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GAS DIODE FLIP-FLOP OR REGISTER CIRCUIT

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FIG. 1

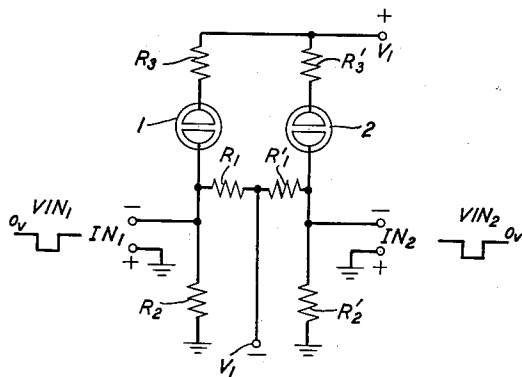


FIG. 2

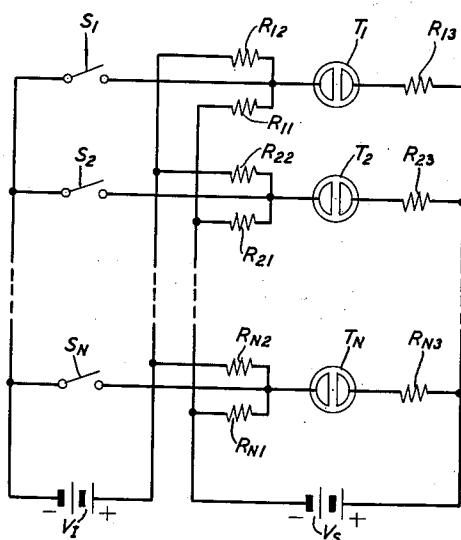
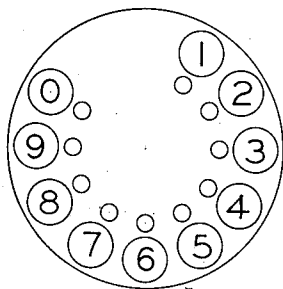


FIG. 3



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GAS DIODE FLIP-FLOP OR REGISTER CIRCUIT

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This invention relates to dialing equipment for telephone subscriber subsets and more particularly to circuitry for push-button dialing.

In preliminary studies involving push-button dialing, some users have found difficulty in dialing properly, resulting in an excessive number of wrong numbers and incomplete calls. When a user presses on a non-locking type push-button corresponding to the digit which he has selected and he does not press with much force, he is not sure whether he has momentarily closed the corresponding circuit and has thereby successfully dialed that digit or not and is likely to become confused. He then either presses the same button again, assumes that he has successfully dialed that digit and continues, or hangs up and starts all over. It is apparent that this confusion can lead to all types of improper dialing resulting in undue tie-up and inefficiency in the utilization of central office switching equipment. Since one of the purposes of push-button dialing is to reduce the dialing time and thereby increase the efficiency in the utilization of central office equipment, it is imperative that such difficulties be minimized. In certain types of push-button dialing equipment it was found that this difficulty was due in part to lack of kinesthetic feedback reinforcement or in other words the sense of touch was not sufficient to indicate to the user that he had depressed the push-button sufficiently to have successfully dialed his selected digit.

Another source of difficulty and one which prevails not only with the push-button type of dialing but also with the present rotatable dial is that the user in dialing a subscriber number which has an extensive number of digits sometimes becomes confused as to which was the last digit that he dialed, thereby resulting in incomplete calls, wrong numbers and re-dialing. In order to provide a commercially acceptable solution to the aforementioned problems it is evident that any device produced for this purpose must be simple, inexpensive, and require the least possible maintenance since this device would necessarily be located with the user or subscriber equipment rather than at the central office.

It is therefore an object of this invention to increase the efficiency of central office switching equipment which utilizes push-button dialing by increasing the percentage of properly dialed calls.

Another object of this invention is to aid a user who is operating a push-button dial telephone in properly dialing the number he has selected.

A preferred embodiment of the invention is an array of push-buttons and glow discharge tubes arranged in a convenient manner to comprise a self-clearing, visual read-out register which "remembers" each input pulse or event until the next input event. When a user selects a desired digit and presses on the corresponding push-button, nothing happens until the push-button has been depressed sufficiently to have successfully dialed the digit, and at that moment a glow discharge tube corresponding to the dialed digit fires and glows brightly until the user releases the push-button, and then glows dimly until the

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next input event, that is until the next desired digit is selected and its corresponding push-button depressed sufficiently. The process repeats itself except that as soon as the glow discharge tube corresponding to the then selected digit begins to conduct, the glow discharge tube corresponding to the last selected digit is extinguished. Therefore, it can be seen that this device not only indicates when and if the selected digit has been successfully dialed but also "remembers" the last digit dialed as well.

The invention is described in more detail in the following discussion relating to the drawing in which:

Fig. 1 is the basic form of the self-clearing, visual read-out register and has many characteristics of a flip-flop circuit;

Fig. 2 is a general form of the self-clearing, visual read-out register of any number of inputs; and

Fig. 3 is an illustration of a push-button dial face employing a ten-tube, self-clearing register circuit of the type illustrated in Fig. 2.

In Fig. 1 there is shown the basic form of the self-clearing, visual read-out register as arranged for two control inputs. In this form the register, which has many of the characteristics of a flip-flop circuit, is comprised of gas-filled glow tubes 1 and 2, anode resistors R_3 and R_3' , cathode resistors R_2 and R_2' , cathode-interconnecting resistors R_1 and R_1' , and a source of holding or sustaining voltage indicated at V_1 . The holding voltage V_1 is high enough to maintain tubes 1 and 2 conducting when they are in a conducting state, but not high enough to initiate glow discharge. If we apply a pulse V_{IN1} of the polarity shown in Fig. 1 to input IN_1 , it will appear across resistor R_2 and divide among resistors R_1 , R_1' , and R_2' . If the input pulse V_{IN1} at input IN_1 is of sufficient amplitude it will fire tube 1 because the voltage drop across resistor R_1 will add to and increase the voltage from plate to cathode of tube 1. However, because of the polarities involved tube 2 will "see" the holding or sustaining voltage V_1 minus the voltage drop across resistor R_1' and therefore will not fire.

As soon as tube 1 fires there is an instantaneous drop in voltage across tube 1 because the whole of the sustaining voltage V_1 is no longer across tube 1 but is divided among the resistor R_3 , tube 1 and resistor R_1' . But also adding to the voltage across tube 1 at this time is the voltage across resistor R_1 which is caused by the input voltage V_{IN1} which is applied to input IN_1 . At this time the glow discharge tube 1 will glow with a first level of illumination which will be called "brightly." As soon as the pulse V_{IN1} is removed from the input IN_1 that part of the voltage which was due to the voltage V_{IN1} and appeared across resistor R_1 no longer exists and does not add to the voltage drop across tube 1 and tube 1 therefore glows with a second level of illumination which will be called "dimly."

Now if we apply an input pulse V_{IN2} to input IN_2 of the polarity shown in Fig. 1, it will appear across resistor R_2' and be divided among resistors R_1' , R_1 and R_2 . Tube 2 will "see" the sustaining voltage V_1 plus the voltage drop across resistor R_1' due to the polarity of the voltage V_{IN2} at input IN_2 and if the voltage drop across resistor R_1' is of sufficient amplitude, tube 2 will begin glow discharge. Tube 1 will see its operating voltage minus the voltage across resistor R_1 and with the resistors R_1 , R_1' and R_2 chosen properly will have its electrode potential difference reduced to such a value that it will be extinguished. The next pulse at input IN_1 will cause tube 1 to fire and tube 2 to extinguish, and so on, in typical flip-flop fashion.

Three or more of the tube circuits of Fig. 1 may be connected to form a self-clearing register such as that shown in Fig. 2. In Fig. 2 the holding voltage is supplied by a battery V_6 common to all tubes and the firing poten-

tial V_I is shown supplied by another battery through individual input switches $S_1, S_2 \dots S_n$. Whenever any one of the input switches is momentarily closed, the glow tube associated with it will begin conducting and will glow brightly as long as the input switch is closed. This occurs because part of the firing voltage V_I will appear across that tube in aid of sustaining voltage V_s . Also any other tube previously conducting will be extinguished because part of firing voltage V_I will appear across every other tube but in such a manner as to subtract from the existing voltage across these tubes and when the firing voltage V_I is of sufficient magnitude it will extinguish any conducting tube. As soon as the selected input switch is opened the glow tube then conducting will continue to conduct but will glow dimly since the removal of the firing voltage V_I removes that part of that voltage that appeared across the tube. Thus, the circuit has self-clearing register action and it also "remembers" the most recent input event.

The read-out from the circuit may be visual, or it may be electrical and non-destructive or both. For electrical read-out in the foregoing example, the drop across any of resistors $R_{13}, R_{23} \dots R_{n3}$ is zero for nonconducting tubes, a first predetermined value for a conducting tube which has its input switch momentarily closed and a second predetermined value after the momentarily closed switch is released. The circuit is degenerative in that the output voltage is less than the input.

Referring now to Fig. 3 there is illustrated a preferred form of the invention which comprises a dial face having ten non-locking push-buttons each representing a digit and each having associated therewith a glow discharge tube. When a user selects a digit and presses on the push-button corresponding to that digit with sufficient force the glow tube associated therewith glows brightly for reasons previously described and when the user releases the push-button the glow tube continues to glow but dimly this time. When the user selects the next digit and causes the associated glow tube to glow brightly, the tube associated with the last selected digit and which was glowing dimly is extinguished and so on.

For purposes of simplicity in a general circuit explanation applicable to both Fig. 1 and Fig. 2, let us assume that resistors $R_1=R_{11}=R_{12}=R_{21}=R_{n1}$,

$$R_2=R_{22}=R_{12}=R_{22}=R_{n2},$$

and $R_3=R_{13}=R_{23}=R_{n3}$, and therefore they may be referred to as simply R_1, R_2 and R_3 , respectively. Let V_I be the input voltage, V_F be the minimum electrode voltage required to initiate glow discharge in a tube, V_M be the minimum electrode voltage at which glow discharge may be maintained, and V_s be the sustaining or holding potential. Then the differential control voltage is given by

$$\Delta V = V_F - V_M \quad (1)$$

For the case of two tubes as shown in Fig. 1, the minimum value of R_3 is set by the maximum current I_{max} which can be allowed to flow through the glow tube. If we assume the worst possible condition namely, that the tube has zero internal resistance, we have

$$I_{max} = \frac{V_s(2R_1 + R_2) + V_I R_1}{R_1^2 + 2R_1 R_3 + R_2 R_3 + R_1 R_2} \quad (2)$$

and

$$R_3 = \frac{V_s(2R_1 + R_2) + V_I R_1 - I_{max}(R_1^2 + R_1 R_2)}{I_{max}(2R_1 + R_2)} \quad (3)$$

is the minimum permissible value of R_3 . In practice, R_3 will usually be several times this value.

R_1 and R_2 have been chosen equal for simplicity in discussing circuit action. However, it will be found desirable to make $R_2 < R_1$ so that as much of the input voltage as possible may be supplied to the glow tube holding circuits through the R_1 's. The lower limit to R_2

is set by the fact that as $R_2 \rightarrow 0$, so does the input resistance of the circuit. A ratio $R_2:R_1:R_3::1:10:100$ should be usable if the resultant low input resistance can be tolerated. For the two-tube flip-flop the input resistance is given by

$$R_I = \frac{2R_1 R_2 + R_2^2}{2(R_1 + R_2)} \quad (4)$$

For the case of n tubes as in Fig. 2, this generalizes very simply to

$$R_I = \frac{n R_1 R_2 + R_2^2}{n(R_1 + R_2)} \quad (5)$$

For the two-tube case, a good choice for the holding voltage V_s is midway between firing and extinguishing, i.e.

$$V_s = V_M + \frac{\Delta V}{2} \quad (6)$$

This sets the minimum input voltage requirement at

$$V_I = (2R_1 + R_2) \frac{\Delta V}{2R_1} \quad (7)$$

An input voltage greater than this should be chosen for reliability of circuit operation.

For $n > 2$, V_I must be increased further in order to be certain of extinguishing all other glow tubes while initiating discharge in the desired one. Some help in this regard might be gained by making V_s less than the value given by (6), but the limit here is that, necessarily

$$V_s \geq V_M \quad (8)$$

The assumption has been implicit here that the characteristics of all n glow tubes were identical. In actuality this is never the case. The effect of variations in tube characteristics is to reduce ΔV for the entire circuit. Tubes should be selected and perhaps also should be aged.

From the foregoing discussion it is apparent that the user is aided substantially in properly dialing his selected number. First of all the lack of kinesthetic feedback reinforcement or the inability of his sense of touch to relate back to him when he has successfully dialed a digit is partially cured by visual feedback when the glow discharge tube glows brightly upon activation. Secondly the user is aided in remembering what digit he has dialed last by the glow tube radiating dimly until the next digit is successfully dialed. Thirdly the lack of either the bright indication or dim indication denotes that neither condition associated with these indications is present thereby also giving information to the user.

What is claimed is:

1. In a push-button signaling system, an array of non-locking push-button switches corresponding to a selected number of digits, an array of glow discharge tubes associated with said push-button switches, resistive circuit means for interconnecting said tubes and said push-button switches, means for applying a firing potential, by closing a selected push-button switch, to the glow discharge tube associated with said selected switch to cause said associated tube to provide a first indication, and means for applying a sustaining potential to provide a second indication when said selected push-button switch is subsequently opened.

2. A push-button signaling system as in claim 1 wherein said resistive circuit means causes said associated glow tube to provide a third indication responsive to the closing of the next selected push-button switch.

3. A push-button signaling system as in claim 2 wherein said first indication is a visible light of a first level of illumination and said second indication is a visible light of a distinguishable second level of illumination and said third indication is the absence of any illumination.

4. A push-button signaling system as in claim 2 wherein said first indication is an electrical potential of a first value and said second indication is an electrical

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potential of a second value and said third indication is an electrical potential of a third value.

5. In combination, a plurality of gas-filled tubes, a first source providing a sustaining potential for said tubes, a resistive network interconnecting said tubes, an input lead associated with each tube and its corresponding position in said resistive network, a source of firing potential, and means for selectively connecting said firing potential to any of said input leads whereby said firing potential is applied to said resistive network, said resistive network causing part of said firing potential to add to the sustaining potential across the tube associated with said selected lead and to subtract from the sustaining potential across the remainder of said tubes, whereby the tube associated with the selected lead is fired and the remainder of said tubes is extinguished.

6. In combination, a plurality of gas-filled tubes, a first source providing a sustaining potential for said tubes, an input lead associated with each of said tubes, a source of firing potential, means for selectively connecting said firing potential to any of said input leads, and resistive means for interconnecting said tubes such that part of said firing potential is added to the sustaining potential across the tube associated with said selected lead and subtracted from the sustaining potential across the remainder of said tubes, whereby the tube associated with the selected lead is fired and the remainder of said tubes is extinguished.

7. In combination, a pair of gas-filled diode tubes, a first source of sustaining potential for said tubes, an input lead associated with each of said tubes, a source of switching potential, means for alternately applying said switching potential to said input leads, and resistive means for

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interconnecting said tubes such that part of said switching potential is added to the sustaining voltage across the tube associated with the lead having the switching potential thereon and part of said switching potential is subtracted from the sustaining potential across the other tube, whereby one tube is alternately switched "on" and the other "off."

8. In combination, a plurality of gas-filled diodes, a first source providing a sustaining potential for said tubes, an input lead associated with each of said tubes, a firing potential, means for selectively connecting said firing potential to any of said input leads, and a resistive network interconnecting the cathodes of said tubes in such a manner that part of said firing potential is added to the sustaining potential across the tube associated with the selected lead and part of said firing potential is subtracted from the sustaining potential across the remainder of said tubes, whereby the tube associated with the selected lead is fired and the remainder of said tubes is extinguished.

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