Sept. 14, 1937. D. G. C. LUCK 2,092,887

IMPULSE OPERATED RELAY

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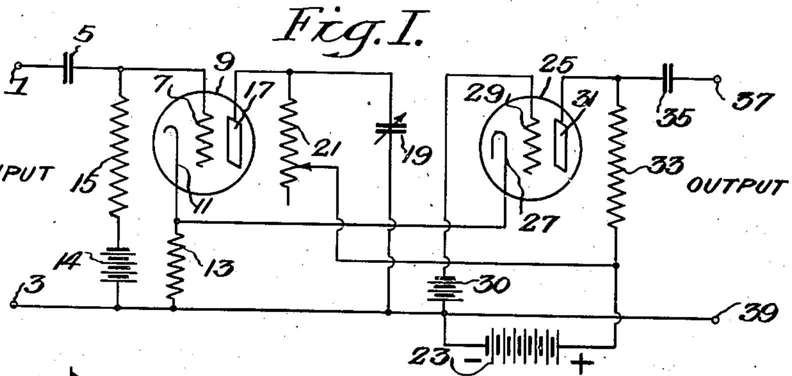
Fig. I.



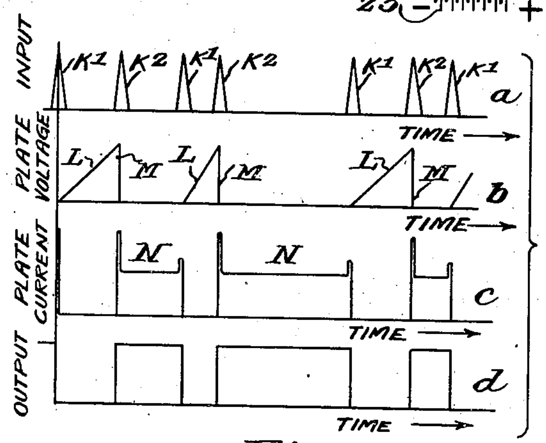
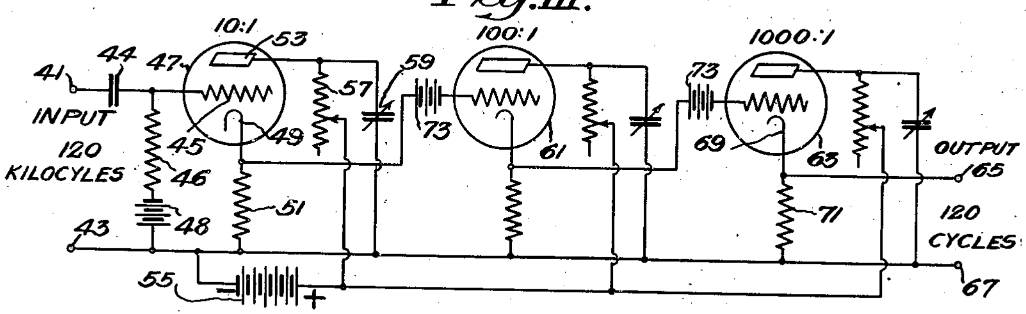


Fig. II.

Fig. III.



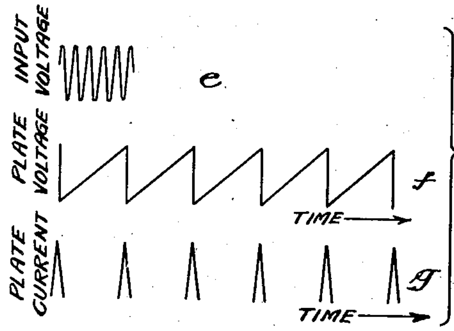


Fig. IV.

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IMPULSE OPERATED RELAY

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Application October 31, 1935, Serial No. 47,675

9 Claims. (Cl. 250—27)

My invention relates to impulse operated relays. Specifically, my invention is a gas tube relay and circuit therefor for alternately starting and stopping current flow by, or for indicating every nth one of, a series of voltage pulses.

I am aware of the so-called relaxation oscillator whose output circuit is usually comprised of capacitance and resistance. The time constant, which is the product of the capacitance, times the resistance, determines the frequency of a series of voltage impulses. These impulses are generally of a saw-tooth wave form. I have found certain critical, and heretofore unknown, relations between the voltage and the current in a gas tube relay which may be used to generate currents of several useful wave forms.

One of the objects of my invention is to generate a series of duration-modulated "dots" or "dashes" of current which are started and stopped by a series of variably timed identical voltage impulses.

Another object of my invention is to devise means for indicating every nth impulse of a series of voltage impulses.

Additional objects will be apparent from a consideration of the accompanying specifications and appended claims.

My invention may be best understood by reference to the accompanying drawing in which

Figure I is a schematic diagram of one embodiment of my invention,

Fig. II, comprising curves II*a*, II*b*, II*c*, and II*d*, is an illustration which shows graphically the operation of Fig. I,

Fig. III is a circuit diagram of an embodiment of my invention which may be used to indicate every nth impulse of a series of voltage impulses, and

Fig. IV is an illustration of the plate voltage and plate current characteristics of one of the tubes used in Fig. III.

In Fig. I a pair of terminals 1, 3, represent the input to the network. One of these terminals 1 is serially connected through a capacitor 5 to the grid electrode 7 of a gas filled relay tube 9. This tube may be an RCA type 885, or the like. The filament of cathode 11 is heated by a suitable source of current. The heating battery is omitted for simplicity. The cathode 11 is connected to the remaining input terminal 3 through a self-biasing and protective resistor 13. A biasing battery 14 may be used in addition to the self bias. The grid 7 is connected through the biasing battery 14 to the input terminal 3 by a grid resistor 15. The plate 17 is connected through a capacitor 19 to the lower terminal of the bias resistor 13. The plate is also connected through an adjustable resistor 21 to the positive terminal of a B battery 23. The negative terminal of the B battery is connected to the lower terminal of the bias resistor 13.

The output from the first tube 9 is taken across the bias resistor 13, which is connected to a second tube 25. This second tube may be any conventional tube, such as an RCA 56. The cathode 27 of the second tube is heated by a battery, or the like. This cathode 27 is connected to the cathode 11 of the first tube. The grid 29 is connected through a biasing battery 30 to the negative terminal of the B battery 23. The plate 31 is connected through a resistor 33 to the positive terminal of the B battery. The plate is also connected through a capacitor 35 to one of a pair of output terminals 37—39. The other output terminal 39 is connected to the negative terminal of the B battery. The operation of this circuit may be described as follows: If a series of voltage impulses are applied to the input circuit of a gas tube, the tube may operate with a steady discharge, or an oscillatory discharge of a saw-tooth pattern occurring at impulse frequency or a sub-multiple thereof. By suitable adjustments of the bias resistor, the plate voltage, and the variable capacitor, I have discovered a narrow region of unusual operating characteristics located between the continuous discharge and the oscillatory condition at impulse frequency. In this region, one impulse may be applied to the grid for initiating a discharge of the plate capacitor through the gas tube as in the state of normal oscillation. This discharge will not extinguish itself but will continue as a low current trickle discharge. In the case of the conventional adjustments, this discharge would extinguish itself immediately. The low current discharge continues until the next impulse is applied to the grid. Probably because of the low current discharge, the second impulse exerts a control action, which decreases the capacitor voltage which in turn extinguishes the discharge. This leaves the tube in its original condition in which the capacitor becomes charged through the anode resistor 21. The next impulse represents the beginning of a second cycle similar to the one just described.

In Fig. II*a* the impulse which initiates the discharge is represented as K^2. The plate voltage is represented by the graph LM of Figure II*b*, The low current discharge is represented by the horizontal portions of the graph N of Figure II*c*. The sharp rise and fall, or surge in the plate current at the beginning and end of each applied impulse may be eliminated by the action of the limiter tube **25**. This tube is adjusted to limit its own output currents to predetermined values. If the limiter tube is adjusted so that the steady low current discharge in the gas tube will provide sufficient bias to cut off the plate current of the limiter tube, then surges above this value will be limited or cut off by the output tube. The resulting output characteristic of the network is illustrated by Figure II*d*.

The saw-tooth wave form of Fig. II*b* may be regulated by adjusting the resistance and capacitance of the plate circuit. The most convenient method for adjusting the circuit constants is to connect a cathode ray oscillograph across the bias or protective resistor **13**. The constants of the circuit are then varied until the proper wave form appears in the oscillograph. The adjustment may likewise be made by connecting the oscillograph to the output terminals **37—39** of the network. Other critical operating conditions also exist between the various regions of normal operation but use has been found only for the one described.

By way of example, I have found that circuits of this type may be operated by impulses at a rate of about 20,000 per second. The resistor **13** should have a resistance not greater than a value ten times the value normally required to protect the tube **9** against excessive current surges. The adjustment of the circuit constants is somewhat critical but the operation remains stable after the required adjustment has been made. The average impulse rate is preferably fairly constant. The individual impulses may have intervals giving 95% off time to 95% on time of the trickle discharge.

The gas tube relay and circuit similar to Fig. I may be used to indicate every *n*th of a series of impulses. A suitable arrangement is shown in Fig. III. One of a pair of input terminals **41**, **43** is connected through a blocking capacitor **44** to the grid electrode **45** of a gas tube relay **47**, of the RCA type 885, or the like. The grid **45** is connected through a grid resistor **46** and biasing battery **48** to the other input terminal **43**. The cathode **49** of this tube is connected through a protective resistor **51** to the lower of the two input terminals. The plate **53** is connected to the positive terminal of a B battery **45** through an adjustable resistor **57**. The plate **53** is also connected through a capacitor **59** to the negative terminal of the B battery **55**. The negative terminal of the B battery is connected to the lower terminal of the protective resistor **51**.

A second tube **61**, preferably similar to the first tube, is connected in a similar circuit arrangement. The input of the second tube is connected to the protective resistor **51** of the first tube **47**. A third tube **63**, also by preference, similar to the first tube, is similarly connected across the protective resistor of the second tube. A pair of output terminals **65—67** are connected respectively to the cathode **69** and lower terminals of the several protective resistors. Biasing batteries **73** may be employed.

The operation of this circuit differs from Fig. I in that the critical region of operation is not used. The operating constants in this case are chosen to lie in the region of submultiple oscillatory discharge. I am aware that the operating condition of a submultiple discharge with a protective resistor in the plate circuit is well known to those skilled in the art. The voltage across the feed resistor **57** in the plate circuit is saw-tooth in form. In many cases a sharp impulse form is desired. I have discovered that the voltages across the protective resistor are a series of sharply defined impulses. By placing the protective resistor in the cathode lead, I have made these impulses conveniently available for any desired use.

If the voltages applied to the grid are of short duration, the submultiple frequency in the output may be of the order of 1/20th of the input frequency. While three stages are shown in Fig. III, one or more stages may be used.

The time constant of the capacitance and resistance of the plate circuit is adjusted to approximately ten times, by way of example, that of the period of the input voltage, Fig. IV*e*. The plate voltage will vary in a saw-tooth pattern as shown in Fig. IV*f*. The voltage changes will correspond to plate current changes across the protective resistor similar to the impulses shown in Fig. IV*g*.

These voltage impulses occur at a rate which is 1/10th that of the input voltages. The second tube likewise reduces the rate of the impulses by picking out, for example, every 10th impulse by a properly adjusted time constant plate circuit. Thus, the output of the second tube includes impulses at the rate of 1/10th of the input to this tube, or 1/100th of the input frequency to the first tube. A third tube may be used to likewise reduce the impulse rate.

If each tube reduces the rate by the ratio of 10:1, the third tube will have output impulses which occur at the rate of 1/1000th of the rate of the input to the first tube. By way of example, in the system described 120 kilocycles per second input will give 120 cycle per second output.

Although I have given a ratio of 10 to 1, I have found that the circuits described may be used as frequency dividers for ratio as high as 20 to 1 if the input voltage is a sharp uniform pulse. Frequency division of the type described is very useful for obtaining uniform low frequency impulses from a constant high frequency source. As an example, a constant 120 kilocycle source may be stepped down to 120 cycles for comparison with clocks, watches and the like. The system of Fig. I may be employed, for example, to reproduce a telegraphic transmission, of a suitable type, from a series of impulses marking the beginnings and endings of the telegraphic signals.

I claim as my invention:

1. In a device of the character described, a relay tube having grid, cathode, and plate electrodes, means for impressing input signals on said grid, a discharge circuit associated with said cathode and plate electrodes, a protective resistance serially connected in said discharge circuit, and means for adjusting said circuit between the limits of a steady discharge and an oscillatory discharge within which limits one input impulse impressed on said grid starts a flow of discharge current which is not completely extinguished until the next input impulse cuts off said discharge.

2. In a device of the character described, a gaseous relay tube having grid, cathode, and plate electrodes, means for impressing input signals between said grid and cathode electrodes, a discharge circuit associated with said cathode and

plate electrodes, a protective resistance joined to said cathode and serially connected in said discharge circuit, and means for adjusting said circuit within a region bounded by a steady discharge and an oscillatory discharge within which region one input impulse impressed on said grid starts a flow of discharge current which is not completely extinguished until the next input impulse cuts off said discharge.

3. In a device of the character described, a relay tube having grid, cathode, and plate electrodes, means for impressing input signals on said grid, a discharge circuit associated with said cathode and plate electrodes, a protective resistance serially connected in said discharge circuit, means for adjusting said circuit within a narrow region between a steady discharge and an oscillatory discharge within which region one input impulse impressed on said grid starts a flow of discharge current which is not completely extinguished until the next input impulse cuts off said discharge, and means for impressing output voltages derived across said protective resistance on a pair of output terminals.

4. In a device of the character described, a relay tube having grid, cathode and plate electrodes, means for impressing input signals on said grid, a discharge circuit associated with said cathode and plate electrodes, a protective resistance serially connected in said discharge circuit, means including an electric charge impressed on said grid for starting a discharge current in said discharge circuit, means for limiting said discharge current at a low value, and means including a subsequent electric charge of the same sign as said first electric charge impressed on said grid for extinguishing said discharge current.

5. In a device of the character of claim 4, means for deriving voltages from currents flowing in said protective resistance.

6. In a device of the character of claim 4, means for limiting voltages derived from currents flowing in said protective resistance to predetermined values.

7. In a gas tube relay having grid, cathode and plate electrodes, a protective resistance, an input circuit including said grid and cathode, an output circuit including said plate, protective resistance, and cathode, means for adjusting said circuits and said gas tube operating parameter so that its operation lies in the region between a steady continuous discharge and an oscillatory discharge of substantially saw-tooth wave form, and means for impressing input potentials of the same electric sign on said grid electrode whereby successive charges of the same sign respectively start and stop said discharge current.

8. In a device of the character described, a relay tube having grid, cathode, and plate electrodes, means for impressing input signals on said grid, a discharge circuit associated with said cathode and plate electrodes, a protective resistance serially connected in said discharge circuit, a source of current for said discharge circuit, and means for adjusting said circuit within a narrow region limited by a steady discharge and an oscillatory discharge, and within which region one input impulse impressed on said grid starts a flow of discharge current which is not completely extinguished until the next input impulse cuts off said discharge.

9. In a device of the character described, a relay tube having grid, cathode, and plate electrodes, means for impressing input signals on said grid, a discharge circuit associated with said cathode and plate electrodes, a protective resistance serially connected in said discharge circuit, a source of current for said discharge circuit the negative terminal of said source being connected to said protective resistance, and means for adjusting said circuit within a region bounded by a steady discharge and an oscillatory discharge at which adjustment one input impulse impressed on said grid starts a flow of discharge current which is not completely extinguished until the next input impulse cuts off said discharge.

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