Jan. 27, 1953 A. J. MULLARKEY 2,626,751

GAS DISCHARGE TUBE COUNTING ARRANGEMENT

Filed June 4, 1949 3 Sheets-Sheet 1

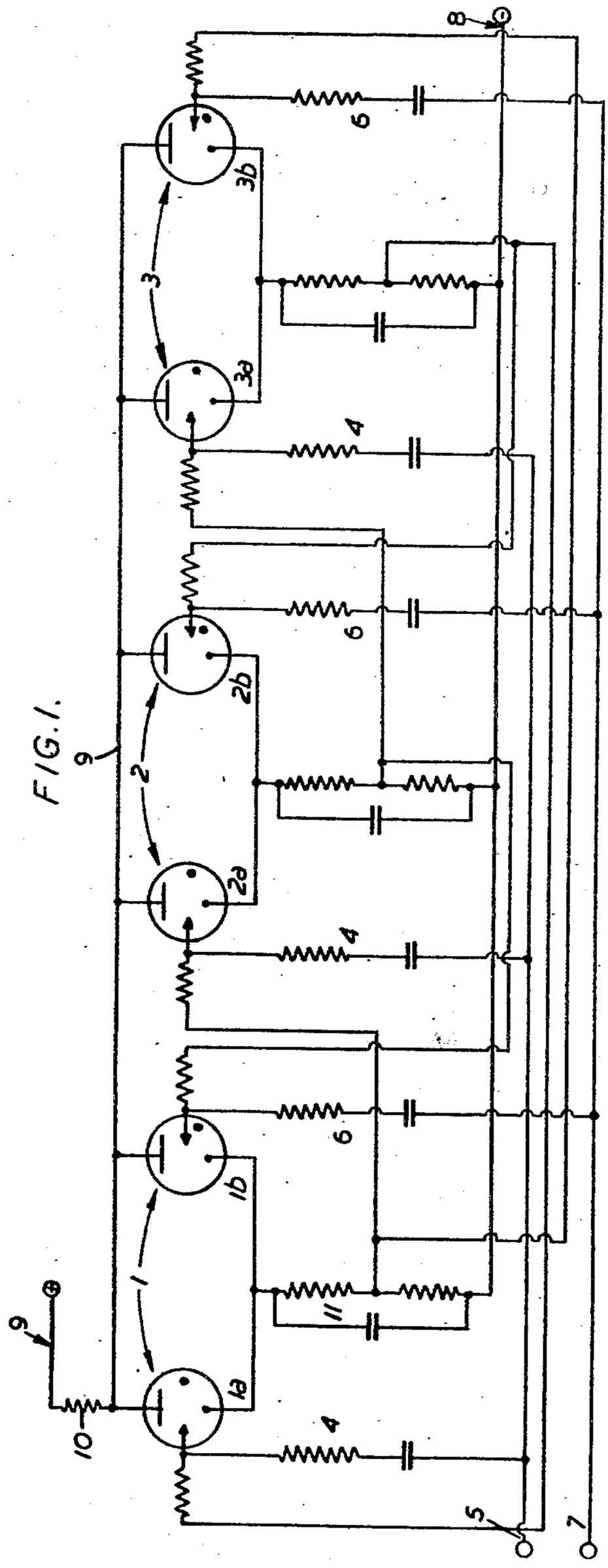

FIG. 1.

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Filed June 4, 1949 3 Sheets-Sheet 2

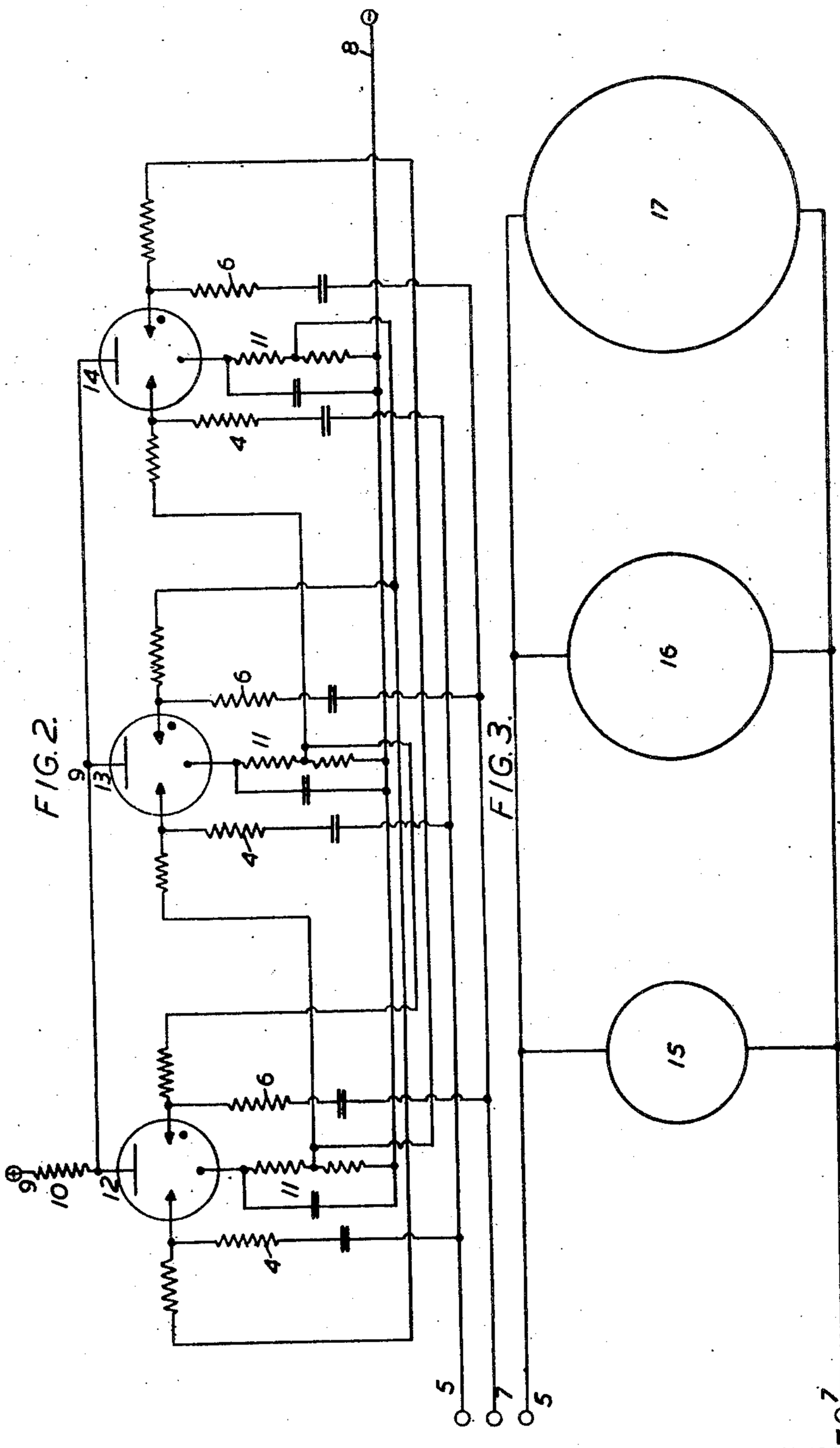

FIG. 2.

FIG. 3.

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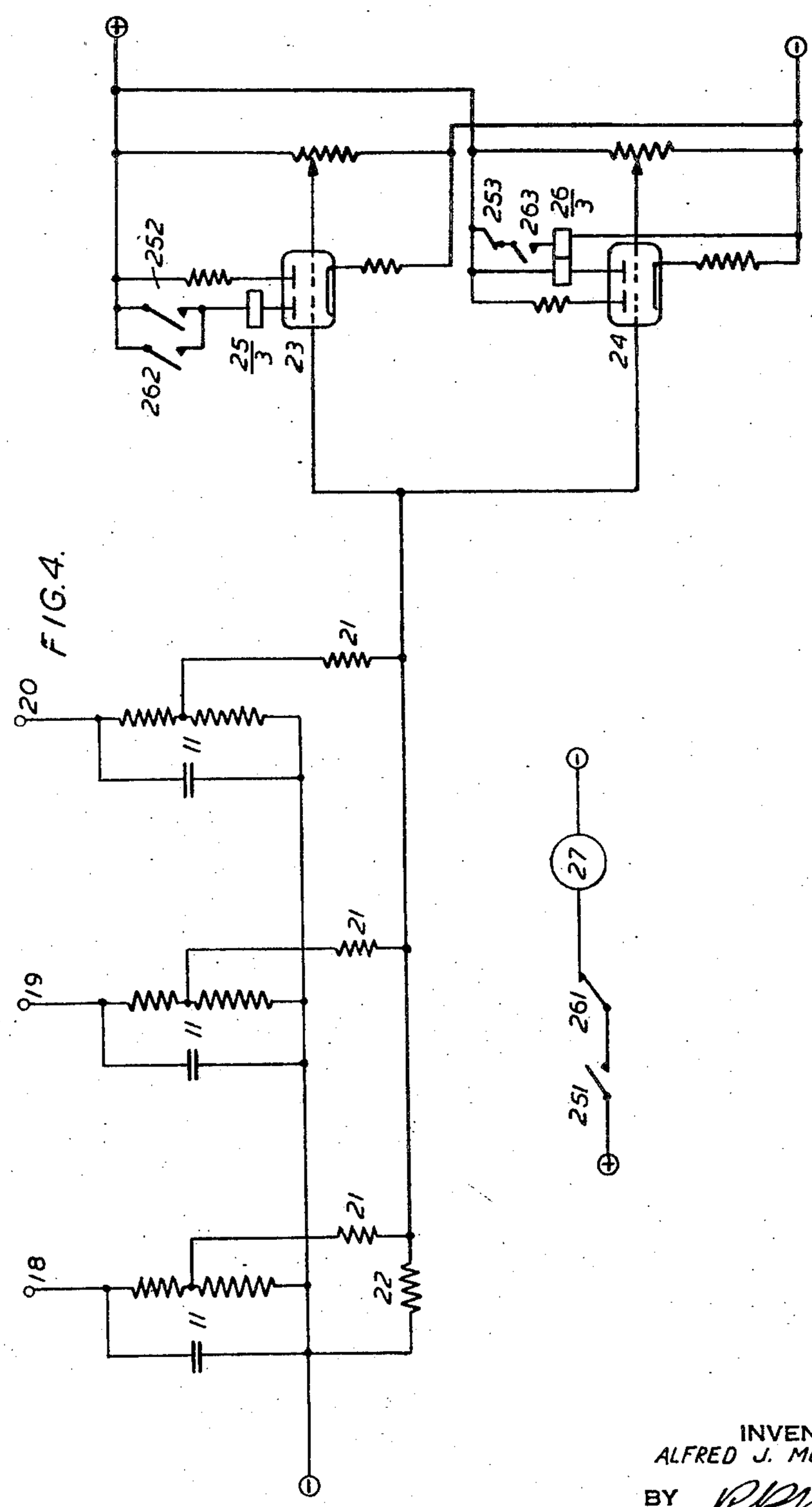

FIG. 4.

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UNITED STATES PATENT OFFICE

2,626,751

GAS DISCHARGE TUBE COUNTING ARRANGEMENT

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Application June 4, 1949, Serial No. 97,140
In Great Britain June 11, 1948

10 Claims. (Cl. 235—92)

1

The invention relates to gas discharge tube counting arrangements.

Electric tube counting rings are well known in the art and are widely used. The rings incorporate cold cathode gas discharge tubes, one example of such rings being found in British Patent No. 567,863 or may alternatively use thyratrons in the manner disclosed in the paper presented by C. Wynn-Williams to the Royal Society in 1931 (Proc. R. S. 1931 pages 295–309).

The object of the present invention is to provide improvements in gas discharge tube counting arrangements, especially by the provision of reversibility in the operation of the circuits.

One application of reversible counting arrangements is to railway axle counting equipment. Such equipment necessitates the employment of counting apparatus operable to receive signals initiated by axles passing in and out of a track section, signal transmitting means being situated at both ends of the section. The significance of the signals is of two kinds, i. e., "in" and "out," and the counter is required to "memorise" the difference between the total of each kind received so that when that difference disappears, i. e., when an equal number of axles have entered and left the section and it is therefore unoccupied, an indication or a transmission of an output signal recording the fact is needed.

The invention provides a gas-discharge tube chain circuit to which is applied pulses from two sources. Pulses from one source effect the firing of a succession of the tubes one at a time in one direction whilst pulses from the other cause the firing of a succession of tubes one at a time in the opposite direction. The chain of tubes is completed into ring formation so that endless sequential operation is obtainable. The tubes may either be arranged in pairs so that one particular tube of a pair fires when the order of firing is in one direction and the other when the order is opposite, or the tubes may be so constructed that the same succession of tubes is able to be used whatever the direction of the sequential firing. A plurality of tube counting rings as outlined above and having different numbers of tubes per ring can be interconnected as a differential counting device. In this case, pulses from the two sources are fed in common to all the rings and each operates as already described. One position in each ring having a single tube or a tube pair thereat is designated the "home" position and an output may be taken from there whenever that particular ring has reached the stage of having a tube at that position fired as a result of sequential operation of tubes. Simultaneous output pulses from all "home" positions are recorded and such a condition indicates that equal numbers of pulses have been received from both sources provided always that the pulses from one source do not exceed those from the other by a number equal to or greater than the product of the numbers of tubes, or tube pairs, in the various interconnected rings.

2

The invention will now be particularly described with reference to certain embodiments shown in the accompanying drawings in which—

Fig. 1 shows the circuit of a cold cathode gas discharge tube counted in which three electrode tubes are used whilst,

Fig. 2 is a schematic diagram of a similar counter which uses four electrode tubes, thus providing economy in the number of tubes.

Fig. 3 shows diagrammatically a differential counter for use with railway axle counting equipment which employs a number of different size ring counters each being of the kind shown in either Fig. 1 or Fig. 2.

Fig. 4 is a safeguard circuit desirable for use with the differential counter of Fig. 3.

Considering first the three-position ring counter shown in Fig. 1, it will be seen that at each of the positions 1, 2 and 3 there are two, three-electrode tubes lettered *a* and *b* respectively. The position 1 will be referred to as the "home" position. The grid electrodes of the *a* tubes are connected by series resistance-capacity circuits 4 to a common lead 5. The grid electrodes of the *b* tubes are connected by similar resistance-capacity circuits 6 to a common lead 7. The tubes at the same positions have their cathodes commoned, negative high voltage supply being provided to them over lead 8. The positive high voltage is led via lead 9 through a dropping resistance 10 to the anodes of all the tubes.

Turning to the operation of the ring circuit it is to be understood that one of the tubes at the position 1, say 1*a*, is initially in a discharging condition. Means for ensuring this are not shown on the drawing but are simple and well known. With 1*a* fired, a potential is applied to the grid of tube 2*a* via a centre-tap on the resistor of the cathode circuit 11 but this is insufficiently large to cause the tube 2*a* to strike. A positive pulse received over lead 5 however, will further raise the potential of the grid of tube 2*a* to a value sufficient to fire it and a discharge will commence. The current flowing through the common anode resistance 10 is increased and the potential across the tube 1*a* is therefore re-

duced. It falls to a value below the maintaining potential required for the tube and tube 1*a* extinguishes. The current through resistance 10 falling, the anode potential will rise. Due to the charge being maintained on the condenser of the network 11 of position 1, the priming voltage is retained at the grid of tube 2*a* so ensuring that the discharge which had commenced in that tube is prolonged. Further pulses on lead 5 effect the firing of the next *a* tube in each case, 3*a* firing off the first of such further pulses and 2*a* being extinguished. The position occupied by the discharging tube can be made to travel continually in a clockwise direction around the ring in response to continual pulses on lead 5, 1*a* following 3*a*, 2*a* following 1*a*, and so on.

The reversing feature is now to be considered. Assume that clockwise counting has resulted in tube 3*a* being fired. From tube 3*a*, a potential is applied to the grids of tubes 1*a* and 2*b*. If now, instead of the next pulse being applied to lead 5 it is applied to lead 7, tube 2*b* will be struck instead of 1*a*. Further pulses on lead 7 result in anti-clockwise operation of the counting ring on the *b* tubes.

It is clear that the above description while referring in detail to a three-position ring counter, could apply to counters of this type having any number of positions. The circuit may be arranged to give an indication or transmit a signal whenever a "home" position tube is discharging. In applications wherein a small number of signals only are received from two sources, such a reversible ring counter is able to determine e. g., whenever an equal number of signals has been received from both sources.

A circuit giving corresponding results but with less equipment is shown in Fig. 2, use being made there of four-electrode cold cathode gas discharge tubes in order to provide the desired economy. Once more, by way of example only, a three-position ring counter is to be considered, but in this case we have one tube per position and not two, as before. Three tubes 12, 13 and 14 are shown and it will be seen that parts of the circuit in this figure which correspond directly in their function to parts in Fig. 1 have been similarly numbered. Considering that tube 12 is the "home" position tube and that at some instant tube 13 is fired with the other two extinguished the operation thereafter in the two cases when either the next received pulse is along lead 5 or lead 7 will be described.

Tube 13 being in a discharging condition, a potential will be applied to the left-hand grid electrode of tube 14 but this will be insufficient to cause striking. A pulse received now along lead 5 has no effect on tube 12 at all, tube 13 is already discharging and is therefore not affected but the continuation of the potential already on the left-hand grid of tube 14 and the received pulse causes tube 14 to strike. Tube 13 is thereupon extinguished.

It will be observed that the cathode connection to the left-hand electrode of tube 14 is also taken to the right-hand electrode of tube 12. The pulse being received over lead 7 would have been applied over the circuit 6 to cause tube 12 to strike, hence reversing the operation of the counting ring. This counting ring has similar possibilities of application to that described with reference to Fig. 1; performing the same function but economising in the number of cold cathode gas tubes employed.

One application of these reversible counting rings is to railway axle counting equipment as has been mentioned. The number of axles entering and leaving a track section as a train passes through it, is, of course, fairly large as a rule. The reversible counter principle is required but impracticable complication would normally result (certainly in long track sections) from using a counter according to Fig. 1 or Fig. 2 with a number of positions slightly larger than the greatest number of axles to be dealt with, i. e.—with the longest train.

To overcome this problem the invention provides for the employment of two or more rings in co-operation. This provision will be understood by the following description relating to Fig. 3.

The two leads 5 and 7 are taken to three ring counters 15, 16 and 17 (either of the three-electrode or four-electrode tube type or of another type to be mentioned later). In the example being considered, ring 15 has five positions, ring 16, seven positions and ring 17 nine positions. Assuming that the three rings all start from their respective home positions and that a chain circuit ensures that an indication is given by some means whenever all three rings are at their home positions. Such indication may be arranged to result in the "Track Unoccupied" condition being shown in the signal cabin. A train entering the section will result in pulse signals being received say along 5, each representative of the entry of one axle. Each ring counter will step from its home position and it will be obvious that if signals were only received on this lead all three rings would not reach their home positions simultaneously until $5\times7\times9=315$ axles had been counted. Such a number is considered to be perfectly adequate for normal railway working. If, in some special case, a larger number needed to be catered for, then rings with other numbers of positions could be used, e. g. $7\times9\times11=693$.

Apparatus immediately prior to this counter is incorporated in axle counting equipment to ensure that in-and-out counting pulses are not transmitted along leads 5 and 7 simultaneously. Such apparatus may be of the kind disclosed and claimed in my copending application filed April 29, 1949 and bearing Serial No. 90,315.

When the numbers of in-and-out-counting pulses are equal, i. e., when a train has passed into and out of a section, the three ring counters will all restore to their home positions and the signal cabin indicator which has been showing "Track Occupied" since the first in-counting pulse was received is also cleared.

To ensure Right Side Failure principles on the counter, which are fundamental requirements in railway signalling equipment, the following conditions must be fulfilled:

(1) To prove all three ring counters are, or are not, in the home position.

(2) To prove all three ring counters have left the home position before "Track Unoccupied" indication is again given, i. e., to prove that no ring has "stuck."

The safeguarding circuits are shown in Fig. 4 and it will be seen that the cathode voltage from every home position tube of the three ring counters indicated at 18, 19, 20 is brought out via a high resistance 21 to a common point which is taken to negative potential via a resistance 22. This forms a potential dividing network the total voltage being fed to the grids of tubes 23 and 24. Tube 23 is biased to such a value that relay 25 will operate only when all three ring counters are in the home position. The operation of relay 25 proves that the counters are in the home position.

It must be noticed that initially, relay **25** must be operated manually.

Tube **24** is biassed so that when all three ring counters have left the home position, relay **26** will operate.

On receipt of the first in-counting pulse, all three ring counters step off from the home position, which causes the release of relay **25** and the operation of relay **26**. Contacts of both relays **25** and **26** will be opened and the indicator **27** gives the "Track Occupied" condition. The "Track Occupied" indication can only be given when relay **25** has re-operated and this can only happen when relay **26** has released, which proves that all ring counters have moved away from the home position and have returned to the home position.

It will be noticed that relay **26** is held operated over contacts **253, 263**. This prevents the relay from releasing every time one home position is reached. The release of relay **26** will only take place when relay **25** operates.

Although the use of cold cathode gas discharge tubes is preferred the invention is not limited to the employment of such tubes only. In addition the differential counter described above which incorporates two or more ring counting chains may have each of such chains in the form of single tubes e. g., as disclosed and claimed in the copending application of D. S. Ridler, filed June 10, 1949 bearing Serial No. 100,462.

What is claimed is:

1. An electronic ring for differentially counting electric pulses received from two sources comprising a train of electronic tubes, each tube having an anode, a cathode and a control electrode, circuit means to allow the conductive operation of any one of the tubes, said means common to said anodes, means coupled to said cathodes and certain of said control electrodes to fire successively tubes in a given direction along the said train form the said first operating tube on receipt of pulses from one source, means coupled to said cathodes and other of said control electrodes to fire successively tubes in the reverse direction along the said train on receipt of pulses from the other source, said circuit means extinguishing the preceding operating tube when a subsequent tube is fired, and means to interconnect the tubes at each end of the train to allow successive tube firings to proceed repetitively around the train in either direction.

2. A device for counting electric pulses according to claim 1 wherein the said circuit means to allow the operation of any one of the tubes and to extinguish the preceding operating tube when a subsequent tube is fired comprises a resistor common to the anodes of the tubes in the said train.

3. A device for differentially counting electric pulses received from two sources comprising a plurality of counting rings, each ring having a sequence of a different number of tubes, each tube having an anode, a cathode a first and a second control electrode, circuit means to allow the conductive operation of any one of the said tubes in each ring, said means common to the anodes of the tubes in each ring, means coupled to the cathodes of the tubes in each ring to condition the first electrode of a tube contiguous on one side of a conducting tube and the second electrode of a tube contiguous on the reverse side of said conducting tube, to fire upon receipt of an electric pulse at the said conditioned electrodes, means to apply the pulses received from

one of the sources to the first electrodes of the tubes in each ring simultaneously, means to apply the pulses received from the other source to the second electrodes of the tubes in each ring simultaneously, said circuit means extinguishing the operation of the preceding tube upon the subsequent firing of a conditioned tube in each ring, and indicating means coupled to the conditioning means of a particular tube of each of said rings, operable only when each of said particular tubes have fired simultaneously, whereby the pulses received from one source will successively fire the tubes along the train in a given direction around each ring and the pulses received from a second source successively fire the tubes along the reverse direction.

4. A device for counting electric pulses received from a first source of pulses and for counting in a reverse direction electric pulses received from a second source of pulses comprising a counting train of electronic tubes arranged in pairs, each of said tubes having an anode, a cathode and a control electrode, each of said tube pairs having a first and a second tube which together constitute a single counting position of said train, circuit means to allow the conductive operation of any one of the tubes, said means common to said anodes, means coupled to the cathodes of each pair of tubes to condition the first tube of the tube pair contiguous on one side of a conducting tube and the second tube in the tube pair contiguous on the reverse side of said conducting tube to fire on receipt of an electric pulse upon the control electrode at the respective tubes, means to apply the pulses received from one of the said sources to the control electrodes of each of the first tubes of each tube pair, means to apply the pulses received from the other of said sources to the control electrodes of each of the second tubes of each tube pair, said circuit means extinguishing the operation of a preceding tube upon the subsequent firing of a conditioned tube, whereby received pulses from one of the sources will sequentially fire the first tubes of each pair in a given direction along the train from the said first operating tube and received pulses from the other source will sequentially fire the second tubes of each pair in the reverse direction.

5. A device for counting electric pulses according to claim 4, wherein said means to condition for firing the first tube of the next tube pair contiguous on one side of a conducting tube and the second tube of the next tube pair contiguous on the reverse side of said conducting tube comprises, a resistance in the cathode circuit of each tube pair and connections from the cathode circuit of each tube pair to the control electrode of the first tube of the contiguous tube pair on one side and to the control electrode of the second tube of the contiguous tube pair on the reverse side.

6. A device for counting electric pulses received from a first source of pulses and for counting in a reverse direction electric pulses received from a second source of pulses comprising a train of gas discharge tubes, each tube having a cathode, an anode, a first and second control electrode, circuit means to allow the conductive operation of any one of said tubes, said means common to said anodes, means coupled to the cathodes of each of said tubes to condition for firing the first control electrode of a tube contiguous to one side of a conducting tube and the second control electrode of the tube contiguous to the reverse side of said conducting tube, said means

operable upon receipt of electric pulses at the said conditioned control electrode, means to apply the pulses received from one of the sources to the first control electrodes of the tubes in the train, means to apply the pulses received from the other source to the second control electrodes of the tubes in the train, said circuit means extinguishing the operation of the preceding tube upon the subsequent firing of a conditioned tube, whereby the pulses received from the first source successively fire the tubes along the train in a given direction from the said first conducting tube and the pulses received from a second source successively fire the tubes along the reverse direction.

7. A device for counting electric pulses according to claim 6, wherein said circuit means to allow the conductive operation of any one of said tubes and to extinguish the operation of a preceding tube upon the subsequent firing of a conditioned tube comprises a resistor common to the anodes of the tubes in the said train, and wherein the said means to condition the first control electrodes of the tube contiguous to said conducting tube on one side and the second control electrode of the tube contiguous to said conducting tube on the reverse side comprises a separate resistor in the cathode circuit of each of the tubes in the train and connections from the positive side of each resistor to the first control electrode of the tube contiguous to said conducting tube on one side and to the second control electrode of the tube contiguous to said conducting tube on the reverse side.

8. A device for counting electric pulses received from a first source of pulses and for counting in a reverse direction electric pulses received from a second source of pulses comprising a plurality of counting trains of electronic tubes, each tube having an anode, a cathode and a control electrode, each train having circuit means to allow the operation of any one of the tubes in the train, said means common to the anodes of the tubes of said train, means coupled to said cathodes and certain of said control electrodes to fire successively tubes in a given direction along the said train from the said operating tube upon the simultaneous receipt by said certain control electrodes of pulses from said first source, means coupled to said cathode and other of said control electrodes to fire successively tubes in the reverse direction along the said train upon the simultaneous receipt by said other control electrodes of pulses from said second source, said circuit means extinguishing the preceding operating tube when a subsequent tube is fired, means to interconnect the tubes on each end of a train to allow successive tube firings to proceed repetitively around the train in either direction, each of said trains firing simultaneously along the same direction on the receipt of each pulse, said device having a different number of tubes in each of said counting trains.

9. A device for differentially counting electric pulses received from two sources comprising a plurality of counting rings, each ring having electronic tubes arranged in pairs of first and second tubes, each tube having an anode, a cathode and a control electrode, each tube pair constituting a single counting position of the said ring, circuit means to allow the conductive operation of any one of the tubes in each ring, said

means common to the anodes of each of the tubes comprising a ring, means coupled to the cathode of each tube pair in each ring to condition for firing the first tube of the tube pair contiguous on one side of a conducting tube and the second tube in the tube pair contiguous on the reverse side of said conducting tube upon the simultaneous receipt of an electric pulse upon the control electrode at the respective tubes, means to simultaneously apply the pulses received from one source to the control electrode of the first tubes of each pair in each ring simultaneously, means to simultaneously apply the pulses received from the other source to the control electrodes of the second tubes of each pair in each ring simultaneously, said circuit means extinguishing in each ring the operation of a preceding tube upon the subsequent firing of a conditioned tube, whereby received pulses from one of the sources will sequentially fire the first tube of each tube pair in a given direction along each ring and received pulses from the other source will sequentially fire the second tubes of each pair in the reverse direction around each ring, the said device having a different number of counting positions in each ring.

10. A device for counting electric pulses received from a first source of pulses and for counting in a reverse direction electric pulses received from a second source of pulses comprising a plurality of discharge paths arranged in a train, discharge control means associated with each of said paths, certain of said control means coupled to said first pulse source and other of said control means coupled to said second pulse source, single circuit means common to said discharge paths to allow conductive operation of but one of said discharge paths at a time, separate means coupling each of said discharge paths with the discharge control means associated with the discharge paths in said train adjacent each said discharge path, said circuit means common to said discharge paths adapted to extinguish the conductive operation of a preceding path upon the conductive operation of a conditioned path, whereby received pulses from said first source will cause sequential conductive operation of the discharge paths in said train in a given direction and received pulses from said second source will cause sequential conductive operation of the discharge paths in said train in the reverse direction.

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