter for reading a total therein. The quotient counter is adapted to be operated upon denomination by denomination, as the division operation proceeds, by pawls 1211 and 1212 carried on a slide 1213 (see also Fig. 105), which is laterally slidable, and also reciprocable, so that, during a reciprocatory forward movement—that is, downwardly, as viewed in Fig. 102, from its normal mid-position, the pawl 1211 will advance the wheels 1208, with which it is associated at that time, additively, whereas, when the slide is reciprocated rearwardly, or upwardly, from its mid-position, as shown in Fig. 102, the pawl 1211 will advance the associated quotient counter wheel subtractively. Normally, the slide is held against leftward movement, under the urgency of a spring 1214, by a latch 1215 (see also Fig. 103). Also, the slide has an upstanding finger 1216, which is adapted to bear against the carriage 425, so that, when the carriage is in an off-normal position toward the left and the latch 1215 is released, the slide 1213 will move laterally under the urgency of the spring 1214 to take up a position corresponding to that of the carriage and, thereafter, is caused to move retractively toward home position with the carriage, as the latter is moved step by step backward to its normal position during subtract operations.

In Fig. 102(1), all of the components are shown in their normal position. The initial operation in division is the direct positive entry of the dividend into the totalizer; that is, the dividend is entered into the digit keyboard, followed by ciphers, to move the carriage to its position of full capacity as indicated in Fig. 102(2), wherein the rows of the pin carriage registering the digits

of the dividend are shown white, while those registering ciphers are shown black. The machine is now operated to enter the dividend into the highest wheels of the totalizer, whereupon the carriage is restored to normal, as indicated in Fig. 102(1). The divisor is now entered into the keyboard, followed by ciphers, to move the carriage to its maximum position, again as represented in Fig. 102(2).

A "Division" key 226, to be described later in connection with Fig. 98, is provided on the machine and is depressed after the entry of the divisor, to cause the machine to enter into a series of subtract cycles and to release the latch 1215 from the slide 1213, which, therefore, under the urgency of the spring 1214, immediately moves to align itself with the highest denominational wheel of the quotient totalizer, as indicated in Fig. 102(3).

At every ensuing cycle of the machine, the divisor, as modified by the additional zeros, and as contained in the pin carriage, is subtracted from the dividend, as modified by the additional zeros, contained in the totalizer, and also the slide 1213 is reciprocated forwardly to enter a unit into the associated quotient counter wheel 1208. This continues until the balance contained in the totalizer is zero or is less than the divisor in the pin carriage, so that in the next machine cycle the totalizer will be caused to move through zero to its negative, or overdraft, side, bringing about a wave of transfers through the totalizer to enter a "fugitive 1" into the wheels of the totalizer. Upon the occurrence of this, the machine executes another cycle, during which the divisor is added into the totalizer, which, therefore, with a "fugitive one" added, will now hold the true intermediate remainder, or balance. Also, the slide 1213 is moved backwardly one step, so that the pawl 1211 subtracts one unit from the wheel of the quotient counter to compensate for the extra unit entered thereinto during the aforementioned entry, which caused an overdraft. If the totalizer is returned to a positive condition, the pin carriage 425 is moved one denominational step toward home position, taking with it the slide 1213, through the position as indicated in Fig. 102(4), where it will also be seen that the zero pin in the lowest denominational row of the carriage has been restored forwardly by the restoring cam 462.

The machine, with the amount in the carriage reduced by one power of ten, now automatically commences a second series of cycles, during which the divisor, as diminished, is subtracted from the intermediate remainder or balance standing in the totalizer, until another overdraft occurs, whereupon, in the next cycle, the totalizer performs an addition cycle to bring the true balance back into it. The pin carriage 425 is then stepped one denomination toward home position, so that the components will assume the positions as indicated in Fig. 102(5). The machine continues to operate in this manner, passing through the stages of operation as indicated in Fig. 102(6) to (10), provided that the amount in the totalizer is not reduced to zero at any stage, eventually to restore to the normal position, indicated in Fig. 102(1). In this position, the quotient will be contained in the quotient counter, while the true final remainder will be contained in the totalizer.

The quotient is taken from the quotient counter by use of a quotient key provided for this purpose. The remainder in the totalizer is gotten by a normal total-taking operation.

It is inherent in a totalizer having positive and negative intermeshing wheels that it has two zero conditions—that is, when the positive wheels are standing at zero and the negative wheels at the nines complement of zero; i.e., 9—and, conversely, when the negative wheels are standing at zero and the positive wheels at the complement nine. Therefore, in view of this, if the totalizer is standing with its wheels at positive zero and an amount is subtracted, this amount will be entered into the nega-

tive wheels, including the "fugitive one," as the negative wheels pass through their zero positions. If, now, the same number is added back into the totalizer, its negative wheels will be reset to negative zero, and the positive wheels to complement nine, and the fugitive transfer will not take place.

This condition is made use of in the present machine in order to obtain a quick automatic return of the carriage in cases where a diminished dividend is an exact multiple of the remaining divisor.

Simple examples will now be given to illustrate the manner in which the machine operates.

Consider an example where the dividend is a multiple of the divisor, as in the case of $999 \div 333 = 3$.

Operational sequence		Quotient counter count
Dividend in totalizer.....	9990	
Divisor in carriage.....	-3330	
First subtract cycle.....	6660	1
	-3330	
Second subtract cycle.....	3330	1
	-3330	
Third subtract cycle.....	0000	1
	-3330	
Fourth subtract cycle.....	-3330	1
Add divisor.....	3330	
	-0000	-1
		3

As in the third subtract cycle, the totalizer was taken to its negative condition, and the subsequent addition of the divisor did not restore the totalizer to its positive wheels to cause a fugitive transfer to take place, the automatic carriage restoring mechanism, therefore, being operated immediately to restore the carriage to its normal, or home, position.

Firstly, consider a case where there is a remainder, such as $100 \div 33 = 3$ with a remainder of 1.

Operational sequence		Quotient counter count
Dividend in totalizer.....	100	
Divisor in carriage.....	-330	
First subtract cycle.....	-230	1
As totalizer has turned negative, divisor is added..	330	
Dividend.....	100	-1
Carriage retracts one step.....	-33	
Second subtract cycle.....	67	1
	-33	
Third subtract cycle.....	34	1
	-33	
Fourth subtract cycle.....	1	1
	-33	
Add diminished divisor.....	-32	1
	33	
Carriage retracts one step.....	1	
	3	
Fifth subtract cycle.....	-2	1
Add.....	3	
Remainder.....	1	-1
Carriage steps to home.....		0 3 0

Therefore, the answer given is 3 with a remainder of 1 in the totalizer.

In the several figures illustrating the mechanism involved in division operations, the division key for initiating such operations is designated 226.

Referring to Fig. 98, the division key 226 is shown in connection with the control mechanism for causing the machine to effect a number of subtract cycles up

to the point where the totalizer moves to its overdraft condition, whereupon the divisor is caused to be added into the totalizer, so that the true positive balance stands therein. This is continued in stages, accompanied by homeward stepping of the pin carriage 425, until the totalizer registers zero or an amount less than the amount remaining in the pin carriage.

The key 226 is secured to an arm 1300, freely mounted on a fixed stud 1301 in the machine frame. Freely mounted on the stud 1301, adjacent the arm 1300, is a lever 1302, the upper end of which is held in contact with a stud 1303, projecting from the arm 1300, by a spring 1304, tensioned between the arm 1300 and the lever 1302.

The lower end of the lever 1302 abuts the stud 657 (see also Fig. 51) at the upper end of the lever 572, which, it will be remembered, is coupled through the shaft 573, the further lever 574, and the stud 575, to the finger 577, having a wedge-shaped end (see also Fig. 51a), which cooperates with the guide member 581 (Fig. 55). The finger 577 is positioned to the right or left of the guide member 581, so that, on the elevation of the finger 577 by the lever 578, the shoulder 582 either by-passes or engages the ear 583 of the add-subtract bell crank lever 566, respectively, to maintain the totalizer in the add position, or to swing it into subtract position. Secured to the shaft 573 is a crooked arm 1306 (Fig. 98), the end of which overlies and abuts a stud 1307 in a right-angled arm 1308, free on the shaft 573, a spring 1309 being tensioned between the two arms normally to maintain the former in contact with the stud 1307. The upwardly-standing limb of the arm 1308 has a roller stud 1310 at its free end.

Also supported on the shaft 573 is a rearwardly projecting arm 1311, this arm being secured to the lever 572, by a screw 1312. A link 1313 depends from a screw pivot 1314, at the rear of the arm 1311, and is connected through a pivot 1315 at its lower end to one arm of a bell crank lever 1316, pivoted on a rod 1317, supported between the extension plates depending from the side frames 202 and 203 (see also Fig. 3).

The depending arm of the bell crank lever 1316 cooperates with a cam rod 1318, mounted between plates 1319 and 1320 (Fig. 105), only one of which is shown at 1319 in Fig. 98, the plates having therein slots such as 1320a, through which passes a rod 1321, secured between the extension frame plates 202 and 203 (Fig. 3). The purpose of this linkage is to control and bring about the operation of the quotient counter in a manner which is to be described later. A right-angled crank member 1322 is mounted on the fixed stud 588 (see Fig. 48) and has the end of its dependent limb formed as an arcuate cam surface 1323, which is adapted to cooperate with the roller stud 1310 in the upstanding arm 1308, under circumstances to be described.

The horizontal limb of the crank member 1322 has therein a stud 1324, which is engaged by the forked end of a crooked arm 1325, mounted on the fixed stud 744 (see also Fig. 20) in the side frame 202, the arm having thereon a roller stud 1326, which is adapted to be engaged by the periphery of a drive sector plate 311 when the machine is set into operation. The upper end of the arm 1325 is provided with a notch 1327, which, as will be described, is adapted to be engaged by a pin 1328 secured in the arm 669, which, it will be remembered from the previous description relating to credit balance operations, occupies an upper position while the totalizer is in positive condition, but is depressed when the totalizer is moved to a subtract position.

When the key 226 is operated, the arm 1300 rocks clockwise, and, through the spring 1304, the lever 1302 is forced to make a similar movement, whereby its lower end moves in the direction of the arrow 1328a. The key is latched in depressed position by a latch 1329 engaging the stud 1303 under the urgency of a spring 1330. The

lever 1302 thus forces the stud 657 to the left (as seen in Fig. 98) thereby to rotate the lever 572, the shaft 573, the arm 1306, the lever 574, and the finger 577 all counter-clockwise. The arm 1308, constrained to follow the arm 1306, through the medium of the coupling spring 1309, so that the roller stud 1310 rises, to come into the path of the arcuate cam surface 1323 of the crank member 1322. The rearwardly-extending portion of the arm 1311 also rotates counter-clockwise with the lever 572 to elevate the link 1313 to cause the clockwise rotation of the bell crank 1316, the dependent limb of which pushes the rod 1318, carried by frame plates such as 1319, toward the left, as seen in Fig. 98. This latter movement is in preparation for effecting the reciprocation of the slide 1213, as referred to in connection with Fig. 102, for bringing about the stepping of the quotient counter for counting the number of subtract cycles of the machine, as will be described in detail later. The depression of the subtract key 274 also causes the operation of the machine in a manner to be described later.

On the first cycles of the machine (see also Fig. 55), the lever 578 is elevated by the cam segment 310 on the drive sector plate 311 to raise the finger 577, which, as it has been moved to its leftward position, passes to the left of the guide stud 581, so that the shoulder 582 therein engages the ear 583 of the add-subtract bell crank lever 566, to swing the latter clockwise and thus tilt the totalizer so that the negative wheels 534 (Fig. 37) thereof are brought into position for engagement with the actuating sectors 500 of the differential mechanism.

Thus, during this machine cycle, the amount standing in the differential-controlling pin carriage is subtracted from that of the dividend standing in the totalizer. During this cycle, the cam plate 311 (Fig. 98) engages the roller 1326 on the arm 1325, causing this arm to rotate clockwise, the upper end of the arm moving from the path of the pin 1328 in the arm 669, whereas the lower end of the arm, through the stud 1324, rotates the crank member 1322 counter-clockwise. In this latter movement, the cam surface 1323 encounters the roller 1310 of the arm 1308, causing the latter to be depressed and rotated clockwise on the shaft 573 against the tension of the spring 1309. The slope 321 of the sector plate 311, leading the arcuate periphery of the sector 311, is provided to delay the movement of the member 1325, the crank 1322, and the arm 1308 until the nose of the finger 577 has been engaged behind the guide stud 581, so as to prevent the arm 1306 and, therefore, the lever 578 and other components therein from following the arm 1308 when depressed by the crank member 1322. Conversely, if the arm 1325 is not restrained against restoration, it is released by the cam 311 to permit the arm 1308 to be restored to its position of association with the arm 1306 prior to the nose of the finger 577, leaving the guide stud 581.

The machine continues to execute subtract cycles to subtract the amount in the pin carriage from the amount in the totalizer until an overdraft occurs. Referring to Fig. 53, it will be recalled that, during subtract operations, the add-subtract bell crank 566, through the medium of the arms 648 and 658, pushes the slide member 660 to its rightward position, thus to position the pin 667 above the end of the arm 669.

Therefore, referring also to Fig. 98, during the machine cycle, when the totalizer passes from a positive condition to a negative condition, with the consequent transfer of the "fugitive" one into the lowest wheel of the positive side, the beam 663 is rotated counter-clockwise to cause the arm 669 to be depressed, in which position it is latched by the latch 675.

At the moment of depression of the arm 669 (Figs. 53 and 98), the arm 1325 (Fig. 98) will be held in its clockwise position by the sector drive plate 311 out of the path of the pin 1328, so that the latter will descend to the front of the arm 1325 opposite the notch 1327.

therein. Thus, when the sector plate 311 disengages from the roller 1326, the arm 1325 and, therefore, the crank member 1322 and the arm 1308 will be held by the pin 1328 and unable to restore, so that the spring 1309 remains tensioned. Therefore, when the finger 577 disengages the guide stud 581, this, together with all the other components of the shaft 573, is subjected to the combined tension of the springs 1309 and 1331, which overcomes the tension of the spring 1304, so that all of these components are returned to their normal inoperative positions toward the right.

Therefore, during the next cycle of the machine, the nose of the finger 577 passes to the right of the guide stud 581, and its shoulder 582 by-passes the ear 583 (Fig. 55) out of the bell crank 566, so that the totalizer engages in add timing and the amount contained in the pin carriage is entered back into the totalizer. As the totalizer passes from the negative condition into the positive condition, a "fugitive" one transfer occurs, and, as the slidable member 660 (Figs. 53 and 54) has been permitted previously to move to its leftward position on the totalizer returning to the positive condition, the beam 665 being rotated counter-clockwise similarly to rotate the member 660, the pin 668 in the latter engages the projection 671 in the arm 669 to restore the arm to its normal upward position. On upward movement of the arm 669 (Fig. 98), the pin 1328 is disengaged from the notch 1327 in the arm 1325, which thereupon restores to normal position on the disengagement therefrom of the drive sector plate 311, so that the cam surface 1323 of the member 1322 moves away from the roller 1310 of the arm 1308. Therefore, as the restraint has been removed from the arm 1308, it is permitted to close to its position of association with the arm 1306, with the result that the tension in the spring 1309 is rendered ineffective as far as supplying torque to the shaft 573 is concerned, so that the spring 1304 is alone, opposed by the spring 1331. The former is stronger than the latter, which, therefore, is overcome, with the result that the lever 572, the shaft 573, and other components thereon are moved counter-clockwise, in preparation for the next cycle of the machine, which will thus be made in subtract timing, as before described.

The foregoing operations will be repeated for each stage of the division operations until the machine is finally brought to rest at the conclusion of the calculation.

The manner of construction of the reciprocal slide carrying pawls for operating upon the wheels of the quotient counter will now be described, particularly with reference to Figs. 98, 104, and 105, the latter two figures being sectional views of each other, Fig. 104 being taken approximately along the line indicated by X—X in Fig. 105, whereas Fig. 105 is taken approximately on the line Y—Y in Fig. 104, except that certain elements above said line are shown.

In said figures (see also Figs. 2 and 2a), the two dependent extensions of the side frames 202 and 203 are shown at 1332 and 1333. Between, and freely supported by, these extensions are two spaced rods 1334 and 1335. Slidably supported on these two rods, so as to be laterally movable thereon, is a metal box-like structure 1336, the holes through which the rods pass in the two opposite walls being reinforced by bushings such as 1337, 1338, 1339, and 1340, these two walls having slots cut therein to allow the passage thereto of a counter-supporting shaft 1341, which carries the wheels of the quotient counter, only one wheel, 1208, of which is shown in the figures, but which will be described in detail later. The right-angled finger 1216 projects upwardly from the front wall of the box and bears on the right-hand side of the pin carriage 425, under the urgency of the spring 1214, as best seen in Figs. 98 and 105.

A channel is cut in the base of the box 1336 and is, in effect, continued in the right-angled apertures 1342

and 1343, cut in the front and rear walls, as best seen in Fig. 103. The slide 1213 fits into the channel and is held slidably located therein by four pairs of plates, one pair at each corner of the channel, the four upper plates 1344, 1345, 1346, and 1347 being shown in Fig. 105, riveted to the top of the base of the box 1336, and the other of the pairs being directly beneath the base, as seen in Fig. 104. A leaf spring 1348 (Fig. 98) is clamped by a plate 1349a to the base of the box and has projecting fingers which protrude upwardly through the apertures in the base of the box to bear onto the operating ends of the pawls 1211 and 1212, secured between pairs of lugs, such as 1349 and 1350, upstanding from the slide, thereby, to maintain these ends resiliently pressed upwardly and to keep the tails of the pawls bearing onto the adjacent surfaces of the slide, as best seen in Figs. 98 and 105.

The slide 1213 has a spring anchor 1351 (see Fig. 105) depending from the middle of its right side. Between this lug and the lugs such as the lug 1352 (Fig. 104), depending from the front and back walls of the box 1336, are tensioned two springs 1353 and 1354, which normally apply equal and opposite tensions to the slide to maintain it centrally with reference to the wheels of the quotient counter.

At the rear of the slide 1213 is secured a vertical cam block 1355, having its upper end shaped as two equiangular but oppositely-inclined cam surfaces.

The cam rod 1318 is adapted to cooperate with the cam surfaces of the block 1355, passing through wide clearance apertures in the dependent extensions of the side frames 202 and 203, so as to allow lateral and downward movement of the rod, and is supported between two plates, designated as 1319 and 1320, exterior to the dependent extensions of the frames 202 and 203, which have longitudinal slots 1320a therein (Fig. 98), in which register the ends of the rod 1321, secured between and projecting beyond the said extensions. Springs 1356 and 1358 (Fig. 104), secured between the plates 1319 and 1320, and studs secured in said extensions, exert an upward and clockwise tension on the plates and on the rod 1318, as seen in Fig. 98, thereby tending to maintain the rod 1318 in the position shown in Fig. 98, located over the right-hand cam surface of the cam block 1355 when it is in neutral position.

It will be remembered from the previous detailed description of Fig. 98 that the arm 1311, secured to the shaft 573, has, pivotally depending therefrom, the link 1313, the link at its lower end being connected, through the pivot 1315, to one arm of the bell crank 1316, secured on the rod 1317. As shown in Figs. 98 and 104, this rod 1317 is supported between the extensions 1332 and 1333, and the dependent limb of the bell crank 1316 cooperates with one end of the rod 1318. On the other ends of the rod 1317 is secured a dependent finger 1357, which corresponds to the dependent limb of the bell crank and which cooperates with the other end of the rod 1318.

Referring generally to the operation of the mechanism just described, it will be remembered from the previous general description of division operations that, after the divisor had been entered into the pin carriage 425 and the division key depressed, the box 1336, carrying the pawls 1212 and 1211, was released, whereby it was caused to move under the action of the spring 1214 until the finger 1216 encountered the pin carriage 425, thereby positioning the pawls 1212 and 1211 oppositely to the wheel 1208 of the quotient counter associated with the highest denominational wheel of the totalizer. The precise manner in which this is accomplished will be described later. It will also be remembered that, during the subtract cycles of the machine, a count of one unit was added to the appropriate wheel of the quotient counter until the totalizer moved to its negative, or over-

draft, side, whereupon an add cycle ensued to subtract one unit from the appropriate wheel or quotient counter.

It will be recollected that, on depression of the division key 226 (see particularly Fig. 98), through the lever 572, the shaft 573, the arm 1311, and the link 1313, the bell crank 1316, the rod 1317, and, therefore, the finger 1357 (see Figs. 104 and 105) are caused to make a clockwise movement, as seen in Fig. 98, whereby the dependent limb of the bell cranks 1316 and 1357 rock the rod 1318 counter-clockwise against the tension of the springs 1356 and 1358, so that the rod becomes positioned over the left cam face of the cam block 1355, as indicated in broken lines in Fig. 98. During each subtract cycle of the machine, the rod 1318 is depressed in a manner to be described later, so that it encounters and presses upon the left cam face of the block 1355, forcing this to the right as viewed in Fig. 98, or upward as viewed in Fig. 105, against the tension of the spring 1354, whereby the pawl 1211 operates upon the associated wheel 1208 of the quotient counter to add one unit thereto. When the rod 1318 returns upwardly, the slide returns to its mid-position under the urgency of the spring 1354 (Fig. 105). When the totalizer is overdrawn and the fugitive transfer occurs, the lever 572, the shaft 573, the arm 1311, the link 1313, and the bell crank 1316 and its counterpart finger 1357 are restored by the spring 1309 to normal position, shown in Fig. 98. Thus, the bell crank 1316 releases the rod 1318, which is returned to the position, shown in full lines in Fig. 98, by the springs 1356 and 1358, where it is located over the right-hand cam face of the block 1355. Therefore, during the ensuing adding cycle of the machine, when the rod 1318 descends, it operates on said cam face to move the slide 1213 leftwardly, as shown in Fig. 98, or downwardly, as shown in Fig. 105, against the tension of the spring 1353, whereby the pawl 1212 subtracts an amount from the associated quotient counter wheel 1208. On the following elevation of the rod 1318, the slide 1213 is returned to its neutral position by the spring 1353. Following this adding cycle, the pin carriage is reverse-tabulated one step toward home position and, through the finger 1216, causes the corresponding movement of the box 1336 and the slide 1213, so that the pawls of the latter become positioned in association with the next lower wheel of the quotient counter.

These operations continue until the count has finally been made, in association with the lowest denominational order of the dividend, as previously described.

In Fig. 103 is illustrated the mechanism controlled from the division key 226, for initiating the operation of the machine, for releasing the box 1336, carrying the slide 1213, to permit this to take up a position corresponding to the position of the pin carriage 425, and also generally indicates arrangements for disabling the normal carriage return mechanism, whereby the carriage is prevented from returning home after an entry operation.

Adjacent the arm 1300, on the stud 1301 is pivoted a lever 1360, secured to the arm 1300 at its upper end through the stud 1303. The lever 1360 has a stud 1361 secured in its lower end, which engages a slot in an inclined arm 1362 and passes through a cam slot 1363, in one arm of a bell crank lever 1364.

The arm 1362 is secured to a bushing 1365, fast on a shaft 1366, passing to the left-hand side of the machine and supported in auxiliary mounting plates 1367 and 1368, secured to the side frames 202 and 203. To the left end of the shaft 1366 is secured a dependent finger 1370, which engages a roller stud 1371 in the member 477, pivotally mounted on the rod 478, mentioned in connection with the description of Fig. 6. This latter member controls the mechanism for normally restoring the carriage in entry operations and carries a further roller stud 488 for this purpose. Also, there is secured to the shaft 1366 a dependent arm 1372, having a bifurcated

end, which embraces a stud 1373, projecting from the upper end of a lever 1374 pivoted on the rod 478. The lower end of the lever cooperates with the tail of the latch 1215, pivoted on a stud 1376 in the base of the machine, the nose of the latch having a shaped end 1377, which is adapted to engage the left-hand side of the box 1336 when the latter is in normal position, as illustrated in Fig. 103, the latch having a counter-clockwise tension applied thereto by a spring 1378, secured between the latch and a stud, not shown, in the under side of the base.

The bell crank lever 1364 is pivoted on a screw stud 1379, secured in the side frame 202, and its free limb cooperates with a stud 1380 in a lever 1381, pivoted at its middle on the pivot stud 711, secured in the frame plate 219. The lower end of the lever 1381 is bifurcated and engages a stud 1382, projecting from the link 301, which, it will be recalled, leads backwardly to the main drive clutch mechanism.

Considering the operation of the mechanism shown in Fig. 103, on the operation of the division key 226, the lever 1360, secured thereto, is caused to rotate clockwise about the stud 1301. The stud 1361 in the lower end of the lever, in moving arcuately in the slot of the arm 1362, causes the arm to rotate clockwise to impart a similar movement to the shaft 1366, the finger 1370, and the arm 1372. The finger 1370, bearing on the roller stud 1371, causes the member 477 to rotate counter-clockwise about the rod 478, whereby its roller stud 488 is caused to disable the normal carriage restoring mechanism in a manner which was described in connection with Fig. 6. The arm 1372, in rotating clockwise, rotates the lever 1374 oppositely, so that the lower extremity of the latter rotates the latch 1215 clockwise to disengage its end 1377 from the box 1336, whereby the latter is released to the urgency of the spring 1214, so that it moves leftwardly until its finger 1216 meets the side of the pin carriage 425, in which position the pawls 1211 and 1212 will be located in operative association with the highest denominational wheel 1208 of the quotient counter.

It is convenient to reiterate at this point that, during the division operations following the cycle where the divisor is added into the totalizer to form the true balance therein, the pin carriage 425 is moved homeward by one step to reduce the divisor standing therein by one power of ten. The pin carriage takes the box 1336 and the pawls 1211 and 1212 with it, so that the latter will now become operatively associated with the wheel of the quotient counter corresponding to the next lower denomination. This is repeated until the end of the division operation, when the pin carriage is restored to its absolute normal position, and, as the key 226 will, at that time, also be released, the latch 1215 will reengage its end 1377 with the side of the box 1336 to hold this in normal position.

On the clockwise rotation of the stud 1361, the latter rides in the cam slot 1363 to cause the lever 1364 to rotate counter-clockwise, which, through the stud 1380, oppositely rotates the lever 1381 clockwise, the latter in turn, through the stud 1382, forcing the link 301 forwardly, or to the left, as viewed in Fig. 103, to cause the engagement of the main clutch in the closing of the switch for the driving motor, as will be fully understood from the previous description.

The mechanism for effecting the reverse tabulation of the pin carriage 1336 by one step at the completion of each denominational stage of the calculation, and for effecting the final restoration of the completion of the calculation, and also for suppressing printing during the operations, is shown in Figs. 106 to 109. Fig. 107 is a plan view of the mechanism shown in Fig. 106. Fig. 109 is a front elevation of the right end of the mechanism shown in plan view in Fig. 108.

The lever 1360 (Figs. 103, 106, and 107), which, as will be remembered, is secured to the arm 1300, has a

stud 1271 projecting from its extremity, which engages the vertical shoulder 1272, formed in a link 1273, supported at one end by a slot 1274 therein, being engaged by the stud in the vertical arm of the trifurcated lever 710 (see also Fig. 71) and at the other end by a slot 1275 therein, being engaged by the screw pivot stud in the lower end of an arm 1276, secured to a shaft which, as before mentioned, is for effecting the setting of a symbol-printing bar in a manner not shown. The link 1273 is preferably in two parts, connected by a pin-and-slot connection, and held together for unitary movement by a spring, as generally shown in Fig. 106. This link is the same link as shown in Fig. 71.

On the stud 1303 is pivoted a cam arm 1277, having a cam slot 1278 therein. The surface 1279 of the arm above the cam slot, which is normally out of line with but, when the key 226 is operated, is adapted to come beneath a pin 1280 in the extremity of one limb of a bell crank lever 1281 pivoted on a stud 1282, secured in the frame 202. The end of the other limb of the bell crank lever 1281 is bifurcated and engages a stud 1283 in a lever 1284, centrally pivoted on the stud 588 in the frame 202, the other end of this lever being bifurcated to engage a stud 1285 in an extension 1286 of the hook arm 669 (Figs. 53 and 98), which, it will be remembered, became depressed consequent upon the occurrence of a fugitive digit transfer when the amount in the totalizer became overdrawn.

The cam slot 1278 in the arm 1277 is engaged by a stud 1287 in the upper end of a cam lever 1288, centrally pivoted on a screw stud 1289 in the frame plate 219, the latter being indicated only by a dot-and-dash line, the lever 1288 having a counter-clockwise tension applied thereto by a spring 1290. A stud 1291 in the lower end of the cam lever 1288 engages a cam slot 1292 in a plate 1229a, pivoted on the pivot stud 711 in the frame plate 219, the cam slot 1292 having a short leading portion concentric with the pivot 1289, and a tangential portion, which forms the cam slot proper. A stud 1228a is secured in the freely-moving end of the plate 1229a.

On a stud 1293, secured in the dependent lug of the plate 1229a, is pivoted a T-shaped member 1233 substantially at the middle of its horizontal limb, the trunk 1264 depending into the base and serving as a lever, as will be described later. The left-hand end of the horizontal limb of the member 1233 is bent over at an angle to form a lug 1232, which acts as a cam surface. The other end of this limb is formed as a hook 1294, which embraces the stud 1123, projecting from the vertical member 1117 (see Fig. 88), which, it will be remembered, carries the dependent finger 1118, having its lower end formed as a cam surface. A spring 1217 is tensioned between the hook end 1294 of the member 1233 and a stud in the vertical member 1117, and maintains the lower surface of the hook in contact with the stud 1123.

Referring again briefly to Fig. 88, it will be recollected that the plate 1129, pivoted on the screw stud 1130, was normally maintained depressed against the pressure of the spring 1132, by the stud 305 secured in the bracket 310 (Fig. 4) secured to the drive sector plate 311, the member being caused to follow the stud on the operative movement of the drive sector plate 311 for a distance depending upon point of application of the tension spring 1132. On the return movement of the drive sector plate, the stud 305 meets the member 1129 at that point in the machine cycle when the totalizer is disengaged from the sectors 500.

Referring to Fig. 106, the stud 1133 also engages a notch in a link 1218, which is slidably supported at its other end by a slot 1219 therein, being engaged by a stud 1220, projecting from a bracket 1221 secured between the end of the stud 298, projecting from the plate 215, free of the keyboard assembly, as previously explained, and the plate 219 (Fig. 3).

In Fig. 106, the link 1218 is shown in the partially

moved position occupied when the machine is in operation; that is, the stud 305 is shown in a position when it is just leaving or meeting the member 1129 during the forward or return stroke of the machine. It should be noted in this connection, and particularly with reference to Fig. 88, that this movement is sufficient to allow the stud 1133 to move from the path of the rear end of the lever 1124.

On a stud 1222 (Fig. 106) in the link 1218 is pivoted a pawl 1223, and a spring 1224 is tensioned between the pawl 1223 and a stud 1225 in the link to exert a clockwise tension on the pawl to make the tail 1226 of the pawl make contact with the check stud 1227, secured in the link. An upper side of the pawl is formed as a gradient, which underlies the stud 1228a in the plate 1229a.

Located back of the link 1218 at the left-hand end, as viewed in Fig. 106, is a slide 1228, which has therein, at its left-hand end, a slot, similar to the slot 1219 in the link 1218, which is engaged by the stud 1220 in the bracket 1221. At the other end, the slide is engaged with the link 1218 by a rivet stud 1229, which clearly passes through a slot 1230 in the link 1218 and is riveted into the slide. A spring 1295 is tensioned between a lug 1296 on the slide 1228 and a lug 1297 on the bracket 1221. A stud 1231 projects laterally inward from the right-hand end of the slide and is in line, and adapted to cooperate, with an ear 1232 of the member 1233. A tooth 1234 is pivoted on a stud 1235 in an upstanding lug of the slide 1228, and a counter-clockwise tension is applied to the tooth by a spring 1236 to maintain its dependent finger in contact with a stop stud 1237 in the slide. The tip of this tooth is adapted to cooperate with the turned-over tip of the pawl 1223. The slide 1228 has an upstanding lug 1238, having thereon a pivot stud 1239, on which is pivoted a cam arm 1240, which has a dependent lug, to which the left end of the spring 1236 is hooked to maintain the pawl against the stop stud 1241 in the lug 1238. The end of the cam arm 1240 is bent inwardly to form a lug 1242 at an inclined angle to form a camming surface.

The cam arm 1240 cooperates with a stud 1243 at one end of a lever 1244, which is pivoted at its middle on the stud 1239 (see also Figs. 107, 108, and 109), secured to the inside of the frame plate 219, the other end of the lever being stepped to engage one arm of a bell crank lever 1245 (see particularly Figs. 108 and 109), pivoted on a stud 1246 in a lug bent over from the frame 202 (Fig. 108). The other limb of the bell crank 1245 has in its end a pin 1247, which engages the turned-down end of a horizontal slide 1248, located above pawls 365 and 360, the tabulating escapement mechanism for the pin carriage 425. The slide 1248 is provided with two slots 1249 and 1250 therein, through which pass screw studs 1251 and 1252, which engage pillars 1253 (Fig. 109), only the right one being shown, upstanding from a cross member, not shown, so as to allow the slide free lateral movement. A spring 1255 (Fig. 108) is secured between the left-hand end of the slide 1248 and the side frame 220, normally to maintain the slide in the leftward position, as shown, which tension is applied backwardly through the linkage just described, finally to exert a counter-clockwise force on the lever 1244.

The slide 1248 has a pawl 1256 pivoted on a stud 1257 therein, the pawl having its tail formed in a hook 1258, and a cam surface 1258a at the entrance to the hook. A coil spring 1260, embracing a pin 1261 in the slide, has one of its ends anchored on a further pin 1262 in the slide, and its other end anchored on a pin 1263 in the pawl, so as to effect a counter-clockwise tension on the latter, normally to maintain the cam surface 1258a against the left-hand stud 1251, in which position the nose of the pawl will be held away from the pins 436 forming the tabulating rack of the pin carriage 425.

Referring again to the T-shaped member 1233 (Fig. 106), a leg 1264 of this member cooperates with a roller stud 1265 at the end of a link 1266, which is pivotally carried for reciprocal movement midway of its link by

an arm 1267, pivoted on a stud in an auxiliary frame plate (not shown), and at its right-hand end by one arm of the bell crank lever 1268, pivoted in the frame plate 1144, while the other arm of the bell crank, having therein the stud 1269, which underlies the nose of the pawl 1147, which, as will be remembered from the prior description relating to multiplication and Fig. 88, is mounted on the slide 1143 and causes the reverse tabulation of the multiplier storage device during multiplying operations. A clearance opening 1270 is provided in the slide 1143 for movement of the slide on the stud.

Referring to the operations of the mechanism shown in Figs. 106 to 109, the member 1129 and the link 1218 normally occupy the positions shown by dotted lines, and the slide 1228 also occupies a leftward position, so that the lug 1242 is located to the left side of the stud 1243 in the lever 1244, as shown in dotted lines. Also, with the slide 1248 in its left-hand position, as shown in Fig. 108, the cam surface 1258a of the pawl 1256, in cooperation with the left-hand stud 1251, causes the pawl to be held from the pins 436 of the carriage 425.

On depression of the division key 226, the machine is caused to commence division operations, as already described in connection with Fig. 103. Also, on the clockwise rotation of the lever 1360 (Fig. 106), the cam arm 1277 is moved to insert its cam surface 1279 beneath the stud 1280 in the bell crank lever 1281. Also, the stud 1271 moves to the left and, by its engagement with the shoulder 1272, starts a corresponding movement to the link 1273, the right-hand end of the link rotating the arm 1276 and the shaft to which it is attached clockwise, to set a symbol type bar, not shown, whereas the left-hand end of the link rotates the trifurcated lever 710 counter-clockwise.

It is convenient here to reiterate the operations consequent upon the rotation of the trifurcated lever 710 with reference to the figures previously described in connection with multiplying operations. When the lever 710 (Fig. 71) rotates counter-clockwise, it depresses the link 709, which causes the counter-clockwise rotation of the plate 708 and the shaft 705, the plate 708 being latched by the latch 714. The counter-clockwise rotation of the shaft 705 (Fig. 87) causes the reverse rotation of a bell crank to pull the slide 1027 so that the stud 1044 therein cams the shoulder 1072 upwardly into the path of the pawl 1051 (see also Fig. 92) and cams the beam 1049 counter-clockwise to release the pawl 1068 to encounter the extension 1059 of the lever 1058. On the first cycle of the machine, the lever 1051 engages the shoulder 1072 and thus reciprocates the slide 1046 (Fig. 87).

In this instance, as the pawl 1068 (Fig. 92) is not restrained by the stud 1069 in the beam 1049, on the movement to the right of the slide 1046, the pawl latches behind the cam lever extension 1059, so that, on the retractive movement of the slide, the cam lever is moved clockwise to shift the rod 1060 from the radial portions into the arcuate portions of the slots 1061 and 1062 in the cam plates 1036 and 1035, and also to move the member 1064 in preparation for the engagement therewith of the tooth 1033 on return to normal. Thus, during the first cycle of subtract operations, the divisor standing in the pin carriage 425 is entered subtractively into the totalizer and is printed.

During the second cycle, as the tooth 1033 is coupled with the member 1064, which is connected through the pivot 1065 to the cam plate 1035, which in turn is connected to the cam plate 1036 by the rod 1050, which carries the pawl 1051, in this instance moving away from the tooth 1072. The cam plate 1036, through the stud 1038 (Fig. 87), will cause the shuttle mechanism to reciprocate, but, as the latter will test the zero condition of the multiplier factor storage device, its movement will be ineffective. The rod 1050 (Fig. 92), in moving clockwise, will cam the lever 1053 clockwise, so that the rod 508 will move the latches 504 to uncouple the sec-

tors 501 from the type-controlling levers 502, so that the latter will not move with the sectors 501, and printing will not take place, this condition prevailing throughout the remainder of the division operation.

Again referring to Figs. 106 to 108, when the drive sector plate 311 (see Fig. 9) moves away from its normal, inoperative, position, the stud 305 moves counter-clockwise, and the member 1129 and the link 1218 are permitted to move, under the urgency of the spring 1132, from the position represented in broken lines to the position shown in full lines, during which movement the left boundary of the slot 1230 in the link encounters and carries with it the stud 1229 and, therefore, the slide 1228, the latter carrying with it the tooth 1234. The lug 1242 of the cam arm overrides the stud 1243 in the lever 1244, the latter moving ineffectually counter-clockwise, the lug thus being moved to the right of the stud, as shown in full lines. On the return movement of the machine operation, the stud 305 returns the member 1129 and the link 1218 to the positions indicated in broken lines. The spring 1295 also partially returns the slide 1228 until the latter is stopped by the lug 1242 of the cam arm 1240 encountering the stud 1243 in the lever 1244, which is held against movement under these conditions by reason of the tension of the spring 1255 (Fig. 108) exceeding that of the spring 1295.

This operation, which is idle, inasmuch as in itself it brings about no consequential function, occurs at each subtractive cycle of the machine until the totalizer is overdrawn—that is, when the amount in the pin carriage 425 is greater than, and is subtracted from, the amount remaining in the totalizer—in consequence of which, at an instant during the return movement of the link 1218, a fugitive digit transfer will occur in the totalizer, causing the depression of the arm 669 (Fig. 98) and the extension 1286 (Fig. 106).

The depression of the extension 1286 causes, through the stud 1285, the clockwise rotation of the lever 1284, which, through the stud 1283, causes the reverse rotation of the bell crank 1281 and the depression of the pin 1280 in its free limb. The pin 1280, in descending, encounters the cam surface 1279 of the cam arm 1277, causing this arm to rotate counter-clockwise about the stud 1303. This movement of the cam arm 1277, through its cam slot 1278 and stud 1287, causes a clockwise rotation of the cam lever 1288, which, through the stud 1291 riding along the cam slot 1292 in the plate 1229a, causes the plate to rotate counter-clockwise about the pivot stud 711, which lowers the T-shaped member 1233, which, apart from another function, mentioned later, is without effect other than introducing the rear surface of the ear 1232 into the path of the stud 1231 of the slide 1228. Also, the stud 1228a in the plate 1229a presses onto the upper cam surface of the pawl 1223 to rotate this counter-clockwise about its pivot 1222, against the tension of the spring 1224.

The timing of this mechanism is such that, when the fugitive transfer is initiated, the link 1218 has returned sufficiently to bring the pawl 1223 very close to the tooth 1234, so that, when these two latter components become immediately adjacent, the nose of the pawl engages over the tip of the tooth, thereby rotating the latter clockwise against the tension of the spring 1236.

During the remainder of the restoring movement of the link 1218, the pawl 1223 slides along the upper surface of the tooth 1234.

As previously mentioned, the following cycle of the machine will be an adding cycle, during which the totalizer may be restored to its positive condition, with the occurrence of a "fugitive" transfer and back spacing of the carriage by one step, or, alternatively, the totalizer may remain in the overdrawn condition—that is, only restored to the minus zero condition—in which case mechanism for quickly restoring the pin carriage 425 to its normal position is operated.

Assuming that the first condition obtains—that is, that the addition of the amount in the pin carriage during the adding cycle restores the totalizer to its positive condition.

During this adding cycle, the link 1218 again moves toward the right when the member 1129 is released by the stud 305. During this movement, the pawl 1223 rides along the tooth 1234 and eventually releases the tooth, so that it is restored upwardly by the spring 1236 to bring its tip into line with the turned-over nose of the pawl 1223.

Near the end of the machine cycle, the stud 305 again engages the member 1129, to commence the return movement of the link 1218 together with the pawl 1223, which is still held in its depressed position by the stud 1228a.

Just prior to the occurrence of the "fugitive" one transfer, the nose of the pawl 1223 engages under the tip of the tooth 1234, which thereby holds the pawl in its depressed position. Immediately following this engagement, and before the stud 1231 comes into a position of cooperation with the lug 1232 of the T-shaped member 1233, the "fugitive" transfer takes place, which, as will be understood, brings about the raising of the arm 669 and also its extension 1286. The latter thus restores the lever 1284 and the bell crank 1281, so that the pin 1280 in the bell crank moves upwardly and away from the surface 1279 of the cam arm 1277. Therefore, as the restraint is removed from the cam arm 1277, the spring 1290 is permitted to exert itself and restore the arm 1288 counter-clockwise, which, through its stud 1287 and the cam slot 1278 in the cam arm 1277, restores the latter. The cam lever 1288, in restoring to normal, rides along the cam slot 1292 in the plate 1229a to restore the latter upwardly to elevate the T-member 1233, so that its ear 1232 comes out of the path of the stud 1231 in the slide 1228.

During the continued movement of the link 1218 toward the left, the pawl 1223 carries with it the tooth 1234 and, therefore, the slide 1228 and the cam arm 1240. The lug 1242 of the latter, therefore, rides under and elevates the stud 1243 to rotate the lever 1244 clockwise, as viewed in Fig. 106. This movement of the lever 1244 causes the rotation of the bell crank 1245 clockwise, as viewed in Fig. 106, which moves the pin 1247 to the right (Figs. 108 and 109) correspondingly to move the slide 1228. The latter carries with it the pawl 1256, and, as the latter moves toward the right, its cam face tends to ride away from the cooperating stud 1251, but the spring 1260 maintains the contact and causes the pawl to rotate counter-clockwise to urge its nose into engagement with a pin 436 of the tabulating rack of the pin carriage 425. During the further movement, the hook 1258 of the pawl engages the left stud 1251 to hold the pawl rigid, and the nose of the pawl engages one of the pins 436 and moves the pin carriage back by one tabular step; that is, to reduce the amount standing therein by one power of ten. The lug 1242 (Fig. 106) moves under the stud 1243, and the stud snaps down behind the nose, as indicated in broken lines, under the urgency of the spring 1236. Thus, the operating force is removed from all of this reverse tabulating linkage, which is, therefore, restored by the spring 1255, the pawl 1256 moving from engagement with the tabulating rack of the carriage 425. At the beginning of the next machine cycle, the link 1218 will move to the right slightly in advance of picking up the stud 1229, so that the tip of the pawl 1223 moves away from the tooth 1234 and is restored upwardly by the spring 1224.

It is to be noted that, during the period that the slide 1228 is being moved toward the left by the pawl 1223, the counter-pressure exerted on the cam arm 1240 from the spring 1255 (see also Fig. 108) causes the slide to be slightly delayed behind the link 1218, so that the stud 1229 in the slide is maintained at a small distance from the left-hand boundary of the slot 1230 in the link.

However, immediately the lug 1242 of the cam arm 1240 rides under the stud 1243 in the lever 1244, the restraint is removed from the slide, which is, therefore, moved leftwardly by the spring 1295 until the stud 1229 encounters the left-hand boundary of the slot 1230. This movement is sufficient to move the tip of the tooth 1234 away from the pawl 1223, which is restored upwardly by the spring 1224, the stud 1228a having previously been raised with the plate 1229a.

In the next machine operation, the link 1218 through the stud 1229, will carry the slide 1228 toward the right, so that the slide will assume the intermediate position, as previously described.

The machine, therefore, continues to operate in the above manner successively to carry out the stages of the calculation through the denominations in descending order either until the carriage is restored step by step to its normal position, or until the addition of the subtrahend, back into the totalizer after being subtracted therefrom, fails to bring about a "fugitive" one transfer.

In the latter circumstances, as a positive "fugitive" one transfer wave will not occur, the plate 1229a, the member 1233, and the pawl 1223 will not be restored during the return of the link 1218, and, therefore, the plate 1229a will maintain the T-shaped member 1233 in its lowered position. Under these circumstances, when the link 1218 is moved to the left by the stud 305 and the member 1129, and the pawl 1223 will engage and move the slide 1228 to cause a single reverse tabular movement of the pin carriage 425, as before described.

Referring again briefly to Fig. 70, it will be remembered that, just prior to the completion of the first half of a machine cycle, the stud 305 meets the forward boundary of the slot 722 in the link 726 to give the latter a forward impulse to rotate the lever 725, the lower end of which, through the stud 693, pushes back the link 301a to its inoperative position, against the tension of the spring 694, where it is latched by the toe 1114 of the segment 1112. If the link 301a is not otherwise held in this position, the segment 1112 is operated upon by the stud 305 on its return to normal to unlatch the link 301a, so that it will again move to the right to cause the clutch mechanism again to engage to cause the machine to carry out a further cycle of operation.

Reverting to Fig. 106, as the T-shaped member 1233 remains lowered during the adding cycle of the machine, when the link 1218, its pawl 1223, the tooth 1234, and the slide 1228 are moved forwardly, the stud 1231 in the slide encounters the inclined face of the ear 1232 of the T-shaped member to cam the said member counter-clockwise; that is, in addition to the small camming movement which it received when the plate 1229a descended. The hook 1294 of the latter member, therefore, rises and elevates the vertical member 1117 (see also Fig. 70), which carries with it the dependent finger 1118, the lower end of which moves away from the stud 1120 in the pawl 1121. This pawl, therefore, is released to the urgency of the spring 1122, and, as the link 301a will at this time be in its rightward, or inoperative, position, the pawl will engage the tooth 1121a in the link 301a to hold the latter in its rightward position irrespectively of the unlatching of the segment 1112 (Fig. 70) therefrom, which follows, thereby preventing the reoperation of the normal clutch mechanism at the end of the machine-operating cycle, and the normal cycles will thus cease.

Referring also to Fig. 88, the elevation of the member 1116, 1117 occurs very soon after the stud 305 meets the member 1129 and prior to the coming of the stud 1133 into the path of the nose of the lever 1124. Therefore, the elevation of the member 1116, 1117 causes the clockwise rotation of the lever 1124, whereby the nose of the latter becomes inserted in the return path of the stud 1133, so that, on the final movement of the latter, it pushes with it the lever 1124 and, therefore, the link

1125 to the left to cause the operation of the auxiliary clutch mechanism.

Also on the counter-clockwise movement of the member 1133, its leg 1264 pushes the link 1266 to the right to rotate the bell crank 1268 clockwise (see also Fig. 88), which imparts a similar movement to the pawl 1147 to move it out of operative relationship with the ratchet wheel 1146, so as to prevent the latter from being advanced during the operation of the auxiliary clutch mechanism.

Referring to Figs. 88 and 99, on the operation of the auxiliary clutch mechanism, the arm 1140 is oscillated to the left and back to reciprocate the slide 1143. The latter, through the lever 1183, rotates the shaft 1057 first counter-clockwise and then back to the position shown. As the arm 1188 (Fig. 99) is secured to the shaft 1057, it moves the slide 1190 first to the left and then back, the latter in the leftward movement causing the lever 1195, carried thereby, to rotate the lever 1193, which, in turn, operates upon the carriage-restoring mechanism, as before described, to insure the return of the pin carriage 425 to its home position.

The movement imparted to the carriage by this restoring mechanism is slightly greater than that imparted by the pawl 1256 (Fig. 108), and in this further movement a cam surface on the carriage depresses a simple vertical slide (not shown), to which the restoring member 1382 (Fig. 98) is attached, this movement of the member 1382 lowering the tail of the latch 1329 to release its nose from the stud 1303, secured in the arm 1300, so that the latter is restored under the urgency of the spring 1331. Also, the said slide at its bottom end, in descending, operates a centrally-pivoted lever, the tip of which cooperates with the tip of the latch 714 (Fig. 71). Therefore, on the restoration of the member 1382 and the division key 226, the plate 710 will restore together the linkage 799 and the shaft 705, and also the cam arm 1277 (Fig. 106) will, in effect, move from the pin 1280, thus allowing the restoration of the lever 1288 and elevation of the plate 1229a, which, in turn, lifts the T-shaped member 1233 to allow the descent of the member 1117, so that the end of the finger 1118 (Fig. 72) will engage the stud 1120 to disengage the pawl 1121 from the link 301a. The member 1117, 1118, in restoring, pivots the lever 1124 (Fig. 88) to disengage the stud 1133, so that the auxiliary clutch mechanism will become disengaged at the end of the auxiliary cycle.

The release of the division key 226 (Fig. 103) will permit the link 301 of the normal clutch-engaging linkage to restore, so that the machine will be disabled from commencing another entry cycle. On the next machine operation, the link 1218 will move to the right to cause the slide 1228 to be brought to its intermediate position, where the stud 1231 will clear the cam surface 1232 of the T-shaped member 1233, which, if the totalizer is returned to its positive condition, will restore to normal. The release of the T-shaped member occurs just prior to the tip of the tooth 1234 engaging the nose of the pawl 1223, so that this also restores.

Thus, the machine is brought to rest, and the totalizer may be cleared by a total operation, the remainder therein being printed.

The mechanism concerned in the reading of a quotient as contained in the quotient counter will now be described particularly with reference to Figs. 98, 104, 105, and 110. It should be noted that the latter figure shows a perspective view, which is somewhat exploded for the sake of clarity.

As before described, the quotient totalizer consists of a number of toothed wheels 1208, one being associated and coplanar with each differential element 1210. Each of the latter is adapted to cooperate with the associated quotient wheel for the purpose of reading the quotient therein. Each of the totalizer wheels has a broad tooth 1209, representing the zero position of the wheel, and,

during the reading of a quotient, is adapted to cooperate with a stopping pawl 1383.

The wheels of the quotient counter are carried on the shaft 1341, which passes through vertical slots in the extensions 1332 and 1333 of the side frames, these extensions being omitted from Fig. 110 for the sake of clarity.

A rod 1400 is secured between the extensions 1332 and 1333, the ends extending exteriorly thereto, and suspended from the rod are two hangers 1401 and 1402, one on each side of the counter wheels 1208, which support the counter assembly by the shaft 1341 passing through the lower ends thereof. Springs 1403 and 1403a are tensioned between the lower ends of the hangers and pins (not shown) in the extensions 1332 and 1333 to exert a downward tension on the hangers to tend to maintain the quotient counter in its lower position, as shown in Fig. 98. Pawls 1404 and 1405 are secured to the shaft 1341, one on each side of the quotient wheels, and have counter-clockwise tensions applied thereto by springs such as 1406. The two pawls have tails, which cooperate with the upper tooth of two teeth in toothed plates 1407 and 1408, secured to the rod 1334, which, as will be remembered, forms one of the sliding supports for the box 1336, the rod being rotatable in the extensions 1332, 1333. The plate 1407 has, attached thereto, a link 1409, which extends forwardly within the machine and is pivotally coupled at its forward end (Fig. 103) to a stud 1410 in a bell crank lever 1411, pivoted on a stud in the plate 219, a stud 1412 in the upper arm of the bell crank engaging the under side of an arm 1413, pivoted on the same screw stud 294 in the plate 219 as the motor bar 224, and which carries the quotient key 225. A spring 1415, secured between the lever 1411 and a stud in the plate 219, exerts a counter-clockwise tension on the lever to maintain it in contact with a stop pin 1416 in the plate 219. The stud 1410 passes into a slot in the link 301, which, as before stated, extends rearwardly to the normal clutch mechanism of the machine (see Fig. 70).

A rod 1417 (Fig. 110) passes between the extensions 1332 and 1333 and through vertical slots therein, and carries two dependent members, 1418 and 1419, one at each end thereof. The ends of the rod 1400 and the shaft 1341 engage in slots in the members 1418 and 1419, the rod 1400 only permitting the members vertical movement. The rod 1417 carries two hooks, 1420 and 1421, which are, respectively, coplanar with, and adapted to cooperate with, the pawls 1404 and 1405. These hooks have long tails, shown broken, as later referred to. The rod 1417 is extended beyond the members 1418 and 1419, and its ends are provided with rollers 1422, which normally cooperate with depressions in segmental cam plates 1423 and 1424, upstanding from toothed partial wheels 1425 and 1426, respectively. These partial wheels are engaged, respectively, by toothed segments 1427 and 1428, extending from arms 1429 and 1430, respectively, pivoted on the shaft 1055 (see also Fig. 92), which, as before described, is supported between the extensions 1332 and 1333. The arms 1429 and 1430 have therein depressions, such as 1431, in which registers the rod 1318, which, as will be remembered, operates upon the cam 1355 of the slide 1213, carrying the pawls 1211 and 1212 for operating the wheels of the quotient counter.

The arms 1429 and 1430 have therein slots in which register, respectively, pins 1432 and 1433, projecting laterally from arms 1434 and 1435, secured to the shaft 1032, which, as will be remembered, particularly from Fig. 92, is coupled through the segments 1031 to the toothed wheel 1030 on the main shaft 312. The latter also carries two fingers, 1436 and 1437, which, respectively, are coplanar with the tails of the hooks 1420 and 1421.

It will be seen from the above that at each cycle of the machine, particularly during division operations, as

the main shaft rocks counter-clockwise and back, the segments 1031 and the shaft 1032 rotate oppositely; the arms 1434 and 1435, through the pins 1432 and 1433, depressing the arms 1429 and 1430, the free ends of the latter arms, therefore, depressing the rod 1318 to cause it to shuttle the slide 1213, carrying the pawls 1211, 1212, to advance or retract the associated wheel of the quotient counter.

When it is required to read a quotient standing in the quotient totalizer, the quotient key 1414 (Fig. 103) is momentarily depressed to cause the clockwise rotation of the bell crank lever 1411, the lower end of which moves the stud 1410 to the left, thereby transmitting corresponding movements to the link 301 and the link 1409. The movement of the link 301 trips the normal clutch mechanism to cause the machine to commence a normal operating cycle. The link 1409 (Fig. 110), in moving to the left (Fig. 103), rotates the member 1407 and, therefore, the rod 1334 and the member 1408 counter-clockwise, so that the upper teeth of the members are disengaged from the tails of the pawls 1404 and 1405, which rotate counter-clockwise, under the urgency of springs, such as 1406, to engage the lower teeth of said members and to engage their own teeth with the hooks 1420 and 1421, respectively.

Immediately the machine commences its operating cycle and the arms 1429 and 1430 have lowered in consequence, the toothed segments 1427 and 1428, associated with the arms, commence to rotate the wheels 1425 and 1426 and, therefore, the segmental cam plates 1423 and 1424 clockwise, the latter inserting their high surfaces beneath the rollers 1422 to elevate the latter together with the rod 1417 and the dependent members 1418 and 1419 attached thereto. The hooks 1420 and 1421, being supported on the rod 1417, also rise, and, as the pawls 1404 and 1405 are engaged with the hooks, these are also elevated to lift the shaft and the wheels 1208, so that the latter are brought into engagement with the differential teeth 1210 of the differential members. The latter now rotate to cause the teeth 1210 to rotate the wheels 1208 of the quotient wheels clockwise to their normal positions until the broad teeth 1209 of the wheels meet their respective stops 1383—that is, when the wheels are restored to zero position—whereupon the forward motion of the differential members, together with the printing bars differential members will take on settings corresponding to the numbers standing in their associated wheels of the quotient counter. At the termination of the setting of the differential members, together with the printing bars, the printing hammers are released to print the amount of the quotient. Also at the end of this operative half cycle of the machine (Fig. 110), the fingers 1437 encounter and depress the tails of the hooks 1420 and 1421 to rotate these clockwise and uncouple them from the pawls 1404 and 1405. It is to be noted that, when the quotient counter was elevated, the tails of the pawls 1404 and 1405 were lifted to come opposite the upper teeth in the members 1407 and 1408. Therefore, when the pawls are released by the hooks, they take a small counter-clockwise movement to engage said upper teeth. On the return half cycle of the machine operation, the segments are rotated counter-clockwise, as will be understood, and finally the rollers 1422 and, therefore, the rod 1417 and the counter assembly are returned to the normal downward position under the vertical pull of the springs attached thereto. In this descent, seeing that the tails of the pawls 1404 and 1405 are engaging the upper teeth of the members 1407 and 1408, the pawls will be rotated clockwise to come out of the paths of the hooks 1420 and 1421.

Thus, at the end of the operating cycle, the normal clutch mechanism is disengaged, and the machine comes to rest with the components restored to normal position.

As will be appreciated, during the quotient reading operation it is necessary to move the zero stop bail 442

(Figs. 25 and 26) from the paths of the fingers of the differential members as in total taking, to permit the settings of the beams in accordance with the amount standing in the quotient counter. Also, it is necessary to prevent the amount from being added into the totalizer; or, in other words, the totalizer should be non-added. The mechanism for accomplishing these two functions is illustrated in Fig. 111.

The top of the member 1418 (see also Fig. 110) co-operates with a flat surface of a lever 1440 pivoted on a stud 1441 in the extension 1332, the lever being connected to the member by a spring 1442. The lever 1440 has an upstanding lug 1443, to which is pivotally connected the lower end of a vertical bar 1444 guided for vertical movement by a slot therein being engaged by a stud 1445 in the frame plate 202. The upper end of the bar 1444 is formed as a curved cam face, which is adapted to co-operate with a cam block 1446 on a slide 1447 supported for horizontal movement by slots therein being engaged by studs 1448 in the frame plate 202. A spring 1449, tensioned between the slide 1447 and a stud in the frame plate 202, tends to maintain the slide in a position toward the right. A hook 1450 is formed at the right-hand end of the slide and embraces a stud in the upper portion of the non-add pawl 604 (see also Fig. 46), which, it will be remembered, in normal operations tips the lever 599 on the segment 311 to effect the engagement of the totalizer with the differential during the return half cycle of a machine operation.

The vertical bar 1444 has, projecting therefrom, a stud 1451, which engages a slot in a bell crank lever 1452 pivoted on a stud 1453 in the frame plate 202, the nose of the upper arm of the lever being located behind the member 443 carrying the zero stop bail 442.

When the member 1418 is elevated to engage the quotient counter with the differential, it rotates the lever 1440 counter-clockwise to elevate the vertical bar 1444. The elevation of the stud 1451 causes the bell crank lever 1452 to rotate counter-clockwise, so that the end of its upper arm rotates the member 443 to remove the zero stop bail 442 from the paths of the differential members. The cam face at the upper end of the bar 1444, in rising, encounters the cam block 1446 and thus forces the slide 1447 toward the left against the tension of the spring 1449. The hook 1450 at the end of the slide engages the stud in the pawl 604, so that the latter is rotated counter-clockwise, whereby its nose is elevated and moved out of its position of cooperation with lever 599, so that it will not be tripped during the machine operation, thus preventing the totalizer from being engaged with the differential.

When the member 1418 descends after quotient reading operations, it pulls down with it the bar 1444, which restores the bell crank 1452 to permit the restoration to normal position of the member 443 and the zero stop bail 442. Also, when the cam face at the upper end of the bar 1444 descends out of engagement with the cam block 1446, the slide 1447 is returned to normal by the spring 1449, so as to release the trigger 246, which restores to its normal position.

While the form of mechanism shown and described herein is admirably adapted to fulfill the objects primarily stated, it is to be understood that it is not intended to confine the invention to the one form or embodiment disclosed herein, for it is susceptible of embodiment in various other forms.

What is claimed is:

1. In a calculating machine the combination of a multiplier pin carriage having a home position and including a denomination series of rows of digit-representing pins which may be selectively set to effective position to represent a multiplier factor; a band of material associated with each row of pins, each band having a stop formation and being positioned along its associated row of pins so that if the band is transported there-along, its

stop formation will strike a pin of the row set to effective position, stopping the band, the ends of each band being wound on drums, one of said drums being equipped with a ratchet mechanism operable for rewinding a moved band a digit-representing step each machine operation; means constantly urging the bands along the associated row of pins; a latch means for each band normally holding the associated band in a zero position; and means for unlatching a band as a pin in its row is set so it will move until its stop formation strikes said set pin, the extent of movement of the band representing the digit value set up.

2. The machine of claim 1 in which the other drum for each band contains a spring for moving the band and has a peripheral formation representing zero, which formation comes to a zero station when the associated band has been returned to zero position.

3. The machine of claim 2 in which there is provided a set of digit keys, operable one at a time, to set up a pin in a row of the pin carriage at a pin-setting station; and means to shift the multiplier pin carriage at each key operation to bring the next adjacent band to the pin-setting station.

4. The machine of claim 3 in which there is provided a cyclically operable main operating means; a selectively operable differential means permitted to make an excursive movement each machine cycle, said differential means having a series of denominational elements; a differential-controlling pin carriage upon which a multiplicand factor can be set by the digit keys; means connectable to the main operating means to operate the ratchet mechanism and thereby move a band at the pin-setting station toward zero one digit step on each cycle of machine operation; means connectable to the main operating means to shift the multiplier pin carriage one row toward home position each time a band has been returned to zero position as determined by its associated zero formation; recycling means which is connectable to the main operating means to keep the machine recycling until the last band to come to the pin-setting station has been returned to zero position; multiplying control means which, when operated, connects the band moving means, the multiplier pin carriage shifting means, and the recycling means to the main operating means; a totalizer engageable with the differential means in item-entering timing each machine cycle so that the multiplicand factor is entered therein each machine cycle; and means to enter a zero into the differential-controlling pin carriage each time the multiplier pin carriage moves a row toward home position.

5. In a calculating machine, the combination of a plurality of digit-representing keys individually operable from normal position to a control position; a pin carriage having a plurality of denominational columns of pins into which digital data may be set; mechanism for stepping the pin carriage column-by-column past a pin setting station; interponent means between the keys and the pin carriage, which means may be moved from an ineffective position to an effective position and vice versa, said interponent means when in effective position transferring the motion of a key to a corresponding pin of the pin carriage to move the pin to an effective position but not doing so when the interponent means is in ineffective position, said interponent means being effective at the pin setting station and said stepping mechanism being operated by operation of the digit keys when the interponent means is in effective position; a pair of drums, supported in said pin carriage, for each denominational column of pins, said pairs of drums being denominationally spaced; a band of material wound on each pair of drums each band of material carrying a stop formation which cooperates with a pin in effective position to position the band according to the digital value of the pin, and the drums of a pair being spaced apart.

6. In a digital calculating machine for carrying out multiplying operations, which machine has a cyclically

operable main operating means, a totalizer consisting of a denominational series of toothed wheels, a corresponding series of toothed differential elements which are given a permissible excursion of movement equal to the capacity of a denominational order during a cycle of machine operation, by the main operating means unless otherwise controlled, totalizer-engaging mechanism by which the totalizer normally is engaged with the differential elements each machine cycle, and operator controlled means for determining whether the totalizer engagement shall be in item-entering timing or total-taking timing, the combination of a plurality of digit keys equal in number to the digits of a denomination of the numerical notation upon which the machine is based, and a zero key, each key being resiliently operable from a normal position to an operative position; a series of rods, there being a rod associated with each key and the rods being arranged in a columnar series beginning with zero and ending with the highest digit; connections between each key and its associated rod, whereby a rod is protruded by the operation of its associated key; a universal bar that is operated each time a digit key is operated; a differential-controlling pin carriage having a number of columns of pins equal in number to the differential elements, spaced according to said differential elements and each row having a pin for zero and each digit of a denomination of the numerical notation except the highest digit; means for transporting the pin carriage from home position where it is ineffective to control the differential elements, past the column of rods, said means including a stepping device operated by the universal bar, so that as the first key is operated, the corresponding pin, if any is involved, of the first pin carriage column is moved into effective position by protrusion of the associated rod and the pin carriage is stepped to bring the first column of pins in line with the lowest order differential element to control its movement during a cycle of machine operation, a pin moved to effective position being in the path of and controlling the excursion of the differential element, the operation of a second key stepping the pin carriage the distance between pin columns and moving to effective position a pin in the second column of pins, if any is involved, such pin-setting and pin carriage stepping continuing until the desired number is set up on the pin carriage; means normally operable at the close of a machine cycle to return the pin carriage to home position and return the pins to ineffective position; a multiplier pin carriage mounted in a frame provided with means operable to move the multiplier pin carriage from a home position step-by-step past a pin-setting station, said multiplier pin carriage having columns of digit-representing pins, the pins of a column being arranged in a series representing the lowest digit to the next to the highest digit of a denominational order of the numerical system involved, but not zero; interponent means arranged in a frame movable from an ineffective position to an effective position between the keys and the multiplier pin carriage, there being an interponent for each digit, zero excepted, a digit key, when operated while the interponent means is in effective position, moving the interponent of associated digit value, which will move to effective position the associated multiplier pin then at the pin-setting station, excepting the missing highest digit pin; a denominational digit representing band of material stretched in line with each column of multiplier pins and mounted to move with the pin carriage, each said band having a stop formation and being mounted on a rotatable drum at each end on which drums the ends of the bands are wound, there being latch means on one of the drums for normally holding the band with the stop formation in position with respect to the associated pins to represent "zero," the other drum having spring means to urge said other drum to turn and move the stop formation toward the pins by movement of the band, the stop formation to be stopped at a pin moved to effective position, or to be moved to a full distance stop provided representing the highest

digit; a zero signal formation on the spring-urged drum on which the band winds as it moves from zero position, the distance of the zero signal formation from home position indicating the number set in the denomination; universal bar means moved by any key-moved interponent to release the latch of the band at the pin-setting station, allowing the band to move until its stop formation strikes the pin moved to effective position or to move to the full distance stop; means operated by the operation of a digit key when the interponent frame is in effective position to cause the multiplier pin carriage to move a step to bring the next band to the pin-setting station; a non-add control means operable for preventing the totalizer from engaging the differential elements during a machine cycle; means operable for printing amounts set up on the differential elements during a machine cycle; a multiplier key which, when operated, operates the non-add control means and moves the interponent means to effective position; printing operating means normally printing the amount set on the differential elements each cycle of machine operation; starting means to cause the main operating means to cycle, whereby if the multiplier key has been operated and an amount has been set up by operation of the digit keys the machine will cycle, printing said amount, returning the differential-controlling pin carriage to home position, and leaving the multiplier amount on the multiplier pin carriage; a shuttle mechanism and control mechanism connectable with the main operating means, and which if so connected will be given a reciprocating movement each cycle of machine operation, said shuttle mechanism having means for causing a return movement of one digit step toward its zero position of a band at the pin-setting station for each cycle of machine operation; a means for causing a repeat cycling of the machine for each return step of a band; a sensing means for sensing the zero signal on the drum of a band as the stop formation arrives at zero position; means controlled by the sensing means and control mechanism causing the entry of a "zero" in the differential-controlling pin carriage and causing the multiplier pin carriage to denominationally move one step toward home position when the band is at zero position to bring the next denominational-representing band to the pin-setting station for step-by-step cycling of the machine, such operation continuing until all the bands have been returned to home position; a multiplicand key, operation of which connects the shuttle mechanism and control mechanism to the main operating means and also prevents return movement of the differential-controlling pin carriage at the end of a machine operation, said multiplicand key, when operated, also returning the multiplier key and interponent means to ineffective position; a latch for said multiplicand key to latch said key in operated condition; means operable when the shuttle mechanism is disconnected from the main operating means to release the latch; and means for disconnecting the shuttle mechanism from the main operating means, thus releasing the multiplicand key, in the cycle of operation in which the last band has been returned to zero position, whereby if a multiplier has been set up in the multiplier pin carriage and printed, followed by operation of the multiplicand key, the setting up of the multiplicand on the digit keys and consequently on the differential-controlling pin carriage, and operation of

the starting means, the machine will go through repeated cycles, in each of which the multiplicand will be entered into the totalizer a number of times in each selected stage of multiplication, under control of the multiplier pin carriage.

7. The machine of claim 6 in which means is provided for disconnecting the printer after the first entry of the multiplicand into the totalizer.

8. The machine of claim 6 in which total-taking means is provided so that the product of a multiplication operation stored in the totalizer may be printed.

9. In a calculating machine, the combination of a first pin carriage having denominational order rows of digit-representing pins each movable from a normal ineffective position to an effective position; a first escapement means operable for moving the said first pin carriage step-by-step so the rows of pins are brought successively into operational alinement with a first setting-up station; a second pin carriage having denominational order rows of digit-representing pins each movable from a normal ineffective position to an effective position; a second escapement means, operable by the first escapement means, for moving said second pin carriage step-by-step so its rows of pins are brought successively into operational alinement with a second setting-up station; a group of operable digit keys equal in number to and representing the various digits of a denominational order; means intermediate the keys and the first pin carriage whereby operation of a key moves to effective position a pin of equal value in the row at the first setting-up station and operates the first escapement mechanism to bring the next denominational row of pins to the first setting-up station; and shiftable means intermediate the keys and the second pin carriage, said means being movable from an ineffective position to an effective position in which position the operation of a key moves to effective position a pin of equal digital and denominational value in the second pin carriage, whereby the same amount is set-up in both pin carriages.

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