Power-adjustment circuit for cathode-biased amps:

In nearly all guitar amps the screen voltage is derived from a simple RC or LC smoothing filter after the anode supply node (and in most cases the screen voltage will be practically equal to the anode voltage). Since the ratio of screen current to anode current is more-or-less constant over the normal working range, the screen voltage will automatically track the anode voltage at least sufficiently accurately that an additional voltage stabiliser for the screen is unnecessary.

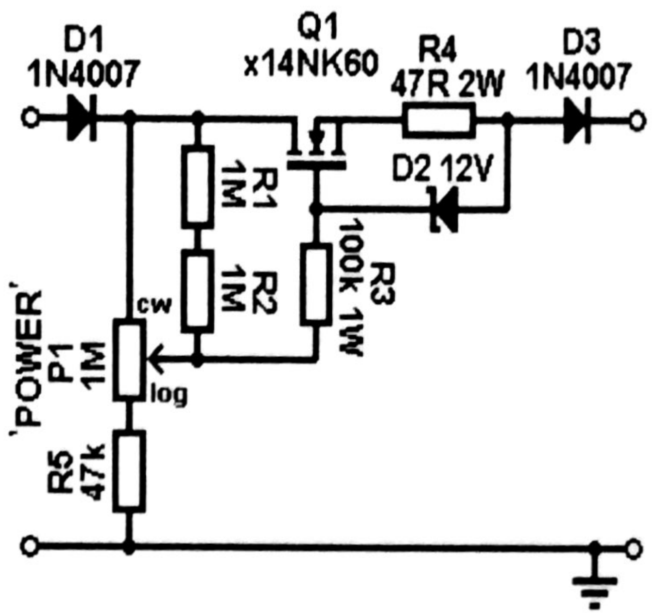

Fig. 10.19: Simple, variable voltage stabiliser circuit for cathode-biased amps up to about 36-watt. Q1 can be bolted to the chassis unless the TO-220FP plastic package is used in which case a 3.5°C/W heat sink will be needed

Similarly, in a cathode biased amp –where the bias is provided by a simple cathode resistor– the bias voltage will track the screen voltage quite reliably, and no extra measures need to be taken. All that is required, then, is a single, variable voltage stabiliser to control the anode voltage; the screen and bias voltages will track this voltage without any additional help. Nearly all cathode-biased amps have audio output power ratings of less than 36 watts, and supply voltages of less than 350V, which is not difficult to accommodate with the following, simple circuit.

Fig. 10.19 is a practical version of the basic premise in fig. 10.16. No attempt has been made to provide ripple reduction/smoothing with this circuit since some readers may wish to insert it between the rectifier and reservoir capacitor. Also, the absence of any smoothing may be seen as advantage by some players, who may argue that the ripple on the power supply contributes to the amp's basic tone.

R1-R2 are included in case the wiper of P1 should ever fail to make contact with the track. Two resistors are used in series so that ordinary ¼W devices can be used without their voltage ratings being exceeded, although a single 2.2MΩ ½W resistor could be used instead. R3 is the usual gate stopper.

R5 sets the minimum output voltage and is added to prevent a 'dead spot' at the end of the pot's rotation, which would occur if the voltage were tuned so low that Q1 switches off (or so low that the amp becomes practically silent). This value may need adjusting to suit the particular amp.

D1 is not strictly necessary but is added for good measure to make the circuit very 'self contained'. D3 *is* necessary and is added to prevent the following smoothing

Passive constant-current limiting:

Fig. 7.14 shows some very simple current-limiting arrangements, which could be applied to almost any series stabiliser circuit. Q1 represents the pass device. A **current-sense** resistor Rs is added to the output of the stabiliser to detect the amount of load current being drawn.

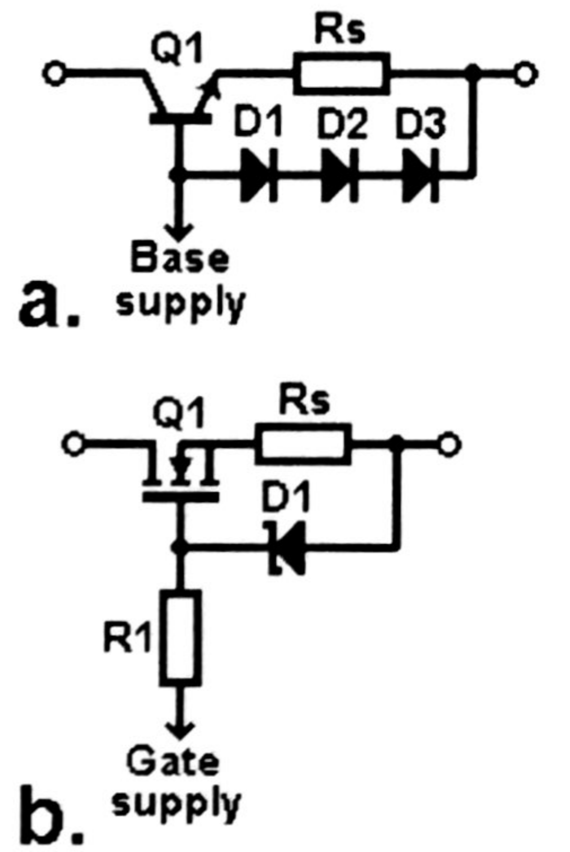

Fig. 7.14: Simple, passive current-limiting arrangements.

In fig. 7.14*a.*, when the load current increases the voltage drop across Rs increases too, until the string of diodes D1-D3 turn on. When this happens current will be 'stolen' from the base of the pass device Q1, so restricting the load current to the preset maximum.
If we use ordinary rectifier diodes we may assume a forward drop of about 0.7V each at low current, so the maximum load current, I_{max}, is limited to:

$$I_{max} \approx \frac{N \times 0.7 - V_{be}}{Rs}$$

Where:
N = number of diodes used.
V_{be} = base-emitter voltage of Q1.

Under ideal circumstances once the protection circuit becomes active the output current will not increase beyond the preset maximum; it remains constant even if the output is a dead short circuit. Thus the name 'constant-current limiting' is obvious. In practice, it is not quite this perfect, but still good enough for most applications (e.g., see fig. 7.16).

The circuit in fig. 7.14*b* works in a similar way except that the string of diodes is replaced with a zener diode. In the case of a MOSFET, the zener can also serve to protect against gate-source over-voltage. When the drop across Rs is enough to turn on the zener, current will be diverted through the gate-stopper R1, pulling the base voltage of Q1 down, which will in turn reduce the output voltage. The output voltage will fall to whatever voltage is necessary to stop the load current exceeding the preset maximum, which is given by:

$$I_{max} = \frac{V_Z - V_{GS}}{Rs}$$

Where:
I_{max} = current limit.
V_Z = zener voltage.
V_{GS} = gate-source voltage of Q1 if it is a MOSFET, or V_{be} if it is a BJT.

However, the gate-source voltage of power MOSFETs is highly variable between samples, and increases with drain current, but may be estimated to be in the region of

4V to 5V for most devices. Also, as seen in the last chapter, diodes do not have a sharply defined turn on characteristic due to their high dynamic resistance at low currents. Thanks to these unpredictable properties, passive current limiting can be rather imprecise. In valve amp applications this does not always matter, however, since we will be usually set I_{max} to a value which is still well below the instantaneous current capability of the devices we are using.

For example, suppose we wished to alter the circuit in fig. 7.11 by limiting its output to 0.5A maximum. We will estimate V_{GS} to be 5V:

$$Rs = \frac{V_Z - V_{GS}}{I_{max}} = \frac{12-5}{0.5} = 14\Omega.$$

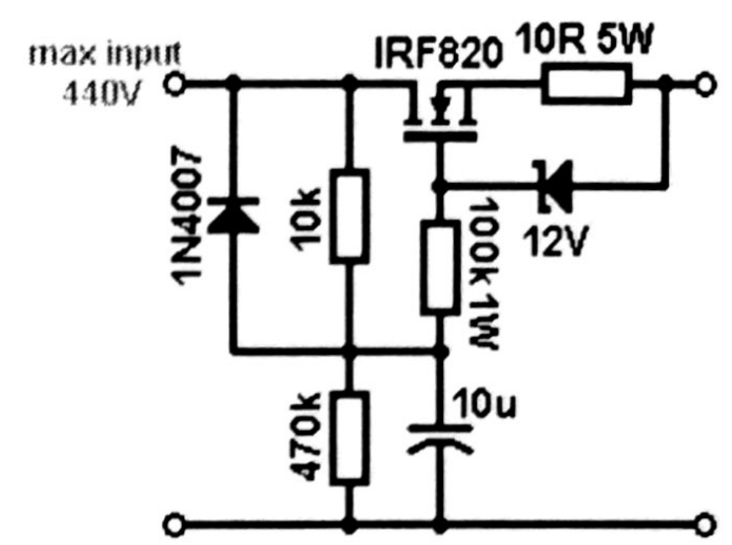

Fig. 7.15: Practical capacitor multiplier with current passively limited to around 0.7A

We will use a 10Ω resistor as a convenient standard, which *ought* to limit I_{max} to 0.7A. Rs will dissipate a maximum of $0.7^2 \times 10 = 4.9$W, so a 5W component will do, since such overloads are not expected to be continuous. Additionally, into a short circuit almost all the input voltage must be dropped across the gate-stopper resistor, so it should be at least 1W rated. The circuit is shown in fig. 7.15 and the resulting performance is indicated in fig. 7.16. It can be seen that the actual current limit occurs at about 730mA, and reaches about 740mA into a short circuit; a modest error.

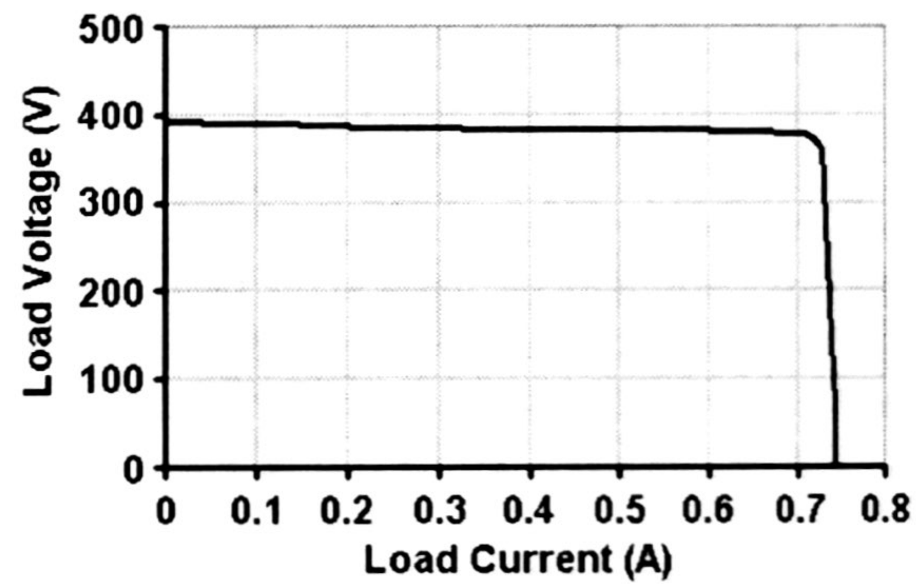

Fig. 7.16: Output characteristics of the circuit in fig. 7.15 when supplied with 400V input.

Active constant-current limiting:

The previous current-limiting techniques are primitive, and the point at which they begin to limit cannot be set precisely without actually testing the components for voltage drop first. Nevertheless, they are still suitable for non-critical circuits. For faster, more accurate current limiting, the circuits in fig. 7.17 are ideal, and are widely used in commercial equipment.

Again, current-sense resistor Rs is added to the output of the stabiliser. Once the voltage drop across this resistor reaches about 0.6V, Q2 will turn on and steal current from the pass device in exactly the same manner as for the circuits discussed previously. With most designs Q2 will have to pass less that a milliamp when on, and since its collector-emitter voltage will be very small, Q2 can be a low voltage, low-power device.