

Feb. 22, 1949.

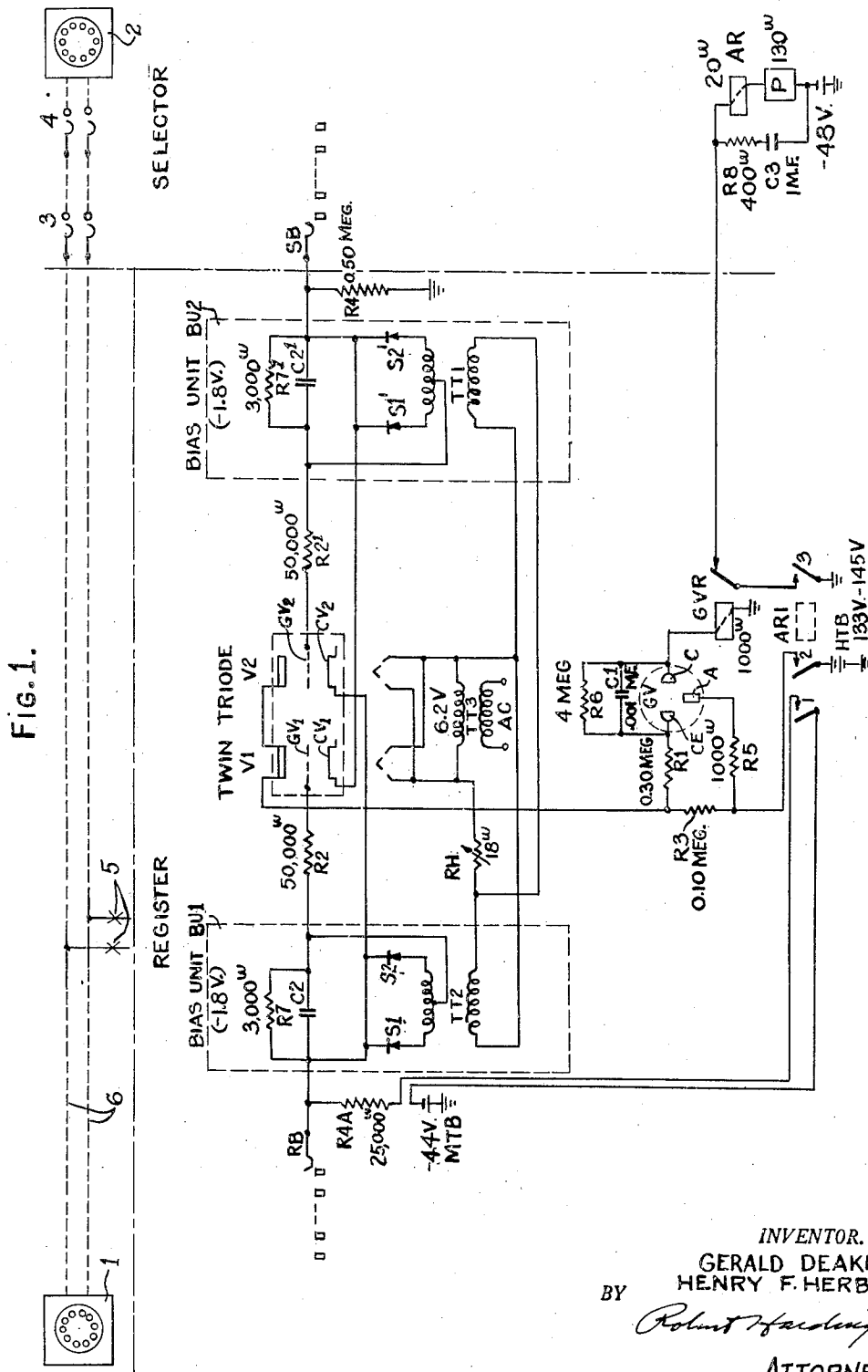
G. DEAKIN ET AL

2,462,074

BIASING POTENTIAL SWITCHING SYSTEM

Filed Jan. 5, 1946

6 Sheets-Sheet 1



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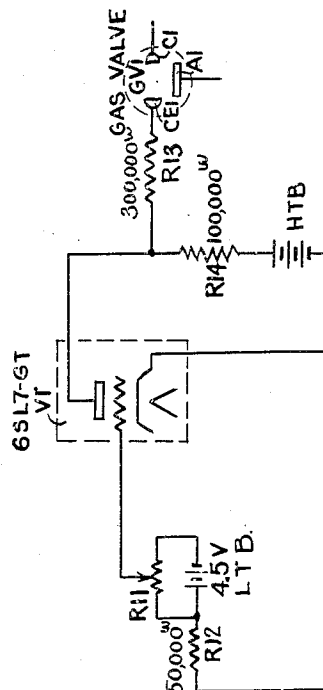
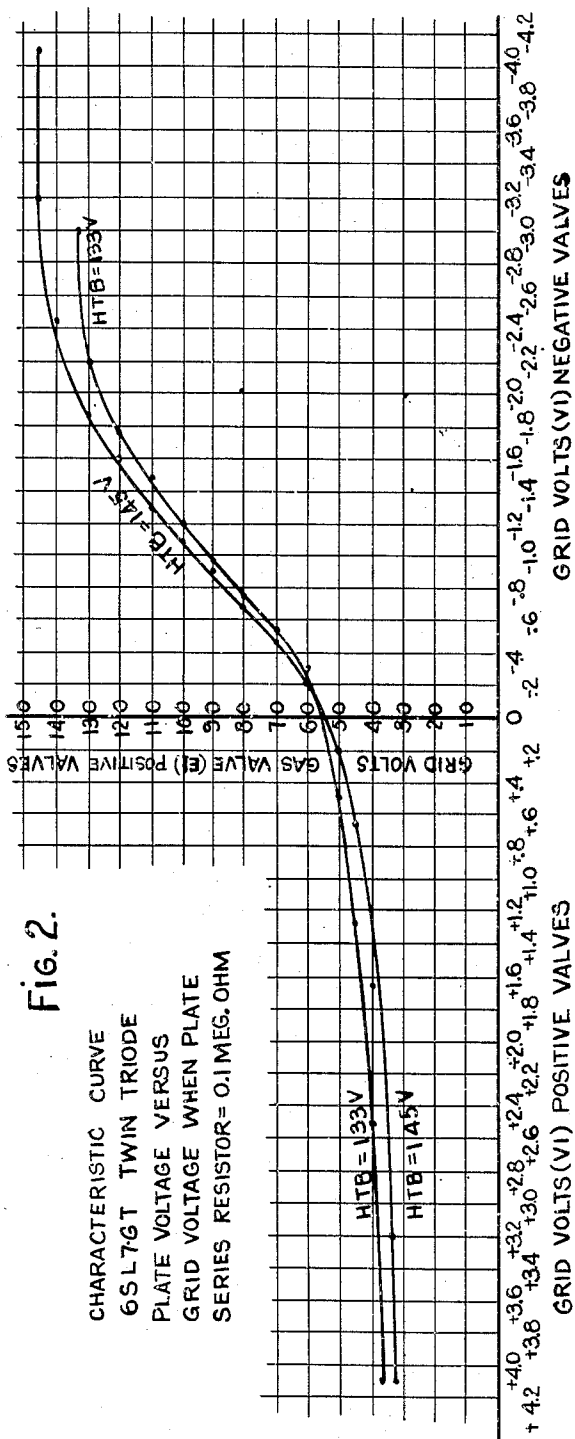
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BIASING POTENTIAL SWITCHING SYSTEM

Filed Jan. 5, 1946

6 Sheets-Sheet 2



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FIG. 4.

ASSIGNMENT OF TEST POTENTIALS FOR REGISTER CIRCUIT									
VOLTS	PN OR PS NO.	LINE FINDER		GROUP SELECTORS		F-(FINAL) SELECTOR-(TENS)		F-(FINAL) SELECTOR-(UNITS)	
		T (PN)	B (PS)	T (PN)	B (PS)	T (PN)	B (PS)	T (PN)	B (PS)
- 4	20	PC1	ML-K	DIGIT Y	DIGIT Y				
- 6	1	PC2	ML-D	DIGIT 1	DIGIT 1			DIGIT 1	
- 8	2		PL-K	DIGIT 2	DIGIT 2			DIGIT 2	
-10	3			DIGIT 3	DIGIT 3			DIGIT 3	
-12	4			DIGIT 4	DIGIT 4			DIGIT 4	
-14	5			DIGIT 5	DIGIT 5			DIGIT 5	AD OR GK CONN.
-16	6			DIGIT 6	DIGIT 6			DIGIT 6	PL-A OR G CONN.
-18	7			DIGIT 7	DIGIT 7			DIGIT 7	PL-D OR K CONN.
-20	8			DIGIT 8	DIGIT 8			DIGIT 8	
-22	9			DIGIT 9	DIGIT 9			DIGIT 9	
-24	10	PL-A		DIGIT 0	DIGIT 0			DIGIT 0	
-26	11	PL-D		DIGIT X	DIGIT X	DIGITS $\frac{1}{0}$			
-28	12	PL-G		MM-2	OT-U	DIGITS $\frac{2}{0}$			ML-FREE
-30	13	PL-K		MM-3	OT-S	DIGITS $\frac{3}{8}$			ML-BUSY
-32	14	I-1		I-1		DIGITS $\frac{4}{7}$			
-34	15	I-2		I-2		DIGITS $\frac{5}{6}$			
-36	16	I-3		I-3		NE NO		NE NO	
-38	17	I-4		I-4					
-40	18	I-5		I-5					
-42	19	I-6		I-6					

PC - CALLING POTENTIAL
ML - MAIN LINE OR PBX
PL - 4 PARTY LINE
K - KEY SET
D - DIAL

PL - A, D, G OR J STATION IDENTIFICATION
I - CALLING LINE NUMBER IDENTIFICATION
OT - OUTTRUNK TO UNIVERSAL
OS - OUTTRUNK TO STROWGER
MM-2-MULTIPLE METERING TWICE
MM-3-MULTIPLE METERING THRICE
PC1-UNRESTRICTED SERVICE
PC2-RESTRICTED SERVICE
NE - NON-EXISTING

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FIG. 5.

E1 SRBO		VOLTS		VALUE OF E1 IN VOLTS																								E1-SRBO 22 V.									
		GND	-2	-4	-6	-8	-10	-12	-14	-16	-18	-20	-22	-24	-26	-28	-30	-32	-34	-36	-38	-40	-42	-44	-48	+70											
	-2																																				
44	-4	30	44	118	45	31																				-45	1										
	-6			117																																	
	-8				116																																
	-10					115																															
	-12						113																														
	-14							112																													
	-16								111																												
	-18									110																											
	-20										108																										
18	-22	-7	-5	-3	-1	2	4	6	9	12	17	32	107	33	18																						
	-24												105																								
	-26													104																							
	-28														103																						
	-30															102																					
	-32																100																				
	-34																	98																			
	-36																		97																		
	-38																			96																	
	-40																				94																
-2	-42																				3	18	93	18	-2	-40											
	-44																						91														

FIG. 6.

E1 VOLTS		VALUE OF E1 IN VOLTS																				E1 - SRB0 27V.									
SRB0	E2	GND	-2	-4	-6	-8	-10	-12	-14	-16	-18	-20	-22	-24	-26	-28	-30	-32	-34	-36	-38	-40	-42	-44	-48	-70					
	-2																														
47	-4		47	123	48																					-44	1				
	-6			122																											
	-8				121																										
	-10					120																									
	-12						119																								
	-14							118																							
	-16								117																						
	-18									115																					
	-20										114																				
21	-22											35	112	36																	
	-24													111																	
	-26														109																
	-28															108															
	-30																107														
	-32																	105													
	-34																		104												
	-36																			102											
	-38																				101										
	-40																					99									
1	-42																						21	97	22	1	-40				
	-44																								96						

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FIG. 7.

E1	VALUE OF EI IN VOLTS																EI-SRBO 15V									
Volts	GND	-2.4	-4.7	-7	-9.4	-11.8	-14.2	-16.6	-19	-21.4	-23.8	-26.2	-28.6	-31.1	-33.6	-36	-38.5	-41	-43.5	-46	-48.5	-51	-53.4	-55.2	-57	
380	2.4																									
42	-4.7	38	118	40																						
36	-7			117																					-45	2
	-9.4				116																					
	-11.8					114																				
	-14.2						113																			
	-16.6							112																		
	-19								110																	
	-21.4									108																
	-23.8										107															
13	-26.2										22	105	24													
	-28.6												103													
	-31.1													102												
	-33.6														101											
	-36															99										
	-38.5																98									
	-41																	96								
	-43.5																		94							
	-46																			92						
	-48.5																				90					
9	-51																					5	88	6	-16	-49
	-54																							85		

FIG. 8.

E1	VOLTS	VALUE OF EI IN VOLTS																EI-SRBO 22V								
580	2	GND	2.4	-4.7	-7	-9.4	-11.8	-14.2	-16.6	-19.9	-21.4	-23.8	-26.2	-28.6	-31.1	-33.6	-36	-38.5	-41	-43.5	-46	-48.5	-51	-53.4	-55.2	-57
	-2.4																									
47	-4.7		43	126	45																					
	-7				124																					-45
	-9.4					123																				
	-11.8						122																			
	-14.2							120																		
	-16.6								118																	
	-19									117																
	-21.4										116															
	-23.8											114														
15	-26.2												26	112	27											
	-28.6														110											
	-31.1															108										
	-33.6																107									
	-36																	105								
	-38.5																		103							
	-41																			101						
	-43.5																				99					
	-46																					98				
	-48.5																						96			
7	-51																						9	94	10	-13
	-54																								92	-49

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Fig. 9.

E1	Volts	VALUE OF E1 IN VOLTS																				E1-SRBo 22V.									
SBo	E2	GND	-1.7	-3.4	-5.1	-6.8	-8.5	-10.2	-11.9	-13.6	-15.3	-17.0	-18.7	-20.4	-22.1	-23.8	-25.5	-27.2	-28.9	-30.6	-32.3	-34.0	-35.7	-37.4	-40.8	-47.0					
	-1.7																														
44	-3.4		53	118	52																					36	-1				
	-5.1				117																										
	-6.8					116																									
	-8.5						115																								
	-10.2							113																							
	-11.9								112																						
	-13.6									111																					
	-15.3										111																				
	-17.0											110																			
20	-18.7												40	108	38																
	-20.4														105																
	-22.1															104															
	-23.8																103														
	-25.5																	103													
	-27.2																		102												
	-28.9																			101											
	-30.6																				100										
	-32.3																														
	-34.0																														
3	-35.7																														
	-37.4																														

Fig. 10.

E1	Volts	VALUE OF E1 IN VOLTS																				E1-SRBO 25V.									
SBO	E2	GND	-1.7	-3.4	-5.1	-6.8	-8.5	-10.2	-11.9	-13.6	-15.3	-17.0	-18.7	-20.4	-22.1	-23.8	-25.5	-27.2	-28.9	-30.6	-32.3	-34.0	-35.7	-37.4	-40.8	-47.0					
	-1.7																														
49	-3.4		57	126	55																									34	-1
	-5.1			54	125	52																									
	-6.8					124																									
	-8.5						123																								
	-10.2							122																							
	-11.9								121																						
	-13.6									119																					
	-15.3										118																				
	-17.0											117																			
24	-18.7												43	116	43																
	-20.4														114																
	-22.1															113															
	-23.8																111														
	-25.5																	110													
	-27.2																		109												
	-28.9																			108											
	-30.6																				107										
	-32.3																					105									
	-34.0																						103								
7	-35.7																							30	102	32	5	33			
	-37.4																									101					

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2,462,074

BIASING POTENTIAL SWITCHING SYSTEM

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Application January 5, 1946, Serial No. 639,287

7 Claims. (Cl. 179-18)

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This invention relates to new and useful improvements in signaling, switching or indicating systems and more particularly to circuits for controlling the numerical selecting operation of selector switches employed in automatic telephone exchange systems.

The present is an improvement on the control circuits disclosed in Patent No. 2,354,682, filed May 6, 1943, patented August 1, 1944, and in the various applications and patents referred to therein.

One of the objects of this invention is a control circuit including a multi-electrode discharge device permitting the symmetrical application of a series of discrete potentials on both register and selector sides.

Another object of this invention is a biasing system permitting the establishment of an accurate output potential which can be used for switching, indicating or any other operative purpose and which depends upon the application of a predetermined potential difference to the control circuit.

More specifically the biasing system includes a circuit or circuits superimposing a relatively small but constant direct current potential over one or both series of discrete potentials.

Another object of this invention is a means for superimposing a continuous potential over at least one of the series of discrete potentials to maintain the output potential below its operative value in case the discrete potentials are absent.

A more specific object of this invention is to bias the several electron discharge paths of a twin multi-electrode tube from a common circuit.

Still another object of this invention is the timing of the control operation, and more specifically, a delay circuit preventing false operation in gas discharge tubes operated from the control circuit.

A further object is a switching means operated from the control circuit at appropriate moments to disconnect certain sources of potential from the system so as to reduce wear on the battery and on any other equipment.

These and other objects of the invention will more clearly appear from the claims, the following description and the appended drawings, in which:

Fig. 1 diagrammatically illustrates as much of a control circuit embodying the various features of the present invention as is necessary for a clear understanding thereof;

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Fig. 2 is a graph showing the control electrode voltage of a gas discharge tube plotted against the grid voltage of a triode;

Fig. 3 is a circuit used in the determination of this graph;

Fig. 4 shows an example of an assignment of test potentials for a large network office; and

Figs. 5 to 10 are test sheets showing the breakdown potential of a gas tube as a result of the matching of test potentials belonging to two series of discrete potentials.

In an automatic telephone system, calling and called subscribers' stations 1 and 2 (Fig. 1) may be inter-connected by means including a plurality of selector switches 3 and 4. The numerical operations of the selectors are controlled by the calling subscriber's customary impulse sender or other number indicating device through the agency of a register provided at the central exchange. The calling station 1 is connected to the brushes of selector 3 by non-numerical switches and a connecting circuit 6, and the register is attached to the connecting circuit 6 through switching means 5.

The selector switches are of the customary type having a bank of terminals with which a set of brushes cooperates. In the drawings, three brushes are shown for selector 3 although the selector may have a larger number of brushes. The selector brushes are moved over the terminals while a magnet P is energized and are stopped on a set of terminals when this magnet becomes de-energized.

The register may comprise a customary arrangement of switches, relays or other electrical digit-storing devices successively operable by the calling device in accordance with the successive digits of the called number. A brush and a set of terminals of one of these register switches is shown in Fig. 1. This is the register switch which responds to the digit destined for selector 3. Register brush RB is advanced toward one of a series of say ten terminals (only four of which are shown) in accordance with the operation of the calling device at the station 1. When a register is selected in the customary manner, relay AR₁ is operated (by means not shown) and a circuit is closed from ground over the armature and front contact of relay AR₁, the armature and back contact of relay GVR also in the register, the winding to a selector relay AR, the winding of the power magnet P of the selector.

The magnet P starts the brushes of the selector

3 moving over the terminals and will continue until GVR becomes energized.

The energization of relay GVR is controlled by a gas valve GV having a cathode C, an anode A and a control electrode CE. The control electrode or grid CE is connected over a resistance R1, of say 300,000 ohms, to the anodes of twin triode V1, V2. High tension battery HTB feeds over AR1 front 2 and resistance R3, of say 100,000 ohms, the anodes of twin triode V1, V2 and over a resistance R5, of say 1,000 ohms to the anode A of gas valve GV. Cathode C is grounded over a relatively high-resistance relay GVR, of about 1,000 ohms. In this way, a potential developed in the output circuit receiving the electrons of the two electron discharge paths of the twin triode is used to control the discharge of tube GV; relay GVR will be energized when the gas valve ionizes. As a result of the discharge of tube GV, the relatively low resistance relay AR and the selector magnet P will be de-energized. The resistance of AR may be about 20 ohms and that of selector magnet P about 130 ohms.

The values of R1, R3, R5 and of the resistances of GVR, AR and D depend among other factors upon the characteristics of twin triode V1, V2 and gas valve GV, and may be varied within wide limits without exceeding the scope of this invention.

Relay AR1, via back contacts 1, 2, disconnects medium tension battery MTB and high tension battery HTB. The same relay AR1, via back contact 3, also removes ground from the energizing circuit for AR and P. When relay GVR is operated due to the ionization of gas tube GV, it opens the circuit of relay AR and selector magnet P, releasing each. Thus, the movement of selector brush SB will be controlled by the discrete potentials applied to the grids of the twin triode V1, V2.

The circuits operating the two grids on the marked (or register) side and the test brush (or selector) side are symmetrical. Brush RB when moving over its associated terminals applies to grid GV1 and cathode CV2 a series of discrete potentials. Similarly, another series of discrete potentials is applied from brush SB to grid GV2 and cathode CV1. Thus the grid in one electron path and the cathode in the other electron path of the twin multi-electrode tube have a predetermined constant potential relationship. In the embodiment shown, the grid of V1 (or V2) and the cathode of V2 (or V1) have substantially the same negative potential, namely, the discrete potential applied by selector and register brushes respectively.

The discrete potentials are applied to CV1, CV2 directly and to GV1, GV2 over grid resistances R2, R2', of say 50,000 ohms.

In accordance with this invention a bias circuit assures the retaining of a desired output potential when the discrete potentials applied to the different grids bear a predetermined relationship and preferably are substantially equal. Each of the registering and selecting grids GV1, GV2 is biased in exactly the same manner by superimposing a constant direct current potential over each of the discrete potentials applied to the grid. In the embodiment shown the biasing potentials applied to grids GV1, GV2 are substantially the same and have the relatively small value of approximately -1.8 volts. However, the biasing potentials may differ, both absolutely and relatively, depending upon the tube and circuit

structure, without exceeding the scope of this invention. The source of bias potential may be any appropriate direct current source, a battery, a dry cell or an A. C. fed rectifier of any desired construction.

In the embodiment shown in Fig. 1, the biasing potential is applied from rectifier pairs S1, S2 and S1', S2' to the grids over balancing resistances R7, R7' of any appropriate value, say 3,000 ohms inserted between brush RB, SB and grid resistance R2, R2', respectively.

Balancing resistances R7, R7' are shunted by a suitable smoothing condenser C2, C2' of say 30-40 microfarad capacity which serves to eliminate or reduce any ripple passing the rectifier pairs S1, S2 and S1', S2'. The latter are supplied from the cathode heater circuit over transformers TT1, TT2.

One end of R7 is connected over rectifiers S1, S2 to the ends of the secondary of transformer TT2. The center tap of the secondary is connected to the other end of resistance R7.

Similarly, balancing resistance R7' is shunted by another capacitor C2' similar to C2; both R7 and C2 are connected with one end over rectifiers S1', S2' to the ends of the secondary of transformer TT1. The other ends of resistance R7' and capacitor C2' lead to the center tap of that secondary.

The two primaries of transformers TT2, TT1 are connected in parallel preferably over a small rheostat RH, of say 18 ohms, to the common cathode heating circuit for the twin triodes V1, V2 and, more particularly, to the secondary of, say about 6.2 volts of cathode heater transformer TT3.

The invention is not limited to the resistance and capacity values specified and to the circuits shown. In fact it is a characteristic advantage of this invention that these values and circuits may be changed within wide limits and adapted to all types of installations and applications without affecting the principle of the invention and the efficiency of its operation.

Balancing resistances R7, R7', smoothing condensers C2, C2', rectifier pairs S1-S2, S1' and S2', and transformers TT2, TT1, on the registering as well as the selecting side, may be attached to each other so as to form a detachable unit BU1, BU2.

The biasing unit or units are not grounded.

If desired, and, especially when twin multi-electrode structure, such as the twin triode V1, V2 shown in Fig. 1, are used, the biasing units controlling the different input electrodes or grids may also be combined in a single detachable structure. Rectifiers and transformers may be mounted on a radio-type plug-in socket of the kind disclosed in the copending application of Henry Herbig, Serial No. 628,923, filed November 15, 1945.

As shown in Fig. 1 the common receiving circuit for the electrons controlled by the interaction of two input electrodes produces an operating potential which is applied to the control point of a gas discharge path, the receiving circuit of which may be used to control a switching operation, such as the movement of selector brush SB. A timing circuit consisting of resistance R6 and condenser C1 in shunt to the gas discharge path serves to assure switching at exactly the moment the operating potential is produced. This prevents false operation, such as premature firing due to transient voltage, while selector brush SB in the course of the movement applies a series of

discrete potentials to its associated input electrode, grid GV2. Resistance R6 is rather high, say 4 megohms, and condenser C1 has a relatively low capacity of, say .001 microfarad. The elements of the timing circuit may have any appropriate values and connections depending on the characteristic of gas tube GV and other factors controlling its operation. In the claims herein R6 is designated as a bleeder resistance.

As selector brush SB moves over its associated terminals, it will eventually arrive at a position where potential E2 on the register brush RB is the same as potential E3 on the selector brush SB; in this case the grids G1, G2 of V1 and V2 are both negative by approximately 1.8 volts with respect to their cathodes C1, C2. Under this condition the plate current through resistor R3 is reduced to such an extent as to allow the potential E1 at the control grid CE of the gas tube GV to rise to breakdown voltage. Thereupon, GV fires and operates relay GVR. The breakdown voltage of the gas tube is between 66 volts and 80 volts. An examination of the test sheets shown in Figs. 5-9 shows that when potentials E2 and E3 between limits of -4 volts and -42 volts are matched, the resulting breakdown potential E1 of the gas tube reaches a minimum of 93 volts (see Fig. 5) and a maximum of 120 volts (see Figs. 10 and 8).

Fig. 2 shows curves representing the potential at the control grid CE as a function of the grid potential on one of the two input electrodes GV1, GV2 for different voltages of the high tension battery HTB, namely, for HTB=133 volts and 145 volts. These latter voltages are the limits of the voltage tolerance permitted in this embodiment of the invention.

The curves have been obtained by means of a measuring circuit shown in Fig. 3. In this circuit, the grid of the V1 section of a 6SL7-GT twin triode is connected over a portion of a small balancing resistor R11 and a grid resistor R12 of about 50,000 ohms, to the cathode of V1 and, simultaneously, to the minus pole of high tension battery HTB. The anode of V1 is connected over a resistor R12, of say 300,000 ohms, to control grid CE1 of gas valve GV1. Cathode C1 and anode A1 of GV1 are connected in a manner not shown but similar to that illustrated in Fig. 1. Resistor R14, of say 100,000 ohms, connects the anode of V1 with the positive pole of HTB. A 4.5 volt low tension battery bridges the balancing resistor R11 and supplies the biasing potential.

Resistance and battery values and their respective connection are, of course, open to wide variations depending upon the characteristic of the type of tube used, the functions to be measured and other factors controlling the measuring circuit.

The gas tube GV does not fire when the difference in potential between register and selector brushes RB and SB, respectively, in Fig. 1, E2 and E3, is equal to or greater than the difference between adjacent test potentials; i. e. 1.7 volts (Figs. 9 and 10), 2 volts (Figs. 5 and 6), and 2.4 volts (Figs. 7 and 8).

As previously stated, the gas tube will not fire when the potential of the control electrode is maintained below 66 volts. It has been found that the highest voltage E1 reached is 57 volts when the test potential separation is 1.7 volts with the register test potentials E2 and E3 at the lower end of the scale (Fig. 10).

The calling subscriber controls potential E2 through the register and when this potential is

set, AR1 or its equivalent operates. The circuit for high tension battery HTB is closed, also the clutch circuit of the selector. The selector brush SB commences to move over the test terminals.

It is assumed for the purpose of explanation that the potential E2 placed on RB is -22 volts. When SB tests -2 volts, potential E1 becomes -5 volts (Fig. 5). When SB tests -4 volts, E1 becomes -3 volts. When SB reaches -20 volts, potential E1 is increased to +32 volts but when it reaches -22 volts, potential E1 jumps to +107 volts and the gas tube fires and operates high speed relay GVR which opens the clutch circuit of the selector, causing it to come to rest. All selections are made in a similar manner.

The potentials actually found in the selector bank need not be in numerical order. They may be mixed up in any manner since it is only when potentials E2 and E3 are matched that the gas tube can fire. The selector brush SB may rub with safety over open test terminals, -44 volt test terminals, grounded test terminals, or those connected to +70 volts for metering.

The purpose of resistor R4 and 44-volt battery MTB is to maintain potential E1 below firing point when selector brush SB is disconnected from a bank terminal or, in other words, from a potential E3. Potential E1 is then known as the SBO (selector brush open) potential. The highest SBO potential reached under this condition is 49 volts (Fig. 10).

Resistor R4A connected to -44 volts is added so as to maintain the potential of E1 below firing point when both SB and RB are opened. E1 is then known as the SRBO (selector register brush open) potential and the highest potential reached under this condition is 31 volts (Fig. 9).

In effect brush SB when not engaging one of its contacts is grounded over R4. However, due to the relatively high resistance of R4 with respect to the control resistance of any source for marking a selector contact, the contacts are not short circuited when SB does engage them. For this reason R4 and similarly R4A may be designated as current limiting resistance. When RB is not engaging one of its contacts it is connected to -44 v. over R4A. This voltage is selected as a value which cannot be matched by the potential of any of the selector contacts so that the circuit is prevented from operating unless RB is in engagement with one of its contacts. For this reason the -44 v. may be designated as a mismatched potential.

The test potentials E2 and E3 may be assigned in many ways and for many purposes. A typical assignment for a large office in a large network is given in Fig. 4. The assignment may be different for line finders, group selectors and final selectors and for the B and T-terminals in case of duplex testing. Referring to the column "Group selectors," it will be seen that for the T-terminals potentials -6 to -24 are assigned to two "extra" digits controlled by the register; potentials -28 and -30 are assigned for double and triple metering and potentials -32 to -42 for six identification circuits, all of which may be used simultaneously without confusion.

The filament current supply is a 60-cycle A. C. at 6.2 volts +5% but may be any type of alternating current system of any desired frequency. Provision should be made for an emergency supply of prime power in case of outside power failures. The reserve equipment may be that provided for the bay motors and high tension bat-

tery supply and, can be driven from the main exchange battery.

A commercial twin triode, such as RCA type 6SL7-GT, may be used to produce the electron discharge paths. It has been found possible to interchange RCA twin triodes without making any adjustment whatsoever in resistances or potentials.

Other twin or single multi-electrode structures may be used for the purpose of this invention without exceeding the scope thereof.

A commercial three-electrode gas valve, such as RCA 1C21, may be used to provide the gas discharge path. The average firing potential of the control electrode is 73 volts with a minimum of 66 volts and a maximum of 80 volts. The gas valve should be shielded to ground to prevent accidental firing from external causes.

The invention is, of course, not limited to the use of the gas valve shown, nor to the use of a gas triode. Any appropriate type of gas or electron discharge device may be operated from the output potential of the control circuit without departing from the spirit of this invention.

The new system operates successfully with the individual battery cell potential varying from 1.7 to the fully charged potential of the cell. The cells of the normal negative main exchange battery may be used for test potential purposes providing the number of potentials required do not cause the uppermost potential to foul the exchange bus bar potential of -48, minimum -44, maximum -55 volts, when the individual cells are at their maximum potential.

For example, if the maximum individual cell voltage can be kept at 2.5 or less, fifteen test potentials are available, but if twenty potentials are required, a small separate battery must be provided for test potential purposes. This battery may be of the smallest commercial type since the current drain is very slight and it may be floated off a rectifier charger. For emergency purposes, a twenty-one pole switch should be provided to transfer the test potential leads to the main exchange battery, the individual cell potential of which during the emergency must be maintained at approximately 2 volts.

The potential of the high tension D. C. supply for the plate and gas tube circuits should be maintained between 133 and 146 volts. A rectifier is recommended. A high tension storage battery may be used.

It is a characteristic feature of this invention that the steps between discrete potentials as well as the biasing potentials are small; the potentials may be derived, as shown in the embodiment of the invention illustrated in the drawings, from the individual cells of a customary exchange battery. It is, however, not necessary to limit the invention to the specified potentials and to the sources of potential shown. Any appropriate type of current source and potentials of any suitable magnitude may be used for the purposes of this invention, without departing from its scope.

Relay GVR operated by the gas tube should break its back contact in not less than about 1.5 milliseconds. No particular form of relay is specified but it should be capable of breaking the circuit indicated in Fig. 1, which contains low resistance relay AR, of say 20 ohms, in series with a clutch magnet P, of say 130 ohms; both relay and magnet are effectively shunted by a spark-quenching circuit consisting of a resistance R3 and a series connected condenser C3. In the em-

bodiment shown, resistance R8 has a value of about 400 ohms and the condenser C3 a capacity of about 1 microfarad. The invention, however, is not limited to the specified values or range of values. Any resistance and capacity serving the purpose may be usefully applied. A back contact pressure of 20 grams is recommended, but successful results have been obtained with a relay having a lesser back contact pressure, of say 10 grams.

C1 and C1' are mica capacitors, C2 and C2' are electrically polarized capacitors, but may consist of paper depending upon the frequency of the A. C. source feeding the rectifiers. C3 is a paper capacitor. The seven independent resistances R1-R7, R1'-R7' are of the radio type.

There is ample margin in the resistances shown in Fig. 1 so that relatively inexpensive standard stock may be used, i. e. resistor R1 may be 110,000 ohms instead of 100,000 ohms and so on. Apart from that, resistance and capacitor values depend on the structure of the circuits and their elements and, therefore, may assume widely varying values without exceeding the scope of this invention.

One is not bound to apply the discrete potentials to two electron discharge paths. Neither is it necessary to feed the common output of these electron discharge paths to a single gas discharge path. If required, any number of electron discharge paths, including a single one, and any number of gas discharge paths may be provided to cause one or more accurate control operations.

Electron discharge may be substituted for gas discharge or gas discharge for electron discharge; gas discharge operation may also be replaced by an electromechanical one such as relay action, without exceeding the scope of this invention.

What we claim is:

1. In a switching system, means for discharging electrons in two separate streams including grid, cathode and anode in each stream, a common receiving circuit connected to the anodes, means including magnet-operated stepping switches for applying a number of discrete potentials, one at a time to each grid, means for maintaining the discrete potentials applied to the grid in one stream in a constant relation with the potentials applied to the cathode in the other stream, the potential maintaining means including a resistance in series with each grid, a source of D. C. potential connected between said resistance and the potential applying means, and means operated from said common receiving circuit to control at least one of the stepping switch magnets when the discrete potentials applied to the different grids bear a predetermined relationship.

2. A system according to claim 1 in which said D. C. source of potential includes a capacity shunted balancing resistance, A. C. fed cathode heating means, rectifying means, transformer means having a primary coupled to the cathode heating means and a secondary coupled through the rectifying means to one end of the biasing element, said secondary having a center tap coupled to the other end of the biasing element.

3. In a control system, an electron discharge tube containing two like multi-electrode structures, means for applying to an input electrode in each structure a series of discrete potentials, one at a time to each input electrode, a common receiving circuit including an output electrode in each structure and operated when the potentials applied to the input electrodes are substantially

equal, a balancing resistance for each input electrode, rectifying means and A. C. fed transformer means connected to apply the same constant biasing potential through said rectifying means and said balancing resistance to each input electrode, said biasing potential being of the order of the potential difference between successive discrete potentials.

4. Apparatus for comparing two potentials to control an automatic switch in accordance therewith, comprising two sources of pluralities of discrete potentials, an automatic switch, electron discharge means for receiving a potential from each source and producing an operating voltage when they are substantially equal, said means comprising electrodes including two cathodes, two control grids and at least one anode which afford two discharge paths, each control grid and each cathode being associated with one of the paths, means for heating the cathodes with alternating current, means responsive to the operating voltage to control the automatic switch including a gas discharge tube having a control electrode, a control gap and a main gap, means for selecting a discrete potential from one of the sources and applying it to the control grid associated with one path and to the cathode associated with the other path, means for applying an ungrounded biasing potential between said grid and said cathode, means for applying an ungrounded biasing potential between the other grid and the other cathode, means for operating said automatic switch to successively apply individual potentials from the other source to said other control grid and said other cathode, a common output circuit for the two electron discharge paths including an anode resistance and a source of anode potential connected in series, means for connecting the control electrode of the gas tube to said output circuit at the end of said anode resistance farthest from said source of anode potential, a source of energizing potential for the main gap of the gas tube, the means responsive to the operating voltage also comprising means including a relay connected in series with said main gap for responding to a discharge of the gas tube to arrest the operation of said automatic switch, each of the means for applying biasing potential comprising a transformer including a primary connected to said means for heating and a secondary, at least one condenser and one rectifier arranged in series and connected across at least a portion of said secondary, and a biasing resistance connected across the condenser and connected on its one end to a control grid and

on its other end to a cathode, whereby when the potentials applied to both grids and both cathodes are substantially equal a gas tube will be ionized to arrest the operation of the automatic switch.

5. Apparatus for comparing as in claim 4, and in which said means for selecting a discrete potential comprises a register switch having a plurality of contacts and a wiper adapted to engage the contacts and means for setting the register switch, one of the sources of discrete potentials is connected to the register switch to apply discrete potentials individually to contacts of said switch, said automatic switch is a selector switch having a plurality of test contacts, and a brush adapted to engage the test contacts, said means for operating includes means for moving the brush over the test contacts, the other source of discrete potentials is connected to the selector switch to apply discrete potentials individually to test contacts, the means for responding to a discharge of the gas tube is adapted to disable said means for moving the brush, and there is included a means for preventing false operation of the electron discharge means comprising a first circuit including in series a current limiting resistance and a source of mismatching potential and a second circuit including another current limiting resistance, one of said circuits being connected between said wiper and ground and the other of said circuits being connected between said brush and ground.

6. Apparatus for comparing as in claim 4, which also includes means for preventing false ionization of the gas tube if a transient voltage corresponding to said operating voltage should be applied to said control electrode including a condenser connected across the control gap and a bleeder resistance connected in parallel to said condenser.

7. Apparatus for comparing as in claim 4, in which the electron discharge means comprises a twin diode.

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