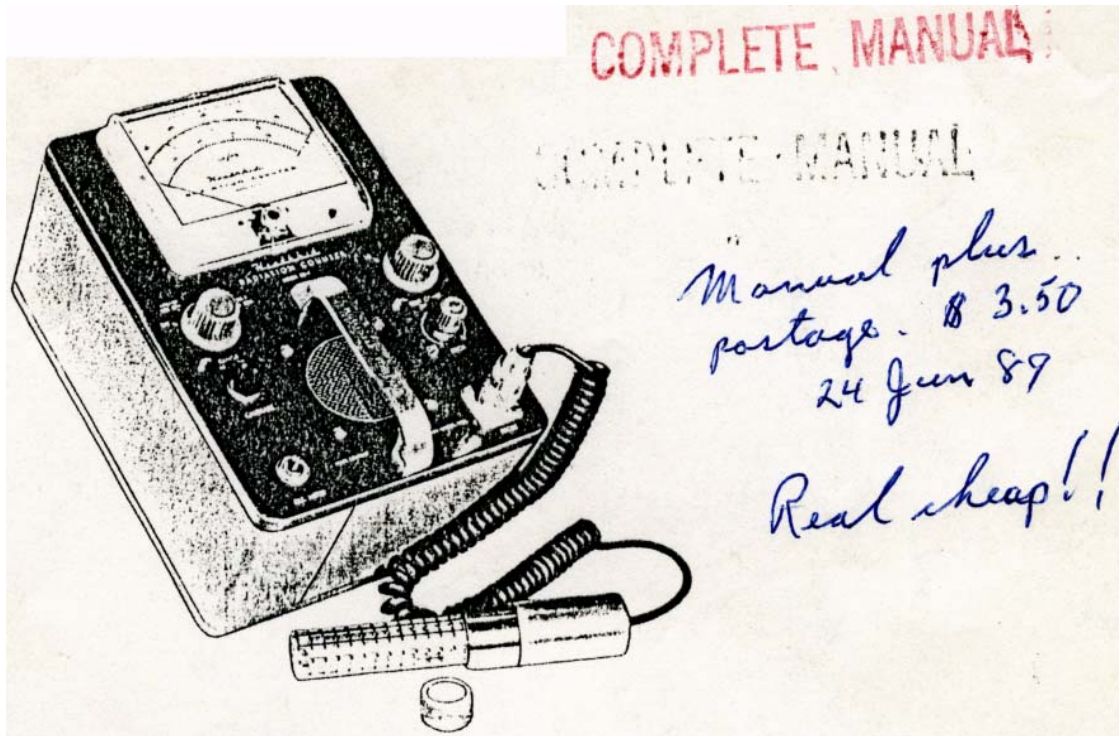


# ASSEMBLY AND OPERATION OF THE HEATHKIT RADIATION COUNTER



## MODEL RC-1

### SPECIFICATIONS

Time Constant:.....	0.5, 1, 5 and 10 seconds
Ranges:.....	0-100, 600, 6000 and 60,000 counts per minute 0-.02, .1, 1 and 10 milliroentgens per hour
Meter:.....	Calibrated 4 1/2" 200 MICROampere movement
Probe:.....	Satin aluminum and chrome plated steel probe contains extra sensitive type 6306 Bismuth geiger counter tube.
Speaker:.....	Loudspeaker driven by transistor gives pleasant tones on most sensitive range, no harsh clicks. Muted by panel control.
Calibration:.....	Calibrate control on panel, radioactive sample furnished.
Batteries:.....	1 - 67 1/2 volt B battery (approximately 200 hours to 40 volt end point), intermittent operation. 2 - 11/2 volt A batteries (approximately 20 hours to 1 volt end point), intermittent operation.
Tube Complement:.....	1 - 1U4 Amplification, pulse shaping and 1 - 3V4 counting tubes. 2 - 1U5 1 - 5841 corona regulator tube 1 - 6306 bismuth counter tube 1 - 2N109 transistor (oscillator)
Provision for use of external meter (jack on panel).	
Prewired high voltage power supply assembly.	
Regulated 900 volt DC applied to 6306 tube in probe.	
Coiled cord between probe and instrument, no tangling.	
Cabinet:.....	Aluminum, 9 1/2" high x 6 1/2" wide x 5" deep
Net Weight:.....	6 1/2 lbs.
Shipping Weight:.....	8 lbs.



## INSTRUMENT DESCRIPTION

The Heathkit Radiation Counter model RC-1 is a highly developed instrument, designed expressly for the serious prospector. A prewired power supply delivering the required high voltage, coupled with a four tube amplifying and pulse shaping circuit, gives extremely high sensitivity far in advance of most other counters now available, regardless of cost. A large 4 1/2" meter calibrated in counts per minute gives full scale readings from 100 cpm to 60,000 cpm. The meter is also calibrated in milliroentgens per hour (mR/hr) from .02 mR/hr to 10 mR/hr full scale.

An added feature is the use of a loudspeaker for aural monitoring, excited by a transistor oscillator, thus allowing a more pleasing (to the ear) tone than the usual harsh clicks. To further increase its flexibility, the circuit has been so designed to operate accurately and sensitively with the Heathkit Geiger Counter Probe model GC-1, which uses a bismuth counter tube. Using the model GC-1 Geiger Counter Probe with the model RC-1 Radiation Counter comprises an instrument more sensitive but otherwise equal to many now selling for \$250.00 or more. A calibrated, completely safe radiation source is provided with each model RC-1 for spot calibration in the field.

## THEORY OF OPERATION

Negative pulses generated in the probe are impressed across the input grid resistor through the .01 ufd blocking capacitor and are amplified and inverted by V1, appearing across the 68 K plate load resistor. V2 further amplifies and reinverts the signal pulses and injects them into the grid of V3. The two stages of amplification have been designed to have a sensitivity of approximately .1 volt and to limit at an input of .25 volts. This insures a pulse of the proper amplitude for triggering V3, even though the input pulses may vary considerably in height.

V3 and V4 together constitute a mono-stable multivibrator, sometimes called a "one-shot," since it makes one complete cycle for each pulse (trigger). Operation is as follows: The two tubes have a common cathode resistor of 15K serving as one leg of the coupling impedance necessary for oscillation and also serving as a source of cut-off bias for V4. The control grid of V3 is returned to a positive point on the voltage divider connected between B+ and ground, causing it to conduct. This conduction causes current flow through the common cathode resistor and the voltage drop across it is sufficient to cut V4 off, since the grid of V4 is returned to ground. This enables the use of a tube with comparatively large emission capabilities as V4 without increasing the B battery drain, since V4 is not allowed to draw current except during the short operating cycle following each input trigger. The RANGE switch connects various precision capacitors between the plate of V3 and the grid of V4 and, in conjunction with the common cathode resistor, provides the necessary cross-coupling to enable multivibrator operation. The capacitors switched between the two tubes determine the period of time the multivibrator will remain in its unstable state. This in turn determines the average current flowing through the meter. The meter is calibrated in both COUNTS PER MINUTE and MILLIROENTGENS PER HOUR. The use of precision capacitors to determine the range and therefore the current for full scale meter deflection enables the use of a single calibration control. Calibration made at one point will hold to within 10% at all points. The calibration control also enables the instrument to be calibrated even when the B battery is quite weak. The overall circuit including the power supply sub-assembly has been designed to operate correctly until the B battery voltage has dropped to 40 volts and/or the filament batteries have dropped to 1 volt or less. This has been done to enable longest battery life commensurate with reliable operation and to preclude the necessity for carrying an excessive number of spare batteries in the field.

An interesting departure from the usual method for aural monitoring has been incorporated in this instrument. A transistor oscillator, using an output transformer as the oscillatory inductance, derives its operating voltage from the voltage drop across a by-passed portion of the plate load resistance for V4, voltage being present only during unstable state immediately following the input trigger pulse. A small loudspeaker is connected directly across the output transformer and reproduces the audio tone generated by the transistor oscillator. This tone may be varied by adjustment of the 2K PITCH control to that most pleasing to the operator. Since it is an audio tone and not a click, it can be recognized in even the noisiest locations and is invaluable when prospecting in a moving vehicle or aircraft.

Two filament batteries (ordinary flashlight cells) and a 67 1/2 volt B battery (such as is used in most portable radios) supply all operating voltages for the instrument. The power supply sub-assembly derives its operating voltage from the 67 1/2 volt B battery. Its output voltage is sufficiently high (greater than 1200 volts) that it may be regulated at 900 volts for use with the Geiger Counter Probe.

The meter used is a 4 1/2" 200 microampere movement for greatest sensitivity combined with ruggedness. When the instrument is turned OFF, the RANGE switch puts a short across the meter for added protection. A TIME CONSTANT circuit has been incorporated to give added flexibility to the counter, allowing a meter time constant of 1/2 second to 10 seconds. The 1/2 second position of the TIME CONSTANT switch is used when moving over the ground rapidly and the 10 second position is used when checking ore samples for the greatest accuracy.

#### OPERATION OF THE CORONA REGULATOR TUBE (Courtesy of Victoreen Instrument Company)

The Corona Voltage Regulator tube exhibits many unique virtues when properly used to regulate the output voltage of a high voltage, low current power supply. Like any other type of regulator, it can be a tremendous source of annoyance when improperly used. Among its virtues are its simplified circuits, low cost, good regulation, low power consumption, small spread between starting and operating voltages, and its ability to regulate against variations both in load current and input voltage. It is also mechanically rugged, supplies its own reference, has long operating life and a relatively wide range of operating temperatures.

Since the operation of a corona tube is not widely understood, a simplified discussion of its behavior is appropriate.

In general, it may be stated that when two coaxially positioned cylindrical electrodes are enclosed in a gas-filled envelope and a DC potential is applied between them in such a direction that the central electrode is positive with respect to the outer, the unit may be considered as a variable resistor which is very current sensitive. The volt-ampere relations will exhibit three distinctly different regions, as illustrated in Figure 1.

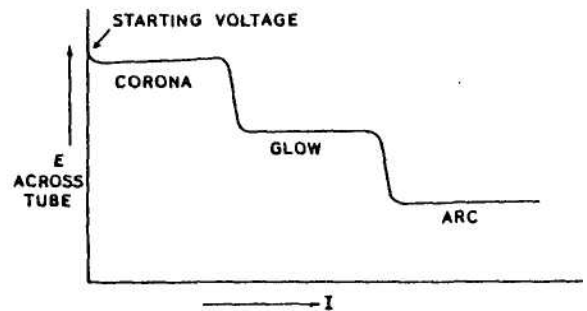


Figure 1

The exact values of voltage and current for any one of these regions are determined by electrode dimensions as well as gas nature and pressure, and other considerations. When these parameters are selected to provide a useful corona region, the other two regions become limited. Similarly, if the tube is designed for the glow region operation, the characteristic curve may pass through the corona region so quickly as to be hard to identify.

Roughly speaking, these three areas of operation may be distinguished by the location of any visible light. The corona will appear around the anode, while the glow appears adjacent to the cathode. The arc is visible between the two.

Obviously corona tubes are useful for high voltage-low current application, glow tubes for medium voltage-medium currents, while the arc involves higher orders of current and lower voltage drops.

As a voltage regulator, the corona tube is connected across the load whose voltage is to be regulated, in series with the resistor, in the same manner as the more familiar glow tube regulator would be used.

The supply voltage is then divided between the series resistor and the parallel combination of regulator and load, and the regulator tube tends to hold the voltage across the load constant. For circuit analysis, the tube may be considered as a constant voltage source (whose value is the nominal operating voltage of the regulator) in series with a resistance (computed from the published regulation curve). For example, the type 5841, regulating at 900 volts with a regulation of 1.5% between 5-50 ua may be considered as a 900 volt battery in series with a resistor.

From this equivalent circuit, other parameters may be established. In most cases, the variations in load are predetermined by the application, and the variations in unregulated supply are imposed by its nature, so the problem becomes one of evaluating the series resistor necessary to produce the required degree of regulation. It should be pointed out that while high values of series resistance tend to produce the best percent regulation, they also produce the smaller values of regulator tube current and vice versa. The circuit used in the Heathkit Radiation Counter tends to keep the operation of the tube as near the center of the corona region as possible, since transients in the supply or load might cause the momentary operation of the tube below the corona region (temporary extinction) or above the corona region (glow and arc). In either case, serious instability would result.

When the supply voltage has appreciable ripple and/or large transients, such as are unavoidable in the vibrator or fly-back type, considerable filtering is necessary between the supply and the regulator. The positive peaks of the waveform of the voltage at the resistor in series with the regulator must not be permitted to drive the corona into the glow or arc region nor must the negative peaks be permitted to fall below the striking voltage of the regulator. Either condition may introduce very objectionable AC components into the load.

The corona regulator greatly aids the filter in attenuating AC components. The AC components ahead of the series resistor are attenuated at the load by the voltage divider action of the resistor in series with the parallel combination of the load and the dynamic resistance of the corona. Since the ratio of the series resistor to the parallel combination is usually high, the degree of attenuation of ripple is also high.

Due to the relatively small spread between striking and operating voltage, its relatively low dynamic resistance (300 K at 50 uamperes), its relatively short ionizing and deionizing time, etc., the corona regulator makes a very poor relaxation oscillator when confined to the corona region. For this reason, small capacities may safely be placed across it to improve filtering. However, care must be exercised, less a transient should inadvertently cause the tube to momentarily pass sufficient current to swing it to the glow or arc region, which would dump the entire charge of the shunt capacitor into the tube and permanently damage it, as well as temporarily impairing its regulation.

Like the glow tube, there is a minimum current required to sustain the corona in a stable condition, but unlike the glow tube, the corona tube may satisfactorily operate in its unstable low current area if bypassed with a capacitor to relieve the transients produced in this region. Adequate filtering ahead of the regulator is required for this type of operation and the degree of regulation may be slightly impaired when operating below the published minimum current. See Figure 2.

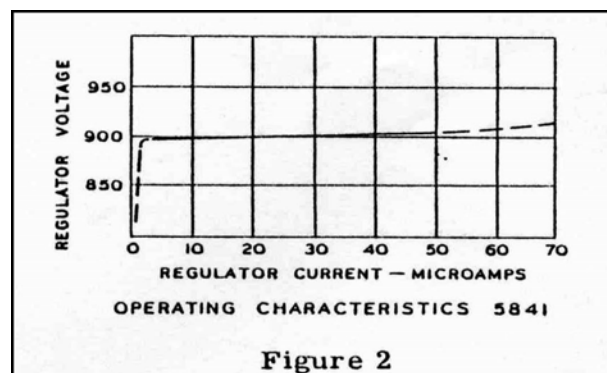


Figure 2

#### TYPE 6306 THYRODE TUBE

A thyrode counter tube is a gas diode designed to produce an electrical pulse when its sensitive volume is penetrated by an ionizing particle.