

April 1, 1941.

H. J. FURBER

2,236,792

CALCULATING APPARATUS

Filed Oct. 9, 1935

4 Sheets-Sheet 1

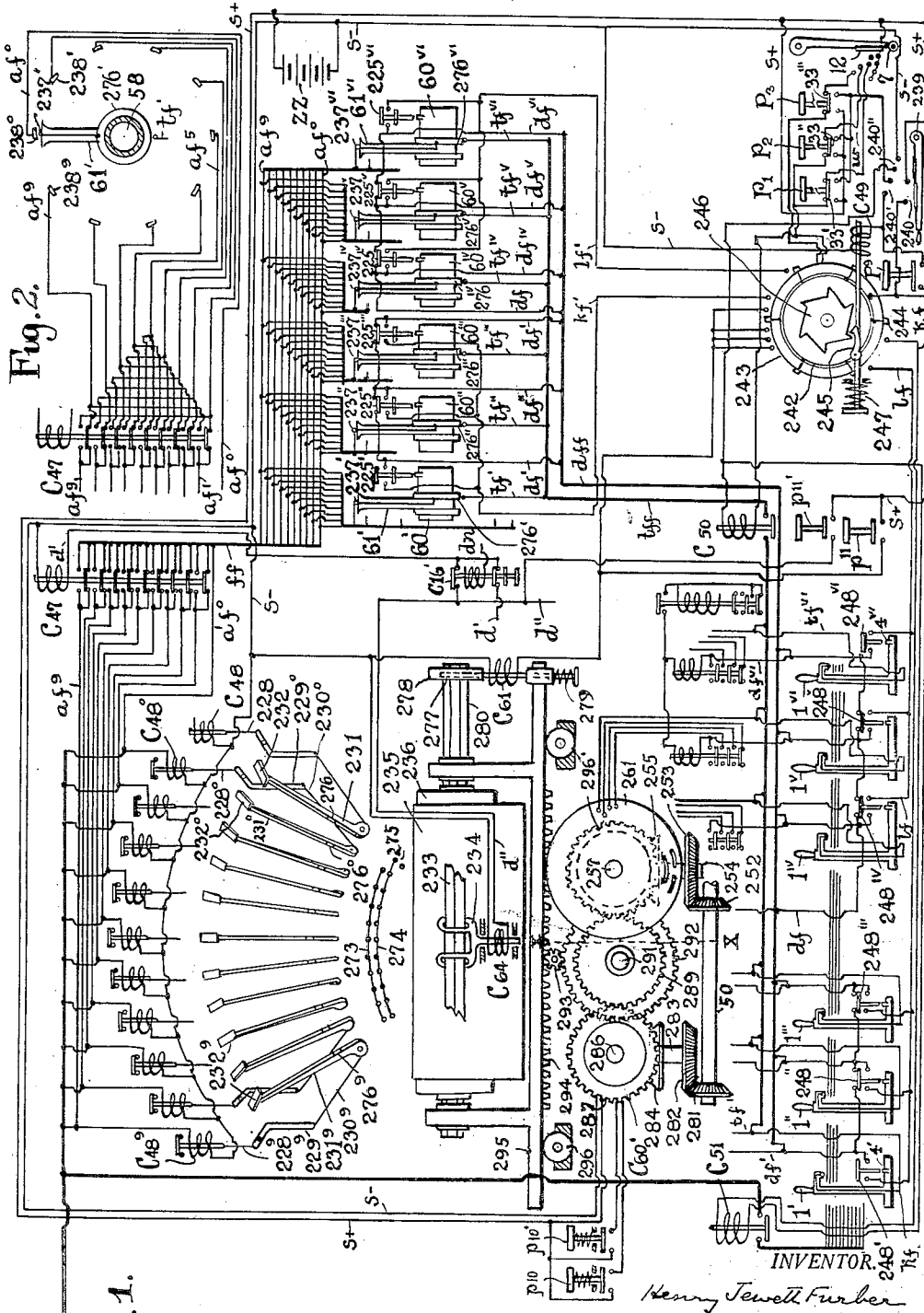


Fig. 2.

Fig. 1.

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4 Sheets-Sheet 2

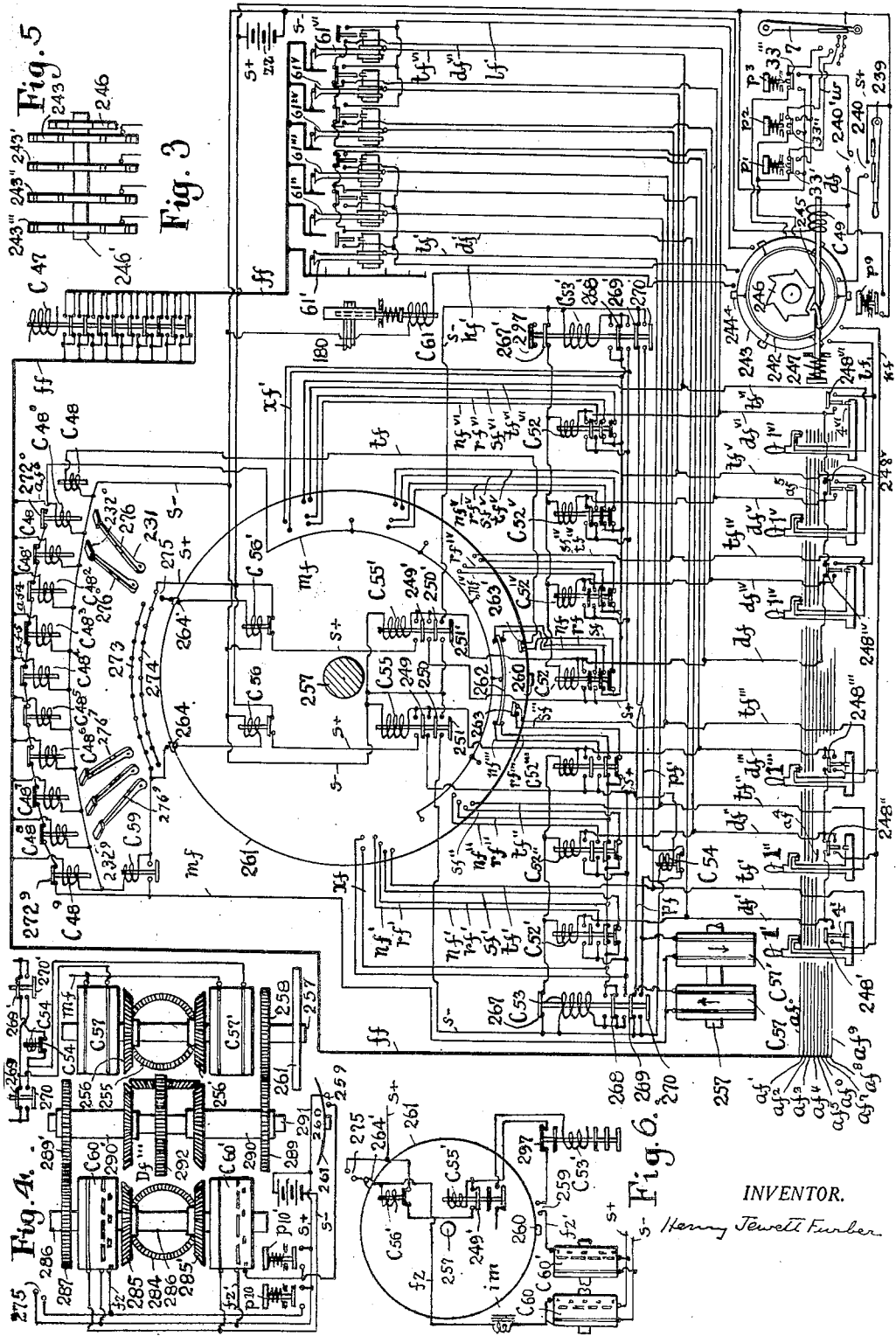


Fig. 5

Fig. 3

Fig. 4

Fig. 6

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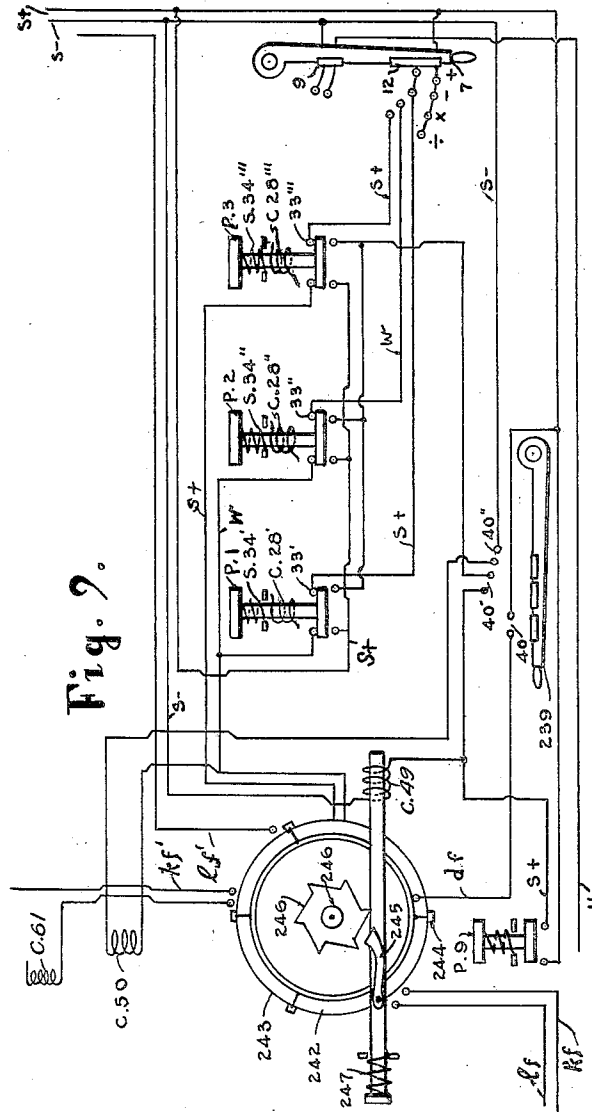
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,236,792

CALCULATING APPARATUS

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Application October 9, 1935, Serial No. 44,159

3 Claims. (Cl. 235—58)

This invention relates to improvements in calculating apparatus and the present application is an extension of copending application Serial No. 723,595, filed May 2, 1934. Divisional hereof are the specifications bearing following serial numbers and descriptive titles: Calculating mechanism, Serial No. 85,359 related to transfer; Multiplying mechanism, Serial No. 153,843; Conservator mechanism, Serial No. 153,844, related to the storage of quantities available as components in different forms of computation, and Mechanism for division, Serial No. 156,198.

The present specification is directed to novel means for recording quantities involved in computation and resultants, whether positive or negative in quality, or involving whole numbers or decimal fractions and differentially inclusive of the decimal point, which, together with redundant cyphers, is, wherever superfluous, suppressed.

With the foregoing and other objects in view, as will presently appear, this invention now will be described in connection with the attached drawings, in which:

Figure 1 is a view of mechanism for recording quantities established at the manual controls, and mathematical resultants.

Figure 2 is a side view from the right, of a typical accumulator arm 61', 61'', 61''', 61^{iv}, 61^v, 61^{vi} shown in Figure 1, with electrical connections.

Figure 3 is a wiring plan of circuits shown in Figure 1.

Figure 4 is a detail plan view of the transmission which operates the letter movement of the platen and controls the vertical alignment of progressive columns.

Figure 5 is a diagrammatic view from the right of disks similar to and integral with the disk 243 shown in Figures 1 and 3.

Figure 6 is a diagrammatic view of the clutches C.60, C.60' shown in Figure 4 with electrical connections.

Figure 7 is a view from the left of mechanism shown with other members in Figure 4, which transmits motion selectively in opposite directions, from the motor shaft 50 to the disk 201 shown in Figure 1.

Figure 8 is a diagrammatic view of the quotient arms together with electrical connections to the recording mechanism shown in Figures 1 and 3.

Figure 9 is a diagrammatic view, of a State control 7 and starting buttons P.1, P.2, P.3 which differentially condition the recording mechanism in different forms of computation.

All wheels disclosed in the above figures are toothed throughout, there being no mutilated gearings. The wires leading from the positive and negative poles of the source ZZ, are designated respectively as wires s⁺ and s⁻. Cables carrying a plurality of wires are indicated by heavy lines. The reference characters in this and in divisional specifications, in so far as they relate to similar elements, remain the same.

The quantities may be automatically transmitted to the recording mechanism by means including electric circuits from either the receiving members 1'-1^{vi}, the accumulator members 61'-61^{vi} (Figure 1), or the quotient members 27'-27^{vi} (Figure 8), as presently described. The State control 7 (Figures 1, 3, 8, 9) determines the form of computation. The depression of a push button P.1, at the beginning of an operation in addition or subtraction; of P.2 at the beginning of an operation in multiplication, and of P.3 at the beginning of an operation in division, complete circuits closed by the State control to the solenoid C.49 which retracting its plunger draws the latch 245 into preparatory position to operate upon the ratchet 246. At the termination of a computation the depressed push button is released, deenergizing the said solenoid and permitting the latch 245 to displace the member 246 integral with the organ 243 (Figures 1, 2, 5, 8, 9) which differentially brings into operation the recording numbers.

Referring to Figure 1, the accumulator arms 61'-61^{vi} are shown with electric wires extending over the bridges of the relay C.47 to the solenoids C.48¹-C.48⁹, the plunger of which and of the solenoid C.48⁹, are respectively connected by means of the draw-wires 228⁰-228⁹, with the bell cranks 229⁰-229⁹. The bell cranks 229⁰-229⁹ are, in turn, connected by the draw-wires 230⁰-230⁹ in manner well known in the art, with the pivoted type-bars 231⁰-231⁹, carrying at their upper extremities the types 232⁰-232⁹. The types 232⁰-232⁹ are respectively impressed with the numerals 0-9. The plunger of the coil C.48 is similarly connected with the type-bar 231, which records the decimal point. When energized by circuits closed either at the accumulator arms 61'-61^{vi}, at the quotient arms 27'-27^{vi}, (Fig. 8) or at the control levers 1'-1^{vi}; the solenoids C.48, C.48⁰-C.48⁹, whose negative poles are connected through the wire s⁻ with the source ZZ, retract their plungers and throw, each its corresponding typebar 231, 231⁰-231⁹ downwards, to the effect that a type 232, 232⁰-232⁹, descends upon the inking ribbon 233 supported by the frame 234, and prints upon a sheet

235 carried by a platen 236, an impression of the decimal point or numeral inscribed upon the type. The restoration of the type-bars 231, 231^o-231^o to normal position, may be effected by springs, not shown, in manner well known to the art.

In Figures 1, 9, the disk 243 is shown provided with the conductor 242 connected with contacts such as contacts 244 at the periphery of the disk. This disk is one of four similar disks 243, 243', 243'', 243''' (Figure 5) mounted on a common shaft 246'. The disk 243 selectively controls the recording of quantities established at the control levers 1'-1^{vi}. The disk 243' controls the recording of quantities reflected at the accumulator arms 61'-61^{vi}. The disk 243'' controls the recording of the quotient; and the disk 243''', the recording of quantities established at the levers 1'-1^{vi} or similar levers not shown. Circuits may be closed to the recording mechanism, selectively, through each of these four disks, the effect upon the recording mechanism being substantially similar through all. Interference of circuits is prevented, by means of these respective disks and by the relays C.50, C.51 (Figure 1) C.66 (Figure 8), which complete circuit to the recording mechanism, only when the quantities registered at accumulator arms, at levers, or at quotient arms, respectively, are to be recorded.

If in addition, for example, it is desired to record a column of figures, suppressing all cumulative resultants except the final sum, the lever 239 (Figures 1 and 9) is closed on the terminals 240. Circuit is thereby completed from the wire s+ leading from the source ZZ, to the relay C.51, which retracting its plunger closes extensions of the wires a¹⁰-a¹⁹ leading from the levers 1'-1^{vi} to the solenoids C.48^o-C.48⁹. Circuit in the meantime remains open at the relay C.50 from the accumulator arms 61'-61^{vi}; and at the relay C.66 (Figure 8), from the quotient arms 27'-27^{vi}.

The wire s+ closed by the switch 239 (Figure 3) at the terminals 240, when quantities established at the levers 1'-1^{vi}, are recorded, leads also to the conductor 242 carried by the disk 243. The push-button P.9 is depressed and immediately released, closing circuit when momentarily depressed, to the positive pole of the solenoid C.49, the negative pole whereof is connected through the wire s- with the source ZZ. The plunger of the solenoid C.49 carries a latch 245, which responsive to the reciprocating movement of the plunger, as circuit to the solenoid C.49 is closed and broken, operates upon a tooth of the disk 246 fixed to the common pivot 246' of the disks 243, 243', 243'', 243''' (Figure 5) and effects a displacement of these disks. A contact, such as the contact 244, connected with the conductor 242 (Figure 3), closes circuit successively and for a moment on the wires kf, lf, the wire kf leading to the bridges 248', 248'', 248''' at the levers 1', 1'', 1''', corresponding to integral orders, and the wire lf leading to the bridge 248^{iv}-248^v, 248^{vi}, at the levers 1^{iv}, 1^v, 1^{vi}, corresponding to the orders of the decimal fraction. The bridges 248'-248^{vi} are normally supported by the cams 4'-4^{vi}, which permit the bridges 248'-248^{vi} to fall when their corresponding levers be deflected, and in so falling to close circuit, from the wire kf to the respective relays C.52', C.52'', C.52''', and from the wire lf to the relays C.52^{iv}, C.52^v, C.52^{vi}. The wiring at the bridges 248'-248^{vi} (Figure 3) is such that any certain bridge in the circuit of the wire kf in falling, closes circuit to all lower bridges in the circuit of the wire kf and energizes their corresponding

relays C.52', C.52'', C.52'''; whereas any certain bridge in falling at the fractional levers closes circuit to all higher bridges in the circuit of the wire lf, and energizes their corresponding relays C.52^{iv}, C.52^v, C.52^{vi}, together with a further relay C.52 which, as will presently appear, corresponds to the decimal point. The relays C.52', C.52'', C.52''' corresponding to the levers 1', 1'', 1''', when momentarily energized by current from the wire kf through the wires df', df'', df''', are held in stick by a circuit of the wire s+ leading from the source ZZ which is closed by the bridge 250 at the relay C.55 momentarily energized, together with the relay C.52''', through the wire df''' and likewise held in stick, by current through the wire s+. The relays C.52, C.52^{iv}, C.52^v-C.52^{vi}, corresponding respectively to the decimal point and to the levers 1^{iv}, 1^v, 1^{vi}, when momentarily energized by current from the wire lf through the wires df, df^{iv}, df^v, df^{vi}, are held in stick, by a circuit of the wire s+ closed by the bridge 250' at the relay C.55', which is momentarily energized together with the relay C.52 through the wire df, and also held in stick by current through the wire s+.

The negative poles of the relays C.52, C.52'-C.52^{vi}, C.55, C.55', are connected through the wire s- with the source ZZ. It is the function of these relays to close circuit on mechanism, now to be disclosed which causes the platen 236 (Figure 1) to travel from normal position to the right, a distance embracing the highest column of the quantity to be recorded, and receive on the sheet 235 the numerals of integral columns on its passage back to its original position; and then to travel further to the left, a distance embracing the lowest column of the decimal fraction, if there be a decimal fraction; and successively to receive the numerals of the decimal fraction, together with the decimal point, as the platen 236, travelling to the right, again returns to its original position. If there be no integral quantity, the platen 236 travels only within the range of the fractional columns which are exclusively involved in the particular resultant, in variable degree according to the number of digits in the fraction. If there be no decimal fraction the platen travels only within the range of the integral columns which are exclusively involved in the particular resultant in variable degree according to the number of digits of whole numbers, and no decimal point is then recorded.

Fixed to an extension of the motor shaft 50 (Figures 1, 7) in constant revolution, is the wheel 252 (Figures 1, 7) which transmits motion selectively in opposite directions, through the wheel 253, shaft 254 and wheel 255 to the wheels 256, 256' floating on the shaft 257, which serve respectively as the armatures of the clutches C.57, C.57', fixed together with the wheel 256 and a disk 261 on the shaft 257. When the clutch C.57 (Figure 7) is energized, the wheel 256 and the disk 261 are rotated in clockwise direction. When the clutch C.57' is energized, the wheel 256 and the disk 261 are rotated in opposite direction. The wheel 256 meshes with the wheel 269 (Figure 4) fixed to a sleeve 290 which floats on the shaft 291.

Fixed to the motor shaft 50 (Figure 1) and operating in similar manner, is the wheel 281, which transmits motion selectively in opposite directions, through the wheel 282, shaft 283 and wheel 284, to the wheels 285, 285' (Figure 4) floating on the shaft 286. The wheels 285, 285' serve, respectively, as armatures for the clutches

C.60, C.60', fixed, together with the wheel 287, on the shaft 286. When the clutch C.60 is energized and receives motion from the armature 285, the wheel 287 rotates in clockwise direction. When the clutch C.60' is energized and receives motion from the armature 285', the wheel 287 rotates in direction opposite to clockwise. The wheel 287 fixed on the shaft 286 is in mesh with the wheel 289' fixed to the sleeve 290' which floats on the shaft 291. Fixed respectively on the sleeves 290, 290' are the two lateral members of the differential gearing Df'''. The central member of the differential Df'''' is the toothed wheel 292 which is fixed to the shaft 291, and is in mesh with the idler 293 (Figure 1). Engaged by the idler 293, is the rack 294 attached to the carriage 295 of the platen 236 (Figure 1), which is supported by the rotary bearings 296, 296'. The disk 261 fixed to the shaft 257 (Figures 1, 3, 4, 8), is a progressively movable switch, which controls circuits to the clutches C.57, C.57', C.60, C.60' (Figure 4). When the clutch C.57 is energized, the disk 261 is rotated clockwise; and the platen 236 (Figure 1) travels to the right. When the clutch C.57' is energized, the movement of the disk 261 and of the platen 236 is reversed. The functions of the clutches C.60, C.60', will presently be explained.

The disk 261 shown, in view to clearness, in Figure 3, as greatly enlarged, carries the conductors 262, 263, 263'. The conductor 262 closes circuits, as presently described, to the clutches C.57, C.57' (Figures 3); and provokes thereby lateral displacement of the platen 236. The conductors 263, 263', close circuits to the solenoids C.48, C.48⁰-C.48⁹, which operate in recording numerals and the decimal point. Assume that the quantity which enters into an operation and is to be recorded, is 40.05. The lever I'' is deflected four steps and closes circuit on the wire af⁴. The levers I''', I'''' remaining at zero, both close circuit on the wire af⁰, and the lever I^v is deflected five steps, closing circuit on the wire af⁵. The contacts which close on the wires af⁰-af⁹ are shown in Figures 1, 3 as fixed on brackets carried at the right of the levers I'-I^v.

At the bridge 248'' which falls when the lever I'' is deflected, circuit is closed through the wire df'', to the relay C.52''; and the bridge 248', in falling closes circuit through the wire df' to relay C.52'. Circuit is closed thereby, as above described, downwards to the relays C.52''', over the wire d''', and upwards to the relays C.52^{iv}, C.52, through the respective wires d^{iv}, df.

In normal position circuit is closed at the extremities of the conductor 262 (Figure 3) both from the wire nf'''' extending from a terminal at the relay C.52'''' corresponding to the units column, and by the wire nf extending from a terminal at the relay C.52 corresponding to the decimal point. The circuits so closed are extended through the wire mf to the positive poles of the clutches C.57, C.57', shown in Figures 4, 7, as fixed, together with the disk 261, on the shaft 257; and shown in arbitrary position, in Figure 3, which is a diagrammatic plan of wiring. Direction of motion of the shaft 257 and of the disk 261, when the clutches C.57, C.57' respectively are energized, is indicated by arrows at these clutches (Figure 3). Circuit to the negative pole of the clutch C.57 (Figure 3) is normally closed through the wires s-, pf, over the bridge 269 on the plunger of the relay C.53; and circuit to the negative pole of the clutch C.57', through the wires s-, pf' normally is closed over the

bridge 269' at the plunger of the relay C.53'. To prevent conflict of circuits, if the wires both pf and pf' be active, the circuit of the wire pf' is broken at the bridge of the relay C.54, which is in the circuit of the wires s+, s- closed; if a lever I', I'', I''' be active, over the bridges 249, 250 at the relay C.55.

The quantity 40.05 having been set up at the levers I'', I^v, (Figure 3) and the push-button P.9 having been momentarily depressed, circuit is completed over the wire nf''', closed by the middle bridge raised at the relay C.52'', to the conductor 262 and by the conductor 262 through the wire mf to the positive pole of the clutch C.57 (Figure 3). Motion in clockwise direction is thereupon transmitted by the clutch C.57 to the disk 261, and the platen 236 (Figure 1) travels to the right. As the conductor 262 is passing from the fixed terminal of the wire nf''', it encounters the terminal of the wire nf'', circuit through which is closed by the middle bridge raised at the relay C.52'', which is active since the quantity to be recorded is 40.05, and the lever I'' is deflected. Circuit to the clutch C.57 accordingly remain unbroken, the disk 261 continues to rotate in clockwise direction, and the platen 236 continues to travel to the right. The conductor 262 next reaches the terminal of the wire nf' circuit over which has not been closed, the lever I' and the relay C.52' corresponding to the hundreds order, not being active. The conductor 262 still closing at one extremity on the wire nf'' transmits current at the other, through the wire rf' over the next to the lowest bridge depressed at the relay C.52', to the positive pole of the relay C.53 which retracts its plunger and is held in stick by current through the wire s+ closed by the bridge 250 at the relay C.55, to following effect: At the bridge 267 circuit to the negative poles of relays C.52'', C.52'''' is broken and the plungers of the relays C.52'', C.52'''' fall. At the bridge 268 raised, current is closed from the wire s+ to the wires rf', rf'', rf''' now closed by the middle bridges at all relay C.52', C.52'', C.52''', and at the lowest bridges, to the wires sf', sf'', sf'''. At the bridge 269 circuit to the negative pole of the clutch C.57 is broken; and at the bridge 270, now raised, circuit to the negative pole of the clutch C.57' is closed. Motion is accordingly reversed. The platen 236 travels to the left and the movement of the disk 261 is opposite to clockwise; current being transmitted to the wire mf and thereby to the positive pole of the clutch C.57', from the wires rf', rf'', rf''', as the conductor 262 returning to normal position successively encounters the terminals thereof. As the disk 261 revolving, carries the conductor 263 into contact with the terminal of the wires sf'', tf'', circuit is completed from the wire sf'' now active, to the wire tf'' closed by the lever I'' on the wire af⁴. The solenoid C.48⁴ is thereby energized, and retracting its plunger records upon the sheet 235 (Figure 1) the numeral 4, in the column corresponding to the tens. On reaching the terminals of the wires sf''', tf'' (Figure 3) circuit is completed to the lever I''', which is closed on the wire af⁰, to the solenoid C.48⁰; and a cypher is recorded in the units column on the sheet 235 (Figure 1). The disk 261 is now in normal position, at which circuit is closed through the conductor 264 from a series of terminals 273 to the positive pole of the relay C.56, the negative pole whereof is connected through the wire s- with the source ZZ. The type-bars 231⁰-231⁹ are provided with conductors

276^o-276^o, which may close circuit at the series of terminals 273 of the wire *s*⁺, to a terminal of the series 274, circuit being completed to the relay C.56, when the disk 261 reaches normal position, through the conductor 264. The type bar 231^o-231^o which is deflected in recording the numeral in the units column, completes circuit to the relay C.56, which retracting its plunger breaks at its bridge, the circuit of the relay C.55. The relay C.55, releasing thereupon its plunger, breaks circuit to the relays C.52', C.52'', C.52''', C.53, C.54, and circuit over the bridges 269, 270, of the relay C.53, to the negative poles of the relay C.54 and clutches C.57, C.57'. Were there no decimal fraction, the recording mechanism then would be at rest. Since, however, the quantity to be recorded is 40.05, action is now extended to the fractional orders. The relays C.55', C.52, C.52^{iv}, C.52^v are still in stick. Current flows through the wire *nf* over the conductor 262 and the wire *mf* to the positive poles of the clutches C.57, C.57' and circuit is completed to the negative pole of the clutch C.57' over the bridge 269' at the plunger of the relay C.53' and the bridge at the relay C.54. The platen 236 continues to travel to the left, and the disk 261 to rotate in direction opposite to clockwise. This movement is sustained by circuits successively completed by the conductor 262 from the wires *nf*, *nf*^{iv}, *nf*^v, until the conductor 262 encounters the wire *nf*^{vi} which is inactive, and momentarily transmits current from the wire *nf*^v to the wire *rf*^{vi}, completing thereby, circuit to the relay C.53', which retracts, in turn, its plunger, and is held in stick by current from the wire *s*⁺, to the effect, that circuit to the negative poles of the relays C.52, C.52^{iv}, C.52^v is broken; that the wires *rf*, *rf*^{iv}, *rf*^v, *rf*^{vi}, all receive current from the wire *s*⁺; that the wires *sf*, *sf*^{iv}, *sf*^v, *sf*^{vi}, are rendered active; and that at the bridge 269' at the relay C.53' circuit to the negative pole of the clutch C.57' is broken, and at the bridge 270' circuit to the negative pole of the clutch C.57 is closed. Motion of the platen 236 and of the disk 262 so again reversed is sustained through the wire *mf* to the relay C.57, as the conductor 262 closes successively on the wires *rf*^v, *rf*^{iv}, *rf*, until the platen 236 travelling to the right and the disk 261 rotating in clockwise direction, are again restored to their original positions.

As the conductor 263' closes on the wires *sf*^v, *tf*^v, circuit is completed through the lever ^{iv} closed on the wire *af*⁵ to the solenoid C.48⁵; and the numeral 5 is recorded on the sheet 235 (Figure 1) in the hundredths column. This circuit as an example, may be traced. Originating at the source ZZ (Fig. 3) the circuit passes through the wire *s*⁺ over the bridge at the relay C.56', the bridges 249', 250', raised, at the relay C.55', the bridges 269', 268' at the relay C.53', the lowest bridge at the relay C.52^v the wire *sf*^v, conductor 263', the wire *tf*^v, lever ^{iv}, wire *af*⁵ carried in the cable *ff*, the solenoid C.48⁵, and thence through the wire *s*⁻ back to the source ZZ. As the conductor 263' closes on the wires *sf*^{iv}, *tf*^{iv}, circuit to the lever ^{iv} is closed on the wire *af*⁰ to the solenoid C.48⁰, and a cypher is recorded on the sheet 235 (Figure 1), in the tenths column. As the conductor 263' (Figure 3) closes on the wire *af*, *tf*, circuit is completed through the wire *tf* which leads from the conductor 263' directly to the solenoid C.48, and the decimal point is recorded between the column of the units and the column of the tens, as will further be described. The decimal point is the last character

recorded. The disk 261 is then in normal position, at which the conductor 264' closes circuit from the terminal 275 to the relay C.56'. The type-bar 231 in falling as it records the decimal point, completes at the terminals 276, circuit, through the conductor 276, from the wire *s*⁺ to the relay C.56', which retracting its plunger breaks circuit to the relay C.55'. The relay C.55' so deenergized, releases its plunger and breaks, at its bridges, circuit to the relays C.52, C.52^{iv}, C.52^v, C.52^{vi}, C.53' and clutches C.57, and C.57'. The recording mechanism thus becomes inactive; and another quantity may be set up at the levers ⁱ-^{iv}. The push button P.9 may again be depressed, and the operation be repeated.

It may be observed, that the decimal point and the numerals of the units column are in common recorded, when the disk 261 is at its original position. In order to prevent the type 232 which records the decimal point, from striking in the units column, the clutches C.60, C.60' (Figure 4), are rendered active.

The clutches C.60, C.60' (Figure 4), shown diagrammatically in arbitrary position in Figure 6, are in the circuit of the wires *s*⁺, *s*⁻, leading from the source ZZ; but they receive initial impulse, respectively, from the auxiliary extensions *fz*, *fz*' of the wire *s*⁺, which operate as primers displacing the clutches C.60, C.60' sufficiently only to close the terminals of the wire *s*⁺ on one of a series of contact bands carried by the clutch C.60, C.60', which are of such arc as to complete the displacement of the platen 236 (Figure 1) the distance of a type space.

When the disk 261 (Figure 6) passes from zero position to operate on the columns of a fraction; the conductor 260 attached to the disk 261 (Figures 3, 6) momentarily closes circuit at the fixed terminals 259 (Figure 6) of the wires *fz*', and transmits an initial impulse to the clutch C.60', which energized immediately thereafter through the wire *s*⁺, imparts to the platen 236 (Figure 1), through the differential gearing *Df*^{'''} (Figure 4) and the idler 293 (Figure 1), a supplementary displacement of a type space to the left, this being the extra space required for the decimal point. On returning, when the disk 261 reaches normal position and the decimal point is printed, the platen 236 lags the distance of a type space from normal position, and the sheet 235 (Figure 1) receives the impression of the decimal point, a type space to the right of the units column. The type bar 231 (Figure 3) in falling closes circuit as already explained, at the terminals 275, from which is extended the wire *fz* (Figure 6) leading to the clutch C.60, which receives through the wire *fz* an initial impulse; and circuit being thereupon sustained through the wire *s*⁺, transmits sufficient movement through the transmission 287 (Figure 4), 289', *Df*^{'''}, 292, 293 (Figure 1) to restore the platen 236 to normal position, a type space further to the right. Inasmuch as circuit at the terminals 275 is immediately broken after being closed by the conductor 276 (Figure 3), the impediment *im* (Figure 6) is introduced into the circuit of the wire *fz*, to insure adequate duration of the initial impulse to the clutch C.60.

In order that the clutch C.60' may not be energized through the conductor 260 (Figures 4 and 6) as the disk 261 returns to normal position; the circuit of the wire *fz*' is broken by the bridge 297 at the relay C.53' (Figure 3, 6), the plunger of which, as hereinbefore described, is in raised position while the platen 236 is traveling through fractional columns, to the right.

In order, at volition, to effect a lateral shift of

the platen 236 (Figure 1), as when, for example, it be desired to record positive and negative quantities in separate columns; the push-buttons P.10, P.10' (Figure 4) are provided, which, when depressed, impart initial impulse respectively to the clutches C.60, C.60'; and cause the platen 236 to travel to the left or to the right, the distance of a type space, at each depression of a push button, P.10, P.10'.

Should the quantity recorded involve the highest integral lever 1^v , or the lowest fractional lever 1^{vi} , there would be no further inactive relays over the depressed bridges of which circuit would be closed to the positive poles of the relays C.53, C.53' (Figure 3) in order to reverse the movement of the disk 261 and the platen 236 (Figure 1). To supply, in such event, the needed currents, the wires x_f , x_f' (Figure 3) are provided, through which, when a terminal thereof is encountered by the conductor 262 at its extreme displacements, circuit of the wire s^+ is closed directly to the respective relays C.53 or C.53'.

Line spacing of the platen 236 (Figure 1) is effected by the solenoid C.61, mounted on the carriage of the platen 236, circuit to the positive pole of which is closed by a contact such as the contact 244, through the displacement of the disk 243, its negative pole being connected through the wire s^- back to the source ZZ. The plunger of the solenoid C.61 terminates in a latch similar in principle to the latch 24' (Figure 8), which is raised when the solenoid C.61 momentarily is energized, and descends under tension of the spring 279 (Figure 1). In descending the latch operates upon a tooth of a disk 278 fixed to the shaft 280, which supports the platen 236. The sheet 235 is thereby carried upwards, and receives the impact of the types 232, 232^o-232^o, at a next lower horizontal line.

In order that the platen 236 may be rotated at volition, the push button P.11 (Figure 1) is provided, at which circuit may be closed to the solenoid C.61, which operates a line space displacement of the platen 236 at each manual depression of the push button P.11.

That a momentary pause in the movement of the platen 236 may be effected, when a type 232^o-232^o is in impact with the ribbon 233, circuit of the wire m_f (Figure 3) leading to the positive poles of the clutches C.57, C.57' is broken, as a solenoid C.48^o-C.48^o contracts its plunger, at a bridge 272^o-272^o, and remains open until the conductor 263 or 263' escapes the terminals of the wires t_f - t_f^{vi} . In order, to renew the movement of the disk 261 and carry the conductor 263 or 263' into such escapement, the relay C.59 is provided, the circuit of which originating at the source ZZ passes through the wire s^+ to the series of terminals 274. When a type bar 231^o-231^o is deflected by a solenoid C.48^o-C.48^o, circuit is completed by a conductor 276^o-276^o between a terminal of the series 274 and the terminal of a series 273, to the relay C.59, the negative pole whereof is connected through the wire s^- with the source ZZ. The relay C.59 so energized, retracts its plunger, and switches current from the wire s^+ closed at contacts 273, 274, to the wire m_f leading to the clutches C.57, C.57' until circuit to the solenoid C.48^o-C.48^o is broken at the conductor 263, 263' and the type-bar 231^o-231^o breaks circuit at the terminals 273, 274. In order that a type 232^o-232^o may not drag upon the inking ribbon 233 (Figure 1) while its type-bar remains deflected, the type-bars 231^o-231^o may be provided with flexible ex-

tremities which effect a whip-lash action of the types, causing them to complete impact on the inking ribbon 233 through momentum, and recoil a minute distance after impact is completed.

The lever 239 (Figures 1, 3) remains closed on the terminals 240, so long as it be desired, for example, to record a column of figures, as in addition, and suppress all resultants except the final sum. The push-button P.9 is depressed, as each quantity is set up at the levers 1^v - 1^{vi} , before depression of the push button P.1 (Figures 1, 9), which initiates each successive operation of addition. When the last component quantity has been recorded, the lever 239 is switched into contact with the terminal 240'; which is its position in recording all resultants; and the push button P.1 is then depressed. In default of automatic control of the detent relays C.28', C.28'', C.28''', a push button P.1, P.2, P.3 may be held manually in depressed position, after recording such component quantities, while a resultant is being developed at the accumulator members 61'-61^{vi} (Figure 1) or at the quotient member 27'-27^{vi} (Figure 8). When push button is released, circuits differentially closed by the State control 7, are completed to record a said resultant in manner now to be described.

Referring to Figures 1, 3, 8, 9, the push buttons P.1, P.2, P.3, when depressed, in order to initiate operations of addition, subtraction, multiplication or division, close circuit to the solenoid C.49 Figures 1, 3, 8 which retracts its plunger in manner already described. As the respective push button P.1, P.2, P.3 be released at the termination of computation, and is restored to normal position by the springs S.34', S.34'', S.34''' circuit is broken, at the bridges 33', 33'', 33''' (Figures 1, 3, 8, 9) to the solenoid C.49, which releasing its plunger, brings the recording mechanism into operation.

In addition, subtraction and multiplication, the resultants are developed at the accumulator arms 61'-61^{vi} (Figures 1, 3): in division, at the quotient arms 27'-27^{vi} (Figure 8). Quotient arms and accumulator arms operate upon the recording mechanism in substantially similar manner, as will presently appear.

In addition, subtraction and multiplication, when the lever 239 (Figure 1) closes on the terminals 240', it closes also at the terminals 240'', circuit from the wire s^- to the negative pole of the relay C.50, which, in turn, closes circuit over the wires t_f - t_f^{vi} , shown (Figure 1) as carried in the cable t_{ff} , to the accumulator arms 61'-61^{vi}. Circuit is completed to the positive pole of the relay C.50, in addition and subtraction, from the wire s^+ over the bridge 33' raised, at the push button P.1; and in multiplication, from the wire w , over the bridge 33'' raised, at the push button P.2. The relay C.50 connects the accumulator arms 61'-61^{vi} with the recording mechanism.

In addition and subtraction, when the push button P.1 (Figures 3, 9) is depressed, circuit is completed at the bridge 33' from the wire s^+ to the solenoid C.49 which retracts its plunger as above described. When the push button P.1 is automatically released at the termination of an operation, circuit to the solenoid C.49 is broken, and circuit is completed at the bridge 33' to a conductor 242' carried by the disk 243' (Figure 5) similar to the conductor 242 (Figure 3). As the disk 243' is revolved through the action of the latch 245, as hereinbefore described, a contact 244' similar to the contact 244,

closes circuit from the conductor 242'; first to the solenoid C.61 (Figure 1) which rotates the platen 236, a line space; next through the wire kf' to the bridges 225', 225'', 225''' (Figure 1) carried respectively by the sleeves 60', 60'', 60''' at the accumulator arms 61', 61'', 61''' corresponding to integral orders; and then through the wire lf' to the bridges 225^{iv}, 225^v, 225^{vi} carried respectively by the sleeves 60^{iv}, 60^v, 60^{vi} at the accumulator arms 61^{iv}, 61^v, 61^{vi}, corresponding to orders of the fraction. The bridges 225'-225^{vi} are exactly similar in operation to the bridges 246'-246^{vi} at the levers 1'-1^{vi} above described, and close circuit through extensions of the wires df' - df ^{vi}, with like effect, on the relays C.52, C.52'-C.52^{vi}. Rotation of the disk 261 and lateral displacement of the platen 236 (Figure 1) follow in the same manner, as when circuits are closed to the relays C.52, C.52'-C.52^{vi} by the levers 1'-1^{vi}.

Extensions of the wires tf' - tf ^{vi} lead, in similar manner, from the terminals closed by the conductors 263, 263' back to the conductors 276'-276^{vi}, (Figure 1), at the accumulator arms 61'-61^{vi}, whence circuits are extended through the accumulator arms 61'-61^{vi}, to the terminals 237'-237^{vi}, which, according to the angular displacement of the accumulator arms, close circuits (Figures 1, 2), through extensions of the wires af' - af ^{vi}, over the bridges at the relay C.47, to the solenoids C.48'-C.48^{vi}, the recording mechanism being similarly responsive to the accumulator arms 61'-61^{vi} and to the levers 1'-1^{vi}.

Inasmuch as the resultants in addition, subtraction and multiplication, are all set up at the accumulator arms 61'-61^{vi}, a circuit is closed in multiplication, to the disk 243', as in addition and subtraction, and thence to the same members of the recording mechanism as in addition and subtraction, in manner above described; the only variation in the operations being, that the push button P.2 is in depressed position instead of the push button P.1, and circuit is transmitted through the wire w . The push button P.2, when depressed, energizes, over the bridge 33'' (Figures 3, 9) the solenoid C.49, in the same manner as does the push button P.1. Returning to normal position, when the multiplication is completed, the push button P.2 breaks circuit at the bridge 33'' (Figure 3) to the solenoid C.49, which thereupon displaces, as hereinbefore described, the disks 243-243''' (Figure 5). At the bridge 33'' (Figure 3) circuit is closed to the conductor 242' at the disk 243', and the recording mechanism completes its operation as in addition and subtraction, in manner above described.

In division circuits from the accumulator arms 61'-61^{vi} (Figure 1) to the recording mechanism are broken at the relay C.50; and circuits from the levers 1'-1^{vi} to the recording mechanism are broken at the relay C.51. Circuits are closed from the quotient arms to the recording mechanism, in division by the relay C.66 (Figures 8, 9), which is in the circuit of the wire u , closed by the State control 7 and active only in division. The positive pole of the relay C.66, is connected through the wire s^+ with the source ZZ. In division circuit is closed by depression of the push button P.3 (Figures 8, 9) over the bridge 33''' to the solenoid C.49 (Figure 8), which operates as in addition, subtraction and multiplication hereinbefore described.

The push button P.3 automatically returning to normal position, when the division is com-

pleted, closes circuit at the bridge 33''' to a conductor at the disk 243'' (Figure 5) similar to the conductor 242 (Figures 3, 8). In similar manner and to like effect, as hereinabove described in disclosing the operation of levers 1'-1^{vi} and of accumulator arms 61'-61^{vi} (Figures 1, 3), circuits are closed at the disk 243' first to the solenoid C.61 (Figures 1, 8) which rotates the platen 236 (Figure 1) a line space; next through the wire kf''' (Figure 8) to the bridges 298', 298'', 298''', supported when in normal position by the cams 215', 215'', 215''', fixed to the shafts of the quotient arms 27', 27'', 27''', and then through the wire lf''' to the bridges 298^{iv}, 298^v, 298^{vi} supported when in normal position by the cams 215^{iv}, 215^v, 215^{vi}, fixed to the shafts of the quotient arms 27^{iv}, 27^v, 27^{vi}. These bridges fall when their corresponding quotient arms are deflected; and close circuits to the relays C.52, C.52', C.52^{vi}, in similar manner and to like effect as when circuits are so closed by the bridges 246'-246^{vi} at the levers 1'-1^{vi} (Figure 3), or by the bridges 225'-225^{vi} at the accumulator arms 61'-61^{vi} (Figure 1). Common connections to the df and tf wires are shown in Figure 3. The df and tf wires are shown as carried by the respective cables dff , fff , in Figure 1; and the cables dff , fff as shown in Figure 8.

The circuits closed by the quotient arm 27' at the terminals 290'-290'', are carried by the cable ffd (Figure 8) to the solenoids C.48'-C.48^{vi}. Similar circuits are closed by the quotient arms 27''-27^{vi}, in common with the quotient arm 27', to the solenoids C.48'-C.48^{vi}. The angular deflection of the quotient arms 27'-27^{vi}, reflects the numerals of the quotient, as hereinbefore described.

The wiring shown in Figure 8 is largely limited to the connections to or from the quotient arms 27'-27^{vi} and the bridges 298'-298^{vi}; since further details are shown in Figures 1, 3; and inasmuch as the operation of the recording mechanism, in recording a quotient, is substantially similar to its operation in recording a resultant set up at the accumulator arms 61'-61^{vi} (Figures 1, 3), except in indicating the positive or negative quality of the resultants, now to be described.

If in addition, subtraction and multiplication, the resultant reflected at the accumulator arms 61'-61^{vi} (Figure 1) be positive, circuits are closed through the wires af^1 - af^2 respectively over the bridges depressed at the relay C.47, to the solenoids C.48'-C.48^{vi}. The relay C.47 is in the circuit of the wire d' , (Figures 1, 2), its negative pole being connected with the wire $s-$ back to the source ZZ. If, the quantity reflecting at the accumulator arms 61'-61^{vi} be negative; circuit is closed to the wire d' , over the top bridge at the relay C.16 (Figure 1) by manual depression of the push button P.11' in default of eventual automatic connection over an extra bridge below. The relay C.47 is energized thereby; and retracting its plunger, switches the circuits of the wires af^1 - af^2 to the C.48 solenoids of complementary serial number.

The quality of a quantity as recorded on the sheet 235 (Figure 1) may be signaled by printing the positive and negative quantities in different colors. To this end the solenoid C.64, in the circuit of the wire $s-$ and the wire d'' , may elevate and lower the frame 234, which is fixed to its plunger and carries the inking ribbon 233. The upper margin of the inking ribbon 233 may be, for example, black and the lower margin red. When the quantity reflected be positive, the upper margin of the inking ribbon 233 may be exposed to the types 232, 232'-232^{vi}. When the quantity

is negative, the solenoid C.64 energized by the wire d'' to which circuit is closed from the wire d' , retracts its plunger upwards; and exposes to the types the red portion of the inking ribbon 233. Positive quantities, accordingly may appear in black, and negative in red.

In division, since the quotient arms 27'-27^{vi} (Figure 8), when reflecting a quotient, are displaced always in clockwise direction, the extensions of the wires a^i - a^j , shown as carried in the cable $ff\delta$, lead directly to the solenoids C.48', C.48^o without passing over the bridges at the coil C.47. A positive quotient is registered with the solenoid C.64 in normal position exposing the black margin of the inking ribbon 233 to the types 232, 232^o-232^o. In default of automatic control of the solenoid C.64, the push button P.11' may be manually depressed closing the wire d'' to the solenoid C.64 causing the said solenoid to shift the inking ribbon and expose the other margin to the type in order that a negative quotient may be recorded red.

If it be desired to indicate the negative quality of a quantity when set up at the levers 1'-1^{vi} (Figure 1), the push button P.11' (Figure 3) may be manually depressed completing circuit from the wire s^+ closed at the terminals 240, to an extension of the wire d'' leading to the solenoid C.64, causing thereby the quantity to appear in red.

In Figure 5, the disk 243''' is shown as adapted to the recording of multipliers which may be set up at levers similar to the levers 1'-1^{vi} (Figure 3); but inasmuch as the description of such operation would be substantially similar to the above description relating to the levers 1'-1^{vi} Figure 3, the description of recording multipliers is not extended further.

I claim:

1. Recording mechanism for service with calculating apparatus provided with denominational numeral members to reflect the digits of whole numbers and of decimal fractions and provided with selective numeral circuits corresponding to said digits and denominational circuits corresponding to the orders of the digits; the said recording mechanism comprising a column-spacing platen, electrically actuated recording members corresponding to respective digits and a recording member corresponding to the decimal point, a motor, reversible transmission from the motor to step the platen in opposite directions, a movable switch controlled by the transmission, circuits corresponding to the column of the decimal point, means including the last said circuits and the denominational circuits selectively completed by the switch for differentially controlling the transmission to step the platen in one direction from zero position in variable degree according to the ordinal column of the denominationally highest significant digit of whole number and in opposite direction in variable degree according to the lowest significant digit of a fraction, and to step the platen back to zero position in relatively reversed directions, means controlled by the switch to complete the numeral circuits and cause the recording members to record the digits corresponding to a whole number in denominationally descending order as the platen is stepped towards zero position in one direction, and to record the digits corresponding to a fraction in denominationally ascending order as the platen is stepped towards zero position in relatively re-

versed direction, and a circuit closed by the switch to the recording member corresponding to the decimal point, to cause the last said member to record a decimal point as prefix to the fraction.

2. Mechanism automatically to record a quantity, for service with calculating apparatus provided with denominational numeral members to reflect the digits of a whole number, selective numeral circuits corresponding to said digits and denominational circuits corresponding to the orders of the digits; the said recording mechanism comprising a column-spacing platen, type members corresponding to respective digits controlled by the numeral circuits, a motor, reversible transmission from the motor including selective contra-directional clutches to step the platen in opposite directions, a movable switch operated by the transmission to synchronize the operation of the type members with the step movement of the platen, means controlled by the denominational circuits for sensing the order of the denominationally highest significant digit, selective actuating circuits to the clutches, means including the denominational circuits and the switch differentially to complete the actuating circuits to step the platen in one direction from zero position in variable degree according to the ordinal columns of the digits, and to step the platen back to zero position, means controlled by the switch to complete the numeral circuits to the type members and cause the last said members serially to record the digits of the whole number in denominationally descending order, as the platen is stepped back to zero position.

3. Mechanism automatically to record a quantity for service with calculating apparatus provided with denominational numeral members to reflect the digits of a decimal fraction, numeral circuits corresponding to the digits and denominational circuits corresponding to the orders of the digits; the said recording mechanism comprising a column-spacing platen, type members to record respective digits controlled by the numeral circuits, a type member to record a decimal point, a motor, reversible transmission from the motor including selective contra-directional clutches to step the plate in opposite directions, a movable switch operated by the transmission to synchronize the operation of the type members with the step movement of the platen, means including the denominational circuits for sensing the order of the denominationally lowest significant digit of the fraction, selective circuits corresponding to the column of the decimal point, means including last said circuits, the denominational circuits and the switch for differentially actuating the clutches to step the platen in one direction from zero position in variable degree according to the column of the decimal point and the ordinal columns of said digits and back to zero position in reverse direction, means controlled by the switch to complete the numeral circuits and cause the type members serially to record the digits of said fraction in denominationally ascending order as the platen is stepped in reversed direction, and a circuit closed by the switch to the type member corresponding to the decimal point to cause the last said member to record a decimal point as prefix to the fraction.

HENRY JEWETT FURBER.