

Sept. 4, 1945.

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2,384,379

ELECTRICAL IMPULSE COUNTING CIRCUIT

Filed March 13, 1943

FIG. 1

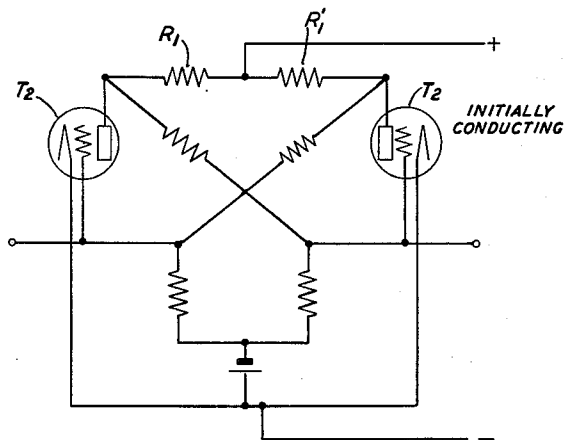
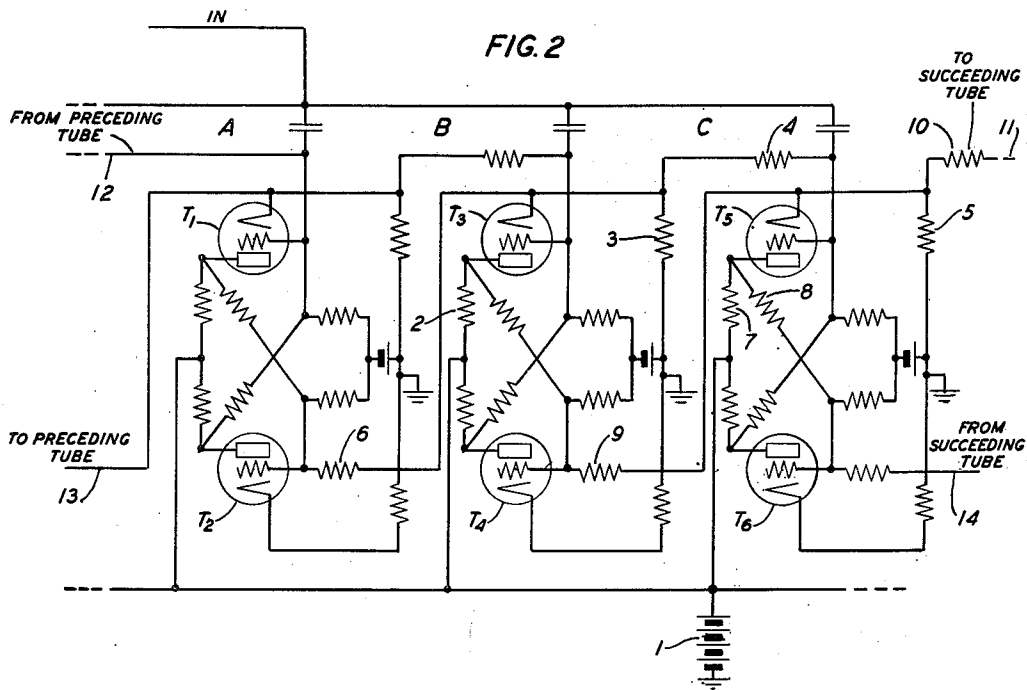


FIG. 2



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2,384,379

ELECTRICAL IMPULSE COUNTING CIRCUITS

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Application March 13, 1943, Serial No. 479,139

3 Claims. (Cl. 250-27)

This invention relates to automatic counting of electrical impulses by means of thermionic vacuum tubes and more particularly to the interconnection of pairs of vacuum tubes in a chain whereby the first of a plurality of successive impulses of electrical potential, which it is desired to count, causes a first tube of one pair to conduct full plate current thereby raising, above "cut-off," the grid potential of the second tube of the preceding pair thus rendering its mate non-conducting and priming the first tube of the succeeding pair in readiness to conduct upon receipt of the next impulse.

Circuits employing gas-filled discharge devices for counting rapidly recurring electrical impulses are well known in the art as, for example, the Thyratron counting circuits described by C. E. Wynn-Williams in the Proceedings of the Royal Society (British) Series A, volume 132 (1931), page 295 et seq. which counting circuits comprise a chain of three-electrode gas-filled devices which successively fire in response to recurring impulses, but, in general, such counting circuits require, as active elements, ionic devices having a trigger action, that is, devices in which conduction between the anode and cathode is initiated by an increase in potential of a control electrode but which conduction will not be affected when the control potential is decreased or completely removed.

Thermionic vacuum tubes have not in the past been used in counting circuits of the Wynn-Williams type because they do not possess such trigger action but in the present invention such trigger action is obtained by an elementary circuit employing a pair of vacuum tubes which trigger action is the property of the arrangement of the circuit and not of the tubes per se. Such elementary circuits may be the well-known Eccles-Jordan arrangement, as shown in British Patent 148,582 and also described in the Radio Review (1919) volume 1, page 143 et seq. which circuit has two stable conditions of operation, i. e., when one tube is conducting the drop in its plate circuit resistance causes a negative bias to be applied to the grid of its mate thus maintaining it in a non-conducting condition which may be referred to as the first stable condition but when a potential is applied to this latter tube sufficient to raise its grid potential above its critical or so-called "cut-off" point the other stable condition results, that is, the non-conducting tube now conducts which causes the grid of the first tube, which was originally conducting, to become sufficiently negative to decrease its plate current which, in turn, decreases the negative potential on the grid of its mate, which action transfers back and forth between the two tubes and finally results in minimum conduction in the first or originally conducting tube and maximum conduction in its mate. Such an arrangement of

two vacuum tubes constitutes a trigger circuit in that a conducting tube of the pair can be rendered non-conducting by applying such an independent potential to the grid of its non-conducting mate as to cause it to conduct thereby changing the circuit from one stable condition to the other.

A feature of the invention resides in so connecting a plurality of vacuum tube trigger circuits that they will operate similarly to counting chains of the prior art employing gas-filled devices which in themselves possess trigger properties.

The invention will be understood from the following description when read in connection with the accompanying drawing, Fig. 1 of which shows a basic trigger circuit of the Eccles-Jordan type, and Fig. 2 shows the combination of a plurality of these circuits in a counting chain.

In describing the arrangement of the present invention, a brief description will first be given of the operation of the trigger circuit of Fig. 1, as more fully described in the before-mentioned British Patent 148,582. This figure (1) shows two vacuum tubes T_1 and T_2 connected in such a manner that the arrangement has two stable conditions of operation, i. e., when one tube (for example T_2) is conducting, the potential drop in its plate circuit resistance R_1 causes a negative bias to be applied to the grid of its mate (T_1) thus holding that tube non-conducting. When a positive voltage from the outside is applied to the grid of T_1 , which is sufficient to raise its potential above "cut-off," the arrangement assumes the other stable condition, i. e., T_1 conducting and T_2 non-conducting, due to the potential drop in resistance R_1 , which condition persists after the disappearance of the outside potential stimulus, applied to the grid of T_1 , until a later positive potential from the outside is applied to the grid of T_2 whereupon the foregoing operation is repeated in reverse, i. e. T_2 again becomes conducting and T_1 becomes non-conducting. It will thus be obvious that trigger action is obtained from such an arrangement of two vacuum tubes similar to that of a single gas tube, i. e., a positive impulse applied to the grid of tube T_1 , for example, causes that tube to conduct which remains conducting after the termination of the impulse.

A counting chain in accordance with the present invention is shown by Fig. 2 in which three trigger circuits A, B and C, each of the character of Fig. 1, are shown connected in such a manner that a change from one stable condition to another will successively occur in each circuit in response to successive positive impulses transmitted over an input circuit IN to the grid of one tube of each trigger circuit.

In describing the operation of the arrangement of Fig. 2 it will be understood that for proper operation, one tube of each trigger circuit

must initially be conducting while its mate is non-conducting and therefore for the present discussion it will be assumed that the last operation of the chain left tubes T_2 , T_3 and T_4 conducting and T_1 , T_4 and T_5 non-conducting.

Assuming as above that T_3 is initially conducting, plate current will flow from the positive pole of battery 1, low resistance 2, from anode to cathode of tube T_3 and through resistance 3 to the grounded negative terminal of the battery. The potential difference across resistance 3, due to this plate current, is applied between the grid and cathode of tube T_2 by a connection serially including resistance 4 and the value of resistance 3 will be so chosen that the drop thereacross due to full plate current in tube T_3 will apply a positive potential to the grid of tube T_2 sufficient to raise it to a value just short of its critical or "cut-off" point.

A connection including resistance 5 also applies this same potential difference (across resistance 3) between the grid and cathode of tube T_2 , which at the time T_3 fired was non-conducting. This potential difference, which is insufficient to raise the grid potential of T_2 to cut-off, is, in the case of T_2 , sufficient to raise its grid potential to such a value that the tube will conduct. This difference in the cut-off potential characteristics between tubes T_1 , T_3 and T_5 and tubes T_2 , T_4 and T_6 is one of the requirements of the system and is provided for by proper adjustment of the circuit elements.

Raising the grid potential of the tube T_2 to cut-off causes that tube to conduct which is effective to stop T_1 .

When the first of a succession of positive impulses is applied to the input circuit IN, the grids of tubes T_1 , T_3 and T_5 , which are connected in parallel thereto, are raised in potential and therefore tube T_5 , whose grid is just short of "cut-off," as before mentioned due to the potential difference across resistance 3, fires and starts to conduct plate current in a circuit including resistances 5 and 7. The potential drop in resistance 7 due to the plate current of tube T_5 reduces the potential on the grid of tube T_4 thereby rendering this tube non-conducting. Tube T_5 now being conducting, the potential difference across resistance 5 connected in its plate circuit is now effective to raise the grid potential of tube T_4 to "cut-off," in a circuit including resistance 9, thus causing that tube to conduct which in turn reduces the potential on the grid of tube T_3 , thus rendering it non-conducting. The potential difference across resistance 5 is also applied to the grid of the next tube in line with T_5 (not shown) which primes this tube in readiness to conduct on the next positive pulse, as previously explained in connection with tube T_5 .

It will be noted that at the end of the first pulse T_2 remains in a conducting condition with its mate T_1 non-conducting, T_4 is conducting, T_3 non-conducting. T_5 is conducting, T_6 is non-conducting and the tube in line with T_5 of the trigger circuit following C (not shown) is primed, i. e., its grid is just short of "cut-off" in readiness to cause that tube to conduct in response to the next impulse.

It will be understood that in case a counting ring is desired of the type described on page 301, et seq. by Wynn-Williams in the paper previously referred to, any number of trigger circuits, connected in a chain and functioning in the manner herein described, can be connected in a closed ring by coupling the first and last trigger circuit

together, i. e., in the case of Fig. 2 by connecting conductor 11 to the grid of tube T_1 over conductor 12 and connecting conductor 13 to the grid of tube T_6 over conductor 14.

As is well known the plate current of any desired tube in the chain can be employed to control any desired counting or recording arrangement.

What is claimed is:

1. In an impulse counting arrangement comprising a chain of vacuum tube pairs, each tube having an anode, a cathode and a control grid, and so connected and arranged within the respective pairs that a potential applied to the grid of either tube, which raises it above cut-off, causes a decrease in current in the anode-cathode circuit of the other tube, characterized by circuit means interconnecting the anode-cathode circuit of the first tube of each pair and the grid of the first tube of the next pair so adjusted that a predetermined current in any one of said anode-cathode circuits will raise the potential of the grid of the succeeding first tube to a potential just short of cut-off, and other circuit means interconnecting said anode-cathode circuit of each first tube and the grid of the companion to the preceding first tube so adjusted that an anode-cathode current in any first tube which increases the grid potential of the succeeding first tube to a point just short of cut-off will increase the potential of the grid of the companion to said preceding first tube to cut-off, and means for simultaneously applying the impulses to be counted to all the first tube grids to raise only the grid near cut-off to that point.

2. In an impulse counting arrangement comprising a chain of vacuum tube pairs, each tube having an anode, a cathode and a control grid and so connected and arranged within the respective pairs that a potential applied to the grid of either tube which raises it above cut-off causes a decrease in current in the anode-cathode circuit of the other tube characterized by circuit means interconnecting the anode-cathode circuit of the first tube of each pair with the grid of the first tube of the succeeding pair and with the grid of the companion to the preceding first tube so adjusted that a predetermined current in any one of said anode-cathode circuits will raise the grid potential of the succeeding first tube to a point just short of cut-off and raise the grid of the companion to the preceding first tube to its cut-off potential, and means for simultaneously applying the impulses to be counted to all the first tube grids to raise the grid which is near cut-off, only, to that point.

3. In an impulse counting arrangement comprising a sequential plurality of vacuum tube trigger circuits connected in a closed ring, each trigger circuit employing a pair of thermionic vacuum tubes arranged in such a manner that an increase in plate current in one tube of a pair will drive the potential of the grid of its companion tube below cut-off thereby decreasing the plate current therein, means for simultaneously applying the pulses to be counted to the first tube grid of all trigger circuit pairs, means responsive to a predetermined current flowing in the anode-cathode circuit of any first tube to apply a positive potential to the grid of the succeeding first tube to raise its potential just short of the critical potential thereof and to raise the potential of the grid of the companion of the preceding first tube to its critical potential value.

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