April 14, 1953 C. A. ROUTLEDGE ET AL 2,635,197

ELECTRICAL APPARATUS

Filed April 26, 1951 4 Sheets-Sheet 1

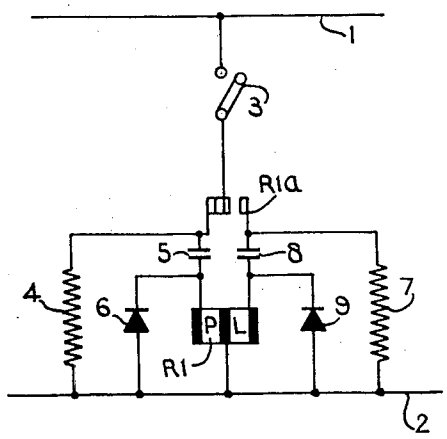


FIG. 1.

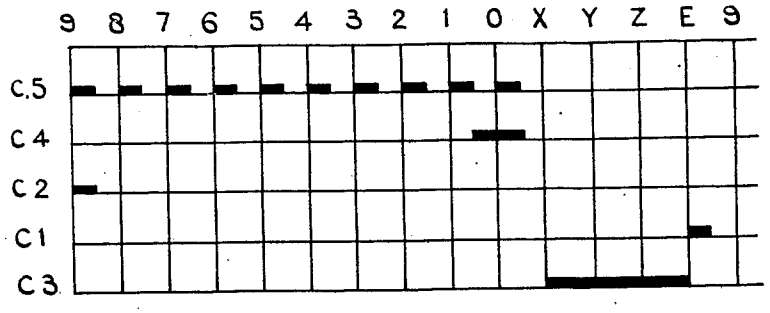


FIG. 2.

Inventors
CHRISTOPHER ADRIAN ROUTLEDGE
ALBERT JOHN KEEN
By Frederick E. Haynes
Attorney

April 14, 1953 C. A. ROUTLEDGE ET AL 2,635,197

ELECTRICAL APPARATUS

Filed April 26, 1951 4 Sheets-Sheet 2

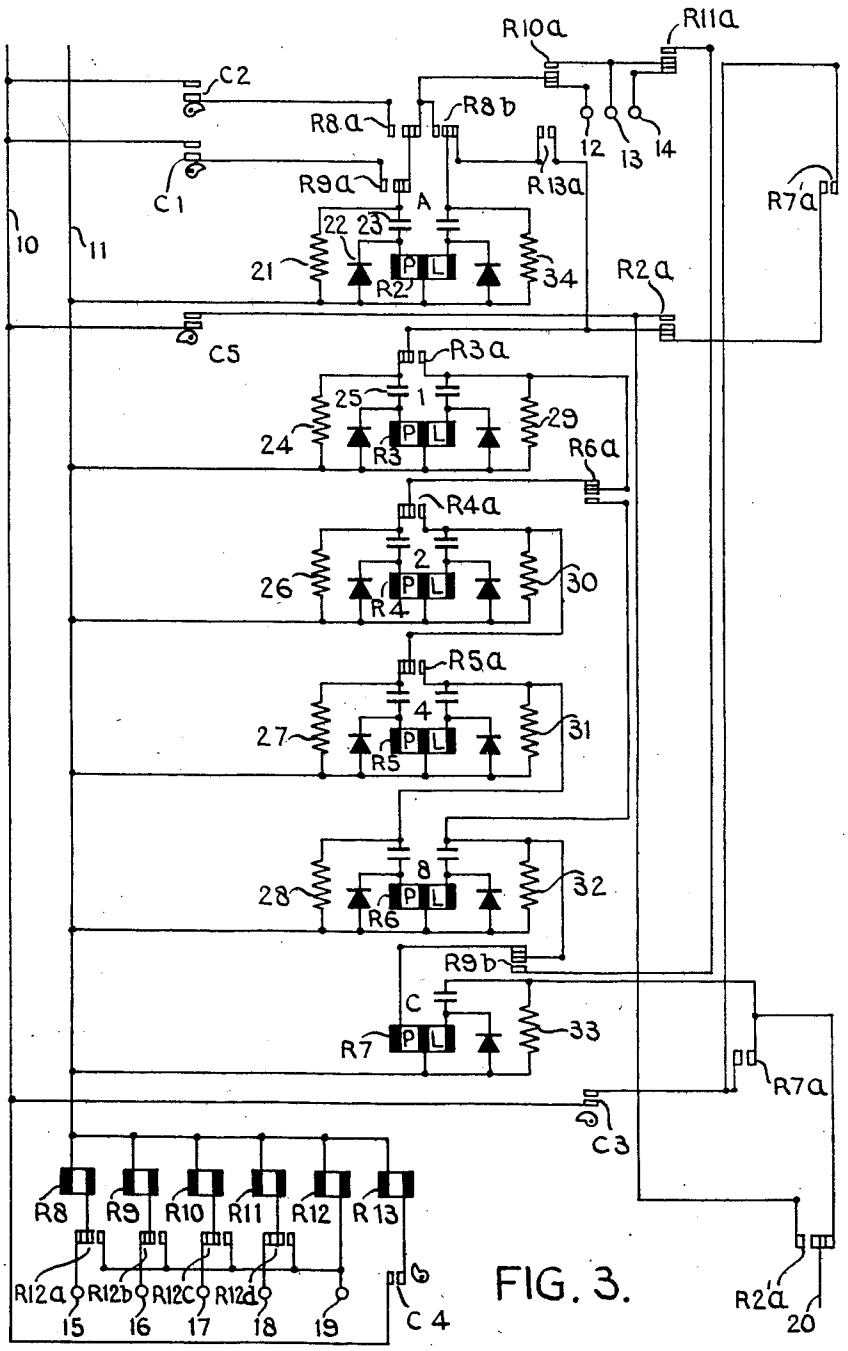


FIG. 3.

Inventors
CHRISTOPHER ADRIAN ROUTLEDGE
ALBERT JOHN KEEN
By Frederick E. Haynes
Attorney

April 14, 1953 C. A. ROUTLEDGE ET AL 2,635,197

ELECTRICAL APPARATUS

Filed April 26, 1951 4 Sheets-Sheet 3

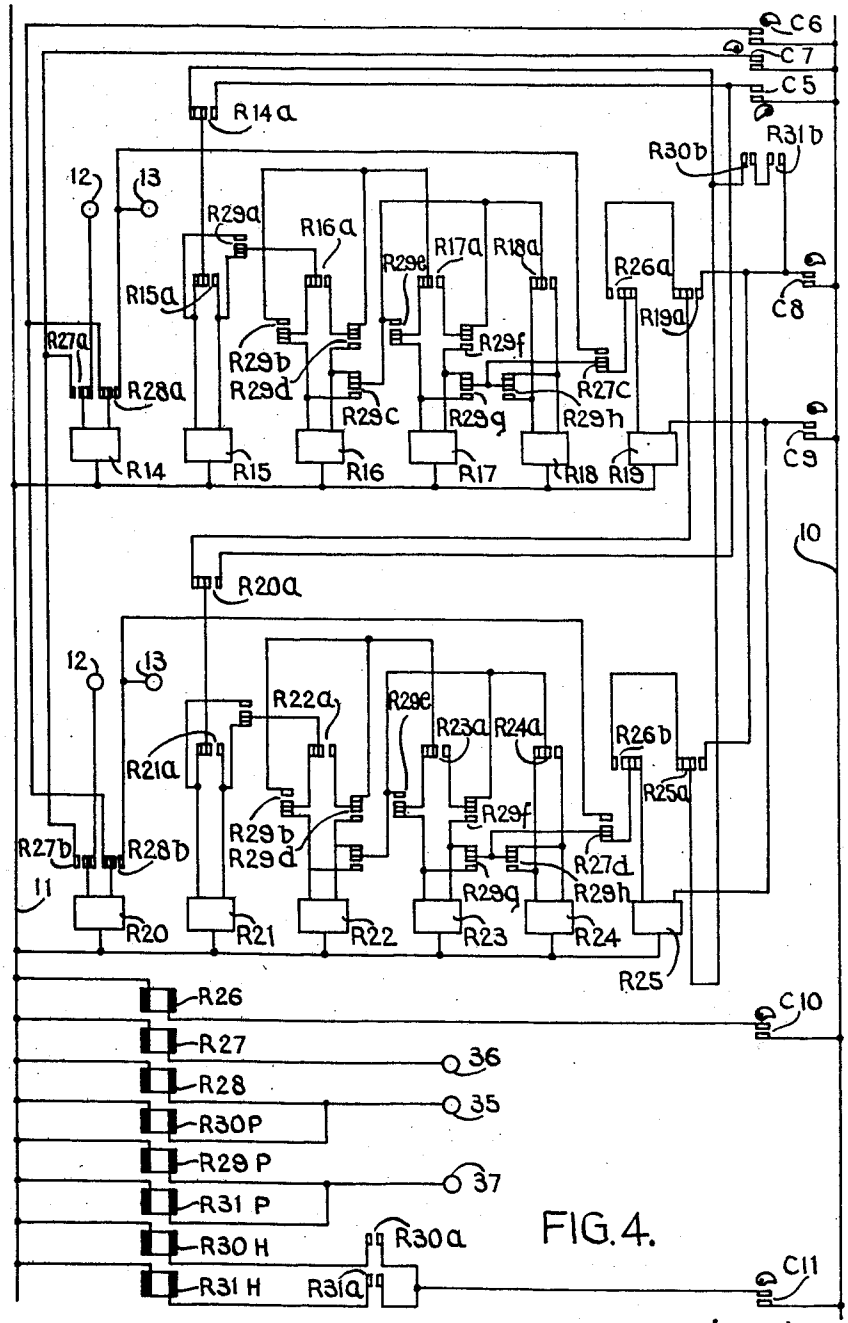


FIG. 4.

Inventors
CHRISTOPHER ADRIAN ROUTLEDGE
ALBERT JOHN KEEN
By Frederick L. Hartz
Attorney

April 14, 1953 C. A. ROUTLEDGE ET AL 2,635,197

ELECTRICAL APPARATUS

Filed April 26, 1951 4 Sheets-Sheet 4

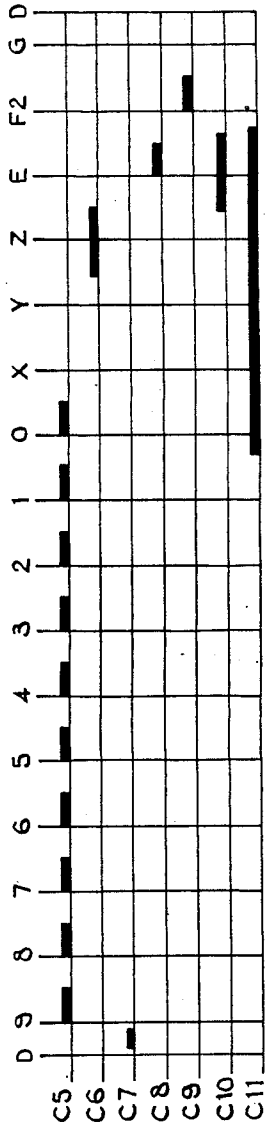


FIG. 5.

Inventors
CHRISTOPHER ADRIAN ROUTLEDGE
ALBERT JOHN KEEN

By Frederick L. Hamm
Attorney

Patented Apr. 14, 1953

2,635,197

UNITED STATES PATENT OFFICE

2,635,197

ELECTRICAL APPARATUS

Christopher Adrian Routledge, Walsworth, Hitchin, and Albert John Keen, Letchworth, England, assignors to The British Tabulating Machine Company Limited, London, England, a British company

Application April 26, 1951, Serial No. 223,002
In Great Britain May 24, 1950

8 Claims. (Cl. 307—37)

1

This invention relates to operating circuits for relays and more particularly, but not exclusively, to relay circuits suitable for use in accounting machinery.

It is often desirable to arrange that the armature of a relay should not be operated until after an operaitng voltage impulse applied to the coil of the relay has ceased, as for example in the case where the relay coil is connected to the voltage source through its own contacts. In order to obtain this delayed operation, it is known to employ electrical "slugging" of the relay, or auxiliary delay circuits employing a second relay or a thermionic valve but if these are to allow operation of the relay armature immediately after the cessation of the operating impulse, it is necessary that the duration of the operating impulse be maintained equal to the predetermined delay provided by the relay.

Accordingly, it is an object of the present invention to provide an electrical operating circuit for a relay, such that the relay armature is not operated until immediately after the operating impulse has ceased, this result being obtained even when the duration of the operating impulse varies between very wide limits.

It is a further object of the invention to provide a simplified electrical circuit for delaying the operation of a relay armature for a time closely approximating the duration of the operating impulse, the said circuit including a condenser which is charged by the operating impulse and which discharges through the relay coil to effect delayed operation of the relay armature, different charging and discharging paths for the condenser being provided by the action of a rectifier, that is to say an asymmetrically conducting resistance, such as a metal dry-plate or crystal rectifier.

It is still another object of the invention to combine a plurality of delayed operation relays to form a relay counter, thereby making the counter tolerant of wide variations in the duration of the operating impulses.

According to the invention, a circuit for obtaining delayed operation of a relay comprises an electro-magnetic relay having a rectifier in parallel with the winding of said relay, a condenser in series therewith, and a resistance in parallel with the combination, a voltage source for applying voltage across the resistance, the voltage source being of such polarity that the rectifier acts as a low resistance shunt across the relay winding during charging of the condenser, thereby prohibiting operation of the relay, and means for terminating the voltage application so that the condenser in

2

discharging operates the relay upon termination of the said voltage, the rectifier then acting as a high resistance shunt.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows the circuit of a double acting relay arranged for delayed operation.

Figure 2 is a cam timing diagram relating to Figure 3.

Figure 3 shows one denomination of a decimal adding relay counter.

Figure 4 shows two denominations of a decimal adding and subtracting relay counter.

Figure 5 is a cam timing diagram relating to Figure 4.

Relay R1 (Figure 1) is of the double acting type, that is to say, when pick-up coil R1P is energized, the relay armature is shifted to the operated position and retained in that position even when the pick-up coil is de-energized. The armature is returned to the normal position by energization of unlatching coil L. This action may be obtained in several known ways. For example, the armature may be so mounted that a toggle action is obtained with the two extreme positions of the armature being conditions of stability. Alternatively, the armature may engage a mechanical latch in the operated position, this latch being disengaged by energizing the coil L, the armature being returned under spring pressure to the normal position.

In Figure 1 the relay R1 is shown with the armature in normal or unoperated position. When switch 3 is closed, a circuit will be made from negative supply line 1, switch 3, contacts R1a, (normal), resistor 4, to positive supply line 2. Condenser 5 is in series with the combination of rectifier 6 and relay coil P in parallel. This network is across the resistor 4 and in consequence, when switch 3 is closed, the condenser will begin to charge to the potential across the resistor. The rectifier resistance in the forward direction is low compared with the coil resistance so that the greater part of the condenser charging current flows through the rectifier and only a small fraction through the coil P, this being insufficient to cause operation of the relay. If the switch 3 is opened when the condenser 5 has become fully charged, then the condenser will discharge through resistor 4 and rectifier 6 in parallel with coil P. The back resistance of the rectifier is high compared with the coil resistance, so that the greater part of the discharge current flows through coil P. This current is sufficient to cause

attraction of the armature towards coil P so that contacts R1*a* will be shifted and retained in the shifted position by the normal mechanical locking action of the relay.

When switch 3 is again closed, a circuit will be made from line 1, switch 3, contacts R1*a* (shifted), resistor 7 to line 2, and condenser 8 will charge through rectifier 9. When the switch is opened, condenser 8 will discharge through the unlatching coil L in the same manner as described for coil P, thus causing the armature to move back to the normal position where it will again be mechanically locked.

It will be appreciated that the relay is operated not when the operating voltage is applied and charges the condenser, but after the operating voltage is removed and the condenser discharges. In the particular circuit shown, this has the advantage both of preventing arcing at the contacts R1*a*, since there is no current flowing in this circuit at the time, and also of avoiding the necessity for special forms of make before break contact which would be necessary if the relay operated whilst the operating impulse was still applied.

Although the example considered was a double acting relay, it will be appreciated that the same method of delay is of general application to relays of other types.

It has been found that in the case of a relay requiring an operating current of approximately 60 milliamps, a condenser of .3 microfarad and a resistance of 1500 ohms provided satisfactory operation. However, these values are given by way of example only, since the optimum values will depend upon the operating current and coil resistance of the particular relay and the voltage employed.

A plurality of the relay units operating in the manner described may be connected together in such a way as to form a relay impulse counter, the facility of being able to feed current to the relays through their own contacts without incurring arcing, enabling a very simple circuit to be used. In Figure 3 is shown the circuit of one denomination of such a counter for operation in the decimal system and intended particularly for operation by impulses derived from the sensing of punched record cards. Various methods of sensing such cards are known to produce an impulse at a time representative of the digit position sensed, as indicated by the timing chart (Figure 2) showing the digit index point timings from 0 to 9, together with index point positions corresponding to the so-called "X" and "Y" positions on the card and index points Z and E corresponding to the interval between the sensing of two successive cards.

An intermediate denomination, for example, the tens denomination of the counter is shown in Figure 3. Essentially, each denomination of the counter is similar and therefore only a single denomination will be described in detail. The denomination comprises six relay units, an accept relay R2 controlling entry to the denomination, four relays R3, R4, R5 and R6, representing respectively the digital values 1, 2, 4 and 8, and a carry registering relay R7.

In order to read a value into the counter denomination, a plug connection is made between socket 12 and the appropriate column of the card sensing device. It will be assumed, by way of example, that the digit 9 is recorded in this particular column. At "9" time (Figure 2) an impulse will be produced by the sensing of the "9" hole and the circuit will be completed from the sensing device through the plug connection, socket 12, contacts R10*a*, R8*a*, R9*a*, resistor 21, to the positive side 11 of the supply line. The condenser 23 will be charged through rectifier 22 and when the impulse ceases, this condenser will discharge through the pick up coil R2P to operate and set relay R2, in the manner already described. Thus contact R2*a* is closed and will remain closed due to the mechanical latching until coil R2L is energized.

At "8" time, a circuit will be made from line 10, cam contacts C5 closed (Figures 2 and 3), contacts R2*a* (shifted), contacts R3*a* resistance 24 to line 11. When the impulse ceases, because C5 contacts open, condenser 25 will discharge to operate relay R3, thus registering 1.

Through cam contacts C5 and contacts R2*a* similar circuits will be set up to energize, after the impulse ceases, one or more of the relay coils as follows:

At "7" time from contacts R2*a*, contacts R3*a* (shifted), resistor 29 to line 11 to reset relay R3, and a parallel circuit from contacts R3*a*, contacts R6*a*, contacts R4*a*, resistor 26 to line 11 set relay R4 and register 2.

At "6" time from contacts R2*a*, contacts R3*a* (normal), resistor 24 to line 11 to set relay R3 and register a total of 3.

At "5" time from contacts R2*a*, contacts R3*a* (shifted), contacts R6*a*, contacts R4*a* (shifted), contacts R5*a*, resistor 27 to line 11 to set relay R5 and register 4 and branch circuits from contacts R3*a* and R4*a* to reset relays R3 and R4.

At "4" time relay R3 will be energized, as at "8" time, to register 5.

At "3" time, relay R4 will be energized and R3 reset, as at "7" time, to register 6.

At "2" time relay R3 will be energized, as at "6" time, to register 7.

At "1" time from contacts R2*a*, contacts R3*a* (shifted), contacts R6*a*, contacts R4*a* (shifted), contacts R5*a* (shifted), resistor 28 to line 11 to energize relay R6 and register 8, and branch circuits from contacts R3*a*, R4*a*, R5*a*, to reset relays R3, R4 and R5.

At "0" time relay R3 will be energized, as at "8" time, to register 9. Also, before "0" time, cam contacts C4 close (Figure 2) to energize relay R13, so that at "0" time a circuit is made from line 10, cam contacts C5, contacts R13*a* (closed), contacts R3*b*, resistor 34, to line 11 to reset relay R2.

Thus after "0" time, a count of nine is registered by relays R3 and R6 being operated, and relay R2 has been reset.

If the next card to be sensed contains the value two in this particular column, then relay R2 will be energized at "2" time through a circuit already described. At "1" time a circuit will be made from line 10, cam contacts C5, contacts R2*a* (shifted), contacts R3*a* (shifted), contacts R6*a* (shifted), contacts R9*b*, pickup coil R7P, to line 11, to energize the carry relay R7. At the same time branch circuits from contacts R3*a* and R6*a* effect the resetting of relays R3 and R6. At "0" time relay R3 is energized and relay R2 reset through circuits already described.

At "X" time, cam C3 closes and a circuit is made from line 10, cam contacts C3, contacts R7*a* (closed), contacts R2'*a* to line 20. Contacts R2'*a* correspond in the next higher denomination, to contacts R2*a* in the present denomination, so that line 20 is connected to the value 1 relay in the higher denomination and an impulse on this line will cause an entry of one, thus correctly entering

the carry. A branch circuit from contacts R7*a* through resistor 33 effects the resetting of relay R7 when contacts C3 open.

Contacts R7'*a* are operated by the carry relay in the next lower denomination, so that if this relay had been operated then an entry of one would have been made into the present denomination also on the closure of C3 contacts. The comparatively long closure of contacts C3, together with the immediate operation of relay coil R7P which has no condenser delay circuit enables "long carries," that is, successive carries occurring when a one is added to the lowest of several denominations all standing at nine, to be successfully dealt with.

A description has been given of how two digits are added; it will now be explained how one digit may be subtracted from another. To condition the counter for subtraction, relay R8 is energized by connecting socket 15 to a suitable source of potential.

It will be assumed that the value 9 has already been registered in the denomination and that the value 2 is to be subtracted. At "9" time a circuit will be made from line 10, cam contacts C2, contacts R8*a* (shifted), resistor 21, to line 11. Relay R2 will be energized thereby, so that from "8" time to "2" time, impulses will be fed to the counter denomination and will add as already described, so that after "2" time the denomination will register 6 since seven additional pulses have been entered and the carry relay R7 will have been energized. At "2" time, the impulse from the card sensing has a circuit from socket 12, contacts R10*a*, contacts R8*b* (shifted), resistor 34, to line 11, to reset relay R2. Thus no further pulses after "2" time are applied to the counter through cam contacts C5, since contacts R2*a* are now open.

In other denominations which are initially at zero and to which no card sensing impulses are applied, the full number of nine impulses are applied and these denominations will therefore all register 9. At "X" time cam contact C3 will close to reset the carry relay and enter the carry. Since all denominations except the one under consideration are registering 9, the carry due to relay R7 being set will successively zeroise these denominations and finally the carry relay of the highest denomination will be operated. The contact of this relay instead of being connected to a contact corresponding to R2'*a* is connected to a plug socket. This plug socket is connected by a plug wire to a socket connected to the "on" side of the contact corresponding to R2*a* in the lowest denomination of the counter, for which there will be no contact corresponding to R7'*a*. In this manner the carry from the highest denomination will be entered into the lowest denomination of the counter, constituting the so-called "elusive 1" entry. The lowest denomination will be zeroised and carry to the tens denomination which is already registering 6, so that a final registration of 7 is obtained, as the result of subtracting 2 from 9 in this denomination. If the number to be subtracted is larger than the number registered, then the result will be registered in the usual manner as a "9's complement."

In order to read out the value registered in the counter it is necessary to energize relays R9 and R11 by connecting sockets 16 and 18 to a suitable source of potential. When cam contacts C1 make at "E" time (Figure 2) a circuit will be made from line 10, cam contacts C1, contacts R9*a* (shifted), resistor 21 to line 11 to energize coil R2P when the cam contacts reopen. With relay R2 set, at "9" time of the next cycle an impulse will be fed to the counter via cam contacts C5 and contacts R2*a* (shifted) to add one to the counter registration. Similarly, impulses will be applied at all the index points down to and including "0," so that a total of ten impulses are added.

Let it be assumed that the initial registration in the denomination is 7. Then at "7" time, the denomination will already have received two impulses and will therefore be registering 9, so that a circuit will be made from line 10, cam contacts C5, contacts R2*a* (shifted), contacts R3*a* (shifted), contacts R6*a* (shifted), contacts R9*b* (shifted), contacts R11*a* (shifted), to socket 13, from which a plug connection may be made to direct the "7" timed impulse to another counter, a printing mechanism etc. Branch circuits will effect the resetting of relays R3 and R6.

The remaining seven impulses produced by C5 during this cycle produce a registration of seven in the denomination and since the shifting of contacts R9*b* prevented the operation of the carry relay R7 when the count went from nine to zero at the end of the readout cycle, the value has been read out and the denomination returned to the original registration.

In order to zeroise the counter, relay R12 is energized by suitable connection from socket 19 to a potential source so that contacts R12*a* to R12*d* are closed, causing the energization of relays R8, R9, R10 and R11 through circuits from socket 19. As in the case of readout the closing of cam contacts C1 will cause the setting of relay R2 and the consequent entry of impulses when C5 closes. However, assuming the initial registration is 7, at "7" time two further pulses will have been counted, making the registration 9 and there will be a circuit from line 10, cam contacts C5, contacts R2*a* (shifted), contacts R3*a* (shifted), contacts R6*a* (shifted), contacts R9*b* (shifted), contacts R11*a* (shifted), contacts R10*a* (shifted), contacts R8*b* (shifted), resistor 34, to line 11, to effect the resetting of relay R2. Since relay R2 is reset no further impulses will be applied to the denomination and relays R3 and R6 will have been reset by branch circuits from the circuit described so that the counter remains at zero. By making a connection to socket 13, a read out of value may be obtained at the same time as zeroising takes place.

Although the counter has been described as operating in the decimal notation, it may readily be adapted for other notations.

In order to count in duodecimal, the circuit to the carry relay R7 through the contacts R6*a* must be prepared at eleven instead of nine. In this case the centre contact R4*a* is connected to the "off" side of contact R3*a* and contact R6*a* is connected between contacts R4*a* and R5*a* instead of between contacts R3*a* and R4*a*.

If contact R6*a* is connected in the same manner as contact R5*a*, then the counter will operate in radix sixteen.

If relay R10 is energized by a connection to socket 17 and a plug connection made to socket 14 from another counter, then read in from the second counter may be made in the same manner as is effective when reading from a card to socket 12.

It is also possible to construct a counter operating in a code other than 1, 2, 4, 8. In Figure 4 are shown two denominations of an adding and subtracting counter using the code 1, 2, 2, 4. The method of subtraction is also a modification of that shown in Figure 3. In this latter

circuit subtraction is effected by operating the accept relay R2 at "9" time and resetting it when the digit impulse occurs, thus entering the complement of the number to be subtracted. In the modified form of Figure 4 the counter is stepped backwards when subtraction is carried out.

In Figure 4 each of the blocks represents a complete relay unit with the associated resistors, condensers and rectifiers, except for relays R19 and R25 which are double acting relays without any delay network. In each case, the left hand lead is connected to the pick up coil P and the right hand lead to the unlatching coil L.

Relays R14 and R20 are the accept relays for the units and tens denominations respectively. Relays R15 to R18 and R21 to R24 represent the digital values 1, 2, 2, 4 respectively in the units and ten denominations. Relays R19 and R25 are the carry relays.

Adding proceeds in a similar way to that already explained. For example, if 7 is to be entered with the counter initially at zero, then the impulse from the card sensing will set up relay R14 at the end of "7" time via socket 12 and contacts R27*a*.

At "6" time, cam contacts C5 (Figures 2 and 4), will provide an impulse to set relay R15 to register 1 through the circuit from line 10, cam contacts C5 (shifted), contacts R14*a* (shifted), contacts R15*a*, relay R15 to line 11, the actual setting taking place after the end of the impulse.

At succeeding digit times the impulses from cam contacts C5 will set and reset the relays as indicated below.

At "5" time relay R16 is set through contacts R15*a* (shifted), contacts R29*a* and contacts R16*a*, whilst relay R15 is reset through contacts R15*a* (shifted).

At "4" time relay R15 is set again through contacts R15*a*.

At "3" time relay R17 is set through contacts R15*a* (shifted), contacts R29*a*, contacts R16*a* (shifted), contacts R29*d*, contacts R17*a* and contacts R29*e*. Relay R15 is reset as before.

At "2" time relay R15 is set again through contacts R15*a*.

At "1" time relay R18 is set through contacts R15*a* (shifted), contacts R29*a*, contacts R16*a* (shifted), contacts R29*b*, contacts R17*a* (shifted), contacts R29*f* and contacts R18*a*. Relay R16 is reset by a branch circuit from contacts R29*f* through contacts R29*c* and relay R15 is reset as before.

At "0" time relay R15 is set again, so that relays R15, R17 and R18 are now set giving a registration of 7.

The contacts controlled by relay R29 are operated when subtraction is to be effected and they are identical in each denomination of the counter.

If a second number, say 5, is now added into the units denomination, then after two impulses the counter will register nine with all four relays R15, R16, R17 and R18 energized. At the third impulse there will be a circuit from line 10, cam contacts C5, contacts R14*a* (shifted), contacts R15*a* (shifted), contacts R29*a*, contacts R16*a* (shifted), contacts R29*d*, contacts R17*a* (shifted), contacts R29*f* contacts R18*a* (shifted), contacts R29*h*, contacts R27*c*, contacts R26*a*, pickup coil of carry relay R19 to line 11. Branch circuits to the unlatching coils of relays R15, R16, R17, and R18 effect their resetting.

The fourth and fifth impulses register two in the units denomination. After "Z" time, cam contacts C10 close (Figures 4 and 5), to energize relay R26. At "E" time, cam contacts C8 close to make a circuit from line 10, cam contacts C8, contacts R19*a* (shifted), contacts R20*a*, contacts R21*a*, pickup coil of relay R21 to line 11, to enter the carry into the tens denomination and provide a final registration of twelve.

In order to effect subtraction, relay R29 is energized by connecting plug socket 37 to a suitable source of potential. This shifts all the related contacts and changes the connections to the counting relays in such a way that they are operated to reduce the value already registered. For example, suppose seven is registered in the units denomination and three is to be subtracted. The first impulse from cam contacts C5 will proceed via contacts R14*a* (shifted), contacts R15*a* (shifted), unlatching coil of relay R15, to line 11 to reset relay R15 and leave a registration of six.

At "1" time, there will be a circuit for the second impulse from contacts R15*a*, contacts R15*a*, contacts R29*a* (shifted), contacts R16*a*, contacts R29*b* (shifted), contacts R17*a* (shifted), contacts R29*f* (shifted), unlatching coil of relay R17 to line 11. Consequently, a registration of five is obtained with relays R15 and R18 set.

At "0" time, there will be a circuit similar to that for the first impulse to reset relay R15 and leave a registration of four.

Carry between denominations is effected in the same way as during adding, but since the counter is set for subtraction, the carry will reduce the registration of the denomination into which it is entered by one. The carry connection from the tens carry relay contact R25*a* is connected back to the units accept relay contact R14*a* to provide for entry of the elusive "1" occurring when the registration of the highest denomination goes through zero.

The method of reading out the actual value registered in the counter is the same as that previously described. Relay R27 is energized by a connection to plug socket 37 and before "9" time the accept relays are set through contacts R27*a* and R27*b* by the closure of cam contacts C7 (Figures 4 and 5). Thus, ten impulses are applied to each denomination of the counter from cam contacts C5 to provide a timed impulse, from the line normally operating the carry circuit, through contacts R27*c* (shifted), to the socket 13.

This circuit is particularly useful in certain applications as it allows the reading out of the complement of the value registered, a facility not available with the previously described circuit. The relay R27 is energized as before, but the subtract relay R29 is also energized. In consequence, the ten impulses will now be subtracted from each denominational registration and the timed output impulse will occur when the registration passes from zero to nine. Thus if the registration were seven in a particular denomination, then at "3" time, seven impulses would have been entered and the registration would have changed to zero. At "2" time, the registration would pass to nine and an impulse would be produced at the socket 13, being the correctly timed readout of the complement of the value registered. The remaining two impulses would return the registration to seven.

Zeroising of the counter concurrently with readout may be obtained by energizing relay R28

by a connection to socket 35, and operates in the manner previously described. However, if the counter is reading out the complement of the registered value, the read out impulse occurs when the counter passes from zero to nine and consequently each denomination would be set to nine. If this condition is set up, then relays R30P and R31P will be energized, being in parallel with relays R28 and R29. Contacts R30*a* and R31*a* close to provide a circuit to the hold coils R30H and R31H through cam contacts C11 (Figures 4 and 5). When contacts C8 close, a circuit will be made through contacts R30*b* and R31*b* (shifted) and contacts R14*a* to reset the relays of the lowest denomination. The circuit will also extend through contacts R26*a* (shifted) and contacts R19*a* to the next denomination to reset the relays of that denomination. If further denominations were employed, similar circuits would exist for resetting these from nine to zero.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In an electrical system, the combination of an electromagnetic relay having a winding, a rectifier in parallel with said winding, a capacitor in series with said parallel-connected relay winding and rectifier, and a resistor in parallel with the capacitor in series with the relay winding and rectifier, and a current source for supplying current to charge said capacitor through said rectifier in the forward direction thereof.

2. In an electrical system, the combination of an electromagnetic relay having a winding, a rectifier offering a relatively low resistance to currents in one direction therethrough and a relatively high resistance to currents in the opposite direction therethrough, said rectifier being connected in parallel with the winding of said relay, a capacitor in series with said parallel-connected relay winding and rectifier, and a resistor in parallel with the capacitor in series with the relay winding and rectifier, a current source for supplying current to charge said capacitor through said winding and also through said rectifier in the one direction whereby said rectifier offers a low resistance shunt to said winding to prohibit operation of said relay, and means for disconnecting said source to permit said capacitor to discharge through said winding and also through said rectifier in the said opposite direction whereby said rectifier offers a high resistance shunt to said winding to permit said relay to operate.

3. A combination as claimed in claim 2, and comprising contacts on said relay, said contacts being included in the charging circuit for said capacitor.

4. In an electrical system, the combination of an electromagnetic relay having two windings thereon, contacts on said relay adapted to be moved in one direction by energization of one of said windings and to be moved in the opposite direction by energization of the other of said windings two rectifiers connected each in parallel with one of said windings, two capacitors each connected in series with one winding and a rectifier in parallel therewith, two resistors each connected one in parallel with one of said condensers in series with a relay winding and the rectifier in parallel therewith and means for supplying a charging current to one of said capacitors through contacts of said relay whereby on cessation of supply of said current said contacts are moved to prepare a charging circuit for the other of said capacitors.

5. A voltage impulse counter comprising a plurality of chain-connected stages, each stage comprising an electromagnetic relay having two windings thereon, contacts on said relay adapted to be moved in one direction by energization of one of said windings and to be moved in the opposite direction by energization of the other of said windings two rectifiers connected each in parallel with a different one of said windings, two capacitors each connected in series with a different one of said windings and a rectifier in parallel therewith, two resistors each connected one in parallel with one of said condensers in series with a relay winding and the rectifier in parallel therewith a current source, circuit means including the contacts of a relay of one stage for supplying charging current for a capacitor of that stage, and further circuit means including contacts of the relay of that stage for supplying charging current for a capacitor of a succeeding stage.

6. A voltage impulse counter as claimed in claim 5, wherein said stages correspond to the values 1, 2, 4 and 8 respectively, and comprising means for causing the relay of the stage corresponding to value 8 to be moved in one direction after 8 impulses and to be moved in the reverse direction after two further impulses whereby said counter operates as a decimal counter.

7. A voltage impulse counter as claimed in claim 5, wherein said stages correspond to the values 1, 2, 2, and 4 respectively, and comprising a carry registering relay, wherein a first impulse moves the contacts of the relay of the stage value 1 in a first direction, a second impulse moves the contacts of the relay of the stage value 1 in the opposite direction and moves the contacts of the relay of the first stage value 2 in the first direction, a fourth impulse moves the contacts of the relay of the second stage value 2 in the first direction without moving the contacts of the relay of the first stage value 2, a sixth impulse moves the contacts of the relay of the stage value 4 in the first direction and moves the contacts of the relay in the first stage of value 2 in the opposite direction and the 10th impulse moves the contacts of the relays of the four stages in the opposite direction and operates the carry-registering relay.

8. A voltage impulse counter as claimed in claim 5, and comprising switching means associated with the contacts of said relays for controlling at will the order of movement of the contacts of said relays, whereby said counter can be made to add or subtract at will.

CHRISTOPHER ADRIAN ROUTLEDGE.
ALBERT JOHN KEEN.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,168,198	Frink	Aug. 1, 1939
2,342,821	Reagan	Feb. 29, 1944
2,427,751	Snyder	Sept. 23, 1947
2,439,405	Zierdt	Apr. 12, 1948
2,538,789	Maynard	Jan. 23, 1951