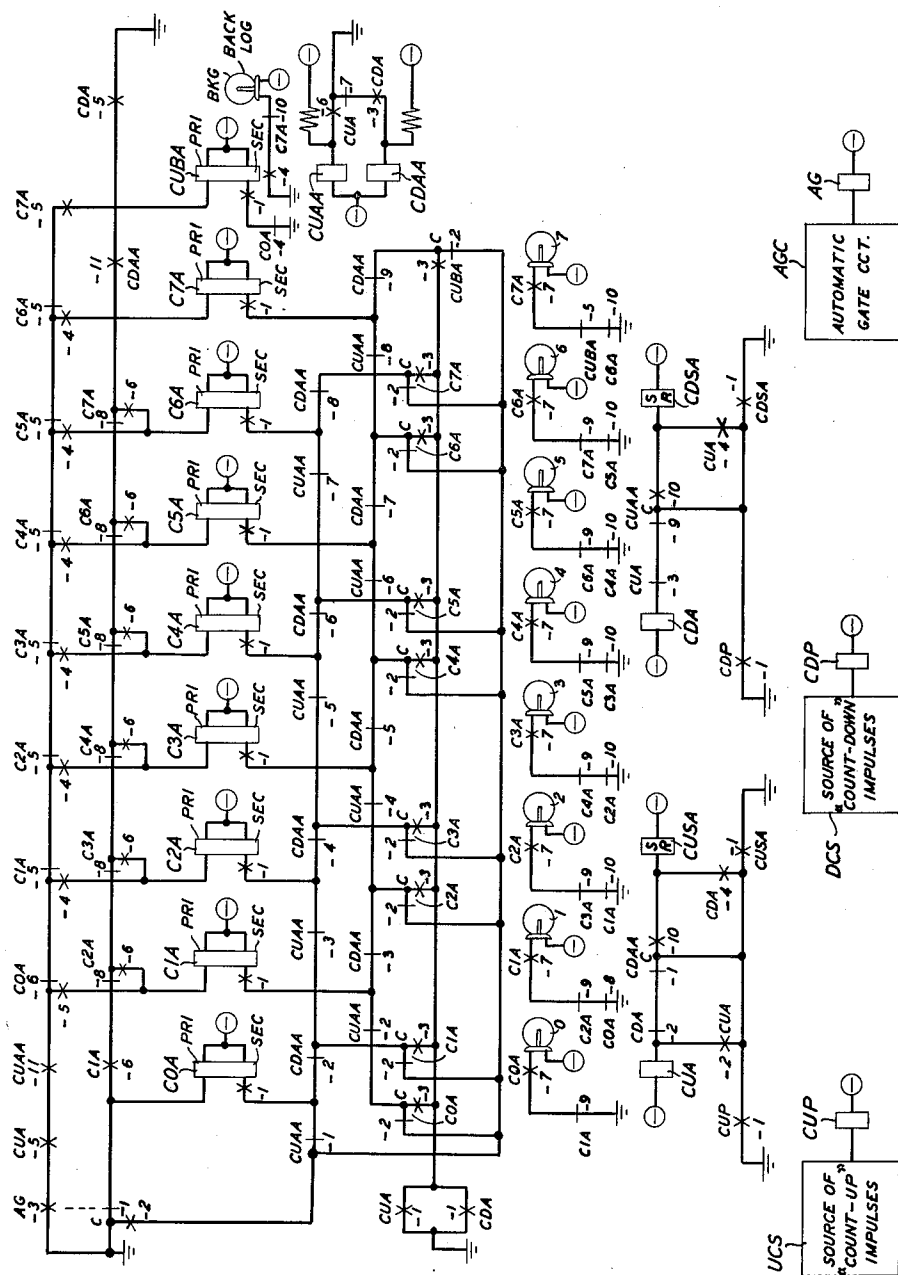


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## REVERSIBLE COUNTING RELAY CHAIN

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1 Claim. (Cl. 235—92)

This invention relates to a counting relay circuit and particularly to a counting relay circuit of the reversible type.

The principal object of this invention is the improvement of counting circuits.

Another object of the invention is the improvement of reversible counting circuits.

Another object of this invention is to provide a counting circuit wherein, in response to electrical impulses received from a first or count-up control source the counting circuit will count up, and in response to electrical impulses received from a second or count-down control source the counting circuit will count down.

Another object of this invention is to provide an improved reversible counting relay circuit having means for indicating the registration of a zero count, an intermediate count, or a predetermined maximum count.

A feature of this invention is a reversible counting relay circuit requiring but a single counting relay per counting stage.

Another feature of this invention is circuitry for deactivating a reversible counting circuit when the count exceeds a predetermined maximum.

Another feature of this invention is circuitry for automatically resetting the count of a reversible relay counting circuit to zero.

Another feature of this invention is circuitry for preventing false operation of a reversible counting circuit when electrical impulses are simultaneously received from the count-up and the count-down control sources.

The reversible counting relay circuit disclosed in the present application may be employed for counting in any system, circuit, device or structure used in processing, transmission or storage of quantities of uniform or non-uniform material or of items or conditions, wherein the number of items or conditions or the magnitude of the quantities in process, transit or storage may vary with time, and where it is required that at any given time an indication be given of whether the number or magnitude of the quantities, items or conditions in process, transit or storage is zero, some intermediate value, or is in excess of a predetermined maximum. In short, the present invention is a reversible or in-out counter designed to afford a current indication of the net count and may be applied to perform this function without known limitation except as to the speed of operation of the fastest available relay having the required number of contacts. This speed presently is about five milliseconds. The reversible relay count herein disclosed by way of example is capable of counting at a speed of about two-hundred in-out total operations per second.

The reversible counting relay circuit herein disclosed, in one of its embodiments and in one of its applications, is disclosed also in Patent 2,978,534 for an automatic telegraph line switching system, which patent, filed simultaneously herewith issued on April 4, 1961, to F. B. Crowson, G. A. Locke and R. R. MacLaughlin.

### EXPLANATION OF DETACHED CONTACT CIRCUIT SYMBOLS

The "detached contact" method of exposition used in Patent No. 2,722,675 granted to J. Michal and R. E. Staehler, November 1, 1955, has been adopted for use in this disclosure. In the detached contact method, the

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relay contacts generally are not shown adjacent to or in relation with the magnetic core and winding, or windings, but are separated or detached therefrom. The core, as may be seen from reference to the drawing, is represented by a small rectangle and is identified by a functional designation such, for example, as CUA, representing count-up relay A. In the specification, the relay is referred to also as CUA. On the drawing, each of the contacts controlled by the relay is given a designation corresponding to that of the relay winding plus a numeral which identifies the number of the contact. Thus, contact "1" on relay CUA will be designated CUA-1 placed in proximity to the contact.

Contacts which are closed when the relay is deenergized, known as "break contacts," are represented by a single short line perpendicular to the line representing the conductor, while contacts which are closed when the relay is energized, known as "make contacts," are represented by two short crossed lines diagonally intersecting the conductor line. A "break" and a "make" contact connected together on one side, in close proximity to each other, and with the designation "C," indicate a set of "continuity" or "make before break" contacts. Lamps and resistors are shown in the conventional manner employed heretofore.

A circle enclosing a minus sign indicates that the conductors terminating thereon are to be connected to a source of negative direct current.

Since, in many instances, the detached contact method of exposition results in a drawing wherein the circuit elements have no apparent physical connection with each other, it is to be assumed that all of the subject-matter appearing within the confines of a single sheet of patent drawing constitutes a single patent figure unless otherwise indicated. Specifically, in the present application all of the information appearing on the single sheet of drawing constitutes a single figure.

### REVERSIBLE COUNTING CIRCUIT—EXEMPLARY EMBODIMENT

An exemplary embodiment of the reversible counting relay chain constituting the present invention is incorporated in an automatic data processing system. In such an automatic data processing system, the data to be processed may be represented by suitable holes on a tape or card, or other suitable data storing device. Each complete set of data consists of a plurality of related items of data recorded in a continuous section of a record medium and will hereinafter be referred to as the "unit." As each unit is received by the system a circuit is closed in the source of up-count impulses UCS, thereby completing an operating circuit for the count-up relay CUP, causing it to operate, and, by closing contacts CUP-1, inaugurates the counting upward by the circuit.

### REVERSIBLE COUNTING OPERATION

#### General

#### COUNT-IN OF UNITARY QUANTITIES

The group of relays C0A through C7A is provided as a part of the circuitry of a data processing system, and is employed to count all received units and to count the units out, as each unit is processed or is disposed of in its turn.

As each unit is processed and is thereby removed from storage or disposed of, a circuit is closed in the source of count-down impulses DCS, thereby completing an operating circuit for the count-down relay CDP.

When there is no unit in storage, the automatic gate circuit AGC is inoperative, but when a unit is received by or is inserted into storage, a circuit is closed in the

automatic gate circuit AGC, thereby completing an operating circuit for automatic gate relay AG.

Circuits such as diagrammatically indicated by the rectangles UCS, DCS and AGC are disclosed in the joint patent mentioned in the foregoing.

The zero count condition of the group of relays C0A through C7A which comprise the reversible counting chain circuit is with the relay C0A operated and with relays C1A through C7A released.

#### DETAILED OPERATION OF COUNTING CIRCUIT

A detailed description of the operation of the reversible counting chain circuit follows.

If a unit is present, the presence of the unit will permit the operation of the circuits of the automatic gate circuit AGC, and the automatic gate relay AG will be operated.

In order to clarify the description of the circuit operation, it will be advantageous at this point to assume, for the moment, that the power has been turned off, and that all of the relays are released.

This description assumes, at this point, that there is no unit present; and that the absence of any unit has caused the automatic gate circuit AGC to open the operating circuit for relay AG, causing it to release. Assuming now that the power is again turned on, ground is extended through continuity contact AG-1 (released) and the primary winding of relay C0A to negative battery, causing relay C0A to operate, thereby "priming" the counting relay chain for further operation.

For the moment, the description will be confined to the operation of relay C0A.

#### ZERO COUNT

Relay C0A operated:

Prepares a locking path through its secondary winding, contacts C0A-1, CUAA-1 (released), and AG-2 (released) to ground;

At continuity contacts C0A-2 cuts off the locking circuit for the secondary winding of relay C1A from the path through contacts C1A-1, CUAA-2, C0A-2 and continuity contact AG-2 to ground;

At continuity contact C0A-3 partially closes a substitute locking circuit from the secondary winding of relay C1A extending through contacts C1A-1, CUAA-2, C0A-3, and CUA-1, or CDA-1 to ground, the latter two contacts being open at this time;

At contacts C0A-4 opens the locking circuit of the secondary winding of relay CUBA;

At contact C0A-5 partially prepares an operating circuit for the primary winding of relay C1A for the count-up;

At contacts C0A-7 completes a circuit whereby ground is extended through contacts C1A-9, C0A-7, and lamp 0 to negative battery, causing lamp 0 to light, thereby indicating that a zero count is now registered in the reversible counting relay chain;

At contact C0A-8 opens the circuit for lamp 1, thereby making it impossible for lamp 1 to light until relay C0A shall have released. Following this, when a unit is received by or inserted into the system, a circuit is completed in the automatic gate circuit AGC, causing relay AG to operate.

Relay AG operated:

Locks up to ground through a locking circuit (not shown), and remains locked up so long as the power supply remains turned on, or until the supply of units has been exhausted, which will open locking circuit for relay AG, causing it to release;

At contact AG-3 partially prepares an operating circuit for the primary winding of relay C1A;

At continuity contact AG-2 first provides ground for the locking circuits for the secondary windings of relays C0A through C7A;

At continuity contact AG-1 subsequently opens the operating circuit for the primary winding of relay C0A.

#### COUNT-IN, ONE

As soon as the first unit has been received by the data processing system, an operating circuit is completed in the source of up-count impulses UCS, causing relay CUP to operate and lock up to ground through a locking circuit (not shown).

Relay CUP operated:

Extends ground through contacts CUP-1, CDAA-1, CDA-2, and the winding of relay CUA to battery, causing relay CUA to operate.

Relay CUA operated:

Locks up to ground through contacts CUA-2 and CUP-1 (operated);

At contact CUA-3, opens the operating circuit of relay CDA;

At contact CUA-4, prepares an operating circuit for relay CDSA;

At contact CUA-5, partially closes the operating circuit for the primary winding of relay C1A;

Extends ground through contact CUA-6 and the winding of relay CUAA to battery, causing it to operate;

At contact CUA-7, opens the operating circuit for relay CDAA;

At contact CUA-1, provides a ground for the locking circuit for the secondary windings of relays C0A through C7A.

Relay CUAA operated:

At contacts CUAA-1, CUAA-2, CUAA-3, CUAA-4, CUAA-5, CUAA-6, CUAA-7, and CUAA-8, opens one of the locking circuits for the secondary windings of relays C0A, C1A, C2A, C3A, C4A, C5A, C6A, and C7A, respectively;

At continuity contact CUAA-9, further opens the operating circuit for relay CDA;

At continuity contact CUAA-10, partially closes another operating path for relay CDSA;

At contact CUAA-11, completes the final circuit closure whereby ground is extended through contacts AG-3, CUA-5, CUAA-11, C0A-5, and the primary winding of relay C1A to battery, causing relay C1A to operate.

Relay C1A operated:

At continuity contact C1A-2, opens the locking circuit for the secondary winding of relay C0A, which locking circuit comprises contacts C0A-1, CDAA-2, C1A-2, and AG-2 to ground;

At continuity contact C1A-3, closes a substitute locking circuit for the secondary winding of relay C0A extending through contacts C0A-1, CDAA-2, C1A-3, and CUA-1 (operated) to ground;

Locks up to ground through contacts C1A-1, CDAA-3, C2A-2, and continuity contact AG-2 (operated) to ground;

At contact C1A-4, prepares an operating circuit for the primary winding of relay C2A for the count-up in the counting circuit;

At contact C1A-6, prepares an operating circuit for the primary winding of relay C0A for the count-down in the counting circuit;

At contact C1A-7, partially closes a circuit to ground for lamp 1;

At contact C1A-9, opens the circuit for lamp 0, thereby making it impossible for lamp 0 to light until relay C1A shall have released;

At contact C1A-10, opens the circuit for lamp 2, thereby making it impossible for lamp 2 to light until relay C1A shall have released.

Shortly after the first unit has been received by or inserted into the system, the circuit in the source of count-up impulse UCS is opened, thereby causing relay CUP to release.

With relay CUP released, contact CUP-1 opens and disconnects locking ground from the winding of relay CUA, causing relay CUA to release. When relay CUA releases, contact CUA-1 opens and disconnects locking ground from the circuit extending through contacts

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CUA-1, C1A-3 (operated), CDAA-2, C0A-1, and the secondary winding of relay C0A to battery, causing relay C0A to release.

A short time later, with contact CUA-6 open, relay CUAA will release, and the circuit will be in the condition in which relay C1A is operated and relay C0A is released.

With relay C0A released, relay C1A operated, and relay C2A released, ground is extended through contacts C0A-8, C2A-9, C1A-7, and lamp 1 to battery, causing lamp 1 to light, thereby indicating that a count of one is now registered in the counting chain circuit.

#### COUNT-IN, TWO

Now let it be assumed that a second unit has been received by the system. An operating circuit is again completed in the source of up-count impulses UCS, causing relay CUP to again operate.

Relay CUP operated:

Extends ground through contacts CUP-1, CDAA-1, CDA-2, and the winding of relay CUA to battery, causing relay CUA to operate.

Relay CUA operated:

Locks up to ground through contacts CUA-2 and CUP-1 (operated);

At contact CUA-3, opens the operating circuit of relay CDA;

At contact CUA-4, prepares an operating circuit for relay CDSA;

At contact CUA-5, partially closes the operating circuit for the primary winding of relay C2A;

Extends ground through contact CUA-6 and the winding of relay CUAA to battery, causing it to operate;

At contact CUA-7 opens the operating circuit for relay CDAA;

At contact CUA-1, provides a ground for the locking circuit for the secondary windings of relays C0A through C7A.

Relay CUAA operated:

At contacts CUAA-1, CUAA-2, CUAA-3, CUAA-4, CUAA-5, CUAA-6, CUAA-7, and CUAA-8, opens one of the locking circuits for the secondary windings of relays C0A, C1A, C2A, C3A, C4A, C5A, C6A, and C7A, respectively;

At continuity contact CUAA-9, further opens the operating circuit for relay CDA;

At continuity contact CUAA-10, partially closes another operating path for relay CDSA;

At contact CUAA-11, completes the final circuit closure whereby ground is extended through contacts AG-3, CUA-5, CUAA-11, C0A-6, C1A-4, and the primary winding of relay C2A to battery, causing relay C2A to operate.

Relay C2A operated:

At continuity contact C2A-2, opens the locking circuit for the secondary winding of relay C1A, which locking circuit comprises contacts C1A-1, CDAA-3, C2A-2, and AG-2 to ground;

At continuity contact C2A-3, closes a substitute locking circuit for the secondary winding of relay C1A extending through contacts C1A-1, CDAA-3, C2A-3, and CUA-1 (operated) to ground;

Locks up through contacts C2A-1, CDAA-4, C3A-2, and AG-2 (operated) to ground;

At contact C2A-4, prepares an operating circuit for the primary winding of relay C3A for the count-up in the counting circuit;

At contact C2A-6, prepares an operating circuit for the primary winding of relay C1A for the count-down in the counting circuit;

At contact C2A-7, partially closes a circuit to ground for lamp 2;

At contact C2A-9, opens the circuit for lamp 1, thereby making it impossible for lamp 1 to light until relay C2A shall have released;

At contact C2A-10, opens the circuit for lamp 3, there-

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by making it impossible for lamp 3 to light until relay C2A shall have released.

Shortly after the second unit has been received by or inserted into the system, the circuit in the source of count-up impulses UCS is opened, thereby causing relay CUP to again release.

With relay CUP released, contact CUP-1 again opens and disconnects looking ground from the winding of relay CUA, causing relay CUA to release. When relay CUA releases, contact CUA-1 opens and disconnects locking ground from the circuit extending through contacts CUA-1, C2A-3 (operated), CDAA-3, C1A-1, and the secondary winding of relay C1A to battery, causing relay C1A to release.

A short time later, relay CUAA will release and the circuit will be in the condition in which relay C2A is operated and relays C0A and C1A are released.

With relay C1A released, relay C2A operated, and relay C3A released, ground is extended through contacts C1A-10, C3A-9, C2A-7, and lamp 2 to battery, causing lamp 2 to light, thereby indicating that a count of two is now registered in the counting chain circuit.

#### COUNT-IN, THREE TO SEVEN

For each complete unit received by or inserted into the system, the relay CUP will operate and release and, in the manner above described, will cause the successive operation of the relays C3A through C7A.

#### BACKLOG ALARM

If more than seven units are received by the system and are counted in before being counted out, when relay CUP again operates in response to the presence of the eighth unit, ground will be extended through contacts AG-3, CUA-5, CUAA-11, C0A-6, C1A-5, C2A-5, C3A-5, C4A-5, C5A-5, C6A-5, C7A-5, and the primary winding of relay CUBA to battery, causing relay CUBA to operate.

Relay CUBA operated:

Locks up to ground through contacts CUBA-1 and C0A-4 (released);

At continuity contact CUBA-2, provides for the release of relay C7A;

Extends ground through contacts CUBA-4, C7A-10, and the Backlog lamp BKG to battery, causing lamp BKG to light to apprise the attendant of an accumulation or backlog of more than seven units;

At contact CUBA-5, opens the circuit to ground for lamp 7.

Under the above-described condition all further counting will cease, and the counting circuit will remain in the condition above described until all of the units are counted out. When all of the units have been counted out, the circuit in the automatic gate circuit AGC will open, thereby opening the operating circuit for relay AG which will release. Relay AG in releasing will open continuity contact AG-2, thereby disconnecting locking ground from the secondary windings of relays C0A through C7A, and the counting circuit will be released. At the same time, ground is extended through continuity contact AG-1, and the primary winding of relay C0A to battery, causing relay C0A to reoperate, thereby again lighting lamp 0 to indicate a zero registration in the counting circuit.

#### COUNT OUT OF UNITARY QUANTITIES

Now let it be assumed that, in the manner previously described, two units have been counted, and that responsive thereto, relay C2A is operated, thereby indicating the condition.

Now, at this time, let it be assumed that one of the units which has been counted in has been counted out. A circuit is now completed in the source of count-down impulses DCS, causing relay CDP to operate. Ground is extended through contacts CDP-1, CUAA-9, CUA-3,

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and the winding of relay CDA to battery, causing relay CDA to operate.

Relay CDA operated:

Extends ground through contacts CUA-7 (released), CDA-3, and the winding of relay CDAA to battery, causing relay CDAA to operate;

At contact CDA-4 prepares an operating circuit for relay CUSA;

At contact CDA-1 provides a ground for the locking circuit for the secondary windings of counting relays C0A through C7A;

At contact CDA-2 opens the operating circuit for relay CUA;

At contact CDA-5 partially closes the count-down circuit for the primary winding of any one of the counting relays C0A through C6A that it may be desired to operate.

Relay CDAA operated:

At contacts CDAA-2, CDAA-3, CDAA-4, CDAA-5, CDAA-6, CDAA-7, CDAA-8, and CDAA-9, opens one of the locking circuits for the secondary windings of relays C0A, C1A, C2A, C3A, C4A, C5A, C6A, and C7A, respectively.

At contact CDAA-1, further opens the operating circuit of relay CUA;

At contact CDAA-10, partially closes another operating path for relay CUSA;

At contact CDAA-11, closes the final count-down operating path for the primary winding of any one of the counting relays C0A through C6A that it may be desired to operate;

Extends ground through contacts CDA-5, CDAA-11, C7A-8, C6A-8, C5A-8, C4A-8, C3A-8, C2A-6, and the primary winding of relay C1A to battery, causing relay C1A to operate.

Relay C1A operated:

At continuity contact C1A-2, opens the locking circuit for the secondary winding of relay C2A, which locking circuit comprises contacts C2A-1, CUAA-3, C1A-2, and continuity contact AG-2 to ground;

At continuity contact C1A-3, closes a substitute locking circuit for the secondary winding of relay C2A extending through contacts C2A-1, CUAA-3, C1A-3, and CDA-1 (operated) to ground;

Locks up through contacts C1A-1, CUAA-2, C0A-2, and AG-2 (operated) to ground;

At contact C1A-4, prepares an operating path for the primary winding of relay C2A for the count-up in the counting circuit;

At contact C1A-6, prepares an operating circuit for the primary winding of relay C0A for the count-down in the counting circuit;

At contact C1A-7, partially closes a circuit to ground for the one count lamp 1;

At contact C1A-9, opens the circuit to ground for lamp 0;

At contact C1A-10, opens the circuit to ground for lamp 2, causing it to be extinguished.

Shortly after the processing of a stored unit currently being processed has been concluded, the circuit in the source of count-down impulses is opened, thereby causing relay CDP to release.

With relay CDP released, contact CDP-1 opens and disconnects operating ground from the winding of relay CDA, causing relay CDA to release. When relay CDA releases, contact CDA-1 opens and disconnects locking ground from the circuit extending through contacts CDA-1, C1A-3, CUAA-3, C2A-1, and the secondary winding of relay C2A to battery, causing relay C2A to release.

A short time later, relay CDAA will release, and the circuit will be in the condition in which relay C1A is operated and relay C0A is released.

With relay C0A released, relay C1A operated and relay C2A released, ground is extended through contacts

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C0A-8, C2A-9, C1A-7, and lamp 1 to battery, causing lamp 1 to light.

Now, let it be assumed that the remaining one of the units has been processed. A circuit is again completed in the source of count-down impulses DCS, causing relay CDP to again operate. Ground is extended through contacts CDP-1, CUAA-9, CUA-3, and the winding of relay CDA to battery, causing relay CDA to again operate.

Relay CDA operated:

Extends ground through contacts CUA-7 (released), CDA-3, and the winding of relay CDAA to battery, causing relay CDAA to operate;

At contact CDA-4, prepares an operating circuit for relay CUSA;

At contact CDA-1, provides a ground for the locking circuit for the secondary windings of counting relays C0A through C7A;

At contact CDA-2, opens the operating circuit for relay CUA;

At contact CDA-5, partially closes the count-down circuit for the primary windings of any one of the counting relays C0A through C6A that it may be desired to operate.

Relay CDAA operated:

At contacts CDAA-2, CDAA-3, CDAA-4, CDAA-5, CDAA-6, CDAA-7, CDAA-8, and CDAA-9, opens one of the locking circuits for the secondary windings of relays C0A, C1A, C2A, C3A, C4A, C5A, C6A, and C7A, respectively;

At contact CDAA-1, further opens the operating circuit for relay CUA;

At contact CDAA-10, partially closes another operating path for relay CUSA;

At contact CDAA-11, closes the final count-down operating path for the primary winding of any one of the counting relays C0A through C6A that it may be desired to operate;

Extends ground through contacts CDA-5, CDAA-11, C7A-8, C6A-8, C5A-8, C4A-8, C3A-8, C2A-8, C1A-6 (operated), and the primary winding of relay C0A, to battery, causing relay C0A to operate.

Relay C0A operated:

Prepares a locking path, through its secondary winding, contacts C0A-1, CUAA-1 (released), and AG-2 (operated), to ground;

At continuity contact C0A-2, cuts off the locking circuit for the secondary winding of relay C1A from the path through contacts C1A-1, CUAA-2, C0A-2, and AG-2 to ground;

At continuity contact C0A-3, closes a substitute locking circuit for the secondary winding of relay C1A extending through contacts C1A-1, CUAA-2, C0A-3, and CDA-1, to ground;

At contact C0A-4, opens the locking circuit of the secondary winding of relay CUBA;

At contact C0A-5, partially prepares an operating circuit for the primary winding of relay C1A for the count-up in the counting circuit;

At contact C0A-7, partially closes a circuit to ground for lamp 0;

At contact C0A-8, opens the circuit to ground for lamp 1, causing it to be extinguished.

Shortly after the processing of the last unit has been concluded, the circuit in the source of count-down impulses is opened, thereby causing relay CDP to release.

With relay CDP released, contact CDP-1 opens and disconnects operating ground from the winding of relay CDA, causing relay CDA to release.

Relay CDA, in releasing, opens contacts CDA-1 and CDA-3 which causes the release of relays C1A and CDAA, respectively, leaving the circuit in the condition where relay C0A only is operated.

With relay C0A operated, and relays C1A through C7A released, ground is extended through contacts C1A-9,

C0A-7, and lamp 0 to battery, causing lamp 0 to again light.

The counting circuit has now been restored to the zero count condition.

Utilizing relays C1A, C2A, C3A, C4A, C5A, C6A, and C7A in the above-described manner, unitary quantities can be counted in and out of the counting circuit, provided that the net number of unitary quantities counted in, at any cycle of operation, does not exceed seven, which is the capacity of the counting circuit.

An anti-contention circuit is provided to guard against false operation of the counting relays when the associated data processing system attempts to count-in and count-out simultaneously. The description of the operation of the anti-contention circuit follows.

#### SIMULTANEOUS COUNT-IN AND COUNT-OUT

Let it now be assumed that the relay CDP operates in the manner previously described, while relay CUP is still operated.

If, at this moment, relays CUA and CUAA are operated, then relay CDA cannot operate because its operating circuit is opened at contact CUA-3, but ground extended through contact CDP-1, parallel-connected contacts CUAA-10 and CUA-4, and the winding of relay CDSA to battery will cause relay CDSA to operate.

Relay CDSA operated:

Locks up to ground through contacts CUA-4 and CDSA-1.

Now let it be assumed that relay CUP releases, opening contact CUP-1 and causing relay CUA to release. Relay CUA, in releasing, opens contact CUA-6, causing relay CUAA to release.

Let it be assumed that when both relays CUA and CUAA are released, the count-down impulse has ceased, thus releasing relay CDP. However, at this time, ground is extended through contacts CDSA-1, CUAA-9, CUA-3, and the winding of relay CDA to battery, causing relay CDA to operate. The release of relay CUA, at contact CUA-4, opens the locking circuit for relay CDSA which, being slow to release, does not immediately release. The operation of relay CDA and the release of relay CUA extends ground through contacts CUA-7 and CDA-3, causing relay CDAA to operate. The operation of relay CDAA closes ground through contacts CDA-5 and CDAA-11 so that the counting circuit is now enabled to count-down.

When slow-to-release relay CDSA shall have fully released, contact CDSA-1 opens the operating path to ground for relay CDA, causing relay CDA to release.

If relays CDA and CDAA are operated first, then relay CUA cannot operate because its operating circuit will be opened at contact CDA-2, but ground extended through contacts CUP-1, parallel-connected contacts CDAA-10 and CDA-4, and the winding of relay CUSA to battery will cause relay CUSA to operate.

Relay CUSA operated:

Locks up to ground through contacts CDA-4 and CUSA-1.

Now let it be assumed that relay CDP releases, opening contact CDP-1 and causing relay CDA to release. Relay CDA, in releasing, opens contact CDA-3, causing relay CDAA to release.

Let it be assumed that when both relays CDA and CDAA are released the count-up impulse has ceased, thus releasing relay CUP. However, at this time, ground is extended through contacts CUSA-1, CDAA-1, CDA-2, and the winding of relay CUA to battery, causing relay CUA to operate. The release of relay CDA, at contact CDA-4, opens the locking circuit for relay CUSA which, being slow-to-release, does not immediately release. The operation of relay CUA causes ground to be extended

through contact CUA-6, causing relay CUAA to operate. The operation of relay CUAA causes ground to be extended through contacts AG-3, CUA-5, and CUAA-11, so that the counting circuit is now enabled to operate the next higher numbered relay.

When slow-to-release relay CUSA shall have fully released, contact CUSA-1 opens the operating path to ground for relay CUA, causing relay CUA to release.

If both relays CDP and CUP operate at exactly the same time, the operation of relay CUA will take precedence over the operation of relay CDA. The reason for this is because relay CUA, when operated, locks up to ground through contacts CUA-2 and CUP-1, whereas relay CDA is not provided with a locking circuit. The count-down operation will then be delayed, but will take place after a short delay interval.

In the exemplary disclosure of the reversible counting relay circuit, as above described, a seven-stage counting chain is shown. This is not to be construed as a limitation, as it will readily be apparent to one skilled in the art that counting relay chains in accordance with the present invention may be constructed to employ a greater or less number than seven counting stages.

It is to be understood that other equivalent apparatus and instrumentalities may be employed without materially departing from the spirit and scope of the invention.

What is claimed is:

In combination in a reversible counting system, a first source of electrical impulses, a second source of electrical impulses, a multistage counting circuit, said circuit having a single counting relay per counting stage, a first means comprising said relays in said counting circuit responsive to each impulse from said first source to thereby unitarily increase the count in said circuit, a second means comprising said relays in said counting circuit responsive to each impulse from said second source to thereby unitarily decrease the count in said counting circuit, means responsive to said relays for indicating the numerical value of the count registered in said counting circuit, means responsive to said relays for resetting said counting circuit to zero, means responsive to said relays for giving an alarm when the count in said counting circuit exceeds a predetermined maximum, an anti-contention circuit connected to said relays and responsive to the simultaneous reception of impulses from said first and second sources for preventing the simultaneous application of impulses from said sources to said first and second means, said anti-contention circuit including means responsive to the simultaneous reception of a first impulse from either one of said first and second sources and a second impulse from the other one of said sources for positively storing an indication that a second impulse has been applied to said system from said second source even if said second impulse is non-persistent and for delaying the operation of the means responsive to said second impulse until the means responsive to said first impulse has completed its operation.

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