

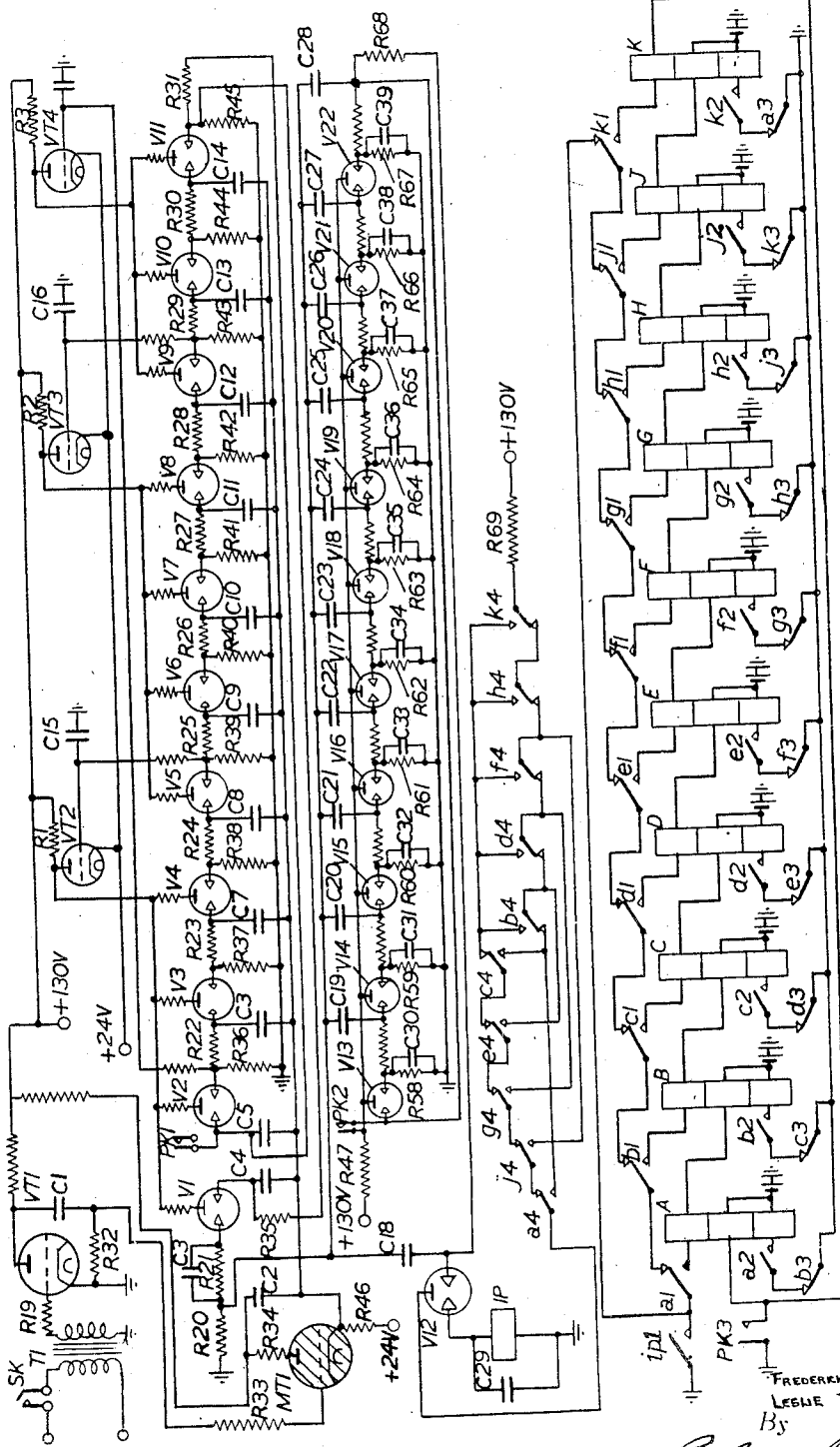
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# ARRANGEMENT FOR COUNTING ELECTRICAL IMPULSES

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ARRANGEMENT FOR COUNTING  
ELECTRICAL IMPULSES

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This invention relates to arrangement for counting electrical impulses comprising a chain of electronic devices, rendered conducting in turn by successive impulses. Such arrangements may be used to count the number of cycles of an alternating current and generate an impulse every  $n$  cycles and thus act as the source of impulses required in the register controllers of step-by-step telecommunication exchange systems or may be used to respond to and register the number of incoming impulses in telecommunication exchange systems, e. g. from a subscriber's dial or a reversibly controlled power driven selector switch or in remote indication for remote control systems for indicating the number of impulses received or for performing a particular operation when a particular number of impulses has been received.

Electronic devices are inherently adapted to respond to impulses of a higher speed than those to which electromagnet contact making relays can respond. If the number of electronic devices is less than the total number of impulses to be received it is desirable or even necessary to arrange such devices in a closed chain so that when the last device in the chain responds to an impulse, the first device responds to the next impulse. For this purpose gas-filled tubes are used as the electronic devices, a received impulse causes one of the devices to be ionised and this ionisation prepares the next device to be ionised by the next impulse. In our British Specification No. 9421/43 we have described such an arrangement in which the ionisation of one tube caused the deionisation of the preceding tube so that when the last tube in the closed chain was ionised the first tube in the chain was already de-ionised and could again be ionised on the next impulse.

In using gas-filled tubes, however, there is a limit to the speed of impulses to which the arrangement will respond, which limit is set by the time required to cause the de-ionisation of a tube which time is of the order of milliseconds as compared with that required to ionise the tube which is of the order of tens of microseconds.

It is the object of the present invention to provide an arrangement for counting electric impulses using a closed chain of gas-filled electronic devices which is adapted to respond to a higher speed of impulses than heretofore.

According to the present invention we provide an arrangement for counting electric impulses comprising a chain of gas-filled electronic devices, means responsive to successive impulses

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for rendering successive devices conducting and means responsive to a predetermined device being rendered conducting for simultaneously rendering non-conducting a plurality of devices preceding said predetermined device.

The invention will be better understood from the following description taken in conjunction with the accompanying drawing which shows an embodiment of the invention adapted to count and register up to one thousand impulses.

Referring to the drawing, there is shown a circuit for counting up to one thousand impulses, which may be received in one second. Thus, in order to send a numerical designation to the circuit shown, a number of impulses equal to the designation required is sent and as this number is received in at least one second, the sending can take less time than if the separate thousand tens and units digits are sent at the usual impinging speed of ten impulses per second.

The circuit shown receives a number of cycles of alternating current equal to the number of impulses required. A pulse is produced from each positive half cycle and applied to the counting device. This counting device comprises two series of gas-filled tubes and a series of electromagnetic relays. The pulses are applied to the control electrodes of tubes  $V1 \dots V11$  in parallel, by way of respective condensers  $C4 \dots C14$  connected to the output resistor  $R46$  of a control valve  $MT1$ . One of these tubes,  $V2$ , is initially ionised and succeeding impulses ionise tubes  $V3 \dots V11$ . The tubes are divided into groups of three and four tubes and the third impulse, which ionises tube  $V5$ , de-ionises tubes  $V2 \dots V4$ . The tenth impulse ionises tubes  $V1$  and  $V2$ , the ionisation of  $V2$  re-starting the cycle of operations whilst  $V1$  is an additional tube used for the purpose of applying, at each tenth received pulse, a pulse to the tubes  $V12 \dots V22$ ; these pulses, however, are effective only in the case of a tube "primed" by the ionization of a preceding tube in the series and will not, in themselves, suffice to ionize any tube of the series last referred to. The tubes  $V13 \dots V22$  are arranged in the same manner as the chain of tubes in British Specification No. 9421/43, tube  $V13$  being initially ionised and succeeding pulses applied to the chain causing a succeeding tube to ionise and the immediately preceding tube to de-ionise. This is possible because pulses are applied to this chain of tubes at only one tenth of the speed at which pulses are received.

When tube  $V22$  has ionised, a succeeding pulse applied to tubes  $V12 \dots V22$  causes the

ionisation of tubes V12 and V13, the ionisation of tube V13 re-starting the chain and the ionization of tube V12 causing the operation of a relay IP. The operation of relay IP causes an impulse to be applied to a relay of the chain of electromagnetic relays A . . . K whose energizing circuit is prepared by the operation of a preceding relay, relay A being initially operated and successive operations of relay IP causing the operation of relays E . . . K and the de-energisation of the already operated relay.

On the conclusion of impulsing therefore, the operated relay of the relays A . . . K denotes the hundreds digit, the ionised tube of the tubes V13 . . . V22 the tens digit and the last ionised tube of the tubes V2 . . . V11 the units digit.

The circuit is prepared for operation by momentary actuation of a priming key which closes contacts PK1, PK2 and PK3. Contacts PK3 cause the operation of relay A which locks over its lowest winding, front contacts a2 and bank contacts b3. Contacts PK2 connect the control electrode of tube V13 to a source of 130 volts positive and this causes the tube to ionise. Contacts PK1 similarly cause tube V2 to ionise. Contacts SK of a start key are then actuated which connect the incoming line to the primary of a transformer T1, the secondary of which is connected in series with a resistance R19 of two megohms in the grid circuit of a thermionic amplifier VT1, having a condenser C1 of 0.0001 microfarad and resistance R32 of 100,000 ohms in series in its output circuit. The voltage across resistance R32 is applied through resistance R33 to the grid of a mercury vapour thermionic valve MT1. Under normal conditions the grid of valve MT1 is biased negatively with respect to the cathode due to the application of a positive potential to the cathode and the valve is not ionised but on each positive cycle from the output of amplifier VT1, the valve MT1 ionises and condenser C2, of 0.003 microfarad capacity, discharges through the valve and a resistance R34 of 100 ohms. This causes the potential across resistance R46, of 50,000 ohms, in the grid cathode circuit of valve MT1 to rise suddenly to between 40 and 50 volts. The condenser C2 having discharged below the sustaining voltage of valve MT1, that valve de-ionises and condenser C2 commences to charge, gradually decreasing the voltage across R46. Thus, there are produced across resistance R46 voltage pulses having a very steep wave front and slow decay.

These impulses are fed through individual condensers C4 . . . C14, of 0.0003 microfarad, to the control electrodes of tubes V1 . . . V11. With tube V2 ionised the voltage across resistance R36 of 150,000 ohms, connected between its cathode and ground, is within approximately 10 volts of the voltage which, when applied to the control electrode of tube V3, will ionise that tube. The first pulse causes the voltage across the control gap of tube V3 to be increased from the original 40 to 50 volts across resistance R36 to 80 to 100 volts and this ionises the control gap and hence the main gap.

When tube V3 ionises the voltage across resistance R37 connected to its cathode is raised to within 10 volts of the ionisation voltage of the control gap of tube V4 across which it is applied but this voltage across the control gap does not rise to this voltage immediately, due to the time constant of resistance R23, of 1

megohm, and condenser C7 which also determine the rate at which the voltage across the control gap due to the applied pulse rises. Thus the voltage across the control gap of tube V4 does not rise sufficiently high to ionise the tube during this first pulse.

On the second pulse, however, tube V4 ionises and this process goes on from tube to tube on succeeding pulses, the resistances R58 . . . R45 performing the same function as resistance R37 and being of the same value, and resistances R24 . . . R31 performing the same function as resistance R23 and being of the same value.

On the ionisation of tube V5 on the third pulse the voltage across resistance R39 is fed not only to the control gap of tube V6 but also to the grid of a thermionic amplifier valve VT2, which is normally biased with respect to its cathode due to the application of a positive potential to the cathode from the source designated by the legend + 24V. The grid of VT2 becomes positive with respect to the cathode and current flows through resistance R1 in the anode circuit of VT2, which resistance is also common to the main gap circuit of tubes V1 . . . V4. The voltage across this resistance decreases the voltage across the main gap of tubes V1 . . . V4 to below their sustaining voltages and tubes V1 . . . V4 start to de-ionise.

Tubes V6 to V9 operate in a similar manner to tubes V2 . . . V5 and on the operation of tube V9 the voltage across resistance R43 is applied to the grid of the thermionic valve VT3 which passes current and the voltage drop across resistance R2 decreases the voltage across the main gaps of tubes V5 . . . V8 which start to de-ionise. The voltage across resistance R39 in the cathode circuit of tube V5 drops to zero and restores negative bias to the grid of the valve VT2. During this time tubes V1 . . . V4 have completely de-ionised so that when the valve VT2 fails to conduct current and the voltage across the main gaps of the tubes V1 . . . V4 rises to its original value of 130 volts these tubes do not re-ionise until the proper sequence of events again recurs.

Tubes V10 and V11 ionise in succession similarly to previous tubes and on the ionisation of tube V11 the voltage across resistance R45 is impressed across the control gap of tube V2 through resistance R31 and across the control gap of tube V1 through resistance R35, and on the next pulse both tubes V1 and V2 ionise. Tube V2 completes the counting chain and biases the grid of thermionic valve VT4 positively to cause this valve to pass current and the consequent drop of potential across resistance R3 to lower the main gap potential of tubes V9, V10 and V11 and thus commence the de-ionisation of those tubes.

On the ionisation of tube V1 the potential across resistance R29 is raised to between 40 and 50 volts. This voltage decreases as the condenser C3 charges until it reaches about 5 volts. This steep fronted voltage pulse is fed through condensers C13 . . . C28 to the control gaps of tubes V12 . . . V22 so for every complete cycle of the primary train a pulse is fed to the secondary train, i. e. in the circuit shown for every tenth cycle of received alternating current.

Since tube V13 is already ionised, on the first pulse applied to tubes V12 . . . V22, tube V14 is ionised and the voltage on the main gap side

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of resistance R47, common to the main gap circuits of all these tubes, is dropped to about 70 volts positive. The voltage on the control gap side of resistance R53 connected to the cathode of tube V13 and the control electrode of tube V14 remains at about 50 volts positive, so that the voltage across the main gap of tube V13 is of the order of 20 volts, insufficient to keep that tube ionised. Tube V13 will therefore de-ionise leaving tube V14 ionised. As condenser C31 becomes charged the voltage across R59 increases up to within 10 volts of the control gap ionisation voltage of tube V15 so that on receipt of the next pulse tube V15 is ionised and in its turn de-ionises tube V14. This operation is continuous throughout the chain until tube V22 ionises.

When tube V22 ionises the voltage across resistance R57 is fed to the control gaps of both tubes V12 and V13 and on receipt of the next pulse both tubes ionise. The ionisation of tube V13 causes the de-ionisation of tube V22 and again starts the operation of the chain. The tube V12 ionises because positive potential of 130 volts is applied over resistance R39, back contacts k4, h4, f4, d4, b4 and front contacts a4 to its main gap. Relay IP operates and closes a circuit from ground, front contacts ip1, front a1, upper winding relay A, middle winding relay B, battery. Relay B operates and at contacts b2 closes a locking circuit for itself over its lower winding and contacts c3 back. At contacts b3 it breaks the locking circuit for relay A, and at contacts b4 it opens a circuit whereby electrical connection is effected at predetermined times between a source of high potential (indicated by the legend + 130V near resistor R69 in the drawing) and the anode of tube V12. Tube V12 begins to de-ionise and relay IP releases slowly due to the condenser C29 in shunt thereto. When relay IP has released, the circuit of relay A is broken at contacts ip1 and relay A releasing re-completes the main gap circuit of tube V12 at contacts a4. Tube V12 is now de-ionised and does not re-ionise until the second counting train has performed another complete cycle.

On the next operation of relay IP, relay C operates over contact ip1 front, a1 back, b1 front. Relay C operating breaks the locking circuit of relay B at contacts c3 and breaks the main gap circuit of tube V12 at contacts c4. Relay IP releases, releasing relay B at contacts ip1. On the following operations of relay IP, relays D . . . K operate in the same way.

If the received alternating current ceases, or the key SK be restored, certain tubes in the first and second counting chains will be left ionised and one relay in the relay counting train will be left operated. The number of cycles of alternating current that have been received will therefore be given by the position of the relay left operated and the tubes left ionised, the position of the relay giving the hundreds digit, the last tube left ionised in the second counting chain the tens digit and the last tube left ionised in the first counting chain the units digit. The contacts a3 . . . k3 may be connected to terminals to which lamps may be connected for visually indicating the hundreds digit, whilst the tubes V13 . . . V22 and V2 . . . V11 may be arranged behind translucent apertures on which digits are marked so that the glow within tubes that are ionised will show numbers to indicate the tens and units digits.

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In the example given the smallest number of tubes in the first counting chain in a group of tubes that are simultaneously de-ionised is 3. If the de-ionisation time of a tube in a closed counting chain of tubes is  $x$  milliseconds, then, in an arrangement in which the ionisation of one tube causes the de-ionisation of the preceding tube, the period between the ionisation of two successive tubes in the train must be at least  $x$  milliseconds and thus the maximum frequency that can be counted is

$$\frac{1000}{x}$$

pulses per second. In the circuit shown the period between the ionisation of two successive tubes can be

$$\frac{x}{3}$$

milliseconds and thus the frequency which the circuit can count is given by

$$\frac{1000}{x/3} \text{ i. e. } \frac{3000}{x}$$

pulses per second. The circuit shown has been shown in practice to be capable of counting up to 1200 pulses per second when using tubes having a neon filling. It is clear that the speed can be increased by using a greater number of tubes in a group to be simultaneously de-ionised.

It is also clear that the arrangement shown is not limited to counting impulses on a decimal basis and thus the number of tubes in each counting chain can be different from that shown.

The arrangement described above may be used to indicate the frequency of an electric oscillator by counting the number of cycles of oscillations received therefrom in a given time. The arrangement described may also be used in a number of industrial applications to count the number of articles being fed to a receiving device by causing the feeding of each article to generate an impulse and by arranging that a relay or relays operated when the required number of impulses have been received shall give an indication or operate a control mechanism.

In the following claims it is indicated that the apparatus disclosed herein is adapted to translate a received series of impulses into a representation of their number such as a representation of a multi-digit number. In telecommunication system such as those using dial impulsing, it is obvious that a number of impulses may represent a digit or may equally represent a letter. Therefore the term multi-digit number as used in the claims is intended to refer to any of a number of useful forms into which the number of impulses may be translated according to telecommunication usage.

What is claimed is:

1. A circuit arrangement for counting rapidly occurring impulses, comprising a chain of gaseous discharge tubes each having a pair of main electrodes and a control electrode, an energizing circuit for each tube connected across the said main electrodes thereof, a source of impulses connected to all of said control electrodes in parallel, an output impedance in each of said energizing circuits, means including said output impedance of any of said tubes for rendering the next following tube in the chain responsive to said impulses, whereby said next following

tube will be ionized, said tubes being divided into a plurality of groups each consisting of a plurality of tubes immediately following one another, a plurality of deenergizing means each common to all the tubes of a respective group, and control means for rendering said deenergizing means effective to quench all the tubes of said respective group upon ionization of a predetermined tube of another group of said chain.

2. A circuit arrangement according to claim 1, wherein said chain is a closed chain, comprising a second chain of gaseous discharge tubes each having a pair of main electrodes and a control electrode, an energizing circuit for each tube of said second chain connected across the said main electrodes thereof, an output impedance in each of the last-mentioned energizing circuit, circuit means connecting all of the last-mentioned control electrodes to a single one of the first-mentioned tubes in parallel, whereby a pulse will be applied to each of said last-mentioned tubes upon ionization of said single tube, and means including the output impedance of any of said last-mentioned tubes for rendering the next following tube of said second chain responsive to said pulses, whereby the same will be ionized.

3. A circuit arrangement according to claim 2, wherein said second chain is a closed chain, further comprising circuit means for quenching each tube of said second chain upon ionization of the tube immediately following.

4. A circuit arrangement according to claim 3, further comprising a chain of additional counting elements each arranged to prepare an energizing circuit for the element immediately succeeding, and circuit means including a certain tube of said second chain for applying a control pulse adapted to energize any of said elements to the energizing circuit thus prepared whenever said certain tube is ionized.

5. A circuit arrangement according to claim 4, wherein each of said additional counting elements comprises an electromagnetic relay.

6. In a device for counting rapidly occurring impulses, in combination, a plurality of closed chains of gaseous discharge tubes each having at least three electrodes including a control electrode, input means for applying an impulse to the control electrodes of all the tubes of one of said chains in parallel, a certain tube of said

one chain being arranged when ionized to apply an impulse to the control electrodes of all the tubes of the other of said chains in parallel, each of said tubes being connected to the tube next following in the chain in such manner as to render, upon its ionization, said tube next following responsive to the impulses applied to the respective chain, whereby said tube next following will be ionized, and respective deenergizing means for each chain adapted to effect the ionization of a tube when another tube of the same chain is ionized, at least the tubes of said one chain being divided into groups each consisting of a plurality of tubes immediately following one another, at least the deenergizing means of said one chain including a plurality of control devices each common to all the tubes of a respective group and adapted to effect the de-ionization of all the tubes of said group upon ionization of a first tube of the group immediately following.

7. The combination according to claim 6, wherein each of said control devices comprises a vacuum tube having an input circuit connected in parallel to said first tube of said group immediately following.

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