

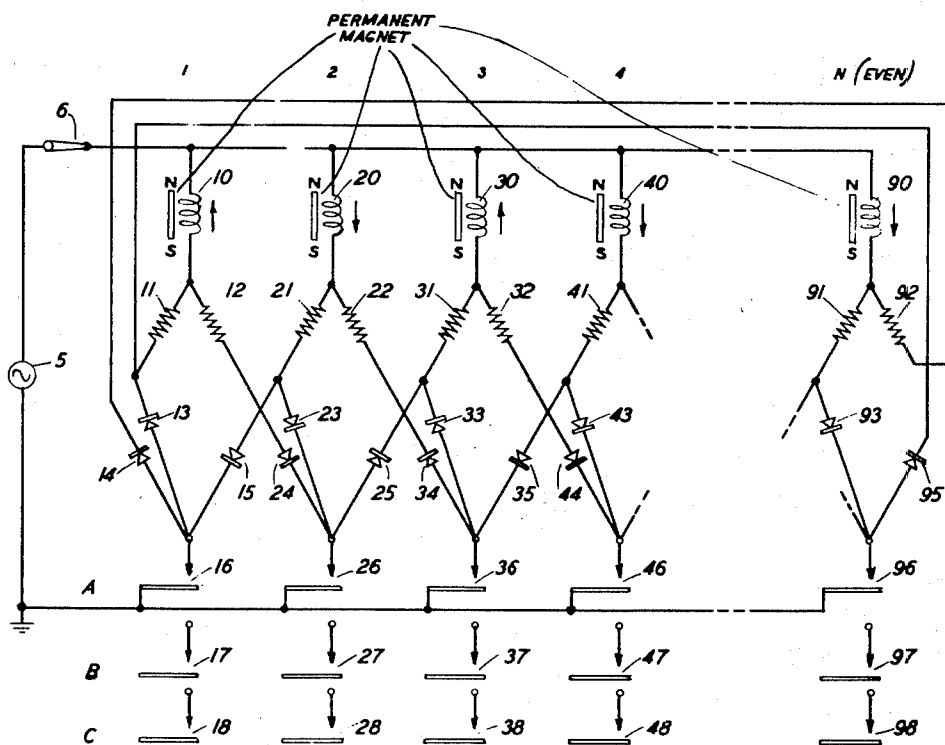
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HIGH-SPEED STEPPING DISTRIBUTOR AND COUNTING CIRCUIT

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HIGH-SPEED STEPPING DISTRIBUTOR AND
COUNTING CIRCUIT

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This invention relates to improved relay stepping circuits for use as relay distributors and relay counting circuits. More particularly, the invention relates to improvements in said circuits which permit the operation of the circuits at a considerably higher speed than heretofore.

In accordance with the exemplary embodiment of the invention set forth herein in detail, a relay stepping circuit of the type disclosed in an application for United States Letters Patent of Hill and Parkinson, Serial No. 115,016, filed September 10, 1949, is modified and improved to permit the operation of such relay stepping circuits at considerably higher rates of speed. Relay stepping circuits of the type disclosed in said application for Letters Patent of Hill and Parkinson, employ a plurality of so called reed-type relays in combination with rectifier elements sometimes called unilateral conducting devices such as electronic tubes, cuprous oxide rectifier, silicon rectifiers, selenium rectifiers, germanium rectifiers, etc. Relay stepping circuits of the type disclosed in said above-identified application may be operated from a source of alternating current having any suitable wave form. As the frequency of such a source is increased the operating speed of the relay distributor is increased until the operation and release of the relays require an appreciable time interval which approaches or exceeds the time of a half cycle of the applied alternating current, at which time the stepping circuits fail and will not step. If it is attempted to increase the speed of operation and release of the relays by merely increasing the magnitude of the applied driving force or voltage of the alternating current source, increased current flows in various spurious circuits which causes false operation of the relays. In addition, as the driving voltage is increased beyond a predetermined limit, it will cause the release and then reoperation of some relays thus causing improper operation of the circuit.

Furthermore, due to the different times of closure of the various reed contacts within one winding it has previously been necessary to select the least sensitive or the slowest set to control the stepping circuit to insure that the other contacts of the relays close.

It is an object of the invention to overcome the various difficulties encountered in attempting to increase the speed of operation of such relay distributors by controlling the currents flowing in the operate and release circuits so as to suppress or reduce spurious currents and improve operation of the relays and in addition, to in-

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sure that all the contacts of a given relay will open or close at the proper time so that some variation in the operate and release times of the reeds within a given relay winding may be tolerated without retarding or causing improper operation of the circuit.

A feature of the invention relates to controlling the operating current of relays so that the relay to be operated receives a sufficient current to operate the relay and at the same time, the current through other spurious operating circuits is reduced to a sufficiently low level to prevent interference with the operation of the circuits and thus prevent the operation of other relays.

Another feature of the invention relates to an addition of a locking or holding circuit for maintaining operating current through a winding of an operated relay during the time interval during which the relay is supposed to operate.

The foregoing and other objectives and features of the invention may be more readily understood by reference to the attached drawing which shows an exemplary embodiment of the invention which is suitable for incorporation in the subscriber's calling and subsets disclosed in the above-identified application for United States Letters Patent of Hill and Parkinson and is also suitable for other relay distributors as well as for relay counting circuits.

The source 5 of alternating current, when switch 6 is closed, is connected to control windings, contacts, circuits, etc., of the exemplary relay stepping system shown in the drawing. As shown in the drawing, this stepping circuit comprises a plurality of relays 1, 2, 3 and 4 having windings 10, 20, 30 and 40.

These relays are the type disclosed in United States Patents 2,245,391, granted to Dickten, Jr., June 10, 1941, and 2,264,022, granted to W. B. Ellwood, November 25, 1941. As set forth in the above-identified patents, these relays comprise a plurality of reed-type contacts in which each pair of contacts is enclosed in a glass or other suitable type of envelope and the envelopes comprising all of the contacts of a given relay surrounded by one or more controlling windings. In the relays employed in the exemplary embodiment of the invention, set forth herein, the contacts are magnetizably polarized by means of a small permanent magnet, which polarizing permanent magnet is insufficient of and by itself to cause the contacts to close. However, the magnetism of the magnet is sufficient to maintain the contacts closed after they have been

closed until the field of the magnet is directly neutralized by reversing current flowing through the winding. In one exemplary embodiment of this invention a single magnet is provided adjacent all of the reed contacts of one relay and the contacts and magnet surrounded by the controlling coil or coils. However, when desired a magnet individual to the reeds of each envelope may be provided within each of the enclosures of each set of reed contacts.

When a reverse current is caused to flow, it neutralizes the field of the permanent magnet so that the contacts will then open. As shown in the drawing, each relay is provided with a single winding and each relay is provided with three sets of make contacts, that is, contacts which close when the current of a proper polarity flows through the winding. These contacts release or remain open when a voltage of opposite polarity flows through the winding.

One terminal of each of the windings 20, 30, 40 etc., is connected to one of the terminals of switch 6 which in turn is connected to the source of alternating current voltage 5. The other terminal of source 5 is connected to one of contacts of each of the relays. These contacts are designated 16, 26, 36, 46 etc., respectively. The other terminal of the contacts is connected through a rectifier and a resistance network to the other terminals of each of the windings.

It is assumed, for purposes of description, that the rectifiers are so poled that current from a positive source flows through the rectifier in the direction of the arrows but will not flow in the opposite direction. In other words, it is assumed in the following description that the arrows represent the anodes of the rectifier. These rectifiers may, of course, comprise solid or crystal rectifier elements as well as tubes evacuated to a low pressure or tubes containing a residual gas or vapor at a reduced pressure.

It is obvious that all of the rectifiers may be connected in opposite direction in which case the distributor will work equally well on the application of an alternating current to the stepping circuits of these relays and contacts but the relays will step in the opposite direction also.

As set forth in the above-identified application for Letters Patent of Hill and Parkinson, a winding common to all the relays may be provided or additional windings or circuits or both may be provided for each relay for conditioning the relays in any desired predetermined condition by the energization of this common winding or other windings and circuits of the relays, so that the relays will be in a predetermined and proper condition for counting or distributing pulses.

Assume for purposes of illustration that in some such manner one of the relays such as relay 2 is conditioned with its contacts 26, 27, 28 closed and the contacts of all the remaining relays are open, prior to the closing of switch 6. Further, assume upon the closure of switch 6, the alternating voltage supply is of such a polarity that positive voltage with respect to ground is applied through switch 6 to the upper winding terminals of the windings 10, 20, 30, 40, etc. With the upper terminal of the voltage source positive when switch 6 is closed, current will flow from switch 6 through winding 20, resistor 21 and rectifier 23 and closed contact 26 of relay 2 to ground or the other terminal of the alternating current source. Current flowing through this path is in the direction of the arrows shown

alongside of winding 20, thus indicating that it is in the direction to close contacts 26, 27 and 28 which will be maintained operated as long as this current continues to flow. In addition, current flows in a path from the upper terminal of source 5 through switch 6, winding 10 of relay 1, resistor 12 and rectifier 24 to the lower terminal of source 5 or to ground through the operated contacts 26. Current flowing in this case, flows through winding 10 in a direction opposite to that indicated by the arrows alongside this winding. Consequently, this current is in such direction that to cause relay 1 to release and open its contacts and thereafter maintain the contacts open. Inasmuch as it was assumed that this relay was already released, this current causes these contacts to remain open.

At the end of the first half cycle, during which switch 6 is closed, the voltage of the upper terminal of alternating current source 5, becomes negative, consequently current now flows in a circuit path from ground through the operated contacts 26 of relay 2, through rectifier 25, resistor 31 and winding 30 of relay 3 to the upper terminal of alternating current source 5 through switch 6. This current flows in such a direction as to operate relay 3 and close contacts 36, 37 and 38, since it is in the same direction as indicated by the arrows adjacent to winding 30.

The closure of contact 36 completes two circuits, the first of which may be traced from ground and the lower terminal of source 5 through contacts 36, rectifier 33, resistor 31 and winding 30 of relay 3 to the upper terminal of source 5 through switch 6. Current flowing through this path causes all the contacts 36, 37 and 38 of relay 3 to remain closed. In other words, the rectifier 33 provides a locking path for maintaining current through winding 30 of relay 3, independently of the operation or non-operation of contacts 26 of relay 2. This path insures that all the contacts of relay 3 are closed and will be maintained closed for a period of substantially an entire half cycle from the alternating current source 5.

Contacts 36 in closing, as described above, in addition, complete a circuit from the lower terminal of alternating current source 5 through contacts 36, rectifier 34, resistor 22 and winding 20 of relay 2 to the upper terminal of source 5 through switch 6. Current now flows through winding 20 in the reverse direction to that indicated by the arrow, thus causing the contacts 26, 27 and 28 to open. The relay circuit has made one step due to the operation of relay 3 and the release of relay 2.

If switch 6 had been closed originally when the upper terminal of the source 5 was negative, then relay 3 is immediately operated and relay 2 released in the manner described above.

At the end of this negative half cycle, the upper terminal of source 5 will again become positive and cause relay 4 to operate and relay 3 to release, in substantially the same manner as the operation of relay 3 and release of relay 2 as described above in response to a negative half cycle from source 5. In this manner, one relay is operated and the preceding relay released in response to each half cycle of the alternating current from source 5.

As shown in the drawing, the last relay in the chain, designated N and having winding 90 and contacts 96, 97 and 98, upon operating, conditions relay 1 for operation during the next half cycle. As indicated in the drawing, relay N of

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the even-numbered relays operates in response to a positive half cycle and relay 1 on the succeeding negative half cycle. The other odd-numbered relays operate on negative half cycles. Assume now that the relay distributor has been actuated so that No. 1 relay is operated with contacts 16, 17 and 18 closed.

As pointed out hereinbefore, as the frequency of the alternating current increases the speed of operation of the distributor as described above increases until the operate time or release time or both these times of the various relays becomes equal to a significant portion of the operating half cycles. At this time, the stepping action of the distributor of the prior art may fail because the relays do not operate in the time allotted or the succeeding relays do not release and as the result more than one relay may be operated during the given half cycle or else the circuit may fail to step. As the voltage of source 5 increases in an effort to increase the speed of taking steps and due to the fact that the impedance of the rectifiers in the operating circuits is small compared to the resistance or impedance of the various windings of the relays, a sufficiently increased current may flow in a plurality of spurious circuit paths through the windings of other relays and cause improper operation of these other relays.

Thus at the end of the negative half cycle during which relay 1 is operated, the upper terminal of the alternating source 5 again becomes positive and causes current to flow in a path through the winding 20 in such a direction as to operate the winding 20 from the upper terminal of source 5 through winding 20, resistor 21, rectifier 15 to the other terminal of source 5 through the operated contacts 16.

At this time, other circuit paths exist from the upper terminal of source 5 through switch 6, winding 40 of relay 4 through resistor 41, rectifiers 35, 34, resistors 22 and 21 and rectifier 15 to the opposite terminal of source 5 through switch 16. If the impedance of the rectifiers 35, 34 and 15 is sufficiently low compared to the impedance of the windings of relay 20 and 40 and if each of the resistors 21, 22 and 41 have been omitted, a sufficiently high current may flow through winding 40 of relay 4 to operate relay 4. In a similar manner other even-numbered relays such as 6, for example, may operate due to the current flowing through a similar circuit. Thus, two or more relays will operate at this time instead of only one. To overcome this difficulty, resistors 21, 31, 41, and other similar resistors have been inserted in the operating circuit of the respective relays. As a result the ratio of current flowing through the winding of relay 20 and the current flowing through the other relay windings is increased with the result that except for relay 2 insufficient current flows through the windings of the even-numbered relays so that they will not operate. However, relay 2 does so operate in the circuit and in the manner set forth herein.

In addition to the difficulty encountered due to false operations of the relays as the operating voltage is raised in an effort to increase the speed, the increased operating alternating voltage also causes improper operation or failure of the preceding relay in the chain to release. As pointed out above, the relays are provided with a polarizing magnetic field from a permanent magnet, which magnet may be individual to each set of contacts or may be common to a group of

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the contacts. As the driving voltage is increased, the reverse field increases and overcomes a biasing field which is holding the relay operated. Consequently, the relay will release. However, if the driving voltage is still further increased, the field will actually reverse and if the driving voltage is still further increased, the reverse field may become sufficiently strong to reoperate the relay instead of maintaining it released. In order to further improve the release circuit characteristics of the relays when operating in a stepping chain in accordance with this invention, resistances such as resistance 12, 22, 32, 92, etc. are connected in series with the respective rectifiers 24, 34, 44, 14, etc., to limit the release current and prevent aforementioned reclosure of contacts.

With the above-described improvements in the relay stepping chain circuit disclosed in the above-identified application of Hill and Parkinson, relay stepping circuits in accordance with the present invention have been operated at speeds in excess of 500 steps a second, whereas previously the circuits could not be operated at speeds in excess of 100 steps per second. Furthermore, any of the contacts of relays may be employed for controlling the stepping circuits, whereas previously it was necessary to test all the contacts under the various operating conditions and select the least sensitive contacts for controlling the stepping circuit. This adverse selection requirement which tended to slow up the operation of the previous stepping arrangements has been removed by the addition of a locking current path as described above.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A relay stepping circuit comprising a plurality of electromagnetic relays arranged in succession, each relay comprising a winding and a plurality of operable contacts, means for magnetically biasing each of said relays to aid in the operation of said relays, an operating circuit path from one contact of each of said relays to the winding of a succeeding relay, a rectifier and an impedance element having an impedance relatively high with respect to the impedance of the windings of said relays connected in said circuits, another rectifier connected in another circuit path from said contact of each of said relays for applying a release current to another of said relays, and an additional rectifier and circuit connected to said contacts to the winding of the relay controlling said contacts for insuring complete operation of all the contacts of said relay.

2. A relay stepping circuit comprising a plurality of reed-type relays arranged in succession, each relay comprising a winding and a plurality of reed contacts, means to magnetically bias each of said relays to aid in holding the relays operated, an operating circuit path from one contact of each of said relays to the winding of a succeeding relay, a rectifier and an impedance element having an impedance relatively high with respect to the impedance of the windings of said relays connected in each of said circuits, an additional circuit path from said contact of each of said relays for applying a release current to another of said relays and a rectifier connected in said additional circuit paths

3. A relay stepping circuit comprising a plu-

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rality of reed-type relays arranged in succession, each relay comprising a winding and a plurality of reed contacts, magnetic bias means for opposing the operation of said relay in response to one polarity of current, an operating circuit path from one contact in each of said relays to the winding of a succeeding relay, a rectifier and an impedance element included in a plurality of said paths, having an impedance high relative to the impedance of the windings of said relays, a release circuit path from said one contact of each of said relays extending to the winding of another relay, a rectifier element poled in the opposite direction to said first rectifier element connected in said release circuit for providing a circuit path for the flow of release current through the winding in another of said relays and a current controlling impedance means included in said release path in addition to the rectifier and winding of said relay.

4. A relay stepping circuit comprising a plurality of reed-type relays arranged in succession, each relay comprising a winding and a plurality of reed contacts, magnetic bias means individual to each of said relays for aiding the operation of said relays in response to one polarity of current and opposing the operation of said relays in response to another polarity of current, an oper-

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ating circuit path from one contact in each of said relays to the winding of a succeeding relay, a rectifier and an impedance element connected in each of said circuit paths having an impedance high relative to the impedance of the windings of said relays, a release circuit path from said one contact of each of said relays to the winding of another relay, a rectifier element connected in each of said release circuits in the opposite direction to said first rectifier element for providing a circuit path for the flow of a release current through the winding in another of said relays, and a current controlling impedance means connected in said release path in addition to the rectifier and winding of said relay, and an additional circuit connected to said one contact of each of said relays which circuit extends to the operating circuit of the winding of the relay controlling said contacts for insuring the complete operation of all the contacts of said relay, and a rectifier connected in each of said additional circuits poled in the same direction as the rectifier in said release circuit.

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No references cited.