4
The Glow Thyratron

The GT21 glow thyratron is a rather unique type of tube manufactured by the Cerberus Company of Switzerland; it has many properties in common with ordinary trigger tubes. The glow thyratron has the advantage that it can be switched to the conducting state by potentials very much smaller than those required to operate a conventional trigger tube. The glow thyratron is very suitable for the operation of a relay, the maximum current being 40 mA.

PRINCIPLES OF OPERATION

A cross sectional diagram of the electrode structure of a glow thyratron is shown in Fig. 4.1. A continuous discharge takes place between the auxiliary electrode, *H*, and the main cathode, *K*, the latter acting as the anode for the auxiliary discharge. Electrons from this discharge penetrate through a hole in the cathode. If the grid *G* is biased with a negative potential of not less than about 5 V with respect to the cathode, the electrons will be repelled back to the cathode. If, however, the grid potential is made less negative, the electrons are accelerated and pass through the holes in the grid towards the anode. Gas multiplication occurs in the space between the grid and anode and the main discharge is thus initiated.

Conduction in the main gap of a trigger tube is initiated by the firing of an auxiliary discharge, but in the glow thyratron it is accomplished by the controlled release of electrons from the priming discharge into the space between the grid and the anode.

The firing characteristic of a glow thyratron is shown in Fig. 4.2. The main gap will conduct if the operating point crosses either of

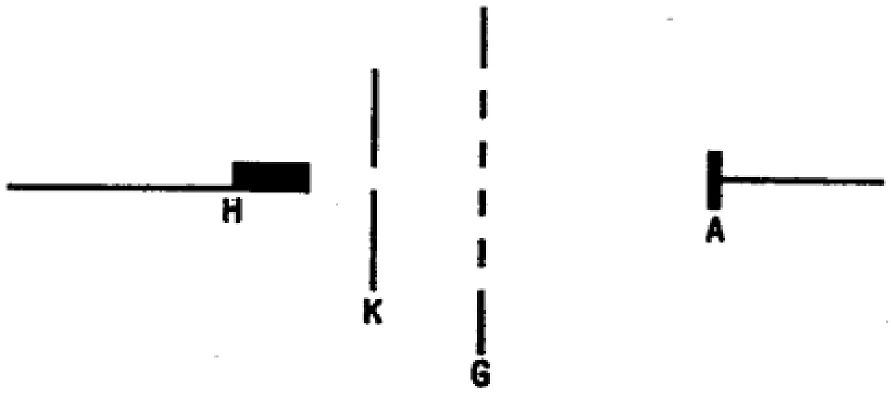

Fig. 4.1. The electrode structure of the glow thyratron.

the lines shown, but in practice it should not be allowed to cross the lower line, since this would result in reverse conduction. The tube is operated at the part of the upper curve where the slope is large. When the grid becomes less negative, the steep part of the curve is crossed from left to right and the main gap fires.

For positive grid voltages up to about 15 V, the characteristic rises somewhat, since the positive grid tends to attract electrons and remove them from the gas so that they do not give rise to gas amplification in the space between the grid and anode. At grid

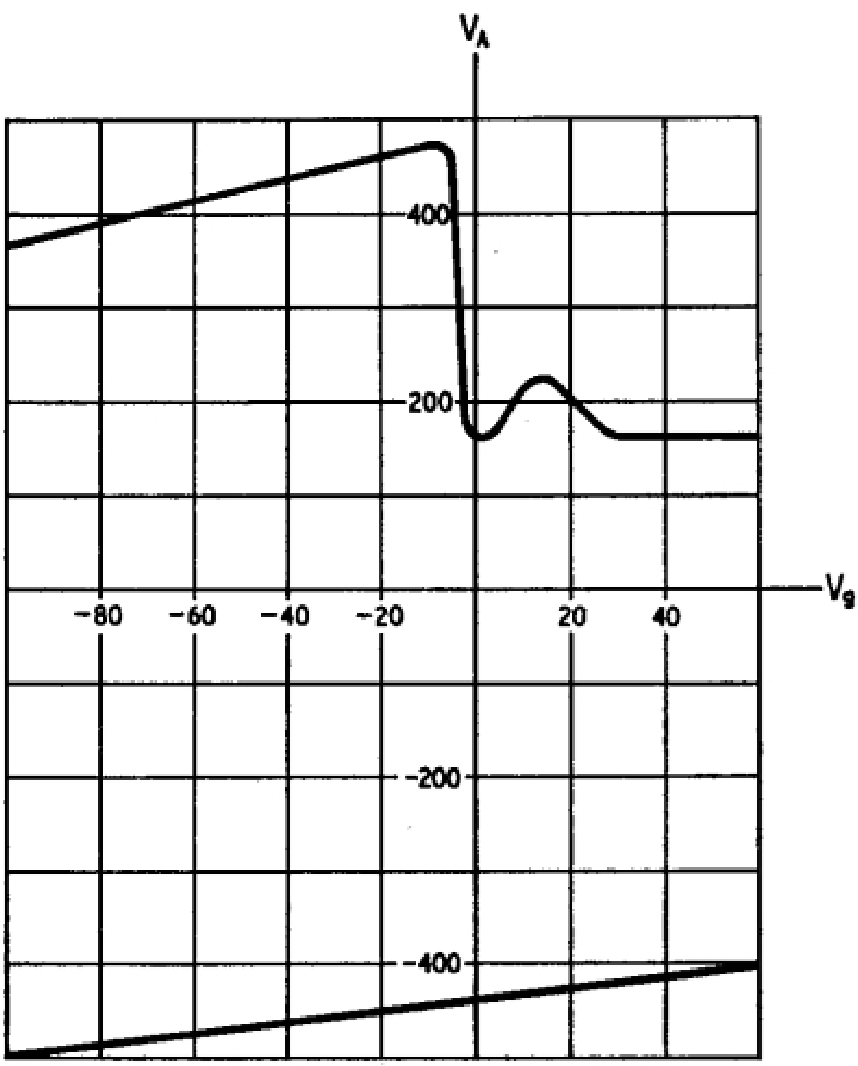

Fig. 4.2. The glow thyratron firing characteristic.

voltages exceeding about +15 V the auxiliary discharge will form between the auxiliary cathode and the grid. If the grid receives a negative potential exceeding 80 V with respect to the main cathode, it may act as a cathode, but this mode of operation should be avoided. Similarly the grid potential should not exceed +50 V with respect to the cathode.

Once a glow thyratron has been switched to the conducting state, the potential of the grid electrode no longer controls the flow of the main anode current. As in the case of a trigger tube, the glow thyratron is extinguished by reducing the main anode potential below the maintaining voltage of the main gap for a time exceeding the deionisation time of the tube.

The auxiliary discharge should consist of a current in the range of 100 to 250 μA. The firing characteristics of the tube are virtually independent of the value of this current provided that it is within the recommended range. The auxiliary cathode, *H*, is returned via a current limiting resistor to a suitable source of negative potential.

When the main anode conducts, the auxiliary discharge takes place between this anode and the auxiliary cathode; the potential of the latter electrode is raised to approximately the potential of the main cathode and the auxiliary discharge current is correspondingly increased.

The grid of the glow thyratron acts as a probe near to the auxiliary discharge when the main gap is not conducting and therefore a small grid current (normally less than a microamp) will pass. In a conducting tube the grid behaves as a probe in the plasma and effectively acts as a source of about 100 V of an equivalent series resistance of about 100 kΩ.

The grid current will result in the grid potential being somewhat different from that applied to the grid resistor. However, if the value of this resistor does not exceed a few hundred thousand ohms, the effect will be small.

The tolerance in the grid potential at which ignition occurs is less than one volt from tube to tube. Glow thyratrons show a thermal hysteresis effect which results in a slightly greater negative grid potential being required to prevent the tube from conducting immediately after it has been passing an appreciable anode current. However, there is little change in the grid voltage at which firing occurs as the ambient temperature varies over the range of −30°C to +90°C.

Apart from the fact that the GT21 glow thyratron can be controlled by small potentials of about 5 V (which enables it to be operated from transistor circuits), it has a number of attractive features. A pure molybdenum cathode is employed and this results in the tube having very stable characteristics and a long life. The high anode breakdown voltage (about 450 V) and the high cathode current rating of 40 mA enable it to control loads of up to about 15 W. The presence of the auxiliary discharge enables ionisation times of less than 1 μsec to be obtained at fairly high anode voltages.

APPLICATIONS OF THE GLOW THYRATRON

The following simple circuits have been selected from those published by the manufacturers of the glow thyratron. They show how

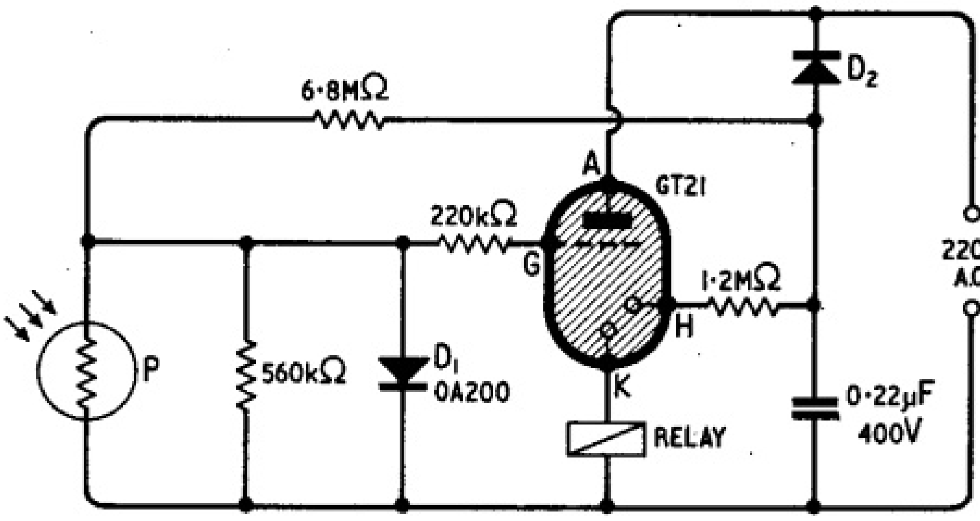

Fig. 4.3. A circuit for controlling a relay by a light beam.

the tube can be employed to operate a relay from small signals. The anodes of the glow thyratrons are supplied with an a.c. signal so that the main discharge is automatically extinguished during each alternate half cycle of the mains supply when the anode is negative with respect to the cathode. The relays employed in these circuits should have a suitable number of shorted turns in their windings so that they will operate satisfactorily from the half wave rectified waveform passing through the tube. No mains transformer is required in these circuits.

RELAY CONTROL BY LIGHT BEAM

A simple circuit for the control of a relay by means of a beam of light is shown in Fig. 4.3. The diode D_2 rectifies the mains supply voltage, the peaks of the alternate half cycles being smoothed by the 0·22 μF capacitor. The resulting negative potential is used to supply both the auxiliary cathode, H, and the photodiode, P.

When P is in darkness, it has a relatively high impedance and, therefore, an appreciable negative potential is developed across it. This potential is fed to the grid of the GT21 and prevents the tube from conducting. When light falls onto the photodiode, the potential across this diode falls. This results in the grid voltage of the GT21 becoming very small. The main gap of the tube, therefore, fires and operates the relay.

The diode D_1 short circuits the positive grid voltage of the tube when it is conducting. The rectifier diode, D_2, should have a peak inverse voltage rating of not less than 700 V, but the forward rating need only be 5 mA. The Texas Instruments H11 photodiode or the Siemens type TP51 11 is suitable for use in this circuit.

THERMOSTAT CIRCUIT

The circuit of Fig. 4.4 may be used to switch a heating element on and off in order to keep the temperature of an enclosure constant.

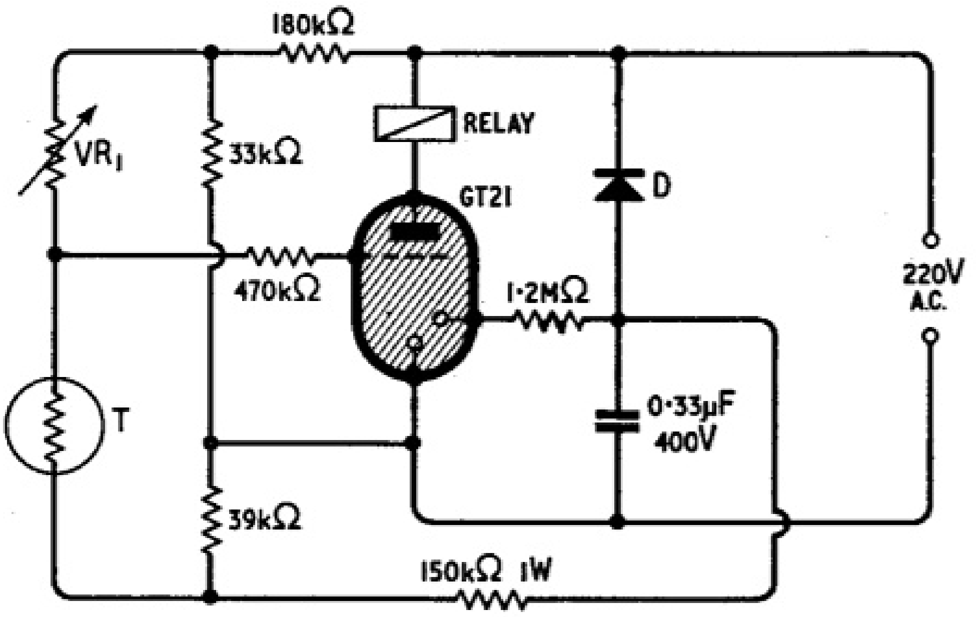

Fig. 4.4. A thermostat circuit.

A thermistor is used as the temperature sensing element, but the operating temperature range is limited to about −25°C to 150°C. The temperature at which the relay operates is controlled by the setting of the potentiometer VR_1.

The resistance of the thermistor decreases with increase of temperature. The thermistor T in Fig. 4.4 is fed from the negative half wave rectified supply via the 150 kΩ resistor. As it becomes cooler, its resistance increases and the potential applied to the grid of the GT21 glow thyratron becomes less negative. When the tube fires, the relay in its anode circuit switches on a heating element to raise

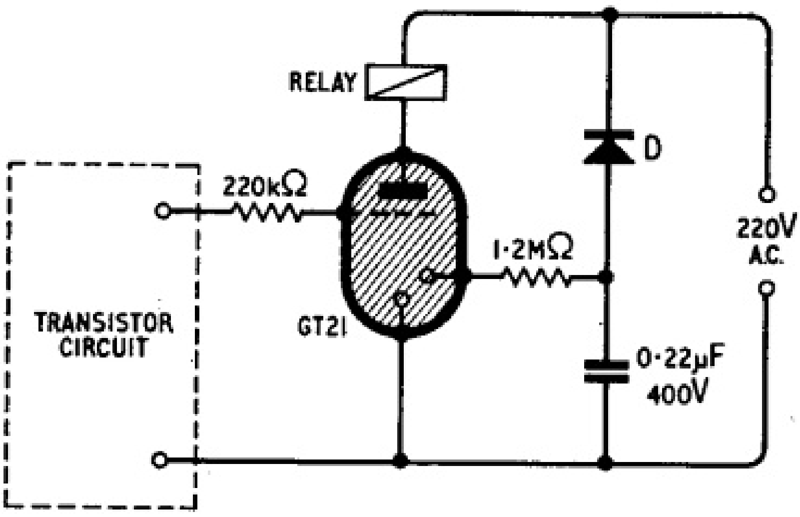

Fig. 4.5. Control of a glow thyratron by a transistor circuit.

the temperature of the enclosure containing the thermostat. The remainder of the circuit functions in the same way as Fig. 4.3.

In order to prevent the circuit from switching on and off too frequently, a capacitor of about 6,800 pF may be placed across the 470 kΩ resistor in the grid circuit. The temperature at which the relay is energised then becomes somewhat lower than the temperature at which it is de-energised after the heater has been operating. The capacitor becomes charged after the tube fires owing to the grid current which flows. The charge of the capacitor assists in causing the tube to ignite in the next half cycle of the mains voltage at which the anode is positive.

The temperature at which the glow thyratron conducts varies somewhat with the mains voltage.

CONTROL BY A TRANSISTOR CIRCUIT

The circuit of Fig. 4.5 shows how a glow thyratron may be controlled by a transistor circuit. The output impedance of the transistor circuit should be about 20 kΩ. The circuit will switch on when the grid voltage is not more negative than —0·5 V with respect to the cathode and will switch off when it is more negative than —5 V. The collector circuits of transistor bistable stages normally meet these requirements.

SUGGESTIONS FOR FURTHER READING

M. VOLLENWEIDER, 'The glow thyratron', *I.E.R.E. Symp.*, Cambridge (1964).
R. A. DÜRR, 'Glimm-thyratrons', *Der Elektroniker*, 3, 29 (1962).