

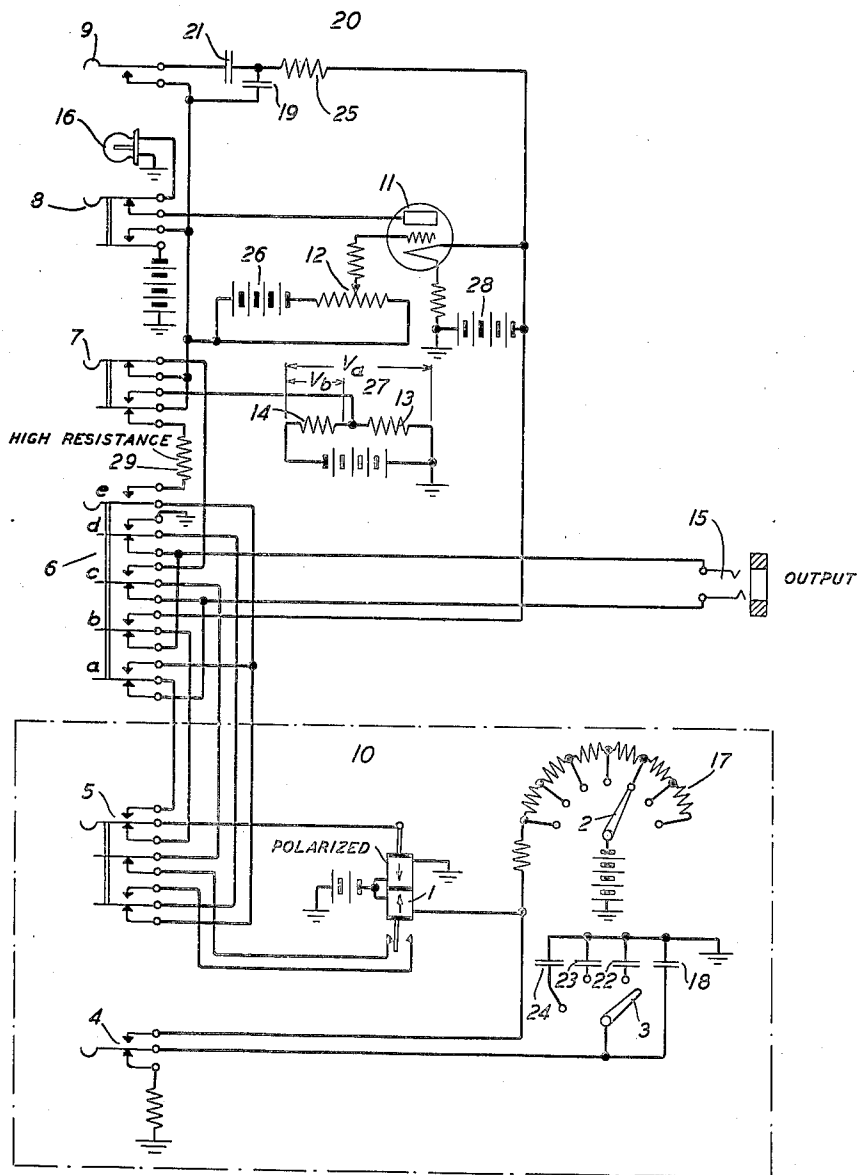
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IMPULSE CIRCUIT

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IMPULSE CIRCUIT

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This invention relates to an impulse producing circuit and more particularly to one capable of producing accurately timed single impulses under manual control. A feature of the invention is the use of a checking circuit to guard against the production and transmission of an impulse longer or shorter than that for which the impulse producing means has been calibrated.

In the first place, impulse producing apparatus now available, makes use of a series of impulses which makes it necessary to perform switching operations at the end of each make or break period of an impulse to initiate the immediately subsequent break or make period respectively. Usually the switching is accomplished by means of relays which release to initiate break and make intervals. These switching operations always introduce errors due to contact chatter and the variable functioning time of relays. If the time interval to be measured is short, the functioning time of the relays performing the switching operations is a very large percentage of the interval being measured and, since relays having sufficient contacts to do the switching are not accurate in functioning time, a large percentage of error may be introduced by them. For this reason it appears desirable to use a circuit

impulse is wanted, each single impulse, within controlled limits, being no different from any other impulse. Further, a checking circuit is provided which is capable of detecting the smallest variations in the limits of an impulse beyond the point of calibration.

In accordance with the invention, therefore, one specific embodiment of which is herein disclosed by way of illustration, this is accomplished in the following improved manner: The impulse producing means comprises a polarized relay whose operating winding is in series with a condenser and in parallel with a resistance, and whose biasing winding is in a local circuit to keep the relay normally on its back contact.

The relay is operated immediately upon the closure of the circuit through the condenser and operating winding and the length of time taken for the relay to release after the condenser is fully charged depends upon the time taken for the charging current to decay to the point when the magnetic flux due to the biasing winding overpowers that due to the value of the decaying current. This time is a function of the capacity of the condenser and the value of the parallel resistance and is found to be expressible by the following formula:

$$(1) \text{releasing time } t = 2.3 RC \log_{10} \frac{(\text{initial ampere-turns in condenser winding})}{(\text{ampere-turns in biasing winding}) - (\text{ampere-turns required to operate relay})}$$

which does not require the switching operations by auxiliary relays and in which, therefore the functioning time of only one relay enters into the output interval to be measured.

Secondly, if it is assumed that a single impulse type of circuit is necessary, then it is desirable to devise some method for checking and calibrating such a circuit because the methods used in checking or calibrating circuits producing a series of impulses cannot be used. To check a circuit producing a series of impulses it is necessary to use a "per cent break" meter to determine the per cent of the pulse cycle (that is, the "break" or "make") and then determine the length of the cycle by measuring the time of a large number of cycles with a stop-watch and cycle-counter. The data may then be used to determine the time of the make or break. Obviously, the per cent break meter, the cycle-counter and stop-watch cannot be used with a single impulse circuit because the length of the pulse cycle (make plus break) is under the control of the operator.

My invention avoids both of these difficulties since small open or closed intervals can be obtained by the operation of a key when and if an

where R = the value of the resistance in ohms and
 C = the value of the capacity in farads

Clearly, with any given capacity, the releasing time is a function of the resistance since all the other terms of the equation are constants of the relay and, accordingly, a range of releasing times can be determined for different values of the parallel resistance and in which said values can be calibrated in terms of said releasing times. The circuit of the impulse relay is, in turn, placed under the control of a key so that the circuit of the impulse producing relay is closed only when the key is operated, thereby producing impulses only as and when required. These impulses are then transmitted either from the back contact of the relay, if an open period is desired, or from the front contact, if a closed period is desired.

The means for checking the accuracy of the impulse produced comprises a circuit having a gas-filled tube the potential of whose grid is controlled by a resistance and condenser whose time of charge to a given potential that will cause the tube to flash may be computed for, and made equal to, the predetermined time-duration which

is a little less than the time of the impulse. If the condenser controlling the grid potential is started to charge when the impulse relay produces the make or break initiating the timed impulse, and is prevented from charging further by the make or break of the impulse relay contacts at the end of the timed impulse, then the voltage on the condenser will be a measure of the length of the impulse produced. If the impulse is of a longer duration than that taken to charge the grid condenser to the voltage that will cause the breakdown of the tube, said tube will flash and close its cathode-plate circuit which includes an alarm lamp the lighting of which indicates that the impulse is not too short. On the other hand, if the impulse is shorter than the time taken to completely charge the grid condenser to the potential at which the tube will flash, the condenser is short-circuited, or its charging circuit is opened, and the tube is prevented from flashing and lighting the alarm lamp, indicating that the pulse is too short, in which event the impulse producing relay is readjusted to the required time of operation. If, on the other hand, the tube does break down it is an indication that the pulse is not too short. A second check is then made with a second condenser connected in parallel with the grid condenser, the combined charging time of which is just a little longer than the required length of the pulse. If the impulse is of a longer duration than this charging time, the tube will again flash and light the alarm lamp as a signal that the impulse is too long, in which event the impulse producing relay is readjusted to closer limits until the impulse produced will cause the tube to break down in the charging time of the first condenser but not in the charging time of the two condensers in parallel.

A clearer conception of the scope and purpose of the invention may be obtained from the following description and attached drawing which show the impulse producing circuit 10 combined with the checking circuit 20. The impulse producing circuit consists of a polarized relay 1 whose operating circuit extends from battery through the lower operating winding, top contacts of key 4, condenser 18 to ground and, in parallel with the lower winding of said relay, through variable resistance element 17, contact arm 2 to battery. The checking circuit 20 consists essentially of a three element ionic gas-filled tube 11, variable potentiometer 12, a fixed potentiometer 27 having resistance elements 13 and 14, timing condensers 19 and 21 and control keys 6, 7, 8 and 9.

In order to cause relay 1 to produce a pulse of a definite duration, contact arm 2 is positioned into contact with some one resistance point which has been predetermined in value in conjunction with fixed capacity 18 for a given operating time for the relay 1. Key 4 is then operated and a charging circuit is closed for relay 1 extending from battery through its lower winding, top contacts of key 4, condenser 18 to ground. Relay 1 operates due to a surge of current through its operating winding and condenser 18. When condenser 18 is charged, the charging current thereafter decays to a point which allows the low turn upper winding of relay 1 to release the relay. The closed or open intervals are obtained at the output jack 15 from the front or back contact of relay 1 as follows: For the open period the output path extends from the armature of relay 1, top normal contacts of key 5, normal contacts of

the "b" set of contacts of key 6, to the tip of jack 15, through the testing receiving loop (not shown), ring of jack 15, normal contacts of the "c" set of contacts of key 6, middle contacts of key 5, to the back contact of relay 1. For the closed period, key 5 is operated and the output path is traced from the armature of relay 1, top outer alternate contacts of key 5, normal "a" contacts of key 6, to the ring of the output jack 15, through the testing receiving loop (not shown), tip of the output jack, normal "d" contacts of key 6, bottom alternate contacts of key 5, to the front contact of relay 1.

It will doubtless be necessary to calibrate the timing relay 1 to the correct time desired by using a tapped capacitance 22, 23 and 24. By means of this capacitance, the circuit is calibrated when set by means of switch arm 2 and tapped resistance 17 for a certain length of pulse (e. g. .020 second) so that it does deliver this length of pulse. When it has been calibrated at this setting it will be in proper calibration for other settings of switch arm 2. That is, while the pulsing circuit has been empirically determined to give different operating times by the selection of suitable shunt resistances in parallel with the fixed capacity 18 yet, due to mechanical variables, the resulting operating time may vary within certain limits. When this occurs, the operating time may be corrected for any given resistance by adding additional capacity to the value of capacity 18, since from formula (1) if the resistance is kept constant (having been previously calibrated in terms of definite operating times) the capacity can be varied. These capacities are indicated as 22, 23 and 24. Once this correction factor is applied for the value of one resistance (and for one operating time) the same factor will be effective in correcting the error throughout the entire range of the calibrated resistance 17, as is evident from formula (1).

The checking circuit 20 is arranged to check either the make or the break period produced by relay 1. With key 6 operated, a charging circuit for condenser 19 is closed during the duration of the output pulse and the voltage on this condenser, as measured by means of a "trigger" tube 11, determines the length of the pulse.

The procedure to be followed in checking the open period will now be given: Keys 6 and 1 are first operated. The potentiometer 12 is then adjusted until the tube "breaks down" and closes the plate circuit to lamp 16 which lights. Key 7 is then released and the lamp and tube are restored by the momentary operation of key 8. Key 4 is now operated momentarily. This causes relay 1 to operate and release as already described. While the back contact of relay 1 is opened, condenser 19 charges in a circuit extending from ground and negative battery 28, resistance 25, condenser 19, lower normal contacts of key 7, high resistance 29, "e" contacts of key 6, lower normal contacts of key 5, "d" alternate contacts of key 6, to ground. If the voltage across the plates of condenser 19 rises high enough, tube 11 will break down and complete the circuit of lamp 16 which lights. Since the capacity of condenser 19 is chosen to be of such value that its charging time to the breakdown potential of the tube is a little less than the required length of the pulse, then the fact that the tube breaks down indicates that the pulse is not too short. However, if the pulse is terminated before the tube breaks down, that is, if relay 1 releases and closes its left or back con-

tact, condenser 19 is short-circuited via the top contacts of key 7, "c" alternate contacts of key 6, middle contacts of key 5, left contact of relay 1, top normal contacts of key 5, "b" alternate contacts of key 6, and resistance 25. The tube is thus prevented from flashing, indicating that the pulse is too short. If, on the other hand, the tube breaks down before relay 1 releases, indicating that the pulse is not too short, the tube is restored by the operation of key 8. Key 9 is then operated to introduce condenser 21 in parallel with condenser 19 and the test is repeated. The combined capacity of condensers 21 and 19 is such that the time taken to charge both to the breakdown potential of the tube is a little longer than the length of the pulse. When key 4 is operated again for the next output pulse, lamp 16 should not operate if the pulse is within the required limits. If it does, the pulse is too long and relay 1 must be readjusted to give a pulse within these limits.

Obviously the check may be inaccurate if there is any variation in voltage or in the characteristics of the tube. In order to make the check practically independent of these variations the circuit is arranged so that the tube always breaks down if the breakdown voltage reaches an arbitrary percentage of the applied voltage in the time interval to be checked. For the open period, for instance, tube 11 is normally blocked by the negative bias of battery 26 so that the voltage across the condenser 19 required for breakdown will be about seven-tenths of the applied voltage. The charging circuit for condenser 19 is through the high resistance 25. The value of this resistance and that of capacity 19 are computed, knowing the time for which the pulse producing circuit is to be checked and the percentage of the applied voltage to which condenser 19 is to be charged in this time. For example, if a time interval of .020 second is to be checked and the voltage is to rise to 70 per cent of the applied voltage in this time, the value of resistance 25 and capacity 19 can be computed from the following formula:

$$R_{25}C_{19} = \frac{t}{1 - \frac{\log_e 1}{\log_e 1 - \text{ratio of condenser voltage to applied voltage}}}$$

After the proper values of capacity and resistance have been chosen then, in a fixed time (.020 second), the voltage across condenser 19 will rise to a fixed percentage (70 per cent) of the applied voltage regardless of the value of the applied voltage. Hence, in order to check the fixed time (.020 second), the circuit must be arranged so that it can be adjusted to cause the tube 11 to break down when the voltage across condenser 19 reaches the chosen percentage (70 per cent) of the applied voltage; that is, when the time being checked (.020 second) has elapsed. This is done as follows:

When key 7 is operated, a voltage V_b is placed across condenser 19 determined by the fixed potentiometer 27, the value of whose fixed resistances 13 and 14 are so selected that voltage V_b is 70 per cent or a predetermined percentage of the applied voltage V_a , and is therefore the same percentage of the applied voltage which the condenser 19 will attain in the time interval to be measured. The potentiometer 12 is then adjusted as described above until tube 11 breaks down. Under such a condition the tube will always break down when the voltage across condenser 19 reaches a certain fixed percentage (70 per cent) of the applied voltage and will there-

fore always break down in the fixed time (.020 second).

It will be observed that this arrangement and procedure makes the circuit independent of applied voltage and tube characteristics. In fact it should be possible to interchange tubes without affecting accuracy.

The make pulse is similarly checked. Key 5 is operated and the sequence of operation of the other keys is the same as it is when an open period is being measured. During the time relay 1 is operated, the charging circuit to the condenser 19 is closed.

What is claimed is:

1. In a signaling system for the production of impulses of checked duration, means including a pair of contacts for generating an impulse of predetermined duration, and means for checking the duration of said impulse comprising a condenser, a source of current, a circuit for charging said condenser from said source, a circuit controlled by said contacts for rendering said charging circuit effective during the transmission of said impulse, a gaseous conductor tube associated with said condenser which is rendered conducting when said condenser becomes charged to the breakdown potential of said tube, and an alarm device operative in a path through said tube when said tube becomes conducting to indicate that the transmitted impulse is of sufficient duration.

2. In a signaling system for the production of impulses of checked duration, means including a pair of contacts for generating an impulse of predetermined duration, and means for checking the duration of said impulse comprising a condenser, a source of current, a circuit for charging said condenser from said source, a circuit controlled by said contacts for rendering said charging circuit effective during the transmission of said impulse, a gaseous conductor tube having a control electrode, a cathode and an anode, said condenser being bridged across said control electrode and said cathode and effective when charged to a definite potential to cause said tube to flash and an alarm device operative over the cathode-anode circuit of said tube to indicate that the transmitted impulse is of sufficient duration.

3. In a signaling system for the production of impulses of checked duration, means including a pair of contacts for generating an impulse of predetermined duration, and means for checking the duration of said impulse comprising a first condenser, a second condenser, a key for connecting said condensers in parallel, a source of current, a circuit for charging said condensers from said source, a circuit controlled by said contacts for rendering said charging circuit effective during the transmission of said impulse, a gaseous conductor tube associated with said condensers which is rendered conducting when said condensers are charged to the breakdown potential of said tube, and an alarm device operative in a path through said tube when said tube becomes conducting to indicate that the transmitted impulse is of too long duration.

4. In a signaling system for the production of impulses of checked duration, means including a pair of contacts for generating an impulse of predetermined duration, and means for checking the duration of said impulse comprising a condenser, a source of current, a circuit for charging said condenser from said source, a circuit controlled by said contacts for rendering said

charging circuit effective during the transmission of said impulse, a gaseous conductor tube associated with said condenser which is rendered conducting when said condenser is charged to the breakdown potential of said tube, an alarm device operative in a path through said tube when said tube becomes conducting to indicate that the transmitted impulse is of sufficient duration, a second condenser and a key for connecting said condensers in parallel in said charging circuit, said tube being rendered conducting to operate said alarm device to indicate that the transmitted impulse is of too long duration if said condensers become charged to the breakdown potential of said tube during the transmission of said impulse.

5. An impulse producing circuit having means for producing single impulses of predetermined duration, and means for checking the accuracy of each of said impulses comprising a thermionic device which is conductive at a definite breakdown potential, means operable during the impulse period for producing said breakdown potential in an interval slightly longer than the predetermined interval of the impulse, and means for applying said potential to said thermionic device to render it conductive if the impulse is longer than its predetermined value.

6. An impulse producing circuit comprising manually controlled means for producing single impulses of predetermined duration, and means for checking the accuracy of said impulses comprising a thermionic device which is conductive at a definite breakdown potential, means for producing and applying said potential to said thermionic device in a time interval slightly exceeding the predetermined period of the impulse, and manually controlled means for varying the time to produce said breakdown potential to any comparable value of the predetermined impulse period.

7. An impulse producing circuit comprising manually controlled means for producing single impulses of predetermined duration, a thermionic device which is conductive at a definite breakdown potential, means rendered operative at the beginning of the impulse for producing a breakdown potential on said thermionic device in a period of time exceeding the predetermined duration of the impulse, and means responsive to the conductivity of said thermionic device after said breakdown potential is applied for indicating that the impulse is longer than its predetermined value.

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