current I_{SC}, which is given accurately by Eq. 25.15, will flow. One can then define a percentage deviation D as follows:

$$D\% = (I_{SC} - I_L)/I_{SC} \times 100 \qquad (25.17)$$

It must be remembered that R_2 includes not only the value of the feedback resistor, applied externally, but also the output impedance of the VDVS which should be in the order of 20 ohms. If R_1 and R_2 are accurate to within 0.1%, a value of $D = 1\%$ is observed over extended periods. The device, when "open," i.e., when no current is being drained, builds up high voltages which endanger the device and may cause excessive heating of the tubes in the VDCS. Therefore, the input of the latter should be kept grounded up to the time of actual use. The input impedance of the VDCS is low, and thus it is necessary to place an isolating device between the network and the VDCS whenever the former does not permit a high current drain.

CURRENT-DEPENDENT VOLTAGE SOURCE

The source described hereafter can only be used if one pole is grounded, i.e., if the current to which the output voltage is proportional flows to ground. The circuit is shown schematically in Fig. 25.18.

Assuming that the input stage does not draw grid current, it is seen that

$$e_o - e_{in} = -iR \qquad (25.18)$$

But due to the presence of the amplifier

$$e_{in} = e_o/K \qquad (25.19)$$

Combining Eqs. 25.18 and 25.19

$$e_o = -iR/(1 - 1/K) \qquad (25.20)$$

which for high negative K becomes

$$e_o = -iR \qquad (25.21)$$

Note that the output voltage is directly proportional to the input

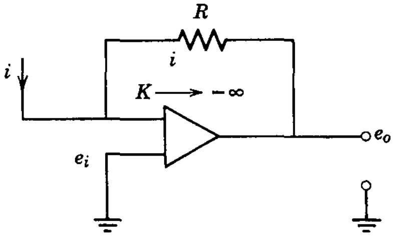

Fig. 25.18. Schematic of current-dependent voltage source.

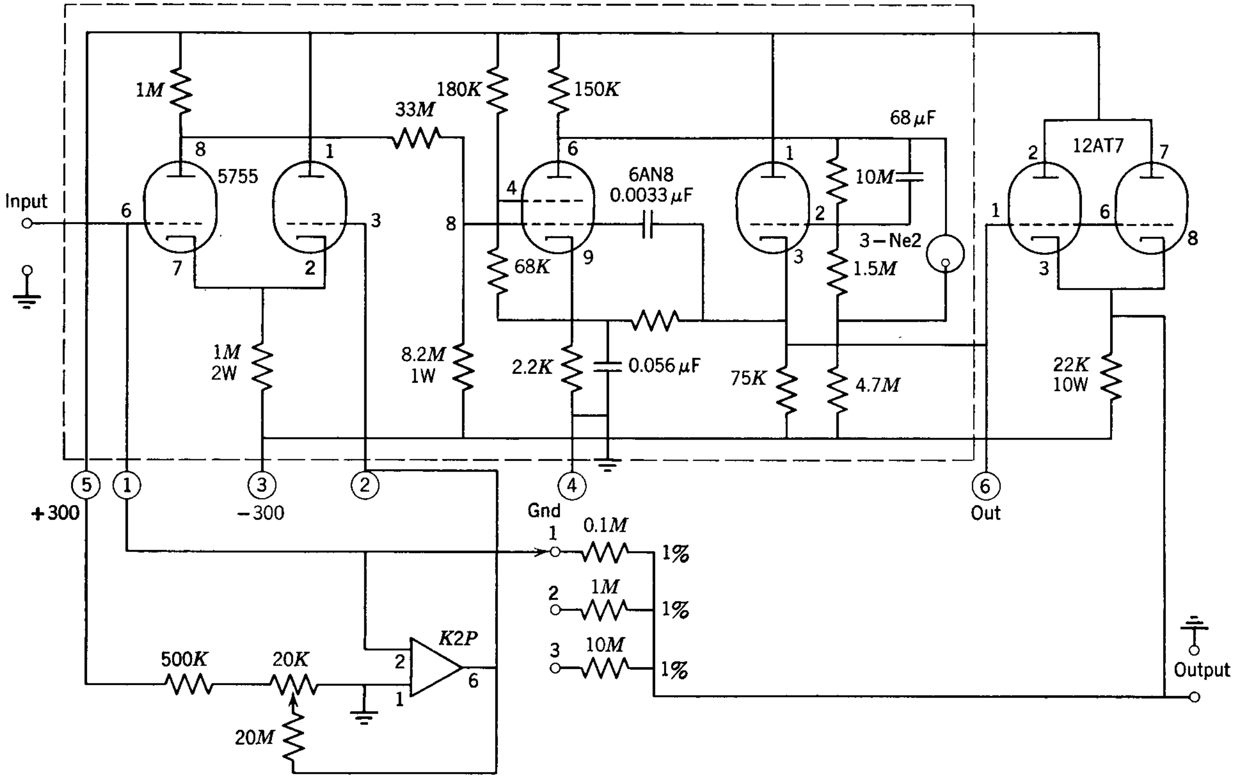

Fig. 25.19. Wiring diagram of the current-dependent voltage source with stabilizing amplifier.

current, with the constant of proportionality being the resistance R. Since e_o and iR have opposite signs, and since the amplifier draws practically no grid current, $e_o - iR = 0$, i.e., the input is near zero. The small positive potential of e_{in} causes only a small error in the circuit (13 mV).

A stabilizing amplifier is used in connection with the CDVS. The wiring diagram covering both the CDVS and the stabilizing amplifier is shown in Fig. 25.19.

25.6. Property Changer

A property changer serves to represent nonlinear parameters. In Fig. 25.20, a curve showing a temperature-dependent property is given as an example. In order to represent such curves on the simulator it would be necessary to have components (resistors or capacitors) which change their value as a function of the nodal voltage. Such units are normally not available. In order to approximate such conditions the continuous curve can be replaced by a step curve as shown. As the voltage changes from one value to the next (e.g., from V_1 to V_2) the property value is changed stepwise from value p_1 to p_2. The more steps used, the better is the approximation that can be achieved. Usually cost considerations will limit the number of steps. For the condition of voltage always changing monotonically, never rising and falling within one computing run, a simpler device, which is described hereafter, can be used.

To represent a nonlinear problem a property changer must be provided for each node. The voltage at a node may follow a curve, as shown in Fig. 25.21. (Of course, the voltage may also rise, but not change direction.) The property changer consists essentially of four

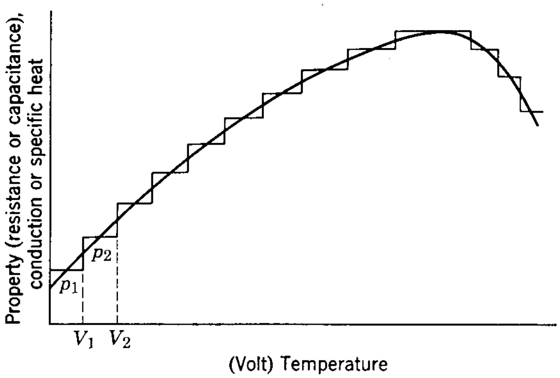

Fig. 25.20. Replacing a continuous curve by a step function.