March 24, 1942. W. H. BURGER ET AL 2,277,579

ELECTRONIC COUNTING DEVICES

Filed March 5, 1940 2 Sheets-Sheet 1

FIG. 1.

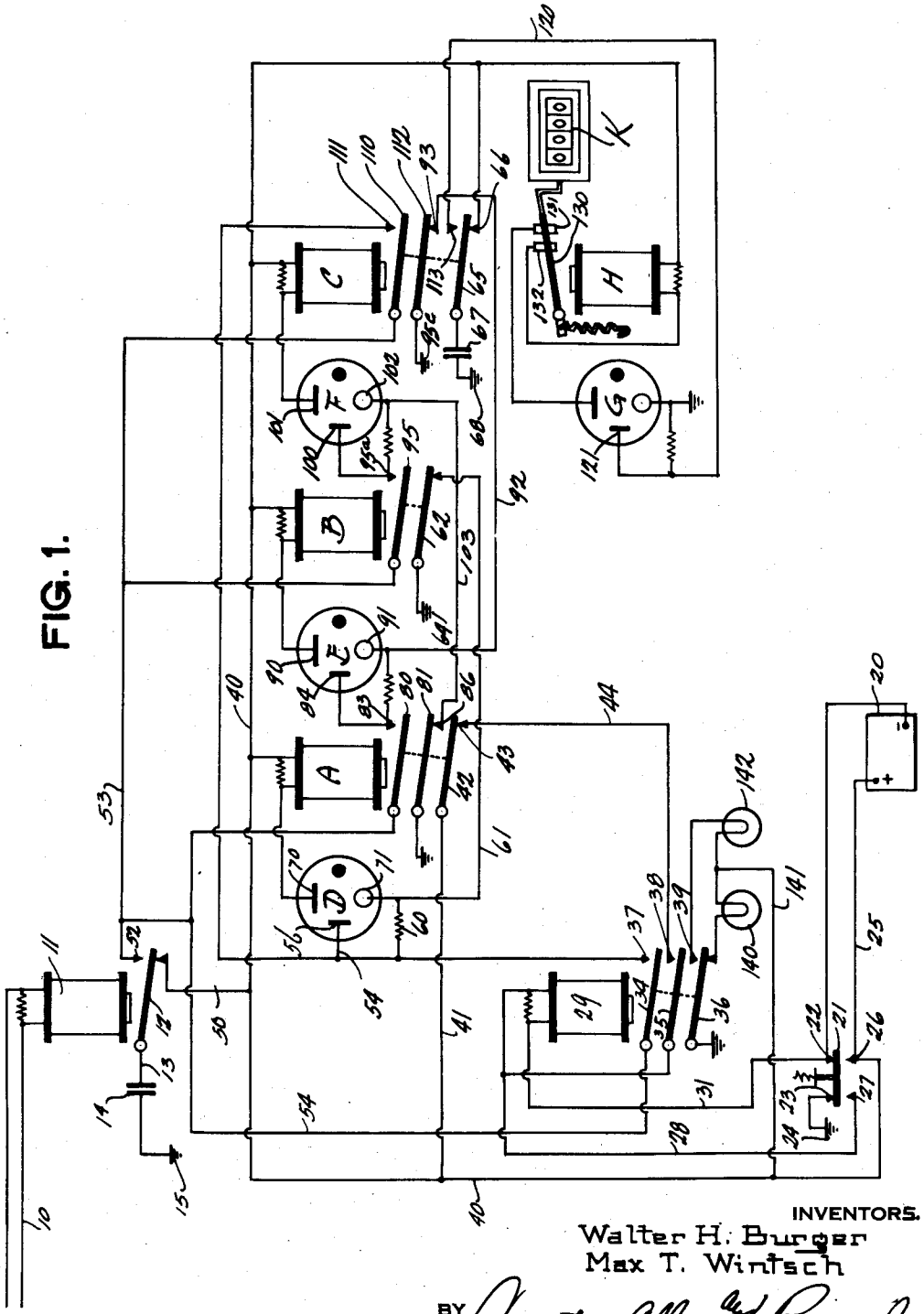

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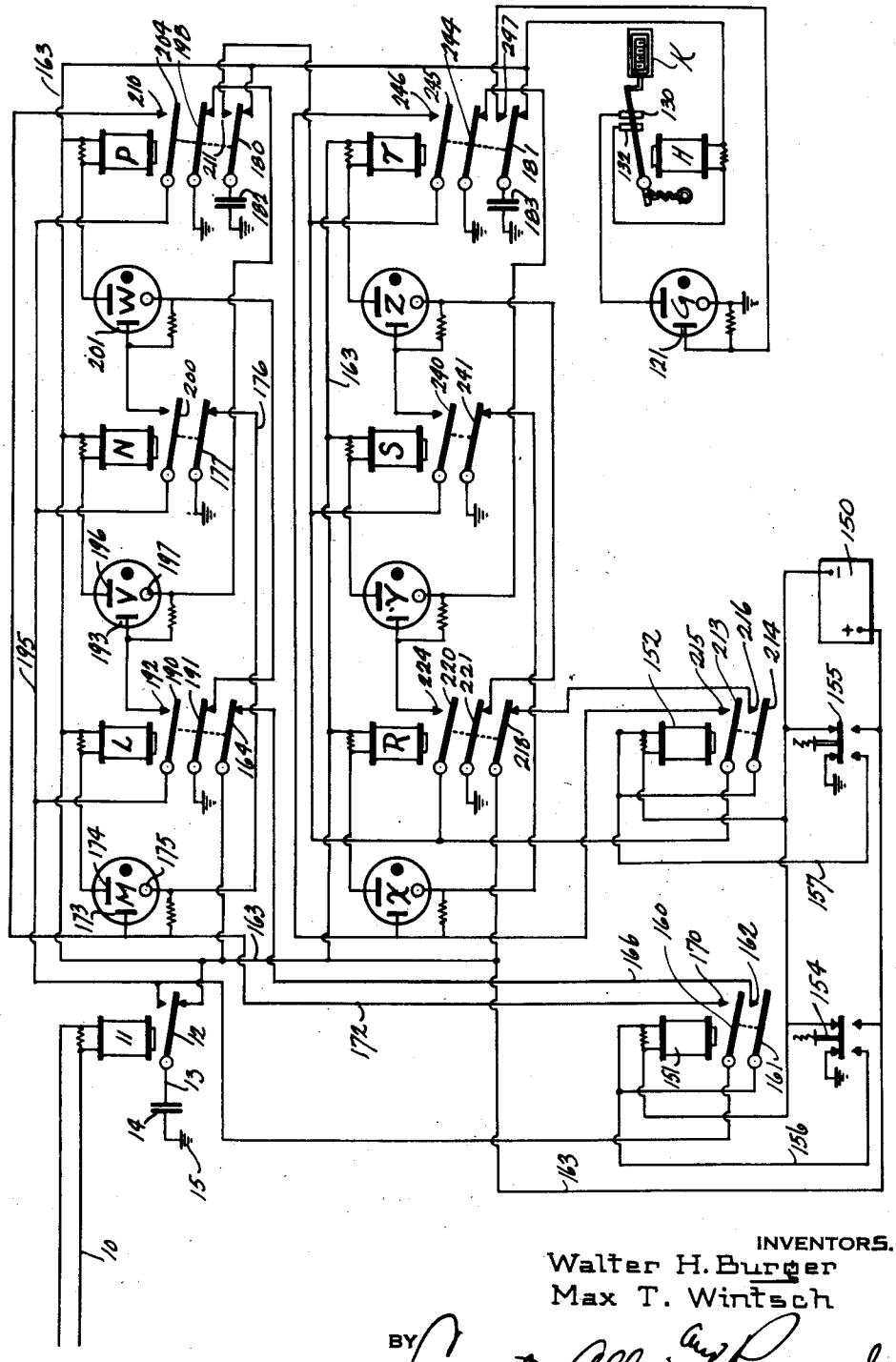
FIG. 2.



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ELECTRONIC COUNTING DEVICE

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Application March 5, 1940, Serial No. 322,418

3 Claims. (Cl. 175—320)

This invention relates to improvements in high speed counting and distributing systems.

The primary object of this invention is the provision of electrical apparatus by means of which accurate counting of movements or objects may be accomplished with facility at high or low speeds.

The apparatus of the present invention embodies a practical system of high speed counting which will stand up successfully at variable speed counting. Heretofore, apparatus for high speed counting has been subject to the fault that the component parts would not stand up under high speed counting, and prior devices for low speed counting, so far as we are aware, have not been successfully used for counting objects or movements at widely varying speeds.

An object of the present invention is the provision of an apparatus for counting objects or motions at low, intermediate or high speeds, which includes an associated series of electronic tube operated relays.

The apparatus of the present system may be used for the purpose of counting movements, such as revolutions of shafts, propellers and the like, or for counting articles such as containers, bottle caps, or other parts; the counting being effected accurately and expeditiously.

The entire system may be conveniently divided into (1) the introductory or input system which is preferably some apparatus or means for converting the count of the movements or objects into impulses; (2) the electronic tube operated relay system for converting the impulses which are necessary to operate the entire system of relays thru a predetermined cycle; (3) the register. The latter is, of course, any approved instrument which will register totals or multiples.

In the drawings we have shown preferred and modified forms of the invention, and in these forms of the invention, so far as possible, similar reference characters designate corresponding parts thruout the several views.

Figures 1 and 2 are preferred and modified set ups of electronic tube operated relays which operate counting registers once for a predetermined number of times that an object or movement creates an impulse in the introductory system. However, it is to be distinctly understood that any number of electronic tube operated relays may be placed in the set up, in accordance with the arrangements to be subsequently described; it being a common characteristic of the invention that the register is actuated every time that there occurs a complete cycle of operation thru the electronic tube operated relays, and of course, in all cases the correct number of movements or objects to be counted will be a multiple of the number of times the complete cycle is operated.

The introductory or input system

For both forms of the invention shown in Figures 1 and 2, the introductory system may be the same. Preferably an impulse is created in a circuit 10, for operating a device such as a master relay; the electrical impulse (as in this case) being created by some such means as the photo-electric cell, tube or other means; the change of resistant values; change of capacity values, or by actual electro-mechanical article or movement contacting means. All of these means for creating impulses are well known in the art and we will not enlarge upon them except to say that photo-electric or variable capacity control are preferred.

The electronic-tube-relay system

In both forms of the invention a master relay 11 is provided in the circuit 10, which is operated by electrical impulses caused by movements or objects to be counted passing or being brought before the means above described, such as photo-electric cell or variable capacity control means. This relay, preferably of a very sensitive high speed operating type, also preferably of the "plug-in" type, has an armature 12 mounted in self-oiling bearings, since it must flutter at as high a rate as sixty times per second for high speed counting purposes. This armature 12 acts as a switch in a condenser circuit 13 which includes a condenser 14 grounded at 15. The charge of the condenser 14 is of course intended to operate the various electron tubes in the count reducing part of the system, as will be subsequently described.

The system includes a series of high speed actuated relays A, B and C, respectively having electronic tubes D, E and F associated therewith. The relays A, B and C are preferably of the plug-in type and the electronic tubes D, E and F are preferably of the gas triode, cold cathode-starter-anode type.

The system is operated by means of electric current of suitable voltage which must of course be first applied to the tubes and relays. The tubes above designated, are worked at 15 to 20 milliamperes, and of course a conventional power tube system may regulate this.

Some means must be provided in initially start-

ing the system to prime the first tube D in the series. The source of electrical energy is designated at 20 in Figure 1, as a battery, altho any source may be desired. A priming switch 21 may be provided, which is normally spring actuated into the position shown in Figure 1, bridging across contacts 22 and 23 in the line leading to the negative side of the source of electric current; the contact 23 being grounded in the circuit at 24. The lead line 25 extending from the battery 20 has contacts 26 and 27 therein which may be bridged by pushing the switch 21 into proper position. This closes the circuit in the line 28 leading thru the starting relay 29, which may be of the ordinary type; the current leaving the relay thru line 31 to the negative side of the battery or source of electrical energy 20, as shown in Figure 1. Energizing the relay 29 will cause the connected armatures 34, 35 and 36 to shift into engagement with the respective contacts 37, 38 and 39 therefor, for performing the various operations to be subsequently described. The switch 21 remains bridged across the contacts 26—27 only long enough for armature 35 of relay 29 to engage contact 38. When relay A is energized as subsequently described, relay 29 will be rendered inoperative. As long as any of relays A, B or C are energized the circuit is in readiness for the following tube.

Energizing the relay 29 will close a so-called "running" circuit thru the switch arm 35 and contact 38; the current passing thru line 25, line 40, line 41, switch arm or armature 42 of the relay A, when the latter is de-energized; contact 43 therefor, and line 44 leading to contact 38. While the starter relay 29 is energized, the contacts 37, 38 and 39 are closed.

As before mentioned, while the armature 12 of the master relay 11 is in the open position, it is connected in circuit for charging the condenser 14. Part of the circuit has been above described, and the remaining lead 50 connects the lead 40 to the positive side of the current supply source 20.

When the first impulse in the master relay 11 operates the latter, the armature 12 will be attracted and engage contact 52 connected in line 53; the latter having a line 54 extending thru the armature 34 of the starting relay, and with the latter engaging the contact 37 the condenser will discharge into line 54 leading to the starter anode 56 of the electron tube D. The tube D is thereby "fired" and thereby passes anode-cathode current for operating the relay A.

The condenser charge also passes across resistance 60 into line 61 and thence thru switch arm 62, which is part of the armature of relay B to ground 64.

The current charged circuit including the lines 25, 40, includes the switch arm 65, part of the armature of the relay C which engages contact 66 when the relay C is de-energized, and leads off thru a condenser 67 into ground 68.

The relay A first to be operated, has its winding connected to the line 40 and the opposite end of the winding connected to anode 70 of the tube D; the cathode 71 thereof being connected in the line 61 above described.

In the cold cathode-starter anode type of tube, it is well understood that current passing into the starter anode will cause a breakdown between starter anode 56 and anode 70, reducing the tube resistance between the anode and cathode to a point where they arc over or ignite, thus energizing and completing the circuit thru the relay A. The same action repeats itself for each tube in the series and will not be further referred to.

Upon energizing of the relay A, its three nonconductively connected armatures 80, 81 and 42, as shown in Figure 1, will be attracted; closing the contact 83 thru the switch arm 80 to the starter anode 84 of the electron tube E, and the arms 42 and 81 will be lifted from their contacts 43 and 86 respectively. This will open the circuit to the starting relay 29, which will become de-energized at this time.

The second impulse in the circuit operating the master relay 11 will cause discharge of the condenser 14 thru the now closed switch arm 80 and contact 83 into the starter anode 84; firing the tube E, which energizes the relay B; the anode 90 therefor being connected to one terminal of the relay B and the cathode 91 being connected via line 92; contact 93 and switch arm 112 to ground 95c. The other terminal of the relay B is connected in line 40, as shown. This energizing of the relay B will attract the connected armatures 95 and 62 thereof. Attraction of armature 62 will open the line 61 leading to tube D deenergizing said tube.

The third impulse actuating the master relay 11 will discharge the condenser 14 into the starter anode 100 of tube F via switch arm 95 and contact 95a. This will fire the tube F; the current will energize the relay C via line 40; anode 101; cathode 102; line 103 leading to contact 86 and the switch arm 81 to ground. The three armatures 110, 112 and 65 of the relay C will be drawn into position; the arms 110 and 65 engaging contacts 111 and 113 respectively, and the arms 112 and 65 respectively, disengaging the contacts 93 and 66.

When the relay C is de-energized, the condenser 67 charges in the closed circuit established via armature 65, contact 66, and lines 40, 25 to ground. Energizing the relay C will open the anode-cathode circuit of the tube E and thru closing of the switch arm 110 engaging the contact 111, the condenser 14 upon the next impulse will then discharge into the starter anode 56 of the first tube D in the series, as can readily be traced. In other words, energizing the relay C places the circuit for the first tube D in position to be again operated.

The condenser 67 upon energizing the third relay C will discharge via the switch-arm-armature 65; contact 113 and line 120 into the starter anode 121 of the register tube G. This will result in energizing the relay H, inasmuch as the armature 130 thereof bridges between contacts 131 and 132 forming part of the anode-cathode circuit in the tube G. Energizing of the relay H of course draws the armature 130 into position for actuating the register or counter K.

Opening of contacts 131—132 will disconnect tube G and likewise the relay H, the armature of which will return to normal position. Every actuation of the counter, advancing one digit, as the case may be, will of course indicate that three objects or movements have passed the detector. The correct number of parts will of course be obtained by multiplying the reading on the counter K by three. The number of objects or movements to be counted by the system is such that if they are not a multiple of a number of tubes in the system excluding the counter tube, in order to obtain the correct number of parts the reading will have to be increased by the number of tubes ignited in the system less than the en-

tire cycle. That is, if the last object to be counted ignited tube E, then to the reading on the counter will have to be added two in order to designate the correct total. Of course the counter can supply the correct multiple if so desired, rather than only a proportionate part of the objects counted. To get a direct reading on the counter you must use a ratio of ten to one or one hundred to one and add either one or two fixed zeros on the counter. Of course, if the final count does not end at ten or a hundred you must add to the count as explained.

Any number of tubes and relays can be provided in the system necessary to give the correct ratio desired. It is possible to obtain a ratio of 144 to 1 with sixteen tubes. To get a ratio of one hundred and forty-four to one with sixteen tubes you must use three sets of tubes, six in the first set, six in the second set and four in the third set. The improved electronic counting unit as herein described may be designed to be movable from one producing machine to another, but if desired, the detector unit, such as photo-electric detecting means may be provided as a part of the machine.

The voltage and current supply must be suitable for the type of relay used. The present circuit requires six volts A. C. at 3 amperes and 175 volts D. C. and 440 volts A. C. for the detector. Constant voltage supply is necessary with loads of from 20 milliamperes to 75 milliameperes.

For visual reference, a yellow signal light 140 may be provided in a circuit 141 which includes current source 20 and the switch arm 36. While the starter relay 29 is deenergized, the yellow signal light 140 will indicate such fact. Similarly, a green signal light 142 also forms part of the circuit 141, but is ignited when the switch arm 36 is attracted by reason of energizing of the starter relay 29, so that said armature 36 engages the contact 39, as shown in Figure 1.

Referring to the system illustrated in Figure 2, the same is operated in a somewhat different manner than the system illustrated in Figure 1, altho a combination of electronic tube operated relays is used.

The system of Figure 2 includes a source of current 150, a starter relay 151 similar to the relay 29 of the form of invention shown in Figure 1. In addition, a so-called recycle relay 152 may be provided. Manually controlled switches 154 and 155 may be provided for the relays 151 and 152, altho a single switch may be used to prime both these relays if so desired. At the start of operation, the switches 154 and 155 are pushed down to close circuits to the windings of the relays 151 and 152 and energize them; these switches being spring operated and will instantly snap back to the original positions, as soon as manually released. As shown, the relays 151 and 152 have circuits 156 and 157 which are closed upon manually operating the buttons 154 and 155 for flow of current from positive to negative and thus energizing the said relays.

The relay 151 is provided with non-conductively connected armatures 160 and 161. Upon initial closing of the circuit to the relay 151, the armature 161 will engage a contact 162 and via the line 163; armature 164 of relay L and line 166 a circuit will be closed thru the relay 151 for holding the same energized after release of the starting switch 154 by the operator. Energizing the relay 151 also causes the armature 160 to engage a contact 170 and a line 172 wherein the starter anode 173 of the first electron tube M is located, and the closing of this circuit enables the condenser 14 to discharge and fire the tube M with operation of the master relay 11 upon the first impulse in the circuit 10.

The anode 174 of the tube M in circuit with the relay L and the cathode 175 extends via line 176 and armature 177 to ground. The armature 177 belongs to the second relay N in the series. The relays L, N, P, R, S and T are all connected in the line 163 leaving from the positive side of the battery or source of current, and it should be noted that this line 163 has a ground thru armature switch arm 180 of the relay P and the armature switch arm 181 of the relay T. Condensers 182, 183 are connected with these armature switches 180 and 181 respectively for a purpose to be subsequently described.

Refering again to the first of the series of electron tubes M, when the same is fired, the relay L will be energized, which will of course attract armatures 190 and 191 which are non-conductively connected together and to the previously mentioned switch armature 164. Energizing the relay L will cause the switch 164 to open and break the circuit thru the starter relay 151. Energizing of this relay L causes the armature 190 to engage a contact 192 connected with the starter anode 193 of the second in the series of electron tubes, designated at V in Figure 2, and on the second impulse in the circuit 10, the condenser 14 will discharge into line 195 and fire the tube V. The anode 196 of this tube is connected with the relay N and the cathode 197 is connected in a circuit wherein an armature switch arm 198 of the relay P is a part. Energizing of the relay N will attract the non-conductively connected armatures 177 and 200. Armature 177 will open the line 176, extinguishing the tube M and then deenergizing the relay L.

Energizing the relay N connects the armature 200, and the starter anode 201 of the third tube W in the series in operation, and upon occurrence of the third impulse thru the master relay 11, the condenser 14 will discharge thus firing the tube W and energizing the relay P, in a manner which will be apparent from the circuit shown in Figure 2 and from foregoing description.

The relay P is provided with non-conductively connected armatures 180, 198 and 204, non-conductively connected together, all of which are attracted upon energizing of the relay P.

It should of course be understood that when the second relay N is actuated, the tube M goes out and likewise upon energizing of the relay P, the tube V will go out, since armature switch arms are located in these circuits operated by the respective relays.

Energizing of relay P causes the armature switch arm 204 to engage a contact 210 and the armature 183 to engage a contact 211. Armature 204 engaging the contact 210 places the tube M in position to be fired again upon occurrence of the next impulse. It would be remembered that the condenser 182 is charged by reason of its normally closed position, that is, when the relay P is de-energized, and upon energizing of the latter, the condenser will discharge into the grid of the tube X associated with the relay R.

At this time we will again refer to the recycle relay 152 which upon closing of the switch 155 was energized, causing the armatures 213 and 214 thereof to respectively engage contacts 215 and 216. The contact 216 is located in a holding

circuit of which switch arm 218 forming an armature of the relay R is part, and up to this time the relay 152 has remained energized. Engagement of the armature 180 with the contact 211, upon energizing the relay P will discharge the condenser 182 into the grid of tube X via circuit shown in Figure 2, of which the switch arm 213 and contact 215 are a part.

The tube X thus ignites and relay R will attract its armatures 218, 220 and 221 opening the circuit thru the relay 152 and de-energizing it. The armature 220 engaging contact 224 completes the grid circuit of electron tube Y, and at this time it should be noted that two tubes X and W are ignited.

Upon occurrence of the fourth impulse to the master relay, the grid on tube M will be charged by condenser 14 causing tube M to ignite and again energizing relay L. This opens the cathode circuit of the tube W, since the armature 191 is connected therewith, permitting relay P to release its armature and again charging the condenser 182.

At this time electron tubes M and X are ignited.

Upon occurrence of the fifth impulse in the circuit 10, the action above mentioned when the second impulse was imposed on the master relay circuit takes place, with the difference that in addition to electron tube V being ignited, the electron tube X is also ignited.

The sixth impulse in the master relay circuit causes the electron tube W to ignite, similar to the occurrence above described during the third impulse on the master relay circuit. However, the closing of switch arm 180 at this time engages the contact 211 and discharges the condenser 182 into electron tube Y, igniting the latter, inasmuch as the switch arm 220 forming one of the armatures of relay R is closed. Relay S is thus actuated. Relay S attracts armatures 240 and 241; this breaking the circuit thru the electron tube X which now goes out, and the grid of electron tube Z is placed in firing position. At this time tubes W and Y are ignited.

On occurrence of the seventh impulse in the master relay circuit, the same action takes place as during the fourth impulse, except that tubes M and Y are ignited.

During the eighth impulse in the master relay circuit, the same action takes place as during the sixth impulse, except that tubes V and Y are ignited.

On occurrence of the ninth impulse in the master relay circuit, the same action takes place as described during the third impulse in the master relay circuit, except that the relay P will be energized for discharging the condenser 182 into tube Z. The relay T thus becomes energized; opening thru its armature switch arm 244, which interrupts the cathode circuit for the tube Y and permits relay S to become inoperative. The armature switch arm 245 engages a contact 246 when the relay T is energized closing the grid circuit thru the tube X. Upon movement of the switch arm 181, at the time that the relay T is energized, the same will engage a contact 247 in the counter circuit, and discharging the condenser 183 in the circuit for actuating the counter mechanism, advancing it one digit, as above described, for the preferred embodiment of this invention.

The entire cycle of operation then repeats itself. The correct reading is obtained by multiplying the number registered on the counter by nine, since the system operates at a ratio of 9 to 1.

In the event the parts to be counted are not a multiple of nine and tubes W and X are not ignited, it is necessary to prorate the number in the circuit to get the correct number of parts. This may readily be accomplished by numbering the tubes M, V, W, X, Y and Z as 1, 2, 0, 3, 6 and 0 respectively. As an example, if the final reading on the counter is 10 and tubes V and Y are ignited, the correct count would be 10 multiplied by 9 plus 2, plus 6. This makes a total of 98 parts creating impulses in the master relay circuit.

In the improved electronic tube-relay counting system of the present invention, the action is quick and efficient. In some prior relay types of counting circuits the action is extremely sluggish and contacts are apt to burn out on relays, due to the use of powerful condensing voltages. In our improved system there are 15 milliampere operations.

The cold cathode type of tube is the most efficient.

Changes in details may be made to the form of invention herein shown and described, without departing from the spirit of the invention or the scope of the following claims.

We claim:

1. In a counting system of the character described, a source of current, a condenser, a condenser charging circuit connected to said source of current, a series of relays including windings and switch means, a series of electron tubes having anode, cathode and firing elements, relay energizing circuits between said source of current and said windings, each relay energizing circuit bridging the anode and cathode elements of one of said tubes and controlled by the switch means of the relay of said series succeeding that relay to which said energizing circuit is connected, tube firing circuits between the condenser and the firing elements of the tubes, the firing circuit for any given tube being controlled by the switch means of the relay of said series preceding that relay whose windings are connected to the relay energizing circuit bridging the anode and cathode elements of said given tube, an impulse receiving input circuit, and means responsive to the reception of impulses in said input circuit for connecting said condenser alternately to said condenser charging circuit and to said tube firing circuits.

2. In a counting system of the character described, a source of current, a condenser, a condenser charging circuit connected to said source of current, a series of relays including windings and switch means, a series of electron tubes having anode, cathode and firing elements, relay energizing circuits between said source of current and said windings, each relay energizing circuit bringing the anode and cathode elements of one of said tubes and controlled by the switch means of the relay of said series succeeding that relay to which said energizing circuit is connected, tube firing circuits between the condenser and the firing elements of the tubes, the firing circuit for any given tube being controlled by the switch means of the relay of said series preceding that relay whose windings are connected to the relay energizing circuit bridging the anode and cathode elements of said given tube, an impulse receiving input circuit, means responsive to the reception of impulses in said input circuit for connecting said condenser al-

ternately to said condenser charging circuit and to said tube firing circuits, a second condenser, an additional relay, means for energizing said additional relay from said source of current, and means responsive to operation of the last relay of said series for connecting said second condenser alternately to said condenser charging circuit and to said means for energizing said additional relay.

3. In a counting system of the character described, a source of current, a condenser, a condencer charging circuit connected to said source of current, a series of relays including windings and switch means, a series of electron tubes having anode, cathode and firing elements, relay energizing circuits between said source of current and said windings, each relay energizing circuit bridging the anode and cathode elements of one of said tubes and controlled by the switch means of the relay of said series succeeding that relay to which said energizing circuit is connected, tube firing circuits between the condenser and the firing elements of the tubes, the firing circuit for any given tube being controlled by the switch means of the relay of said series preceding that relay whose windings are connected to the relay energizing circuit bridging the anode and cathode elements of said given tube, an impulse receiving input circuit, means responsive to the reception of impulses in said input circuit for connecting said condenser alternately to said condenser charging circuit and to said tube firing circuits, a second condenser, a charging circuit for the second condenser connected to the source of current, an additional relay including windings and switch means, an additional electron tube having an anode element, a cathode element and a firing element, a relay energizing circuit between the source of current and the windings of said additional relay, said latter circuit bridging the anode and cathode elements of said additional tube and controlled by the switch means of said additional relay, a firing circuit connected to the firing element of the additional tube, and switch means responsive to energization of the last relay of said series for connecting said second condenser alternately to its charging circuit and to the firing circuit of said additional tube.

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