Sept. 27, 1938. C. BOREL 2,131,497

APPARATUS FOR COLLABORATING STATISTICAL DATA

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Fig. 17.

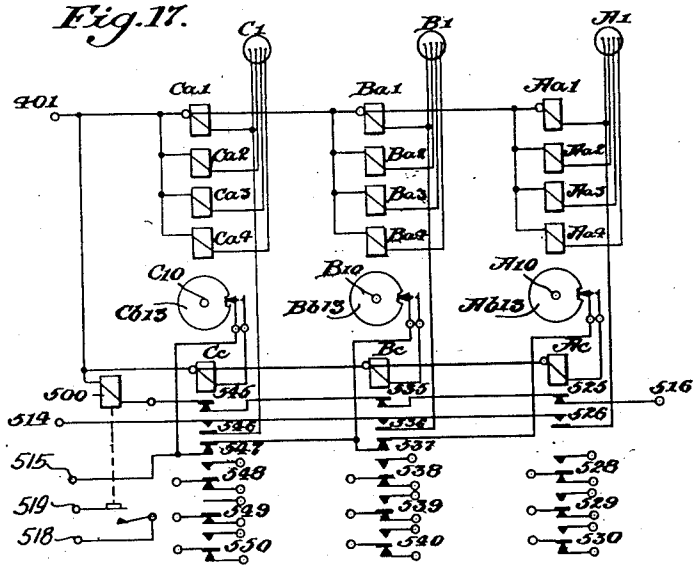


Fig. 22.

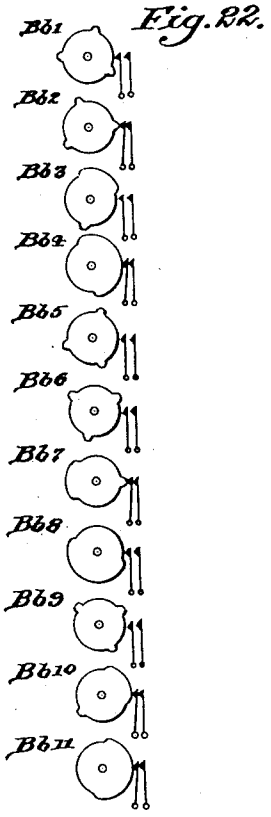


Fig. 1.

	1	2	3	4
0	+	+	+	+
1	○	+	+	+
2	+	○	+	+
3	+	+	○	+
4	+	+	+	○
5	○	+	+	○
6	+	○	+	○
7	+	+	○	○
8	○	·	○	○
9	+	○	○	○
10	○	○	○	○

Fig. 14.

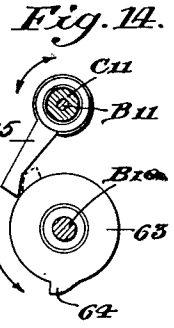
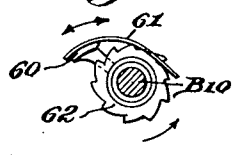


Fig. 13.



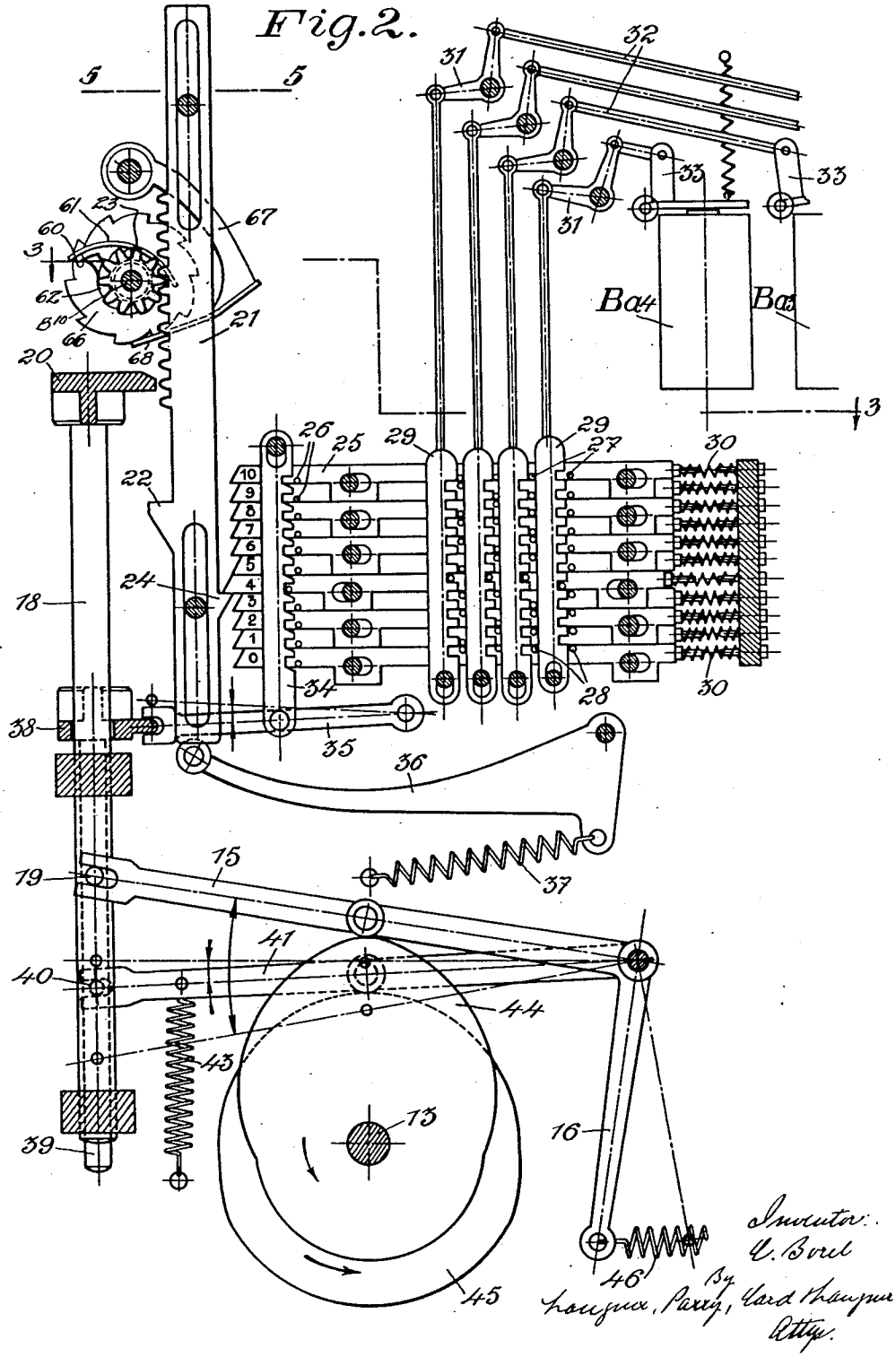
Inventor:
Charles Borel,
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Sept. 27, 1938. C. BOREL 2,131,497

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Fig. 2.



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Fig. 3.

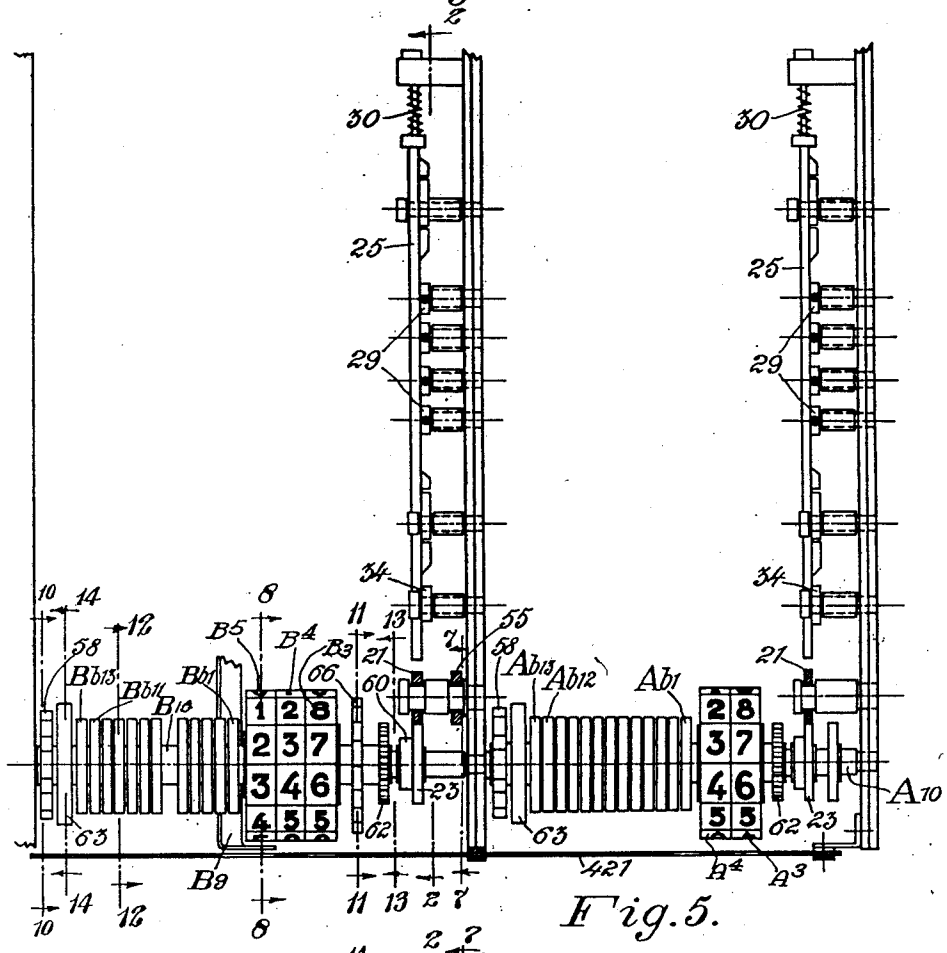
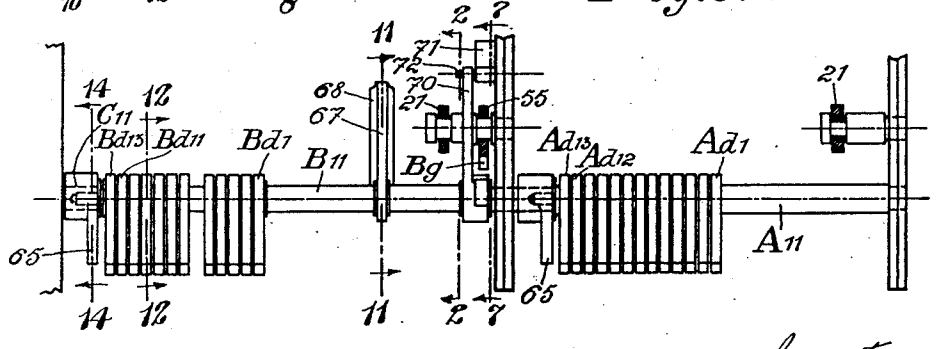


Fig. 5.



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Fig. 4.

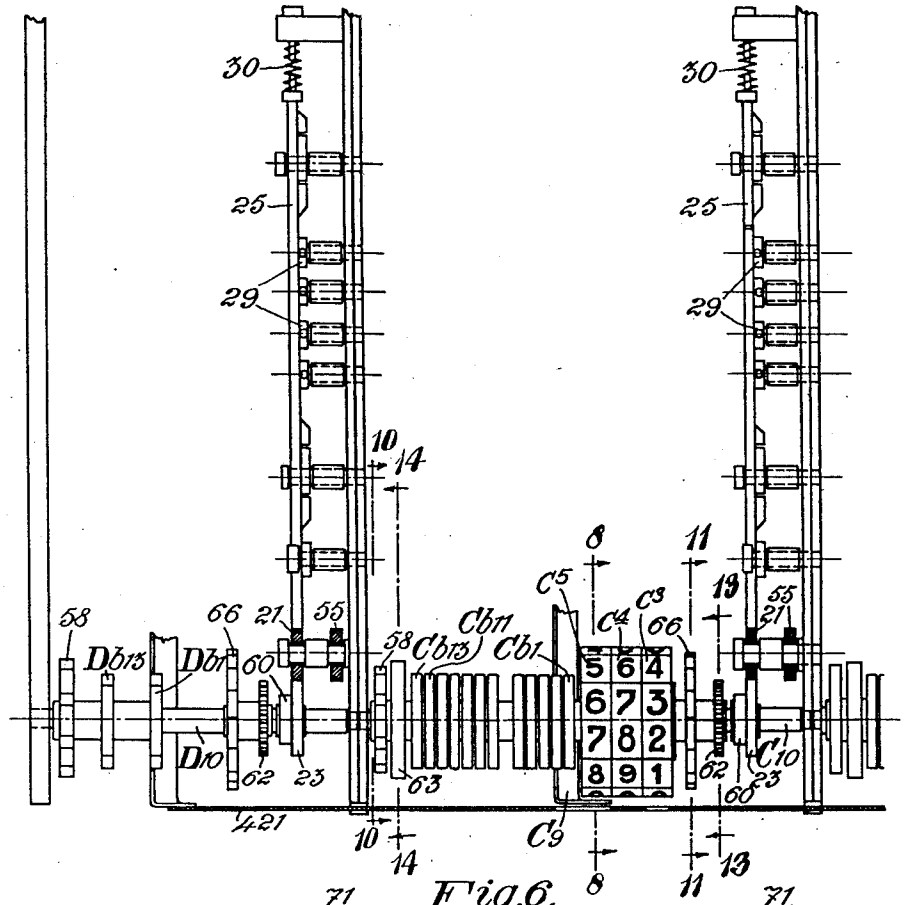
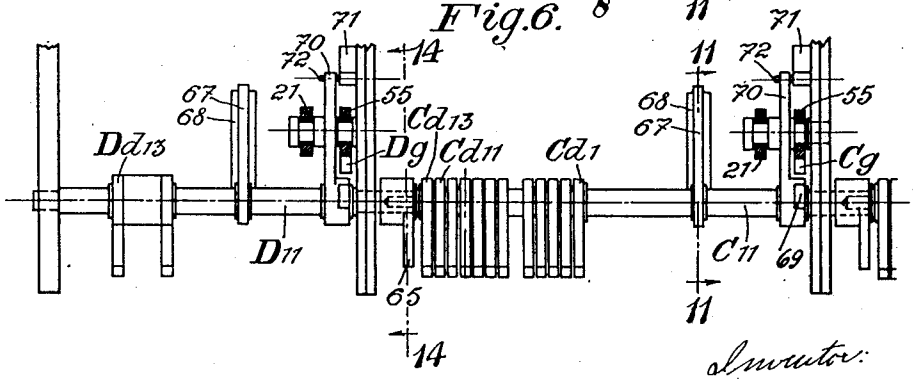


Fig. 6.

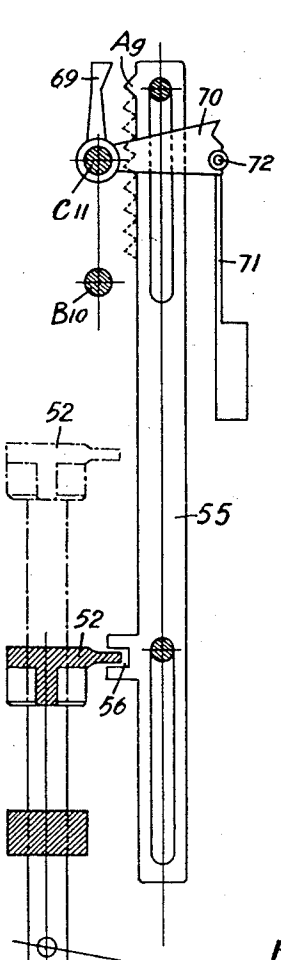


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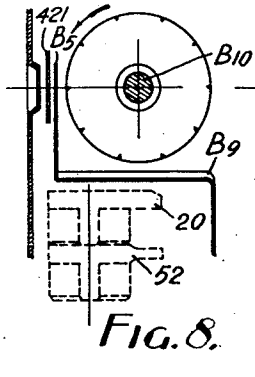


FIG. 8.

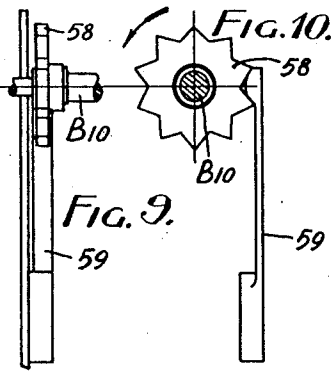


FIG. 9.

FIG. 10.

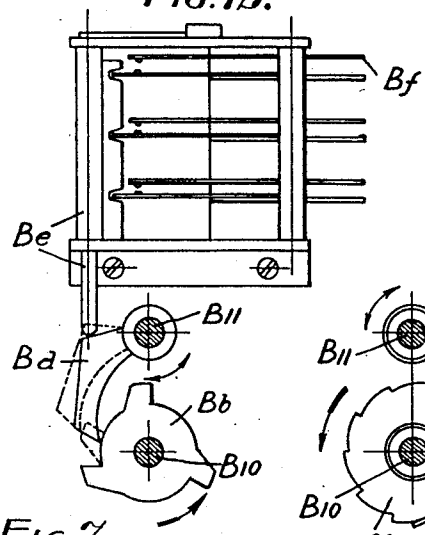


FIG. 12.

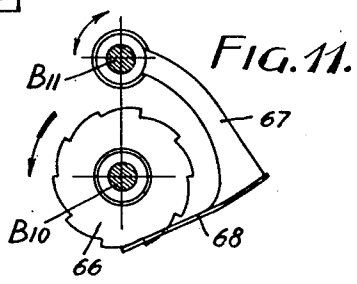


FIG. 11.

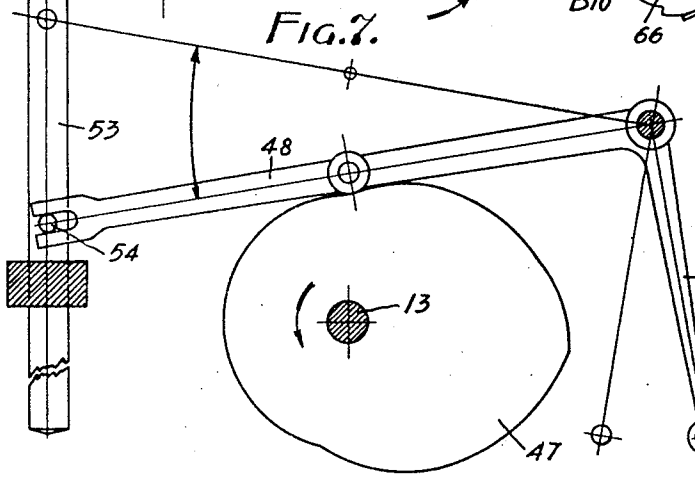


FIG. 7.

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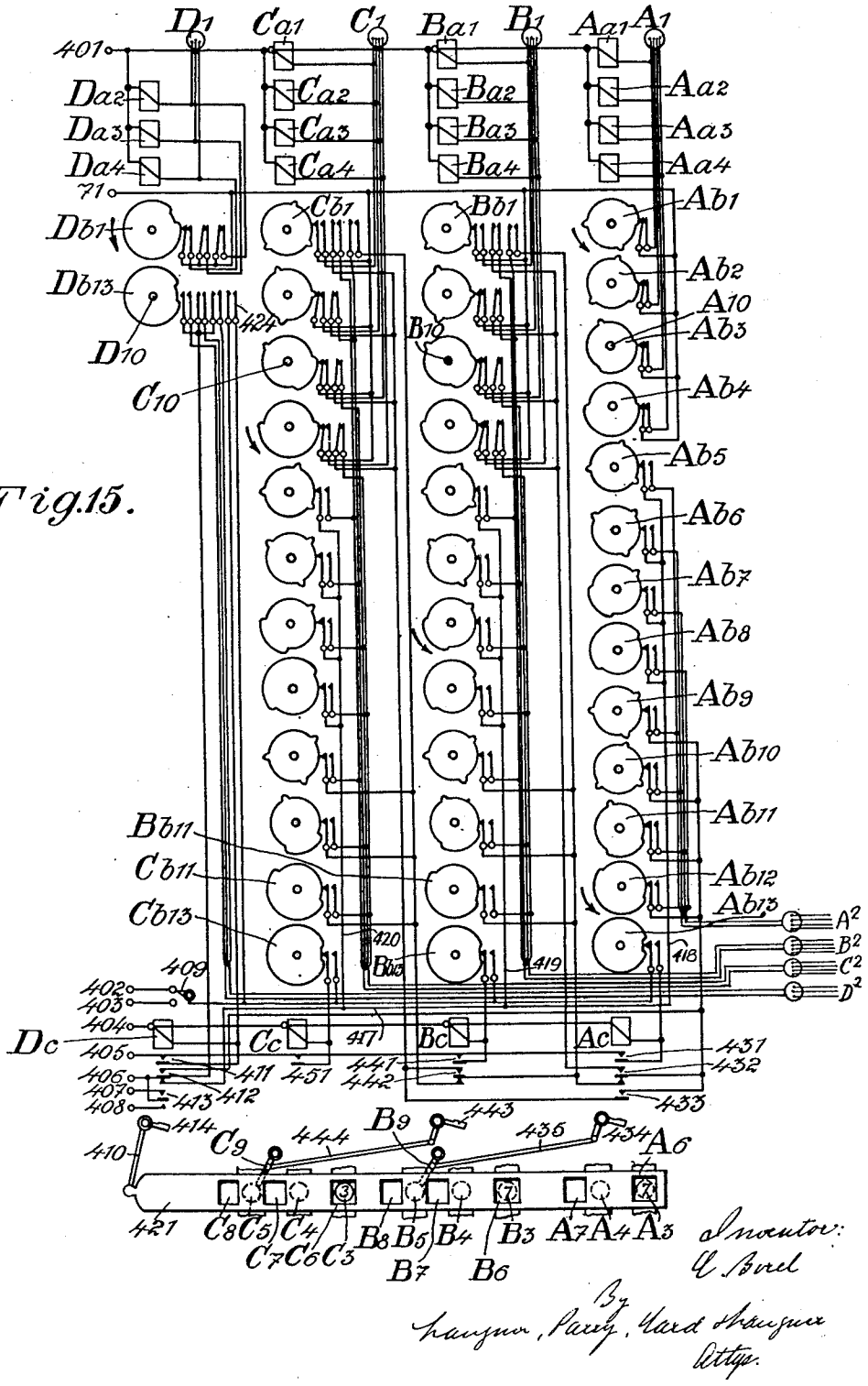


Fig.15.

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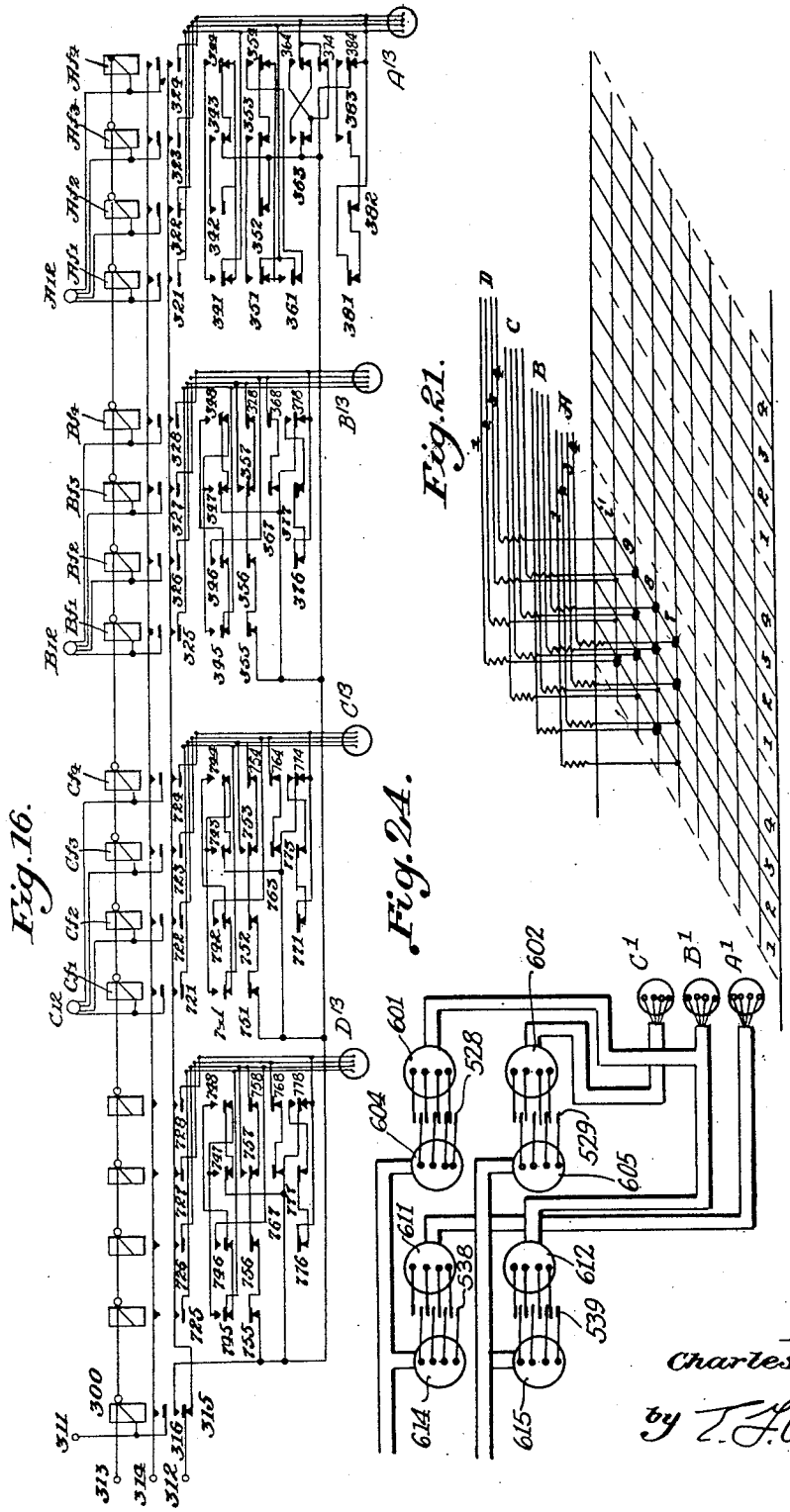


Fig. 16.

Fig. 21.

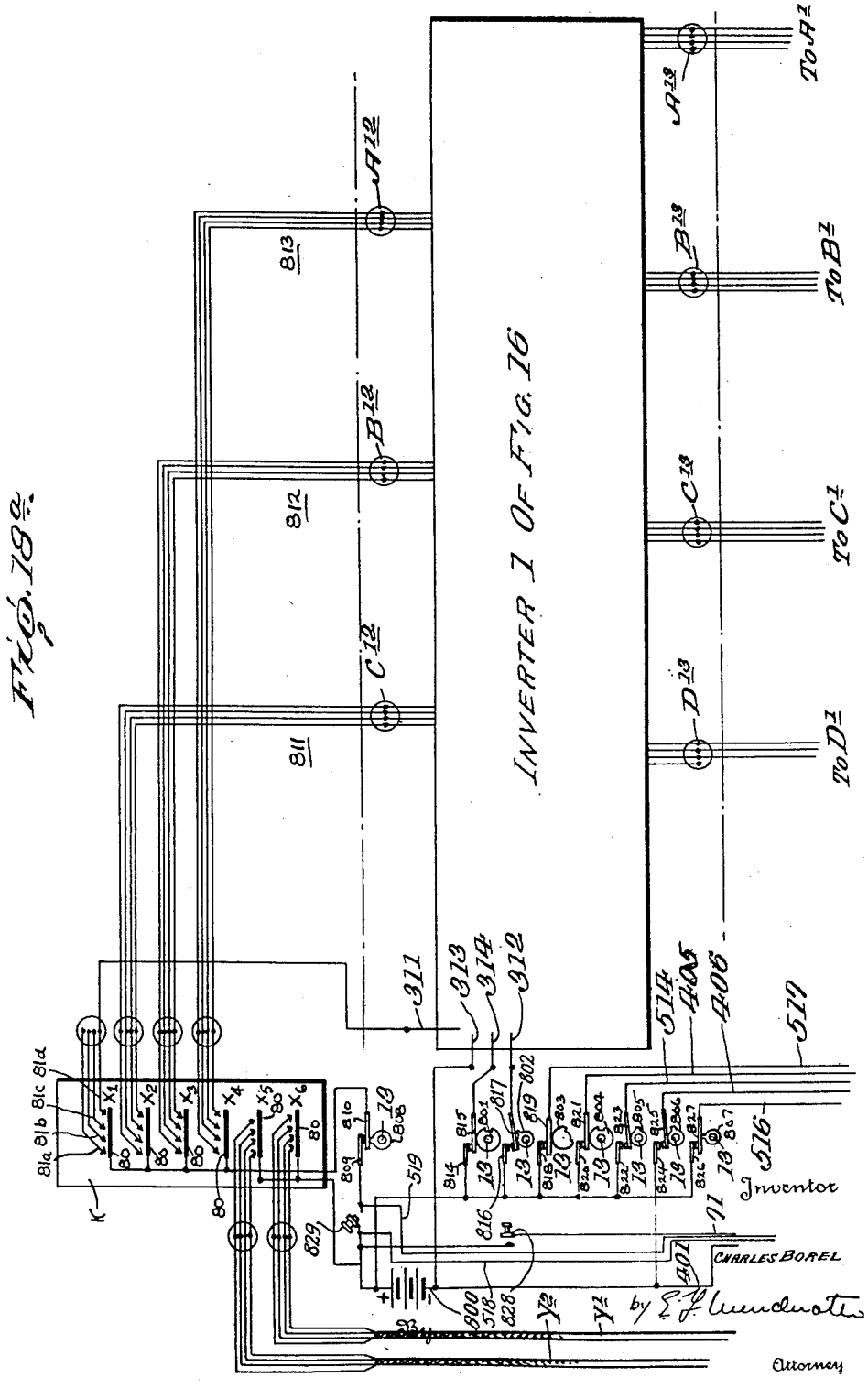
Fig. 24.

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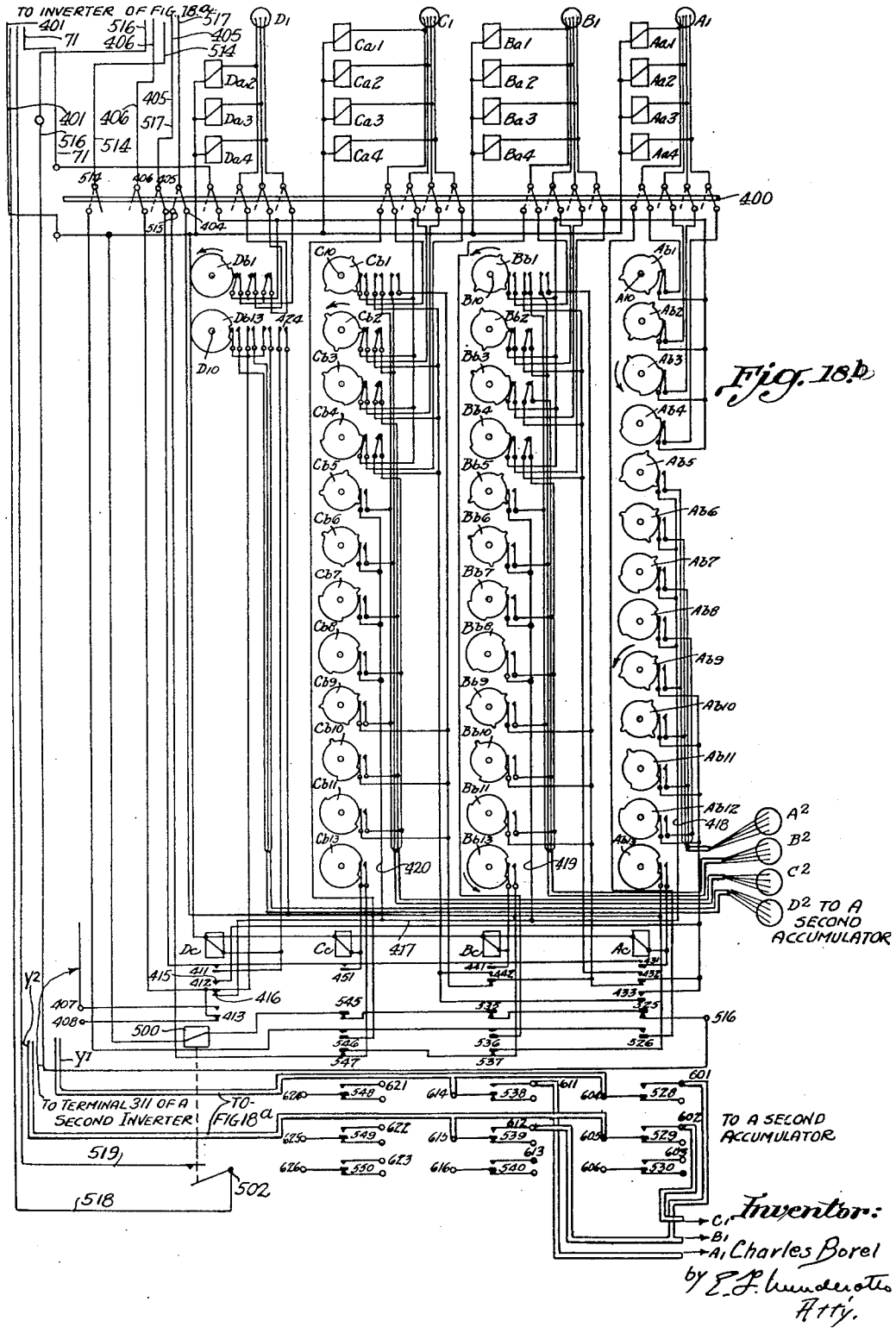


Fig. 18b

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Sept. 27, 1938. C. BOREL 2,131,497

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Fig. 19.

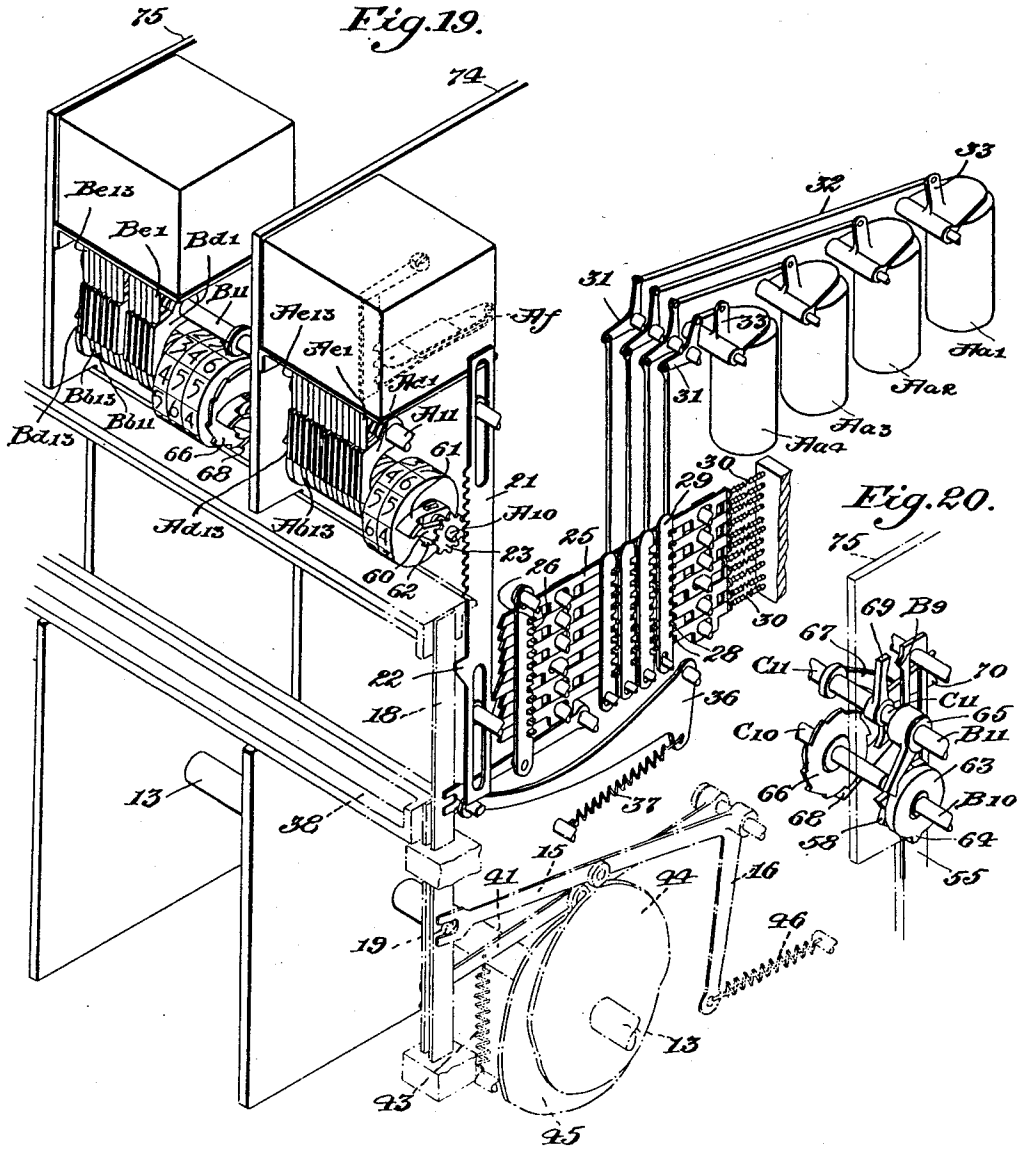


Fig. 20.

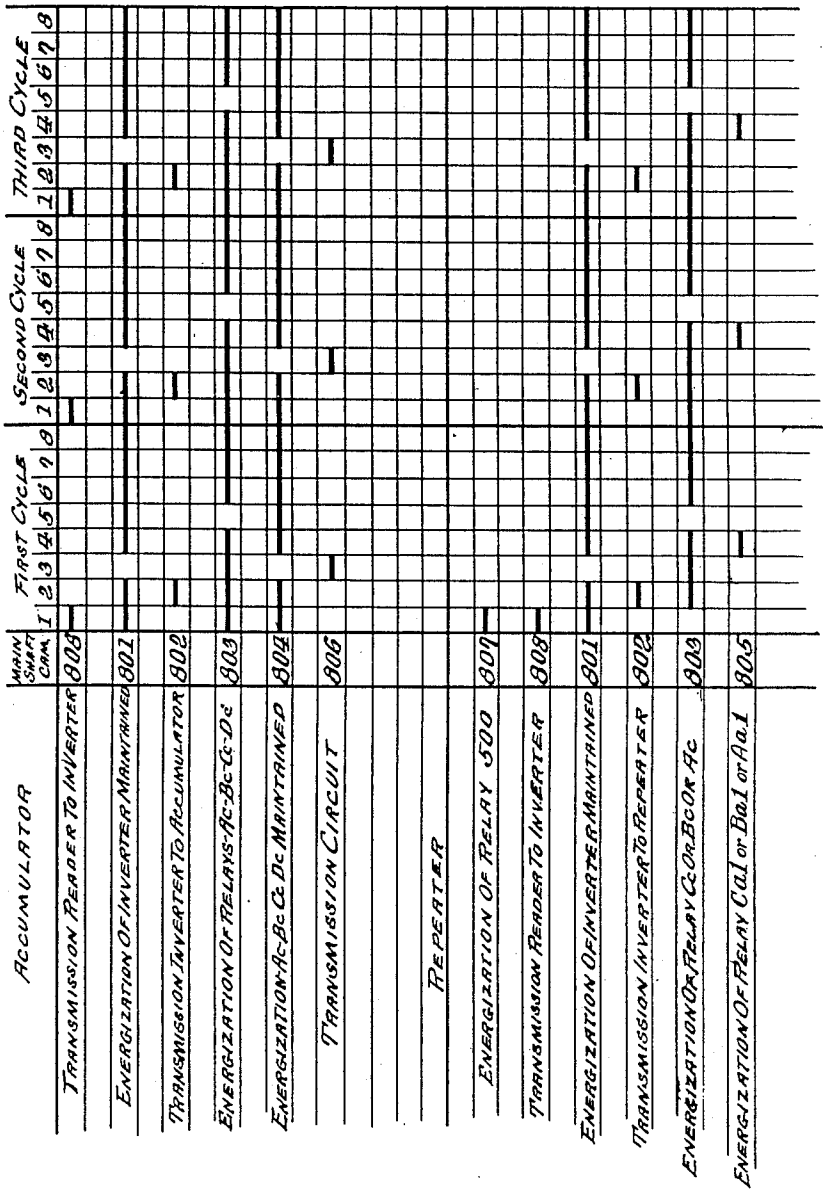
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Fig. 23.



Inventor

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Attorney

Patented Sept. 27, 1938 2,131,497

UNITED STATES PATENT OFFICE

2,131,497

APPARATUS FOR COLLABORATING STATISTICAL DATA

Charles Borel, Geneva, Switzerland

Application December 3, 1928, Serial No. 323,544
In Switzerland December 5, 1927

7 Claims. (Cl. 235—61.6)

The invention is directed to an apparatus for collaborating statistical data which, for instance, may be represented by means of perforations appearing on cards, recording strips or bands, or the like. This apparatus is so arranged that either actual figures or their complements may be used. It can serve as an accumulator, a transmitter of figures to another apparatus at any given moment, and, by a minor modification, as a repeater cooperating, for instance, in the execution of multiplications.

The apparatus according to the invention comprises several so-called denominational units, each of which units contains a receiving, a translating, and an accumulating device, and each of which units corresponds to a sign or number place of the indications received from the perforations.

One form of the invention, illustrated only by way of example, is shown in the attached drawings, wherein

Fig. 1 shows a preferred form of the perforation combinations on a paper strip, for showing the various data values.

Fig. 2 is a cross section on the lines 2—2 of Figs. 3 and 5 through the apparatus, the relative position of the three figures being best verified by comparing the positions of shafts A10 and A11 in Fig. 19. Parts lying in the rear of this sectional cut and irrelevant to the description of this figure are omitted.

Fig. 3 is a view of the lowest denominational (right hand) units of the apparatus taken on line 3—3 of Fig. 2, looking downward.

Fig. 4 is a view similar to Fig. 3, through the highest (left hand) denominational units of the apparatus.

Fig. 5 is a view of the lowest denominational units of the apparatus, taken from line 5—5 of Fig. 2, looking downward. The positions of the parts represented in this figure are best ascertained by comparing the location of shaft B11, which is directly above shaft B10 of Fig. 3. A number of parts have been omitted on Fig. 2 in order to avoid obstructing parts required for the explanation of the operations connected with this figure. Connections and relative positions of parts shown in Figs. 3, 4, 5 and 6 are best seen in Figs. 19 and 20.

Fig. 6 is a view, similar to Fig. 5, through the highest denominational units.

Fig. 7 is a vertical section on the line 7—7 of Figs. 3 and 5 (mechanism for the transfer to the next higher denomination).

Fig. 8 is a cross section on the lines 8—8 of Figs. 3 and 4 (reading-off drums), additional parts being shown to locate the position of the various parts of the machine.

Fig. 9 is a view of the mechanical unit for exact adjustment of the drum shaft and

Fig. 10 is a cross section on the line 10—10 of Figs. 3 and 4 showing the same mechanical unit.

Fig. 11 is a cross section on the lines 11—11 of Figs. 3 and 4 (carrier for the transfer to the next higher denominations).

Fig. 12 is a vertical section on lines 12—12 of Figs. 3 and 5 through one of the cams Bb1 to Bb13 and levers Bd1 to Bd13. The location of the various parts shown on this figure are best seen from Fig. 19.

Fig. 13 is a cross section on the lines 13—13 of Figs. 3 and 4 and shows part of the mechanism for entering a digit in an accumulator unit.

Fig. 14 is a cross section on the lines 14—14 of Figs. 3 to 6 illustrating means for preparing the transfer onto the next higher denomination.

Fig. 15 is a diagrammatic view of the electric equipment of the apparatus serving as an accumulator.

Fig. 16 shows diagrammatically the electric connections in the inverter for replacing an indication value by its complement.

Fig. 17 is a diagram of the electric equipment of the apparatus when used as a repeater.

Fig. 18a shows diagrammatically the reader, and schematically illustrates the inverter and the various main shaft cams and circuits leading to the accumulator.

Fig. 18b shows diagrammatically the complete accumulator (except for the shutter) including the repeater elements. This figure in part adds to Fig. 15 certain features shown in Figure 17.

Fig. 19 is a perspective view of the apparatus showing the relative position of the various parts. However, the shutter is not shown in this figure.

Fig. 20 is a perspective of the parts used in transferring a unit to the next higher denominational units.

Fig. 21 shows schematically the arrangement of the strip fields, perforations and contacts.

Fig. 22 shows the position of the discs Bb1 to Bb11 of Fig. 15, for the position 3 of the shaft B10.

Fig. 23 is a timing chart for the repeater.

Fig. 24 is a fragmentary detail of the circuits shown at the bottom right hand corner of Figure 18b.

The term "mechanical unit" is employed to designate any of the units A, B, C, or D, (Figs. 3, 4, and 15), together forming an accumulator in

which A, B, and C respectively constitute the units, tens, and hundreds orders, while D merely indicates the sign of the reading of the accumulator. In other words, each unit A, B, and C comprises a group of four electromagnets Aa_1—Aa_4, Ba_1—Ba_4, etc., of Fig. 18*b*, the cam-actuated switches Ab_1—Ab_{13}, Bb_1—Bb_{13}, etc., and the relays Ac, Bc, Cc, and Dc, together with the reading and driving mechanism appertaining thereto.

Entering operations

Each of the four contacts of the perforated line (Fig. 1) (one of the lines in each field) in the contact or reading apparatus as covered by my U. S. Patent No. 1,863,097 connects the positive pole of a source of current **800** (Fig. 18*a*), over the hand-operated contact **829** which is always closed when the apparatus is used as an accumulator, with the terminals A^1 or B^1 (Fig. 15) and so on, and with the electromagnets a^1—a^4 forming part of the corresponding denominational unit (Aa^1—Aa^4, Ba^1—Ba^4, etc.), all the said electromagnets being connected by a common lead to the terminal **401** and to the negative pole of the source of current supply **800**. The perforation of one or more points in a so-called "hole line" in a field effects the energization of the electromagnets corresponding thereto in the accumulator (Fig. 2). Their armatures **33** (Figs. 2 and 19) are attracted, and raise the corresponding toothed latch bars **29** by means of the rods **32** and the bell-crank levers **31**. Each locking rod **25** is shown as carrying four pins corresponding to, and arranged to the right of the four toothed latch bars **29**. These pins are placed either near the lower edge of the respective rod **25**, and are then marked **27**, or near the upper edge of the rod, in which they are marked **28**. The pins are so arranged that they permit the displacement to the left of only one locking rod **25** for each case when either none, one, or any predetermined combination of latch bars **29** are raised. A raised toothed latch bar **29** releases the lower pins **27** of the locking rods **25**, while the upper pins **28** thereof rest on a tooth of the raised toothed latch bar **29**. Immediately after the energization of the electromagnets a^1—a^4 of the particular unit, represented schematically in Fig. 18*b*, and mechanically in Fig. 2, the toothed cross rod **34** is lowered, as will be explained hereinafter, whereby its teeth apertures release the pins **26** of the locking rods **25**. Because of the arrangement of the pins **27** and **28**, one of the eleven locking rods **25** (in the drawing rod **25—4**) is released and is then forced to the left by the helical spring **30**, dependent upon a selected one or more latch bars **29** being raised; that is, in accordance with the perforated indications in the reading apparatus.

At this moment the cam **44** (Fig. 2) of the continuously rotating driving shaft **13** of the apparatus raises the arm **15** of the bell-crank lever **15—16** and by means of the fork at the end thereof, raises the pin **19**, the round rod **18**, and the cross bar **20** attached thereto and extending over the whole front of the accumulator. The cam **44**, the lever **15**, and the rod **18** are duplicated at the other end of both the accumulator (Figs. 3 and 4) and of the cross bar **20**. This cross bar **20** prevents movement of the toothed rod **21**, despite the pressure of the lever **36**, by means of contact with the projection **22** on the rod **21**. The toothed rod **21** follows the movement of the cross bar **20**, but only until the projection **24** engages that locking rod **25** which is projected. In Figs. 2 and 19 the bar **21** is raised by lever **36** through the distance corresponding to four units; its teeth thus effect a four-tenths rotation of the toothed wheel **23**, (Fig. 2 and Fig. 19) as well as of the arm **60** fastened thereto (Fig. 13 and Fig. 19) which arm rotates freely on the shaft **B10** (Fig. 3). On the occurrence of this rotation, the spring-action pawl **61** (Figs. 13 and 19) of the arm **60** carries with it the toothed wheel **62** fastened on the shaft **B10** and thus also carries the said shaft, the number drum (Figs. 3, 4, and 19), and the other wheels keyed thereon. In this manner the number drum is moved forward four units, corresponding to the perforated indication in the paper strip under the reading apparatus. The part of the aparatus described above, particularly the electromagnets **Ba1** to **Ba4** (Fig. 2), the locking rods **25**, the latch bars **29** and the pins **27** and **28**, constitute a decoding device, because the value is received in code by the electromagnets and is there changed into decimal units by the above-mentioned parts, and is thus entered in the number drums on shaft **B10**.

During the further rotation of the driving shaft **13**, (Fig. 2) the spring **46**, the bell-crank lever **16—15**, and the cross bar **20** under the action of the cam **44** are permitted to return to the lower position, the toothed rod **21** and the toothed wheel **23** being brought back into the starting position due to the engagement between the projection **22** and the cross bar **20**. The arm **60** (Fig. 13) follows this movement, but the wheel **62** and the shaft **B10** are unaffected due to the engagement of the spring **59** (Figs. 9 and 10) in the star wheel **58** (Figs. 3, 4, 9, and 10) on this shaft, and are held in their new position.

In the meantime the cam **45** on the shaft **13** (Fig. 2 and Fig. 19) has raised the lever **41**, and, through its forked end, this lever raises the pin **40** of the rod **39** as well as the cross bar **38** fixed thereto and extending over the whole front of the accumulator. By means of its forked end, engaging with the cross bar **38**, the lever **35**, as well as the toothed cross rod **34**, is raised, and the inclined edges of the teeth of the rod **34** then force back the pins **26** of the released bar **25**, as well as the bar itself. The points of the teeth of the cross rod **34** rest opposite the pins **26** and prevent a forward movement of the locking rods **25** until the next registering movement, that is, until the cam **45** allows the spring **43** to again draw down the lever **41**, together with the rod **39**, the cross bar **38**, the lever **35**, and the toothed cross rod **34**.

Tens carry operations

If on setting up a value in any denominational unit, for instance, the tens mechanical unit B, the shaft **B10** (Fig. 2) is rotated until it reaches its position corresponding to the zero of the number drum, then by means of the tooth **64** (Figs. 14 and 20) of the cam **63** mounted on the shaft **B10** (Figs. 1, 14 and 20), the lever **65** (Figs. 5, 14, and 20) on the shaft **C11** of the next higher unit is rotated forward in clockwise direction. In this rotation of the shaft **C11** the end of the lever **69** (Figs. 7 and 20) which forms part of the transfer mechanism, bears on the rod **55** (also in Fig. 3), while the pin **72** of the spring **71** rests in the top indentation of the arm **70** and holds the shaft **C11** in the new position. The cam **47** on the driving shaft **13** (Fig. 7) now raises the arm **48** of the bell-crank lever **48—50** and, through the forked end, thereof raises the pin **54**, the rod **53**, and the cross bar **52** which is fastened thereto and which extends over the whole of the front of the accumulator of Fig. 3. In consequence of the engagement of

the bar 52 in the catch 56 of the rod 55, the latter is carried upward. This rod 55, of each denominational unit, carries a tooth *g* (shown in Fig. 7 as A*g*) disposed in each mechanical unit along its length, which tooth occupies the highest position in the tens order, the next highest in the hundreds order, and in the following orders always one position lower. On raising the rod 55, the levers 69 (upon rotation to the right) of those mechanical units to which the tens of the previous mechanical unit are to be transferred, are again forced back to the left by the tooth *g*. This action does not take place simultaneously, but occurs successively, beginning with the second lowest denominational unit. There is no bar 55 in the units order because it cannot receive any transfer from the right, this being the lowest mechanical or denominational unit. By the rotation of the shaft C11, B11, or D11 (Figs. 2, 5, 6, 7 and 20) which is thus brought about the arm 67 (Figs. 2 and 11) fastened thereon and its spring-actuated pawl 68 (referring to shaft B11) carry with them the toothed wheel 66 mounted on the shaft C10, so that this shaft is rotated through an angle corresponding to one unit, and its number drum is moved forward accordingly.

When in this manner all the necessary transmissions of a unit to the next following mechanical unit or order, or what is known as tens carry operation, have taken place, the cam 47 is in such position that the spring 51 (Fig. 7) can pull down the lever 48, together with the rod 50, the cross bar 52, and the rod 55, into the initial position.

Registration of negative values

The registration of negative values in the accumulator (Fig. 18*b*) is achieved by the addition of their complements. This substitution of the complement for negative values is accomplished by introducing the inverter (Fig. 16) between the reader or sensing mechanism and the accumulator as illustrated by Figs. 18*a* and 18*b*. The reader K (Fig. 18*a*) which corresponds to the reader disclosed in my copending application Serial No. 756,169 filed December 24, 1923, matured as Patent #1,863,097 of June 14, 1932 is connected at all its sensing contacts 80 to the positive pole of the source of current 800 (Fig. 18*a*) through the contact of cam 808, positioned on the main shaft 13 of the apparatus, which cam closes contacts 809, 810 once in each revolution or phase. The fourth sensing rod 81*d* of the first perforation line, designated as x_1, corresponds to a perforation *i'* (also shown on Fig. 21) indicating negative values, and is connected to the inverter terminal 311. The next three sets x_2, x_3, and x_4 of four sensing rods 80 are connected by four-wire cables 811, 812 and 813, respectively, to the inverter terminals C12, B12 and A12 respectively. The inverter terminal 313 is shown connected to the negative pole of the source of current 800. The inverter terminal 314 is shown as connected to the positive pole of battery 800 by the contacts 814, 815, actuated by cam 801, and the terminal 312 is connected to the positive pole by the contacts 816, 817 of cam 802. The inverter terminals A13, B13, C13 and D13 are connected to the terminals A1, B1, C1 and D1 of the accumulator (Fig. 18*b*) by four-wire cables respectively. A hand-operated switch 828 (Fig. 18*a*) permits an impulse to be sent from the positive pole of battery 800 to terminal 71 of the accumulator (Fig. 18*b*). The terminal 401 is shown as directly connected to the negative pole of 800. The other circuits, respectively involving leads 517, 405, 514, 406 and 516, are connected between the source of current 800, over contacts actuated by cams 803—807 (shown in Fig. 18*a*) positioned on the main shaft 13 of the apparatus, to the terminals of the accumulator (Fig. 18*b*). These circuits are: From the positive pole of 800 over the contacts 818 and 819 of cam 803, to lead 517; over contacts 820, 821 of cam 804, to lead 405; over contacts 822, 823 of cam 805, to lead 514; over contacts 826, 827, of cam 807, to lead 516; and from the negative pole of source 800 over contacts 824, 825 of cam 806 to lead 406. This inverter can transfer to the accumulator either positive values or the complements of negative values. The working current entering terminal 312 passes over rest contact 315 of relay 300 (Fig. 16) in the case of positive indications, and passes over the working contact 316 in the case of negative indications. As relay 300 becomes energized through the closing of the circuit, current passes from the positive pole of the source of current, through the perforation *i'* (schematically shown with reader contact in Fig. 21) in the reading apparatus, terminal 311 (Fig. 16), the relay 300, terminal 313, to the negative pole. Four wires lead to terminals D13 of the inverter (Fig. 16), but only the three wires to the right enter into action. It therefore is necessary only to connect these three wires to the three wires of terminal D1 of the accumulator (Fig. 18*b*). The inverter (Figs. 16 and 18*a*) does not require terminals D12 because unit D in the accumulator (Fig. 18*b*) will be required only to receive the value 9, which permits the arrangement of the circuits in such manner as not to require the energization of the relays corresponding to A*f*1 to A*f*4 in unit A. In the case of positive figures, the working current arriving at 312 passes over 315 and directly to unit C, thus leaving unit D at zero. In the case of negative figures the working circuit, arriving at 312, passes over contact 316 and, due to the arrangement of the circuits, always over the second, third and fourth wires of terminal D13, counting from the left. The relays A*f*1 to A*f*4, B*f*1 to B*f*4 and C*f*1 to C*f*4 (Fig. 16) are now energized by the reader circuits x_4, x_3 and x_2 (Fig. 18*a*) in place of the electromagnet A*a*1 to A*a*4, B*a*1 to B*a*4, etc. Cam 801 (Fig. 18*a*) on the general shaft 13 (Fig. 19) of the apparatus, closes a circuit from the positive pole of the source of current over terminal 314 (Fig. 18*a*), the relay 300 and over terminal 313 to the negative pole, thus keeping the relay 300 energized, for the interval indicated in the second horizontal line of the timing chart comprising Fig. 23.

A cam 802 (Fig. 18*a*) then causes an impulse to be sent over terminal 312 (Fig. 18*a*), and in case of negative indications over contact 316 of relay 300. This impulse, passing over contact 316, reaches either none, one, or a plurality of the four circuits leading to terminals A13, B13, etc., (as explained subsequently), according to the position of the armature contacts of the relays A*f*1 to A*f*4, and B*f*1 to B*f*4 of the several denominational orders, dependent upon the contacts closed by the reader. This impulse reaches the electromagnets A*a*1 to A*a*4, B*a*1 to B*a*4, etc. of the accumulator (Fig. 18*b*) over the terminals A13, B13, etc. (Fig. 18*a*) and A1, B1 etc. (Fig. 18*b*). The circuit from contact 316 (Fig. 16) is branched in such manner that the relays A*f*1 to A*f*4, B*f*1 to B*f*4 and C*f*1 to C*f*4 effect the transmission of the complement of the negative

figure to the terminals A_{13}, B_{13}, etc. In the denominational unit A the complement is given with respect to **10**, while in the other units it is given with respect to **9**, for reasons which are readily apparent. If the negative value of the units order (A) is 3 for example, then the relay A*f***3** is energized, and the impulse arriving at contact **316** reaches the unit A and branches out in the manner recited hereinafter. The impulse through the working or upper contact of armature **343** is stopped at contact **342**, the relay A*f***2** being at rest. Another branch leads through the rest or lower contact of the armature **352**, and then through the working or upper contact of the armature **353**, and is stopped at **351**, the relay A*f***1** being at rest. In the third branch the impulse reaches the working or upper contact of armature **363**, then the rest or lower contact of armature **364**, and then passes through the third circuit to terminals A_{13}. The fourth branch leads to the rest contact of armature **384** and connects with the fourth circuit at terminals A_{13}. The accumulator (Fig. 18*b*) thus receives impulses in electromagnets A*a***3** and A*a***4**, and therefore will register 7 in the units (decimal order), that is, the complement with respect to 10 of the original negative value 3.

In the same manner, the inverting of negative indications in the tens and hundreds order (units B and C) takes place, with the exception that in the latter instance, the complement is calculated with respect to 9. For example the indications zero, 3, or 9, effect respectively the registering in the accumulator of the values 9, 6 or zero. In this way the negative indications are registered in the following manner:—

If in the sending apparatus there occurs—	Then in the accumulator we find—
0 0 0	9, 9, 10=0 0 0 (tens are transferred).
7 0 4	2 9 6
2 1 0	7 8 10=7. 9. 0 (ten is transferred "unit" to "tens" or from "A" to "B."
0 6 1	9 3 9

The mechanical unit D (Figs. 16 and 18*b*) is used in case of negative indications only. The working circuit entering terminal **312** now extends over contact **316** (relay **300** being energized) through the various branches in unit D over the second, third and fourth wires counting from the left of the terminals D**13** to terminals D**1** of Fig. 18*b* where it energizes the electromagnets D*a***2**, D*a***3** and D*a***4** which correspond to the values 2, 3 and 4, and which therefore cause the value 9 to be entered in the D unit of the accumulator in the same manner as previously explained. The switch D*b***1** is a composite switch for all three electromagnets D*a***2**, D*a***3**, and D*a***4**. This arrangement is made possible by the fact that 9 is the only figure ever entered into unit D and by the further fact, that any registration will always require the action of all three relays. Consequently, the above-mentioned negative indications are registered in the complete accumulator as follows:

9. 9. 9. 10 by transfer to tens=0 0 0 0
9 2 9 6
9 7 8 10 by transfer to tens=9, 7, 9, 0
9 9 3 9

the leftmost value in each line representing the value set up in the auxiliary mechanical unit D. As long as the addition of the indications gives a negative result, the auxiliary denominational unit D gives a value different from zero, while should positive results be produced, it gives the value zero.

Resetting operations and transfer of values

The shaft A**10** (Figs. 3, 15 and 19) carries a set of 13 cams, A*b***1** to A*b***13**, while shafts B**10** and C**10** carry a set of 12 cams each, namely B*b***1** to B*b***11** and B*b***13**, and C*b***1** to C*b***11** and C*b***13**, which cams through their projections, can raise levers A*d***1** to A*d***13**, B*d***1** to B*d***11** and B*d***13** and C*d***1** to C*d***11** and C*d***13** (Figs. 5, 6 and 12) and which in turn will close, when raised the contacts A*f*, B*f*, C*f* (Fig. 12 and schematically shown but not marked opposite the cams in Fig. 18*b*) by means of the rods A*e*, B*e* and C*e*. The cams A*b***1** to A*b***4**, B*b***1** to B*b***4** and C*b***1** to C*b***4** are so arranged on their shafts that their projections close the contacts A*f*, B*f* and C*f* (in the manner described above) corresponding to the complement of the respective shaft, and, therefore, accumulator position. In unit A the complement is figured in regard to 10 while in the other units it is figured in regard to 9. They are used for setting the accumulator to zero and taking part in the transfer of complements to another apparatus, as for instance, an accumulator in the manner described hereafter. The cams A*b***5** to A*b***8**, B*b***5** to B*b***8** and C*b***5** to C*b***8** have projections that close the contacts A*f*, B*f* and C*f* correspond-to the actual positive position of the respective shafts, and are used for the transfer of the actual momentary accumulator reading to another apparatus. The cams A*b***9** to A*b***12**, B*b***1** and B*b***9** to B*b***11** and C*b***1** and C*b***9** to C*b***11** close through their projections, the above-mentioned contacts according to the complement to ten to each shaft and accumulator unit position and serve for the transfer of complements to another apparatus as described hereafter. The cams A*b***13**, B*b***13** and C*b***13** establish contacts for the energization of relays A*c*, B*c* and C*c* respectively in any position of the corresponding shafts except in their zero position.

The cams A*b*1 to A*b***13**, B*b***1** to B*b***11** and B*b***13**, etc., illustrated in Fig. 18*b* are shown in the zero position of the shafts A**10**, B**10** and C**10**. The cams carry single teeth or elongated projections according to the requirements for the closing of contacts. B*b***5** (Figs. 18*b* and 22), for instance, has three teeth which will close a contact in positions, 1, 5 and 8 of the shaft B**10** because the code number 1 is required for values 1, 5 and 8 (see code in Fig. 1). B*b***8** has an elongated projection closing the contact during positions 4 to 9 inclusive because the code number 4 is required in all values from 4 to 9.

Resetting operations

The setting of the accumulator to zero will now be explained. The cams A*b***1**—A*b***4**, B*b***1**—B*b***4**, and C*b***1**—C*b***4** (Figs. 3, 4 and 15) either raise or leave at rest, dependent upon the position of their projections (Fig. 12, B*b***1** to B*b***4** being indicated by B*b*, B*d***1** to B*d***4**, by B*d*, B*e***1** to B*e***4** by B*e*, and B*f***1** to B*f***4** by B*f*), the corresponding rotatable arms A*d***1**—A*d***4**, B*d***1**—B*d***4**, and C*d***1**—C*d***4** (Figs. 5 and 6), and in the first case raise the respective bolts *e* (B*e*, C*e*, etc., Fig. 12, A*e***1**, B*e***1**, etc. in Fig. 19) thus closing the contacts in the contact *f* (B*f*, C*f*, etc.). The cams A*b***4**, B*b***1** to B*b***4**, C*b***1** to C*b***4** are so mounted on the shafts A**10**, B**10**, and C**10** (Fig. 15) that they close the circuits energizing the electromagnets A*a***1** to A*a***4**, B*a***1** to

Ba4, etc. (Fig. 18b) corresponding to the complement of the accumulator reading of the respective unit. This complement is again with respect to 10 for the unit order A, and with respect to 9 for mechanical units B and C. The connections are diagrammatically represented in Fig. 18b.

The terminal 71 (Fig. 18b) is connected through hand-operated switch 828 (Fig. 18a) to the positive pole of the source of current 800 (Fig. 18a), and if this contact be closed, then the impulse passes from terminal 71 to the contacts of cams Ab1—Ab4, Bb1—Bb4, Cb1—Cb4, and Db1, and according to whether these contacts are in open or closed position, are stopped or extended to the corresponding electromagnets Aa1 to Aa4, Ba1 to Ba4, etc. The energized electromagnets cause the complement of the accumulator reading to be entered in each unit and thereby return the accumulator to zero.

If, for instance, the indication of the tens order B is the value 3, then the cams Bb2 and Bb4 (Fig. 22) are in such position that they close their contacts (representing the complement of 3 with respect to 9, or 6), while the contacts of cams Bb1 and Bb3 remain open. The circuit from the positive pole over terminal 71 extends over contacts of cams Bb2 and Bb4 and energizes the electromagnets Ba2 and Ba4, which in turn raise their corresponding latch bars 29 (Fig. 2) and release the locking rod 25—6. The raising of the toothed rod 21 by six teeth turns the accumulator drum of the mechanical unit B by six units, bringing it to the position 9 (the value 3 having previously been set up therein). The entering of the complements to the original entry in the accumulator brings the units order to zero and all the others to the position 9. The setting of the units order A to zero will cause the transfer of a unit to the tens order B, as explained previously for positive figures. The tens order, being in the 9 position, will be carried forward to zero, and the transfer of a unit to the hundreds order C will be effected. The hundreds order being returned to zero, a unit will be transferred to the auxiliary unit D. If D were originally at zero, then the number 9 has been entered during the process of setting the accumulator to zero, and a unit is now transferred from the hundreds order, to advance it to zero. If D were originally at 9, then it did not receive a complementary figure, and remained at 9 until a unit is carried forward from the hundreds order, thus effecting its advance to zero.

Transfer of values

It may become desirable to transfer the indications of the accumulator to another apparatus, for instance another accumulator. This second accumulator may be of various types. For the sake of simplicity, however, we shall assume the construction of the second accumulator to be identical with the accumulator described in these pages. The terminals A2, B2, C2 and D2 (Fig. 18b) of the first accumulator are then connected to the terminals A1, B1, C1 and D1 of the second accumulator. The transmission can take place in any position of the accumulator elements A, B, C through the switch cams Ab5—Ab8, Bb5—Bb8 and Cb5—Cb8 (Fig. 18b). These cams raise or leave at rest, according to the position of their projections, the corresponding rotating arms Ad5—Ad8, Bd5—Bd8 and Cd5—Cd8 (Figs. 5, 6, and 12 the latter showing the rotating arms Bd5—Bd8 as Bd), thereby raising the respective bolts e (Be in Fig. 12), thus closing the contacts in the cam-actuated switches f (Bf in Fig. 12) in the same manner as previously explained. The corresponding working circuit leads from the negative pole of the source of current 800 through a cam 806 (Fig. 18a) to the terminal 406 and the contact 416 of the relay Dc (Figs. 18a and 18b). It then passes over the trunk line 417 and branches into three circuits 418, 419 and 420 to the contacts of the above-mentioned cams Ab5 to Ab8, Bb5 to Bb8, and Cb5 to Cb8, and from there, over those contacts that are closed by the cams, thus transmitting code values, to the terminals A2, B2, and C2. These terminals are connected to the terminals A1, B1, and C1 of a receiving accumulator (Fig. 18b) (to be described hereinafter), and the current, passing over any wire going to these terminals, will reach the corresponding electromagnet Aa1 to Aa4, Ba1 to Ba4, Ca1 to Ca4, thereby registering the corresponding value in the receiving accumulator in the same manner as described for this accumulator. If, for instance, the mechanical unit B, through the position of its axis B10, registers the positive value 5, then the projections of the cams Bb5 and Bb8 corresponding to the values 1 and 4 (=5) will cause their contacts to be closed, thereby transmitting current through terminals B2 and extending over the terminals B1 (Fig. 15) of a receiving apparatus identical with the accumulator under discussion to the corresponding relays Ba1 and Ba4 of said receiving apparatus as described subsequently.

As previously stated, the negative character of the accumulator reading is evidenced by the shaft D10 taking up the position corresponding to the digit 9. This position is attained in the same manner as are the other negative indications and as described previously. The short impulse received, in case of negative indications, through terminal 312 over working contact 316 of the relay 300 (Fig. 16) invariably passes through the three leads 2, 3 and 4 of terminals D13 in case of negative indications, and extends to the electromagnets Da2, Da3, and Da4 (Figs. 15 and 18b), thus causing the locking rod 25—9 (Fig. 2) to advance and effect the registration of digit 9 in the auxiliary unit D. If the figure previously registered in the accumulator were positive and if the result of the subtraction of the said negative figure, accomplished by the addition of its complement, still leaves a positive figure, then the addition of the complement will result in the transfer of a unit from C to mechanical unit D and the latter is returned to zero in the manner described for transferring of tens to the next mechanical unit. If the figure registered in the accumulator after the addition of the complement of the negative figure is negative, then the shaft D10 remains in the position 9. The complement registered in the accumulator can be directly transmitted to another apparatus in the same manner as indicated for the transmission of positive figures, the transmission taking place through cams Ab5—Ab8, Bb5—Bb8, and Cb5—Cb8. In most cases the practice, however, is to transmit the absolute (negative) value with due regard to the negative sign and not the complementary figure. For this purpose, in the first place, the relay Dc is employed, the said relay receiving current from the positive pole of the source of current supply, through contacts 818, 819 of cam 803, the cam closing a circuit through lead 517 (Fig. 18a) to the terminal 517 (Fig. 18b), 404, contact 424 of the cam Db13 which is closed

whenever the thousands order wheel is not in zero position, through relay Dc to terminal 401 which is connected to the negative pole. The negative character of the accumulator reading can be transmitted to another apparatus by an impulse over lead 406 and working contact 413, relay Dc being energized, over terminal 407 to a receiving apparatus. The working circuit coming from the negative pole over the contact of cam 806 (Fig. 18a) to terminal 406 (Fig. 18b) passes, now that relay Dc is energized, over the upper contact of 412 and to the contacts of the cams Ab9 to Ab12 and extends in case of closed contacts over the corresponding circuits of the four wire lead to the outgoing terminals A2. The mechanical operation is performed in the same manner as for cams Ab1 to Ab8 which raise the rods Ae (the same as Be in Fig. 12) and close the contacts Af (the same as Bf in Fig. 12), the latter being diagrammatically shown opposite the cams Ab9 to Ab12. Whenever one of the shafts A10, B10 and C10 is not in zero position and the corresponding contact closed by cam Ab13, Bb13 or Cb13, the respective relay Ac, Bc, or Cc, is energized by the circuit leading from the positive pole of the source of current 800 over contacts 818, 819 of cam 803, lead 517, the corresponding lead to the contact Ab13, Bb13, or Cb13, through its corresponding relay Ac, Bc, or Cc, over lead 401 to the negative pole of the source of current. The energization of the relay is maintained by the secondary circuit coming from the positive pole of the current over contacts 820, 821 of cam 804, lead 405, contact 431, 441 or 451, through the relay, and over lead 401 to the negative pole of the source of current. The cams Ab9 to Ab12 are so positioned on the shaft A10 that they close the contacts representing the complement with respect to 10 of the momentary indication of the mechanical unit and the position of its shaft 10 which in the case of negative values is the complement of the complement registered in the accumulator, or the absolute negative value. If the indication of the mechanical unit A is for instance 7 and its negative character is expressed by the position 9 of the mechanical unit element D (the real value of A is minus 3) then the contact of cam Ab11 (Ab9, Ab10, Ab11 and Ab12 closing contacts according to code values 1, 2, 3 and 4 respectively) is closed and the value 3 is transmitted over the third circuit to the outgoing terminals A2.

The complementary values of negative indications of mechanical units B and C must be transmitted as calculated either with respect to 10 or to 9, according to whether the previous units indicate zero or another figure. This distinction is required because the complement of a value is obtained by deducting the first digit to the right other than zero from 10 and all the succeeding digits to the left thereof from 9. When the real value is 230 for instance, the complement is 9770, and when the real value is 600, the complement is 9400.

The energization of the relays Ac, Bc and Cc (Fig. 18b) depends upon the closing of the respective contacts by the cams Ab13, Bb13 and Cb13 (Fig. 18b). In the zero position of the shaft A10, B10 and C10 these contacts are broken, but in all other positions, they are closed, thereby making the energization of the relays Ac, Bc and Cc possible. These relays determine the direction of the working current as subsequently explained. If complementary values of negative figures are registered in the accumulator, the thousands order wheel therefore indicating a value different from zero and the relay Dc being energized, then the following operation can take place (Fig. 15): If the shaft A10 is in its zero position, that is, if the indicator drum (as shown in Figs. 3, 4 and 8), reads zero, then the relay Ac is not energized. A working circuit leads from the negative pole of the source of current through the contacts 824, 825 of cam 806 (Fig. 18a) leading to lead 406 (Figs. 18a and 18b) to the terminal 406 (Fig. 18b) and then working contact 412, thereby reaching the contact 432, and extends over its rest contact, since relay Ac is not energized, to the contacts of cams Bb1, Bb9, Bb10, and Bb11 and extends over the wires of the closed contacts to the exit terminals B2 and to a receiving apparatus. If, however, the shaft A10 is not in the zero position, then the relay Ac is energized and the rest contact of 432 is replaced by its working contact. The circuit arriving from the negative pole of the source of current through the contacts 824, 825 of cam 806 (Fig. 18a) over lead 406 (Figs. 18a and 18b), working contact 412, to the contact 432, now extends over its working contact to the contacts of cams Bb1, Bb2, Bb3, and Bb4 and extends over the wires of the closed contacts to the exit terminals B2 and to a receiving apparatus. The cams Bb1, Bb9, Bb10 and Bb11 are so positioned on the shaft B10 that the contacts which are closed by the cam projections correspond to the complement with respect to 10 of the indicated value. The cams Bb1, Bb2, Bb3, and Bb4 are the same as used for setting the counter back to zero and they now close a parallel set of contacts according to the complement with respect to 9. The details of the operation through these cams is exactly the same as for the setting to zero and the transmission of positive values, and needs no further explanation. If both of the mechanical units A and B (units and tens) are in zero position, then the circuit coming from the negative pole of the power source 800 in the same manner as described above over lead 406 over the rest armatures of contacts 432 and 442 (relays Ac and Bc being without current) passes to the contacts of the cams Cb1, Cb9, Cb10 and Cb11, causing the complement of the accumulator position in C with regard to 10 to be transferred through terminals C2. If the units (A) are not zero, then the working circuit passes over the working contact 412 and contact 433 to the contacts of cams Cb1, Cb2, Cb3 and Cb4 representing the complement with respect to 9 which applies whenever one of the previous digits to the right is different from zero. If the units (A) are zero but the tens (B) are not zero, then the working circuit from 406 passes over working contact 412, rest contact 432, working contact 442 to the same cams Cb1, Cb2, Cb3 and Cb4 which through their positions (complements to 9) close certain contacts and cause the complement to the accumulator position in mechanical unit C to be transferred through terminals C2. In both of the mechanical units, B and C the arrangement of the cams is the same, and consequently the result is the same.

Accumulator readings

At the bottom of Fig. 15, which shows only that portion of Fig. 18b which is necessary for the operation of the apparatus as an accumulator, there also is illustrated the shutter (cover plate) 421, through the openings of which the accumulator drum indications are read. The position of the readings of the two number drums

of the units order A are indicated by A3 and A4; of the three number drums of the tens order B by B3, B4 and B5; and of the three drums of the hundreds order C by C3, C4, and C5. The readings A3, B3, and C3 correspond to the positive values of the positions of the accumulator shafts; the readings A4, B4, and C4 correspond to the complementary values with respect to ten; and the readings B5 and C5 correspond to the complementary values with respect to nine of the positions of the accumulator shafts. The shutter 421 in Fig. 15 is shown in its rest position and exposes the positive accumulator drum readings A3, B3 and C3 through the respective windows A6, B6 and C6, all the other drum readings being covered by the shutter. The positioning of the shutter 421 for negative values is performed as follows:

The energized relay Dc (negative values) attracts its armature 414 (Fig. 15) so that the shutter 421 is moved by the lever 410 to the right. The indications of the positive wheels or drums (extreme right drum in Figs. 3 and 4) A3, B3 and C3 (Fig. 15), are covered as a result of the shifting of the windows A6, B6 and C6, while the windows A7, B7, B8, C7 and C8 are moved into position to permit the observation of the wheels or drums having negative indications, (complements of positions of the shafts A10, B10 and C10). The shutter windows A7, B7 and C7 expose the drum readings A4, B4 and C4 respectively while the shutter windows B8 and C8 expose the drum readings B5 and C5 respectively. The accumulator drum indications A4, B4 and C4 corresponding to the complements of the shaft position with respect to 10, and the accumulator drum indications B5 and C5 correspond to the complements of the shaft position with respect to 9. The necessity of these two readings has been explained previously. Should the mechanical unit A be in its zero position, then the relay Ac is without current and its armature 434, the lever 435, and the lever B9 with attached swinging cover disc remain in the position shown in Fig. 15 over the negative accumulator drum indication B5 for the complement with respect to nine, and leaving visible through the window B7 the accumulator drum indication B4, which is the complement with respect to ten. If the mechanical unit A is not in the zero position, then the relay Ac is energized, the armature 434 is attracted together with the lever B9 with attached swinging cover disc which now will cover the negative drum reading with respect to ten B4 and uncover the negative drum reading with respect to nine B5 through the window B8. The same reasoning applies to mechanical unit C.

Repeater

By means of a single multiple switch of conventional type the electrical connections of the accumulator (Fig. 15) may be replaced by those of the repeater (Fig. 17). Such a multiple switch is shown at 400 in Fig. 18*b* where it is positioned to the right and establishes the connection for the accumulator. When it is thrown to the left, the multiple switch 400 establishes connections and disconnects others, as shown by the broken lines, adapting the apparatus for use as a repeater. In this position the following changes take place: The positive pole is connected through contact 822, 823 (Fig. 18*a*) of cam 805, over lead 514 to the contacts 546, 536 and 526 (Fig. 18*b*) of relays Cc, Bc, and Ac respectively. It disconnects leads 406 and 405. The lead 517, with current arriving from the positive pole, contact 818, 819 (Fig. 18*a*) of cam 803, is now connected to lead 515 (Fig. 18*b*). The connections for the lead 71, for the entire unit D, for the contacts of cams Ab1 to Ab12, Bb1 to Bb11, Cb1 to Cb11, for the electromagnets Aa1 to Aa4, Ba1 to Ba4, Ca1 to Ca4, are all cut or broken, and new connections are established for the electromagnets Aa1, Ba1, and Ca1.

In order that the apparatus can function as a repeater, the apparatus is connected through an inverter of the type shown in Fig. 16 but adapted to produce complements with respect to ten in all the units A, B, and C, the connections then continuing to a reading apparatus, such for example as that shown in my U. S. Patent No. 1,863,097, as may be seen from Figs. 18*a* and 18*b*. The connections which are established between the reading apparatus and the inverter consist of a lead 81*d* (Fig. 18*a*) from the fourth contact of line X1 of the reading apparatus, over 311 to relay 300 (Fig. 16) of the inverter, four leads each from the four contacts of lines X2, X3, and X4, respectively, to the four-wire terminals C12, B12, and A12 of the inverter. The inverter terminal 313 is connected to the negative pole of the source of current 800, terminal 314 over contact 814, 815 of cam 801 to the positive pole, and terminal 312 over contact 816, 817 of cam 802 also to the positive pole. The inverter terminals A13, B13, C13 and D13 are connected to the repeater terminals A1, B1, C1 and D1, each representing a four-wire terminal.

The operations of the repeater will now be explained in connection with Figs. 18*a* and 18*b*, the succession of operations being shown in the timing chart of Fig. 23. The cams 801, 802, 803, 804, 805, 806, 807, and 808 are mounted on the main shaft of the apparatus and make one complete revolution in each cycle. In the beginning of the first cycle the relay 500 is energized by the circuit from the positive pole, contact 826, 827 of cam 807, lead 516, contacts 525, 535 and 545 of relays Ac, Bc and Cc which are at rest, relay 500, lead 401, and back to the negative pole. This relay can only be energized in the beginning of the first cycle because immediately after and during the succeeding cycles one of the relays Ac, Bc or Cc will be energized and break the relay current in the respective contact 525, 535 or 545. Also in the beginning of the first cycle the indications of lines X1, X2, X3 and X4 in the reading apparatus are transmitted to the inverter I by the circuit traced from the positive source, lead 518, contact 502 which is closed by the relay 500, lead 519, contact 809, 810 of cam 808, contact plates 80, through any perforations in the record strip, momentarily in the reading apparatus, leads 311, 811, 812 and 813 into the inverter and over terminal 313 to the negative pole. The transmission of indications or values from the reader to the inverter are dependent upon the energization of relay 500 and can, therefore, occur only in the beginning of the first cycle. The entry of indications into the inverter and the transmission to the repeater, which in this respect is the same as the accumulator, was previously explained and will not be repeated here. The relays of the inverter are kept energized by the circuit traced from the positive pole of the source of current, contact 814, 815 of cam 801, terminal 314, the respective relays, terminal 313, and back to the negative pole. Immediately succeeding this operation the complements with respect to ten of the indications received in the inverter are trans-

mitted to the respective electromagnets Aa1 to Aa4, Ba1 to Ba4, and Ca1 to Ca4 by the circuit traced from the positive pole of the source of current, contacts 816, 817 of cam 802, terminal 312, the various branches under the inverter relays, inverter terminals A13, B13, C13 and D13 to the repeater terminals A1, B1, C1 and D1, the electromagnets mentioned above, lead 401, and back to the negative pole. This operation brings the shafts A10, B10 and C10 and the cams Ab13, Bb13, and Cb13 to positions corresponding to the complements with respect to ten of the indications in the reading apparatus. The relays Ac, Bc and Cc can now be energized. Assuming that the reader indications in X2, X3, and X4 are respectively 3, 8 and 6, then Cb13 will be in the position 7, Bb13 will be in the position 2, and Ab13 will be in the position 4. The relay Cc is next energized by the circuit from the positive pole of power source 800, contacts 818 and 819 of cam 803, lead 517, lead 515, contact of cam Cb13, relay Cc, 401, to the negative pole (Fig. 18a). The energization of relay Cc breaks the release relay (500) current coming from 516 and interrupts the working current over lead 517 at contact 547 so that, during the period the relay Cc remains energized, neither relay Bc nor relay Ac can be energized. This energization of relay Cc, and subsequently of Bc and Ac, will be repeated in each cycle or revolution of the main shaft of the apparatus and will in each cycle be immediately followed by an impulse from the positive pole of the source of current 800 over the contacts 822, 823 of cam 805 (Fig. 18a) on the main shaft, lead 514, contact 546 which was closed by relay Cc, electromagnet Ca1, terminal 401, to the negative pole. The energization of the electromagnet Ca1 causes the transmission of a unit into the mechanical unit C as previously described for the accumulator, and advances the cam Cb13 from position 7 to position 8.

This action is repeated with the next and the following rotations (or cycles, since each rotation constitutes a cycle) of the driving shaft, the cam Cb13 is thus finally brought to its zero position, its contact is broken, and the relay Cc is set at rest. The contact 547 of this relay Cc is closed and consequently the relay Bc is energized by the circuit from the positive pole, contacts 818 and 819 of cam 803, 517, 515, 547, contact of cam Bb13, relay Bc, 401, negative pole. The relay Bc being energized, the relay Ac cannot receive any current due to the interruption of contact 537. In mechanical unit B the value 2 was previously registered so that its shaft B10 with the cam Bb13 are in position 2 and are moved forward with each cycle by one unit; relay Bc remains energized during 8 cycles (10 minus 2), relay Ac enters in action during the next 10—4=6 cycles, the value 4 having been registered in this mechanical unit. After this last cycle the rest contacts 525, 535 and 545 of the relays Ac, Bc and Cc, respectively, are all closed, and the release relay 500 can again be energized.

The showing of Fig. 17 may be likened very much to that of Fig. 15, except that all that equipment of Fig. 15 not necessary for the operation of the device as a repeater has been omitted.

Below the relays Ac, Bc, and Cc (Figs. 17 and 18b) and actuated by them, are three corresponding sets of contacts 528 to 530, 538 to 540 and 548 to 550. These contacts are closed each time the respective relay is energized. As explained previously, the relays Ac, Bc, and Cc are energized in each cycle as long as the respective cams Ab13, Bb13 and Cb13 are not returned to zero, or during the same number of cycles as impulses to Aa1, Ba1 and Ca1, respectively, are required to set the mechanical units back to zero. These contacts can, therefore, be used to transmit repeatedly impulses in predetermined number.

Operations for multiplications

The use of these contacts will be explained by an example involving multiplications. The connections between the source of current, the reader, the inverter and the accumulator acting as repeater will remain the same with the following exceptions, which were made to limit the example to two digits. The four-wire cable from the second line x_2 of the reader K (Fig. 18a) is discontinued, the four-wire cable from the third line x_3 (tens order) is connected to terminals A12, of the inverter, and the four-wire cable from the fourth line x_4 (units order) is connected to the inverter terminals B12. In this manner the complement of the two digit multiplier appearing in the reading apparatus is registered in the repeater in the manner described previously.

The contacts of the two digit multiplicand of the fifth and sixth lines x_5 and x_6 (Fig. 18a) in the reading apparatus are connected by four-wire cables Y_2 and Y_1 (one wire for each line contact) to the left hand terminals 605 and 615 of the contacts 529, 539, respectively, and left-hand terminals 604 and 614 of contacts 528, 538 (Fig. 18b), respectively, in the manner described subsequently. Each group of contacts 529, 539, 528 and 538 is connected with four insulated wires, one for each lead of the four-wire cables Y_1 and Y_2. The right-hand terminal 601 of contact 528 is connected to terminal B1 of a second accumulator; terminal 611 of contacts 538 to terminal A1; terminal 602 of contacts 529 to terminal C1; and terminal 612 of contacts 539 to terminal B1 of said second accumulator.

Multiplications can now be performed by the process of successive additions. In order to illustrate the procedure the figure 68 (multiplier, third and fourth lines in the reader) will be multiplied by the figure 53 (multiplicand, fifth and sixth lines in the reader), and I will call $w=68$ and $y=53$; then

w_1=number of units of w $w_1=8$
w_2=number of tens of w $w_2=6$
y_1=number of units of y $y_1=3$
y_2=number of tens of y $y_2=5$

The four-wire cable Y^1 connected with the reading apparatus contacts for the sixth line registering y_1, the units of the multiplicand (Fig. 18a), is then connected with the two accumulator repeater terminals 614 and 604 (Fig. 18b) simultaneously, and the four-wire cable Y^2 for the fifth line registering y_2, which is the tens order of the multiplicand, to the terminals 615 and 605. The connections with the second accumulator-repeater (Fig. 18b), which acts as an accumulator, are established as follows:

611 to A1 (units) of second accumulator (Fig. 18b).

612 and 601 to B1 (tens) of the second accumulator (Fig. 18b).

602 to C1 (hundreds) of the second accumulator (Fig. 18b).

As previously explained, the complement of

w_1=8, or 2, is registered in the mechanical unit B and the cam Bb13 closes its contact, thereby permitting the energization of the relay Bc. In each one of the succeeding eight cycles the following procedure will take place. An impulse from the positive pole of the power source 800 passes over the contacts 818 and 819 of cam 803, terminal 517 (Fig. 18b) over lead 515 (upper left-hand section), passes over 547, 537, contact of cam Bb13, relay Bc, 401, to the negative pole, and energizes the relay Bc and attracts all its contacts. In this manner the working contacts of 538 and 539 are closed, the value y_1 is transmitted a single time from the reading apparatus over 614, the contacts 538, 611 to the mechanical unit A of the second accumulator (Fig. 18b), as previously described for registration of values in the accumulator. Likewise the value y_2 is transmitted over 615 (Fig. 18b), 539, 612 to the mechanical unit B. The second accumulator (Fig. 15) now registers the value 53. During the same cycle an impulse will be received from the positive pole of the power source 800 over contacts 822 and 823 of cam 805 (Fig. 18a) to terminal 514 (Fig. 18b), 536 (which is closed by relay Bc), Ba1, 401, to the negative pole, which will register a unit in B and will advance the shaft B10 and the cam Bb13 by one position. The closing of working contacts 538 and 539 and the registration of a unit will be repeated in each cycle until B10 and Bb13 reach the zero position, and the circuit energizing Bc is interrupted in Bb13. The described procedure will be repeated in this example 8 times (two having been set up), so that the value 53 is transmitted 8 times from the reading apparatus to the second accumulator, which is equivalent to its multiplication by 8.

Mechanical unit A remains inactive during the operation of mechanical unit B, because the energization of relay Bc interrupts the circuit from 515, over 547 in 537, thus preventing the energization of relay Ac. Now, after relay Bc came to rest, the relay Ac will become energized by means of the circuit from the positive pole of the power source 800, contacts 818 and 819 of cam 803, (Fig. 18a) to lead 517 (Fig. 18b), 515, 547, 537, contact of Ab13, relay Ac, 401, to the negative pole; and the energization of Aa1 will take place over the circuit from the said positive pole, contacts 822 and 823 of cam 805 to lead 514 (Fig. 18b), 526 (which is closed by relay Ac), Aa1, 401, to the negative pole. The operation taking place in the mechanical unit A is now the same as described previously in connection with unit B. The value 4 having been entered in A, the operation will be performed 6 times. y_1 is transmitted 6 times from the reading apparatus over 604, contacts 528 (Fig. 18b) of relay Ac, 601, to mechanical unit B (Fig. 18b) of the second accumulator, and y_2 is transmitted 6 times from the reading apparatus over 605, contacts 529, 602, to mechanical unit C (Fig. 18b). The value 53 is in this manner registered 6 times in the second accumulator, and as the unit 3 now registers in the tens order (B) of the second accumulator and the tens 5 in the hundreds order (C), this successive addition is equivalent to a multiplication by 60. This completes the multiplication of 53 by 68.

From the description and the drawings it will be seen that the transmission of values or indications from the acculumator-repeater to a receiving apparatus (in the description assumed to be another accumulator but which may be a different apparatus) do not necessarily depend upon the momentary movement or position of the perforated record in the reader, nor does it have to coincide with such movement or position.

It is of course obvious that once the broad features of my invention are disclosed, numerous modifications and adaptations thereof will readily occur to those skilled in the art. Accordingly, it is contemplated that the invention be limited only by the scope of the appended claims.

What I claim is:

1. As part of statistical apparatus, including receiving apparatus, a plurality of differentially positionable accumulator elements, corresponding to successive denominational orders, a plurality of pairs of contacts for each of the said accumulator elements, a plurality of cams for each of the said accumulator elements movable by the corresponding accumulator element and adapted to close certain of said pairs of contacts, singly or in combination, in accordance with either the value standing on and indicated by the position of the said accumulator element or a selected one of its complements, and transmission circuits connected to said contacts for transmitting the value standing on said accumulator elements to selected receiving apparatus, a relay for each accumulator element controlled by the positioning into and out of zero position of a selected one of said plurality of cams, the transmission circuits of higher orders extending through and controlled by a relay associated with an accumulator element of a lower order to select pairs of contacts of the higher order accumulator element, dependent upon which of said complements is to be transmitted, the selection of a particular relay-controlled-transmission circuit being dependent upon the energization or de-energization of said relay.

2. As part of statistical apparatus, including receiving apparatus, a differentially positionable accumulator element, a cam movable by said accumulator element, contacts closed by said cam, a second differentially positionable accumulator element, a plurality of sets of cams movable by said second accumulator element, the first of said accumulator elements indicating by the position of its cam whether the value standing on said second accumulator element is positive or negative and closing said contacts in the latter case, the plurality of sets of cams in said second accumulator element indicating the value standing thereon or its complement, a plurality of pairs of contacts, the sets of cams of said second accumulator element being adapted to close certain of said pairs of contacts in accordance with the position of said second accumulator element, one set of said cams of the second accumulator element being adapted to close certain of said pairs of contacts for transmitting the value standing on said accumulator element, another set of cams of the second accumulator element being adapted to close certain others of said pair of contacts for transmitting the complement of said value, a relay energized under the control of said first-mentioned contacts, a circuit controlled by the contacts of said relay for directing current to the contacts of one or the other of said sets of cams of said second accumulator element depending upon whether said relay is energized, and transmission circuits connected to said pairs of contacts of said cams of the second accumulator element, for transmitting an impulse over those pairs of closed contacts to which current is directed, in accordance with the value standing on said second accumulator element, said impulse being transmitted to selected receiving apparatus.

3. As part of statistical apparatus, including receiving apparatus, a differentially positionable accumulator element, a pair of contacts, a cam movable by said accumulator element for controlling said contacts, the said cam indicating by its position whether the value standing on the accumulator is positive or negative, a plurality of other differentially positionable accumulator elements corresponding to successive denominational orders, a plurality of pairs of contacts and a plurality of sets of cams and a special cam for each of said denominational accumulator elements and positioned by the latter, a first set of said cams for each of these denominational accumulator elements being adapted to close selected ones of said pairs of contacts in accordance with the value standing on the respective accumulator element, a second set of cams in each of the denominational accumulator elements being adapted to close certain others of said pairs of contacts in accordance with the complement with respect to ten of the value standing on the respecive accumulator element, and a third set of cams in each of the denominational accumulator elements with exception of the one representing the unit denomination, adapted to close a third set of said pairs of contacts in accordance with the complement with respect to nine of the value standing on the respective accumulator element, a first circuit, a relay for directing said circuit to the contacts of the first set of cams or to either of the second or third set of cams of the denominational accumulator elements depending upon whether said relay is energized, a second circuit controlling said relay and controlled by the pair of contacts of the cam in the first-mentioned accumulator element, second relays, one for each of the denominational accumulator elements and controlled by the pairs of contacts of said special cams in the corresponding accumulator element and controlling said first circuit and coming into or out of operation, depending upon whether a value is standing on the respective denomination accumulator element, circuits controlled by contacts of said second relay of each of the said denominational accumulator elements for connecting the first circuit, in case of negative values, to the contacts of either the second or third set of cams of the accumulator element corresponding to the next higher denominational order, depending upon whether or not the said second relay is energized, the current of the first circuit passing to the contacts of the second set of cams if no value is standing on any preceding accumulator elements, or to the contacts of the third set of cams if a value is standing on any preceding accumulator elements, and transmission circuits connected to the contacts of each set of cams for transmitting an impulse over each closed transmission circuit corresponding to the value standing on the accumulator element, the said impulse being transmitted to selected receiving apparatus.

4. As part of statistical apparatus, a denominational order comprising a translating element for receiving data and an accumulator element controlled thereby, means forming part of said translating element for setting up in said accumulator element data received by said translating element, a pair of contacts and a cooperating cam associated with the accumulator element of said denominational order, said cam being positioned by said accumulator element and being adapted to close said pair of contacts if there is a value standing on the accumulator element of the respective denominational order, a relay associated with said accumulator element, a first circuit controlled by said contacts for energizing said relay, a second means for closing and opening said first circuit cyclically for causing the latter to transmit one impulse per cycle until the respective accumulator element reaches its zero position, and a second circuit connected to the translating element and including contacts closed by energization of said relay, means for closing and opening said second circuit cyclically, each said impulse causing the translating element to enter a unit in the accumulator element, said entering of a unit being repeated upon each energization of said relay.

5. Statistical apparatus comprising a differentially positionable accumulator element, a pair of contacts, a cam movable by said accumulator element, said cam indicating by its position whether the value standing on the accumulator is positive or negative, and controlling said pair of contacts accordingly, a plurality of other differentially positionable accumulator elements corresponding to successive lower denominational orders, each denominational accumulator element having a plurality of sets of cams positioned thereby, a plurality of pairs of contacts, each pair of contacts being controlled by a related cam, a first set of cams positioned by each of the denominational accumulator elements being adapted to close pairs of contacts for transmitting the values standing on the respective accumulator element, a second set of cams positioned by each of the denominational accumulator elements being adapted to close pairs of contacts for transmitting the complement with respect to ten of the value standing on the respective accumulator element, and a third set of cams positioned by each of the denominational accumulator elements, except the one comprising the units denomination, being adapted to close pairs of contacts for transmitting the complement with respect to nine of the value standing on the respective accumulator element, a circuit connected to contacts of the denominational accumulator of highest order, means controlled by said first-mentioned pairs of contacts for directing said circuit to the contacts of the first set of cams or to either the second or third set of cams of said denominational accumulator element of highest order, depending upon whether said means is energized, a plurality of devices, one for each denominational accumulator element and controlled by the accumulator element of immediately lower order, for connecting said circuit to the contacts controlled by either the second or the third set of cams of the corresponding accumulator elements, the said circuits being connectable to selected receiving apparatus.

6. Statistical apparatus comprising a plurality of denominational orders, each said order including a translating element for receiving data and an accumulator element controlled thereby, means forming part of said translating elements for setting up in said accumulator elements data received by said translating elements, a pair of contacts and a cooperating cam associated with the accumulator element of each denominational order, said cam corresponding to each accumulator element being positioned by such accumulator element and being adapted to close the corresponding pair of contacts if there is a value standing on the accumulator element of the respective denominational order, a plurality of relays, one for each of said accumulator elements,

circuits for connecting said relays to the contacts of the corresponding accumulator elements for energizing said relays, means for closing and opening said circuits cyclically, a plurality of pairs of contacts in said circuits, each pair controlled by one of said relays, when the latter is energized, for preventing the opening and closing means from causing energization of the relay or relays of lower denominational order, a plurality of pairs of contacts each closed by energization of a related one of said relays, means for cyclically directing an impulse to said last-mentioned pairs of contacts, and circuits for connecting said last-mentioned pairs of contacts to the corresponding translating elements, said last-mentioned pairs of contacts, when closed, directing said cyclic impulses to a translating element, to cause a unit to be entered in the corresponding accumulator element.

7. Apparatus of the character set forth in claim 5, including further pairs of contacts controlled by the cam of the first-mentioned accumulator element, and circuits including said first-mentioned pairs of contacts for controlling said selected receiving apparatus, in accordance with the negative sign of the value on said accumulator.

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