EXERCICES

CHAP. 4

POLARISATION DES TRANSISTORS BJT

2. Given the information appearing in Fig. 4.109, determine:
   a. I_C.
   b. R_C.
   c. R_B.
   d. V_{CE}.
3. Given the information appearing in Fig. 4.110, determine:
   a. I_C.
   b. V_{CC}.
   c. β.
   d. R_B.

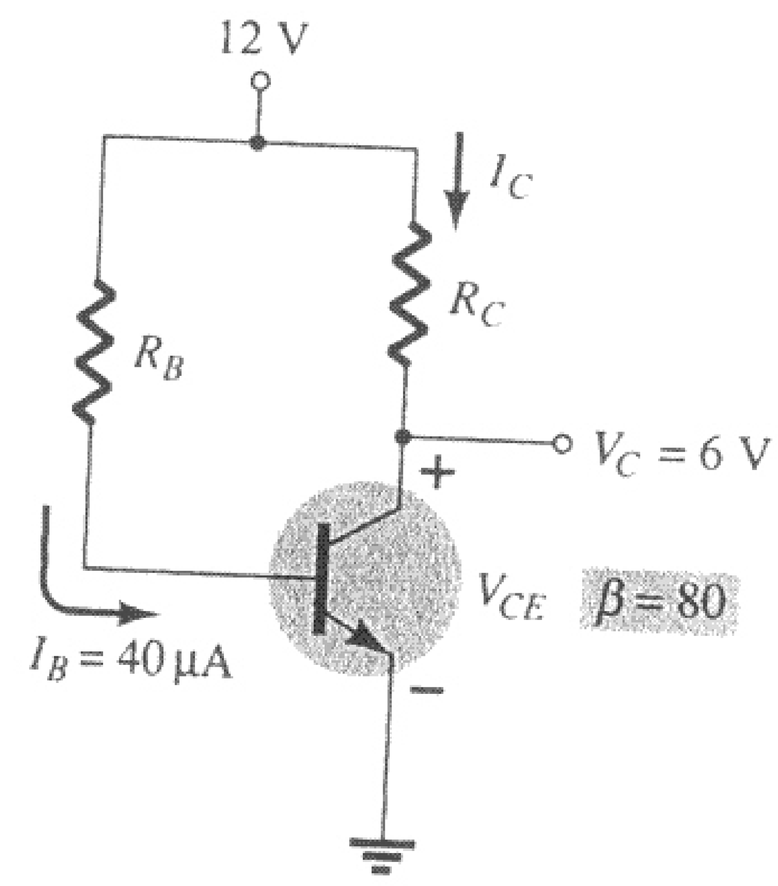

FIG. 4.109
Problem 2.

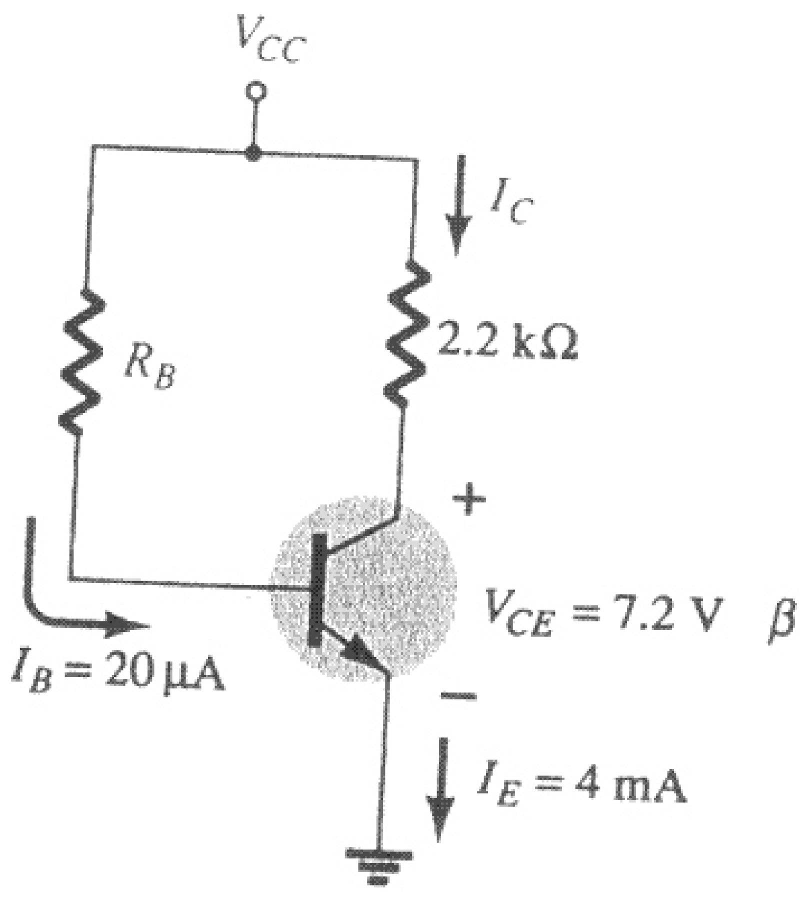

FIG. 4.110
Problem 3.

4. Find the saturation current ($I_{C_{sat}}$) for the fixed-bias configuration of Fig. 4.108.
5. Given the BJT transistor characteristics of Fig. 4.111:
   a. Draw a load line on the characteristics determined by $E = 21$ V and $R_C = 3$ kΩ for a fixed-bias configuration.
   b. Choose an operating point midway between cutoff and saturation. Determine the value of R_B to establish the resulting operating point.
   c. What are the resulting values of I_{C_Q} and V_{CE_Q}?
   d. What is the value of β at the operating point?
   e. What is the value of α defined by the operating point?
   f. What is the saturation current ($I_{C_{sat}}$) for the design?
   g. Sketch the resulting fixed-bias configuration.
   h. What is the dc power dissipated by the device at the operating point?
   i. What is the power supplied by V_{CC}?
   j. Determine the power dissipated by the resistive elements by taking the difference between the results of parts (h) and (i).

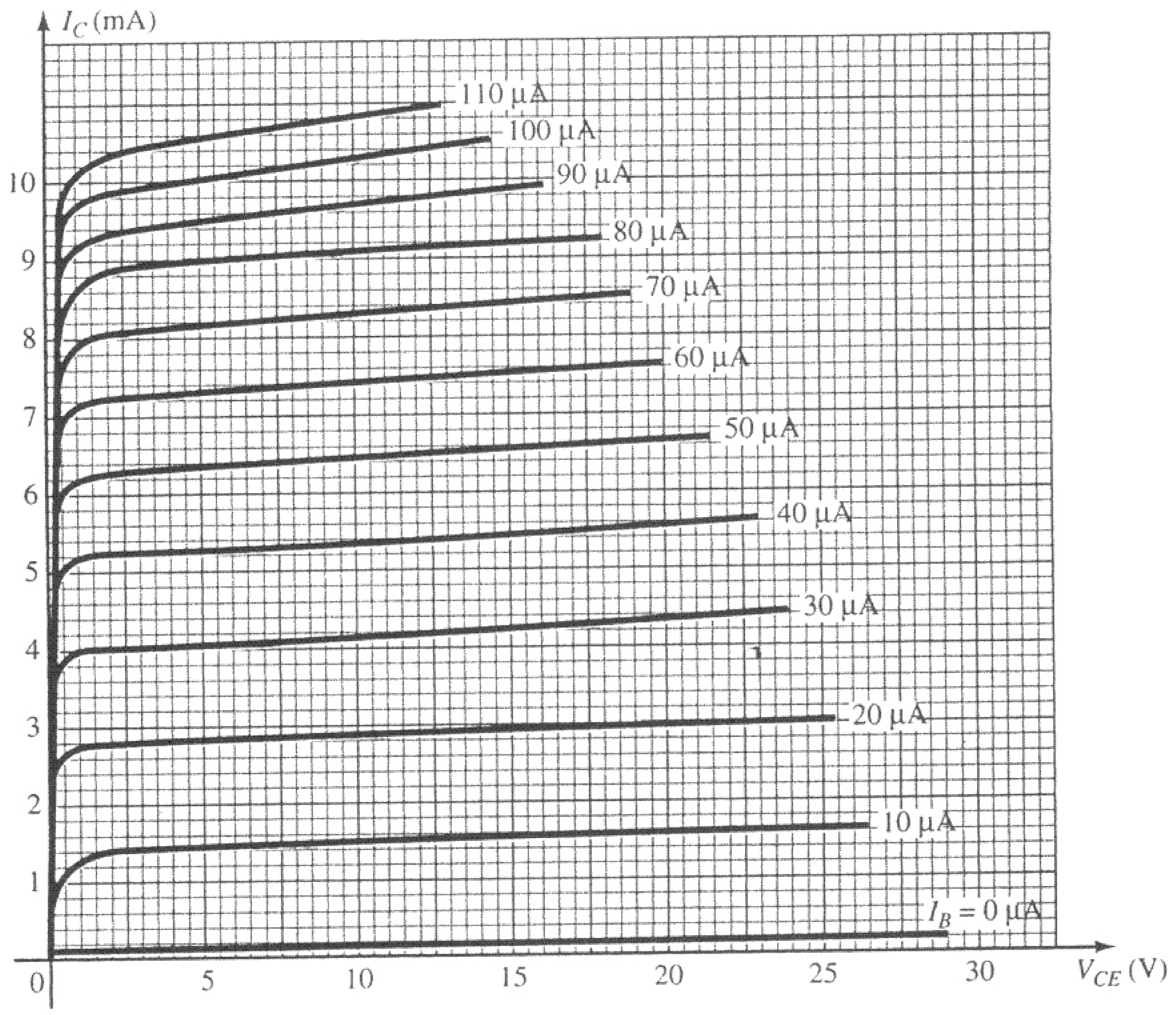

FIG. 4.111
Problems 5, 10, 19, 35, and 41.

4.4 Emitter-Bias Configuration

6. For the emitter-stabilized bias circuit of Fig. 4.112, determine:
   a. I_{B_Q}.
   b. I_{C_Q}.
   c. V_{CE_Q}.
   d. V_C.
   e. V_B.
   f. V_E.
7. Given the information provided in Fig. 4.113, determine:
   a. R_C.
   b. R_E.
   c. R_B.
   d. V_{CE}.
   e. V_B.

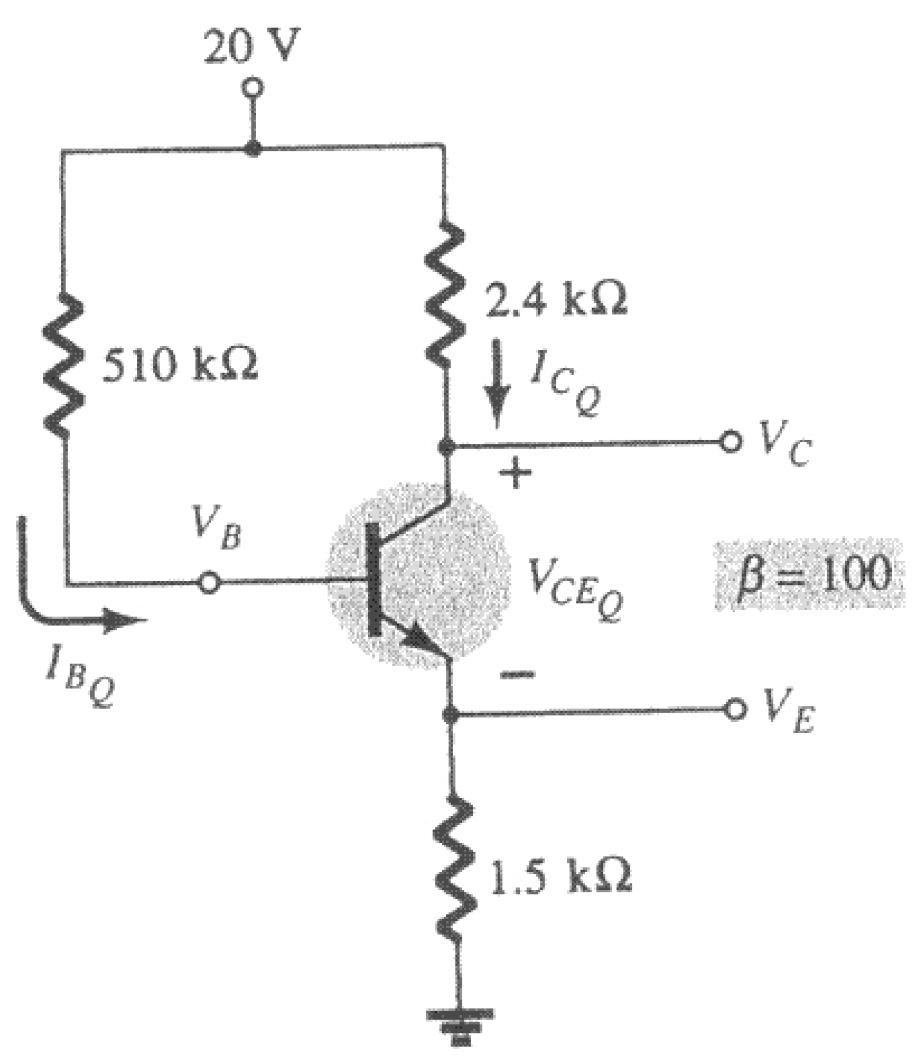

FIG. 4.112
Problems 6, 9, 11, 48, 51, and 54.

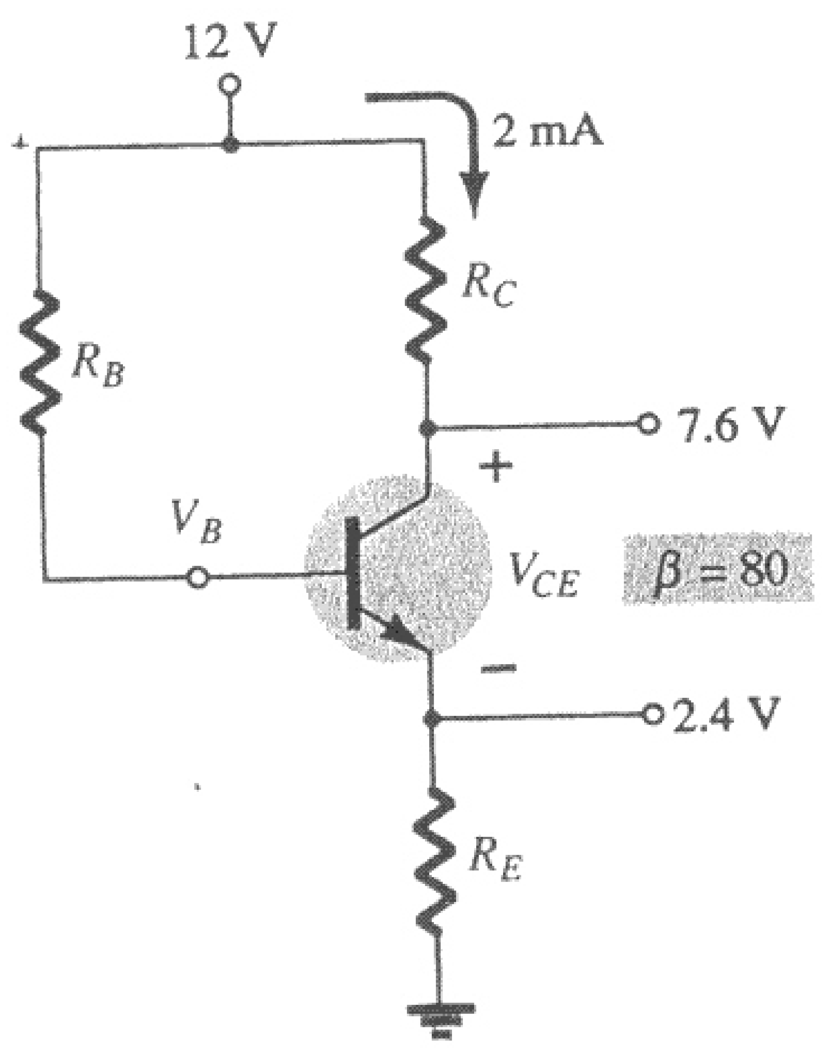

FIG. 4.113
Problem 7.

8. Given the information provided in Fig. 4.114, determine:
   a. β.
   b. V_{CC}.
   c. R_B.

9. Determine the saturation current ($I_{C_{sat}}$) for the network of Fig. 4.112.

*10. Using the characteristics of Fig. 4.111, determine the following for an emitter-bias configuration if a Q-point is defined at $I_{C_Q} = 4$ mA and $V_{CE_Q} = 10$ V.
   a. R_C if $V_{CC} = 24$ V and $R_E = 1.2$ kΩ.
   b. β at the operating point.
   c. R_B.
   d. Power dissipated by the transistor.
   e. Power dissipated by the resistor R_C.

*11. a. Determine I_C and V_{CE} for the network of Fig. 4.108.
   b. Change β to 135 and determine the new value of I_C and V_{CE} for the network of Fig. 4.108.
   c. Determine the magnitude of the percentage change in I_C and V_{CE} using the following equations:

$$\%\Delta I_C = \left|\frac{I_{C(\text{part b})} - I_{C(\text{part a})}}{I_{C(\text{part a})}}\right| \times 100\%, \qquad \%\Delta V_{CE} = \left|\frac{V_{CE(\text{part b})} - V_{CE(\text{part a})}}{V_{CE(\text{part a})}}\right| \times 100\%$$

   d. Determine I_C and V_{CE} for the network of Fig. 4.112.
   e. Change β to 150 and determine the new value of I_C and V_{CE} for the network of Fig. 4.112.
   f. Determine the magnitude of the percentage change in I_C and V_{CE} using the following equations:

$$\%\Delta I_C = \left|\frac{I_{C(\text{part c})} - I_{C(\text{part d})}}{I_{C(\text{part d})}}\right| \times 100\%, \qquad \%\Delta V_{CE} = \left|\frac{V_{CE(\text{part c})} - V_{CE(\text{part d})}}{V_{CE(\text{part d})}}\right| \times 100\%$$

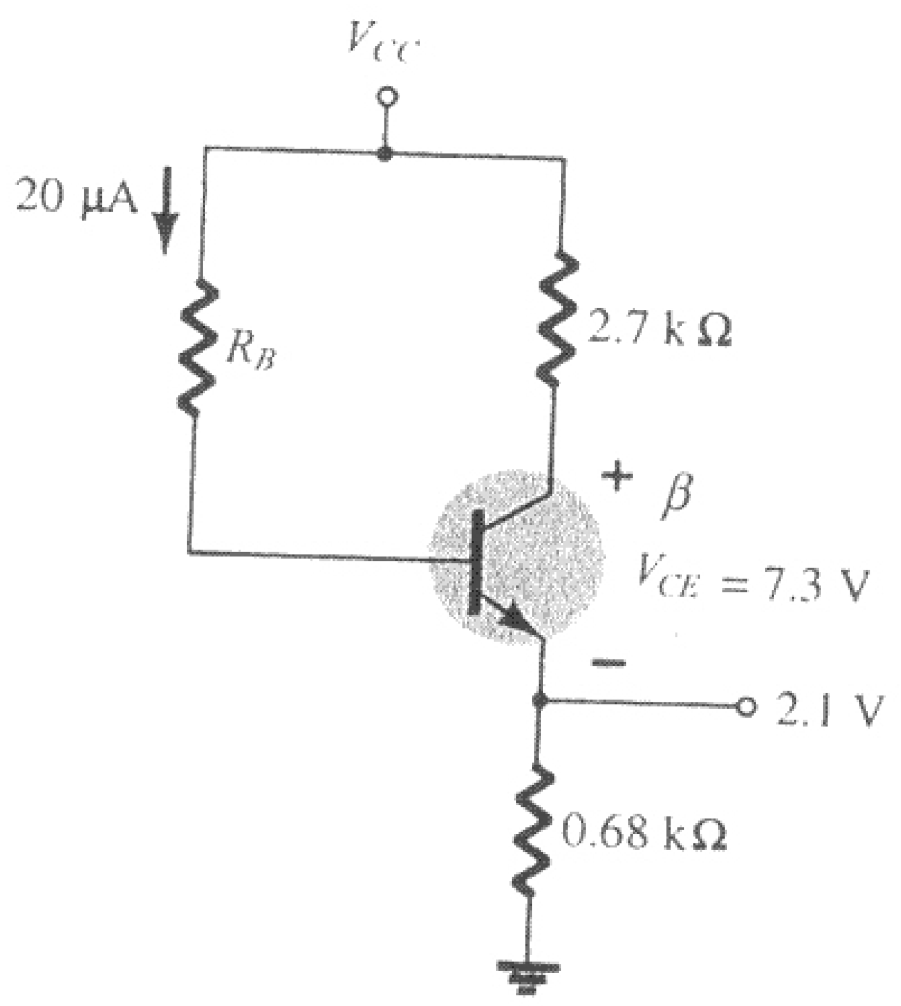

FIG. 4.114
Problem 8.

   g. In each of the above, the magnitude of β was increased 50%. Compare the percentage change in I_C and V_{CE} for each configuration, and comment on which seems to be less sensitive to changes in β.

4.5 Voltage-Divider Bias Configuration

12. For the voltage-divider bias configuration of Fig. 4.115, determine:
   a. I_{B_Q}.
   b. I_{C_Q}.
   c. V_{CE_Q}.
   d. V_C.
   e. V_E.
   f. V_B.

13. Given the information provided in Fig. 4.116, determine:
   a. I_C.
   b. V_E.
   c. V_B.
   d. R_1.

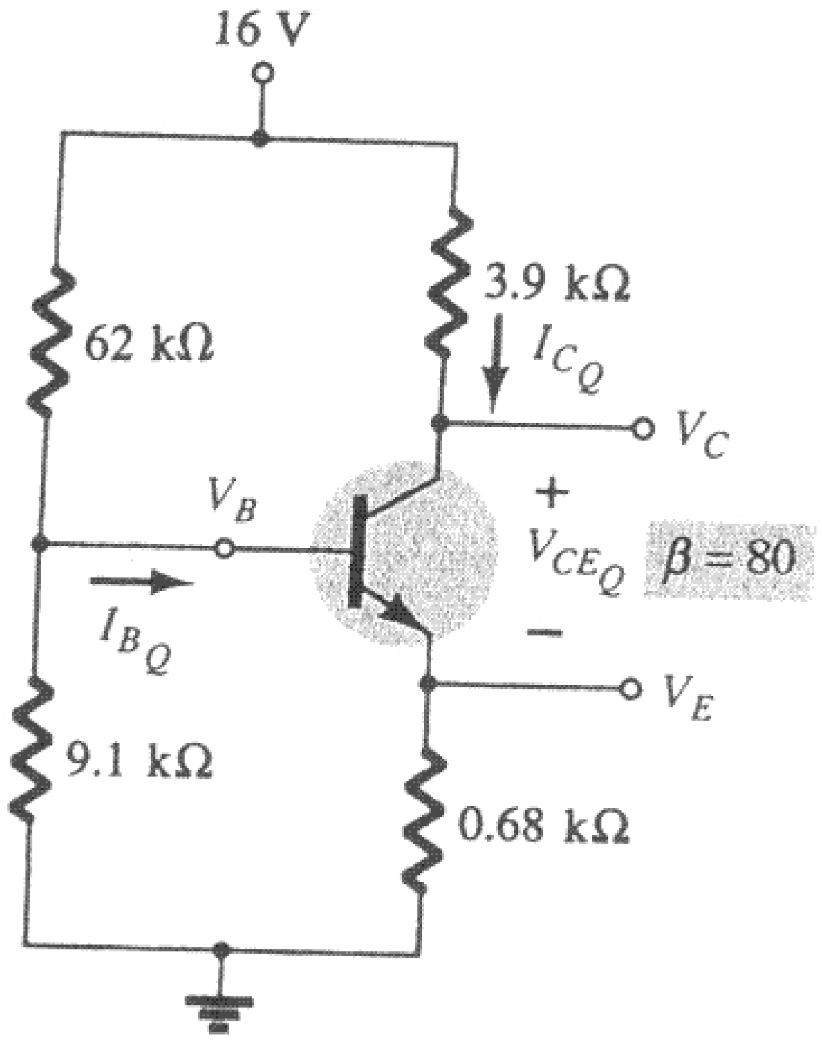

FIG. 4.115
Problems 12, 15, 18, 20, 24, 54, 56, 57, and 60.

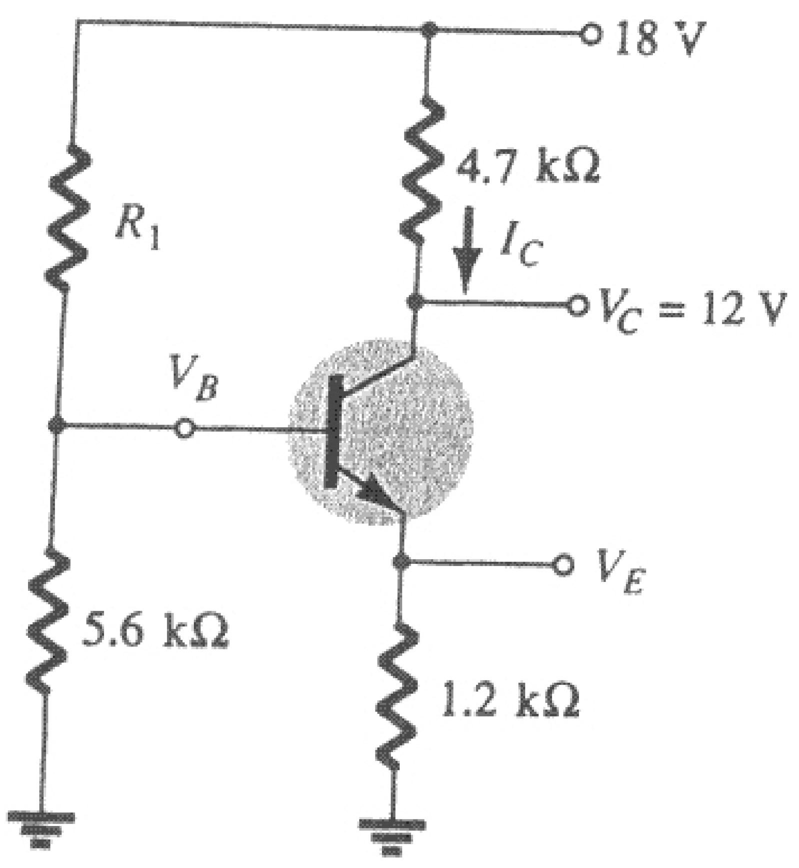

FIG. 4.116
Problem 13.

14. Given the information appearing in Fig. 4.117, determine:
   a. I_C.
   b. V_E.
   c. V_{CC}.
   d. V_{CE}.
   e. V_B.
   f. R_1.

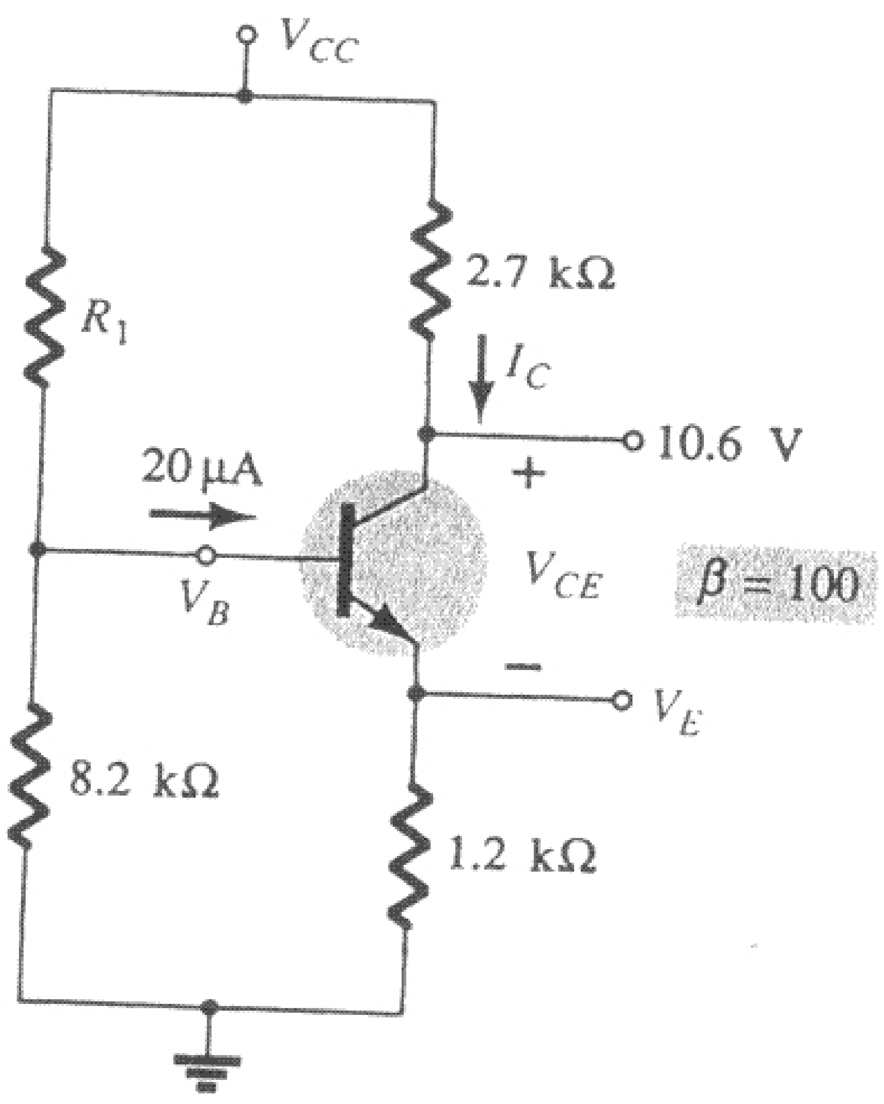

FIG. 4.117
Problem 14.

15. Determine the saturation current ($I_{C_{sat}}$) for the network of Fig. 4.115.

*16. Determine the following for the voltage-divider configuration of Fig. 4.118 using the approximate approach if the condition established by Eq. (4.33) is satisfied.
   a. I_C.
   b. V_{CE}.
   c. I_B.
   d. V_E.
   e. V_B.

*17. Repeat Problem 16 using the exact (Thévenin) approach and compare solutions. Based on the results, is the approximate approach a valid analysis technique if Eq. (4.33) is satisfied?

18. a. Determine I_{C_Q}, V_{CE_Q}, and I_{B_Q} for the network of Problem 12 (Fig. 4.115) using the approximate approach even though the condition established by Eq. (4.33) is not satisfied.

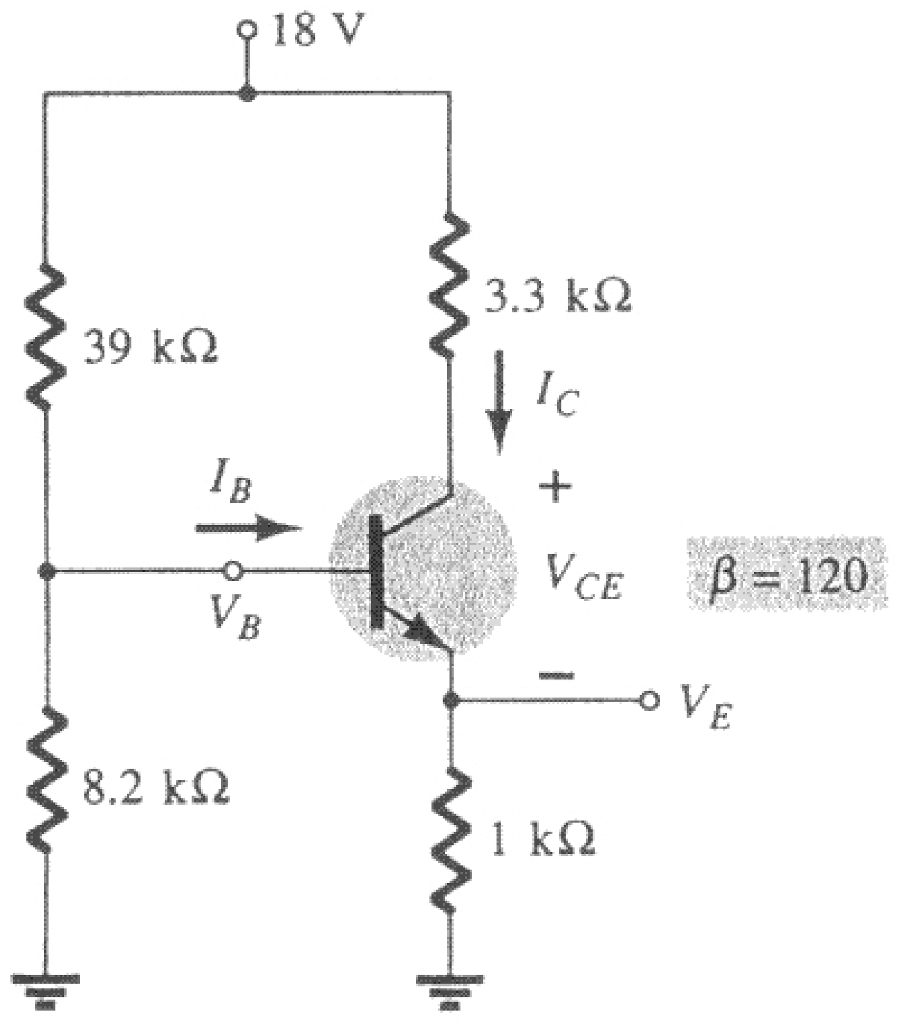

FIG. 4.118
Problems 16, 17, and 21.

b. Determine I_{C_Q}, V_{CE_Q}, and I_{B_Q} using the exact approach.
c. Compare solutions and comment on whether the difference is sufficiently large to require standing by Eq. (4.33) when determining which approach to employ.

*19. a. Using the characteristics of Fig. 4.111, determine R_C and R_E for a voltage-divider network having a Q-point of $I_{C_Q} = 5$ mA and $V_{CE_Q} = 8$ V. Use $V_{CC} = 24$ V and $R_C = 3R_E$.
b. Find V_E.
c. Determine V_B.
d. Find R_2 if $R_1 = 24$ kΩ assuming that $\beta R_E > 10R_2$.
e. Calculate β at the Q-point.
f. Test Eq. (4.33), and note whether the assumption of part (d) is correct.

*20. a. Determine I_C and V_{CE} for the network of Fig. 4.115.
b. Change β to 120 (50% increase), and determine the new values of I_C and V_{CE} for the network of Fig. 4.115.
c. Determine the magnitude of the percentage change in I_C and V_{CE} using the following equations:

$$\%\Delta I_C = \left|\frac{I_{C(\text{part b})} - I_{C(\text{part a})}}{I_{C(\text{part a})}}\right| \times 100\%, \qquad \%\Delta V_{CE} = \left|\frac{V_{CE(\text{part b})} - V_{CE(\text{part a})}}{V_{CE(\text{part a})}}\right| \times 100\%$$

d. Compare the solution to part (c) with the solutions obtained for parts (c) and (f) of Problem 11. If not performed, note the solutions provided in Appendix E.
e. Based on the results of part (d), which configuration is least sensitive to variations in β?

*21. a. Repeat parts (a) through (e) of Problem 20 for the network of Fig. 4.118. Change β to 180 in part (b).
b. What general conclusions can be made about networks in which the condition $\beta R_E > 10R_2$ is satisfied and the quantities I_C and V_{CE} are to be determined in response to a change in β?

4.6 Collector-Feedback Configuration

22. For the collector-feedback configuration of Fig. 4.119, determine:
a. I_B.
b. I_C.
c. V_C.

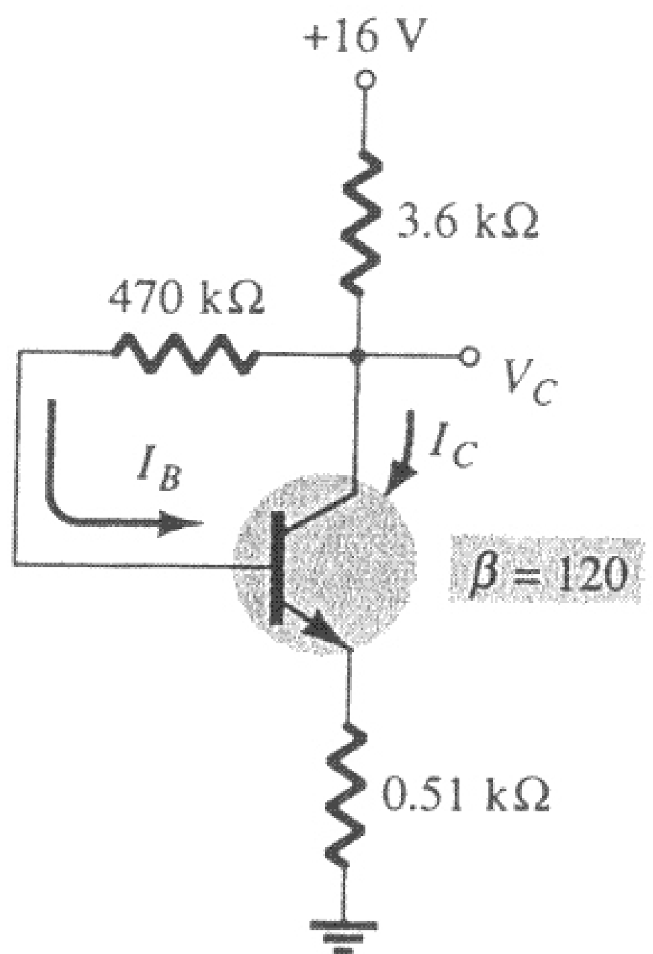

FIG. 4.119
Problems 22 and 61.

23. For the voltage feedback network of Fig. 4.120, determine:
   a. I_C.
   b. V_C.
   c. V_E.
   d. V_{CE}.

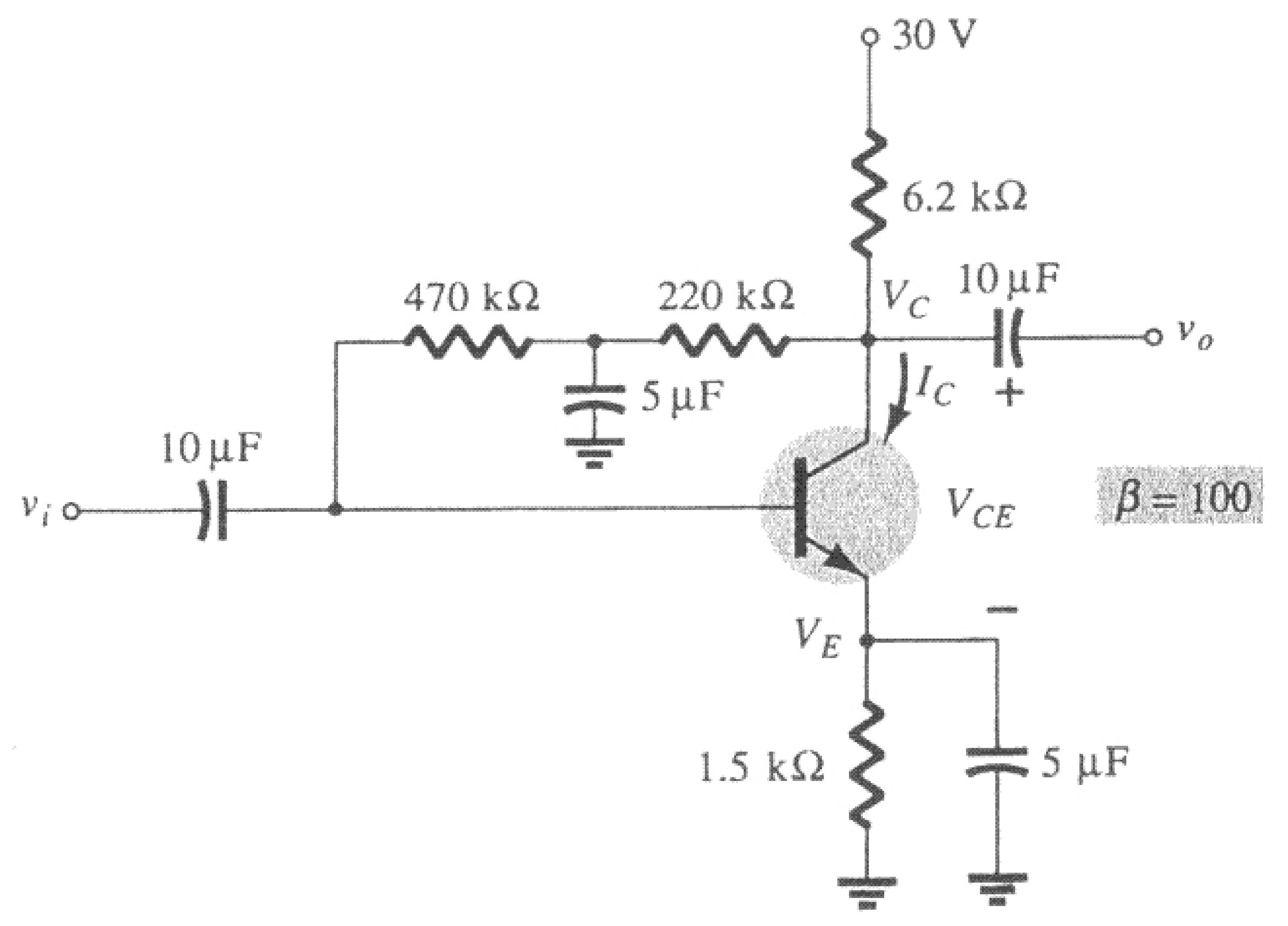

FIG. 4.120
Problem 23.

*24. a. Determine the levels of I_C and V_{CE} for the network of Fig. 4.121.
   b. Change β to 135 (50% increase), and calculate the new levels of I_C and V_{CE}.

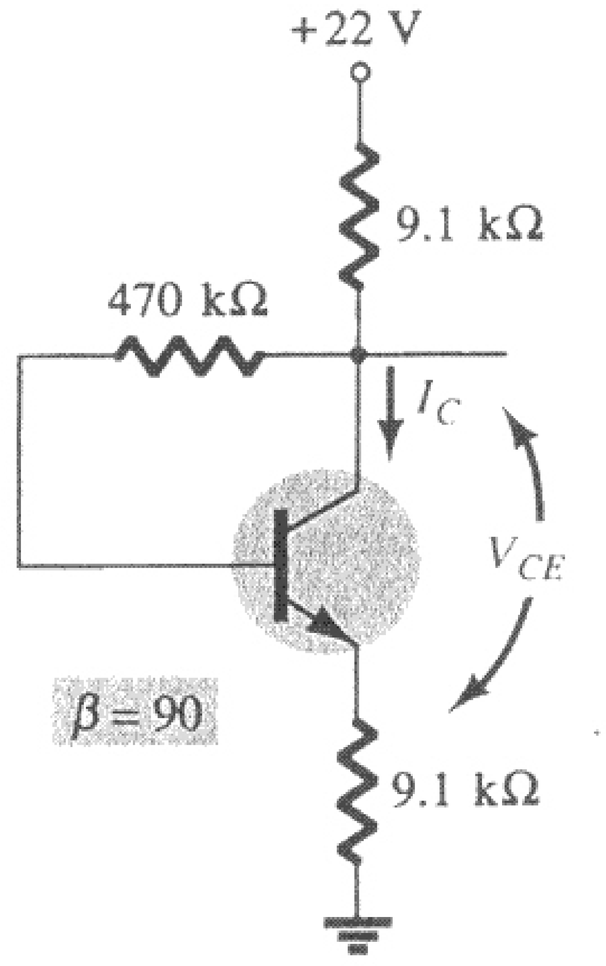

FIG. 4.121
Problem 24.

   c. Determine the magnitude of the percentage change in I_C and V_{CE} using the following equations:

$$\%\Delta I_C = \left|\frac{I_{C(\text{part b})} - I_{C(\text{part a})}}{I_{C(\text{part a})}}\right| \times 100\%, \qquad \%\Delta V_{CE} = \left|\frac{V_{CE(\text{part b})} - V_{CE(\text{part a})}}{V_{CE(\text{part a})}}\right| \times 100\%$$

   d. Compare the results of part (c) with those of Problems 11(c), 11(f), and 20(c). How does the collector-feedback network stack up against the other configurations in sensitivity to changes in β?

25. Determine the range of possible values for V_C for the network of Fig. 4.122 using the 1-MΩ potentiometer.

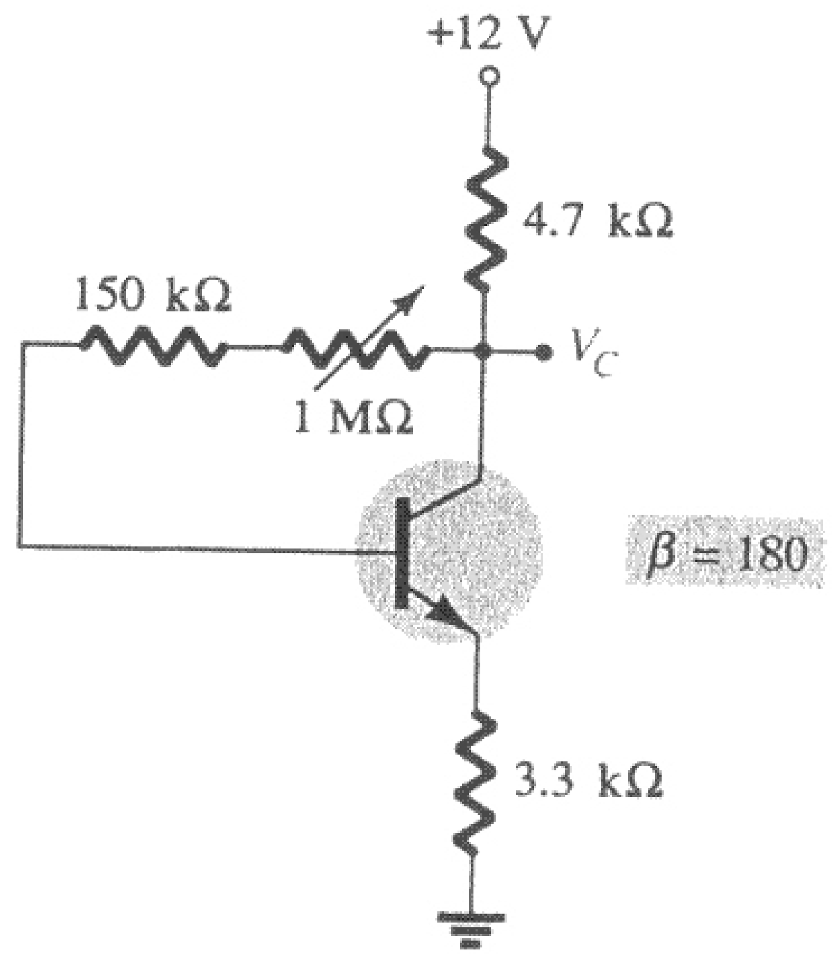

FIG. 4.122
Problem 25.

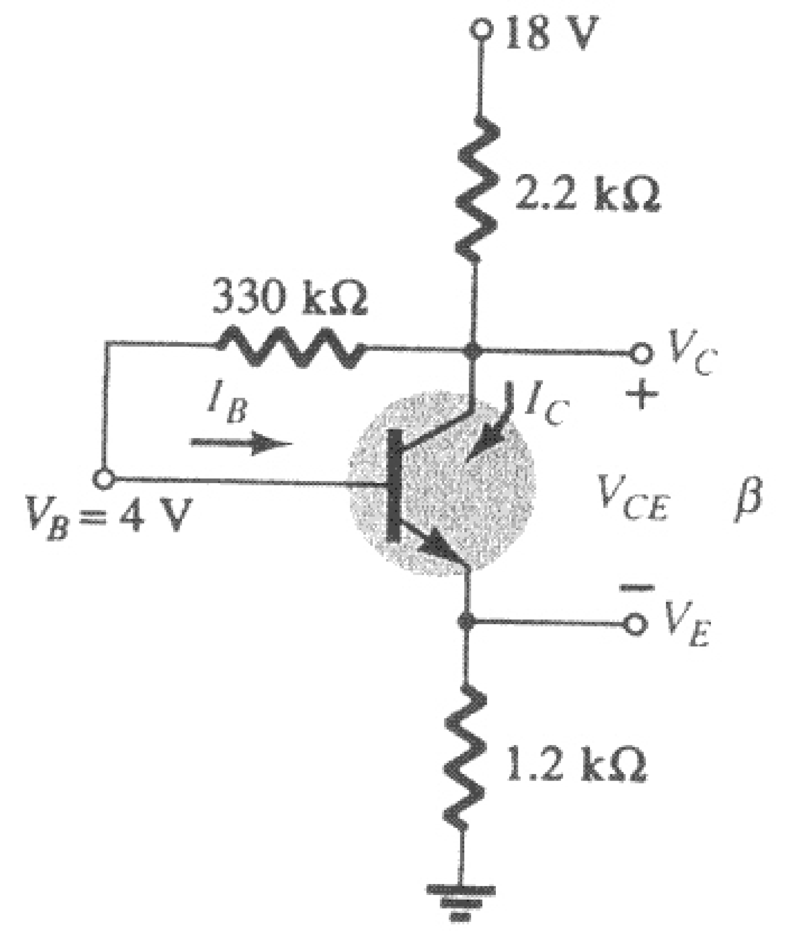

FIG. 4.123
Problem 26.

*26. Given $V_B = 4$ V for the network of Fig. 4.123, determine:
- a. V_E.
- b. I_C.
- c. V_C.
- d. V_{CE}.
- e. I_B.
- f. β.

4.7 Emitter-Follower Configuration

*27. Determine the level of V_E and I_E for the network of Fig. 4.124.

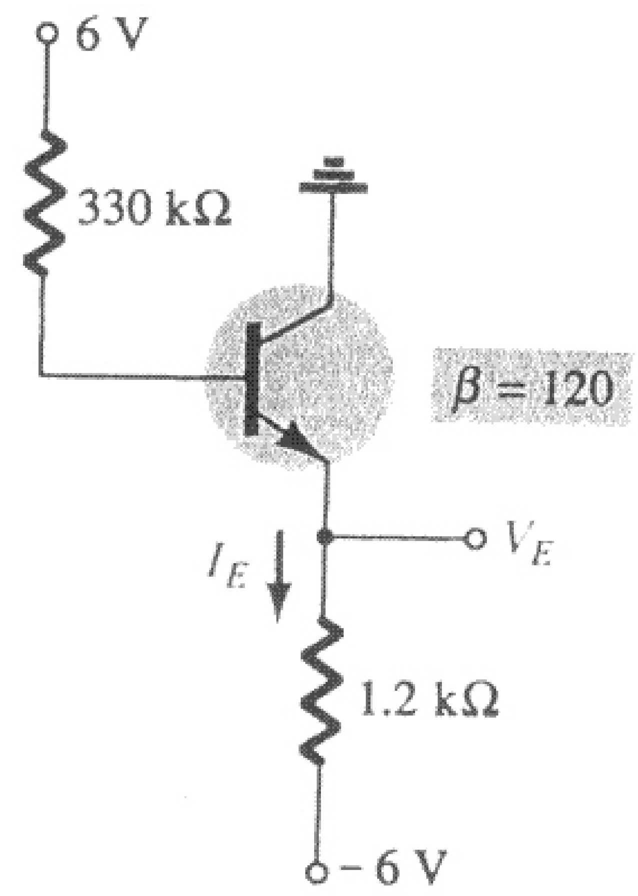

FIG. 4.124
Problem 27.

4.8 Common-Base Configuration

*28. For the network of Fig. 4.125, determine:
- a. I_B.
- b. I_C.
- c. V_{CE}.
- d. V_C.

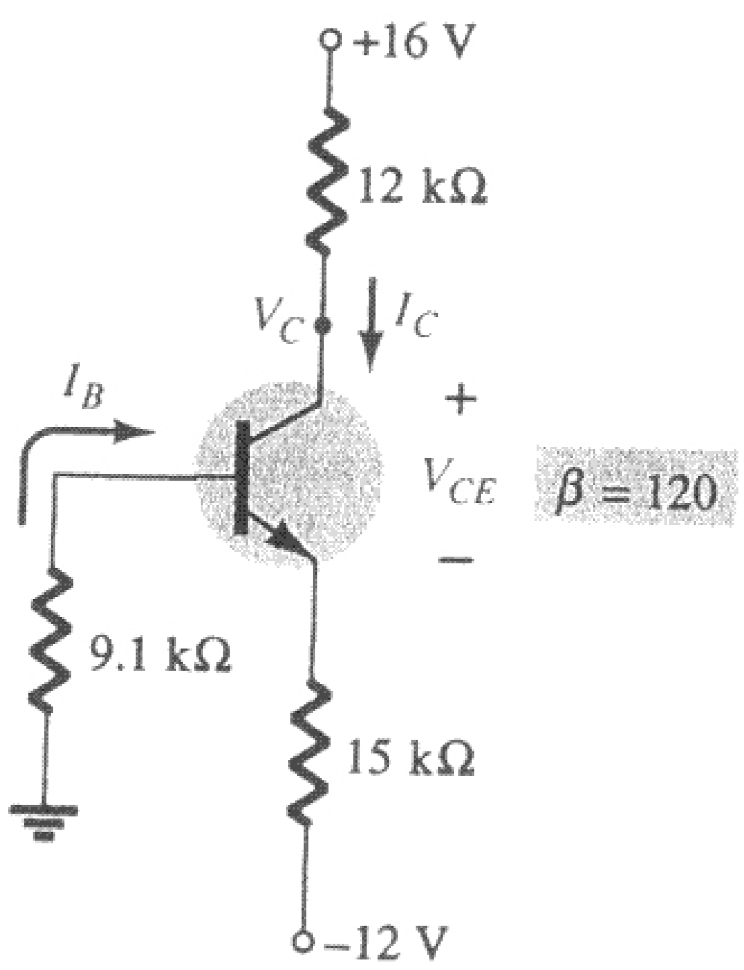

FIG. 4.125
Problem 28.

*29. For the network of Fig. 4.126, determine:
   a. I_E.
   b. V_C.
   c. V_{CE}.

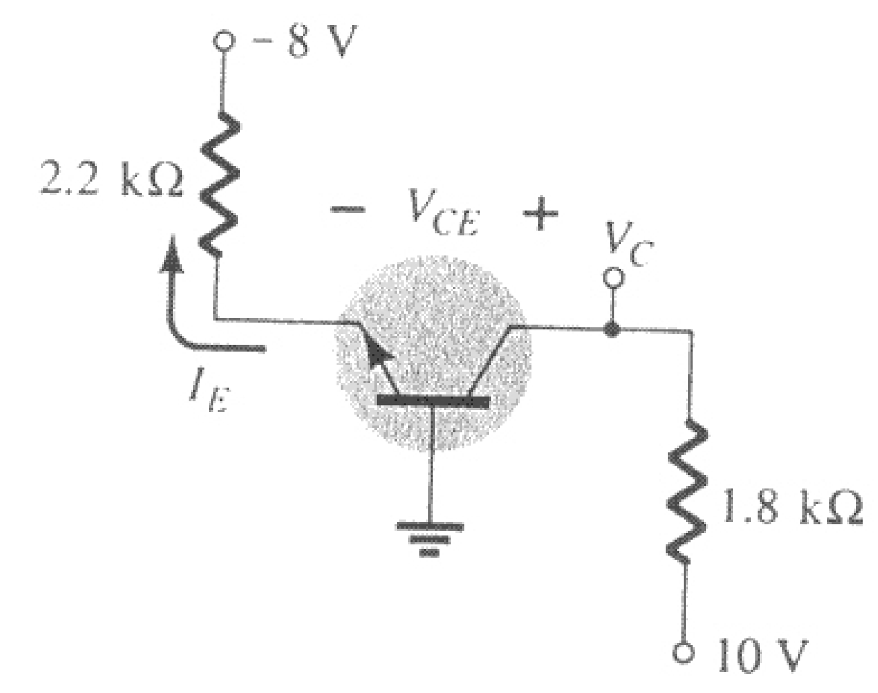

FIG. 4.126
Problem 29.

4.9 Miscellaneous Bias Configurations

*30. For the network of Fig. 4.127, determine:
   a. I_B.
   b. I_C.
   c. V_E.
   d. V_{CE}.

31. Given $V_C = 8$ V for the network of Fig. 4.128, determine:
   a. I_B.
   b. I_C.
   c. β.
   d. V_{CE}.

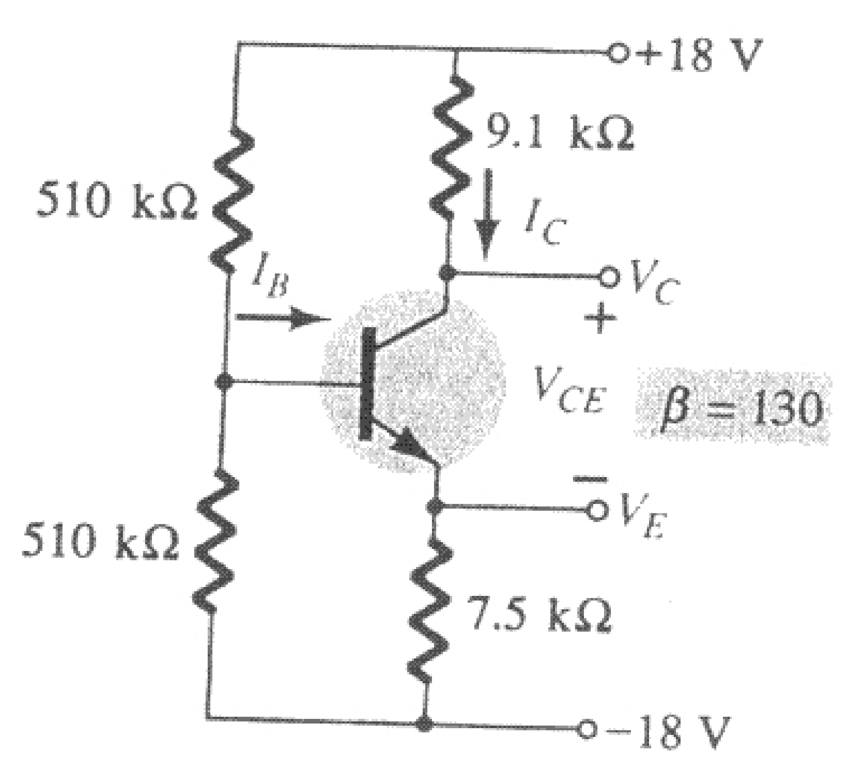

FIG. 4.127
Problem 30.

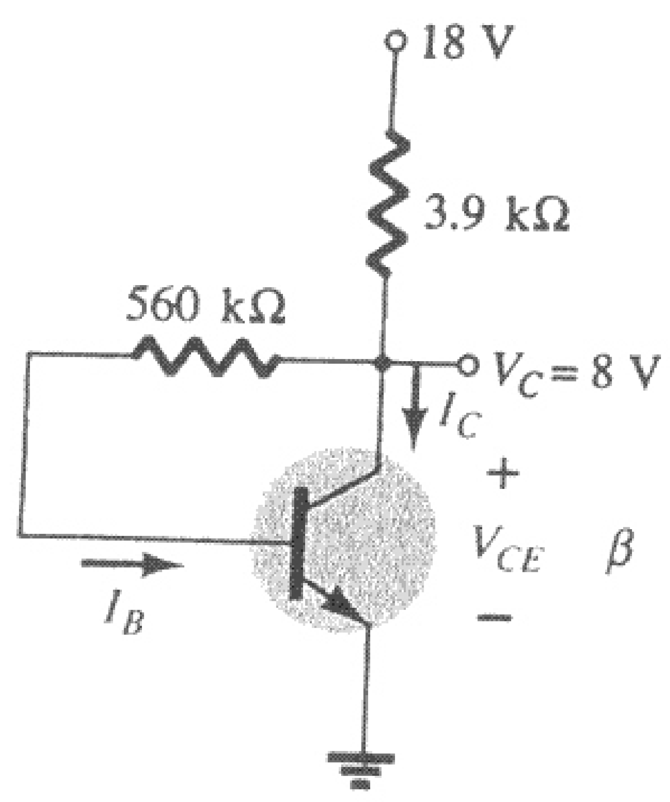

FIG. 4.128
Problem 31.

4.11 Design Operations

32. Determine R_C and R_B for a fixed-bias configuration if $V_{CC} = 12$ V, $\beta = 80$, and $I_{C_Q} = 2.5$ mA with $V_{CE_Q} = 6$ V. Use standard values.

33. Design an emitter-stabilized network at $I_{C_Q} = \frac{1}{2}I_{C_{sat}}$ and $V_{CE_Q} = \frac{1}{2}V_{CC}$. Use $V_{CC} = 20$ V, $I_{C_{sat}} =$ 10 mA, $\beta = 120$, and $R_C = 4R_E$. Use standard values.

34. Design a voltage-divider bias network using a supply of 24 V, a transistor with a beta of 110, and an operating point of $I_{C_Q} = 4$ mA and $V_{CE_Q} = 8$ V. Choose $V_E = \frac{1}{8}V_{CC}$. Use standard values.

*35. Using the characteristics of Fig. 4.133, design a voltage-divider configuration to have a saturation level of 10 mA and a Q-point one-half the distance between cutoff and saturation. The available supply is 28 V, and V_E is to be one-fifth of V_{CC}. The condition established by Eq. (4.33) should also be met to provide a high stability factor. Use standard values.

4.12 Current Mirror Circuits

36. Calculate the mirrored current I in the circuit of Fig. 4.129.

*37. Calculate collector currents for Q_1 and Q_2 in Fig. 4.130.

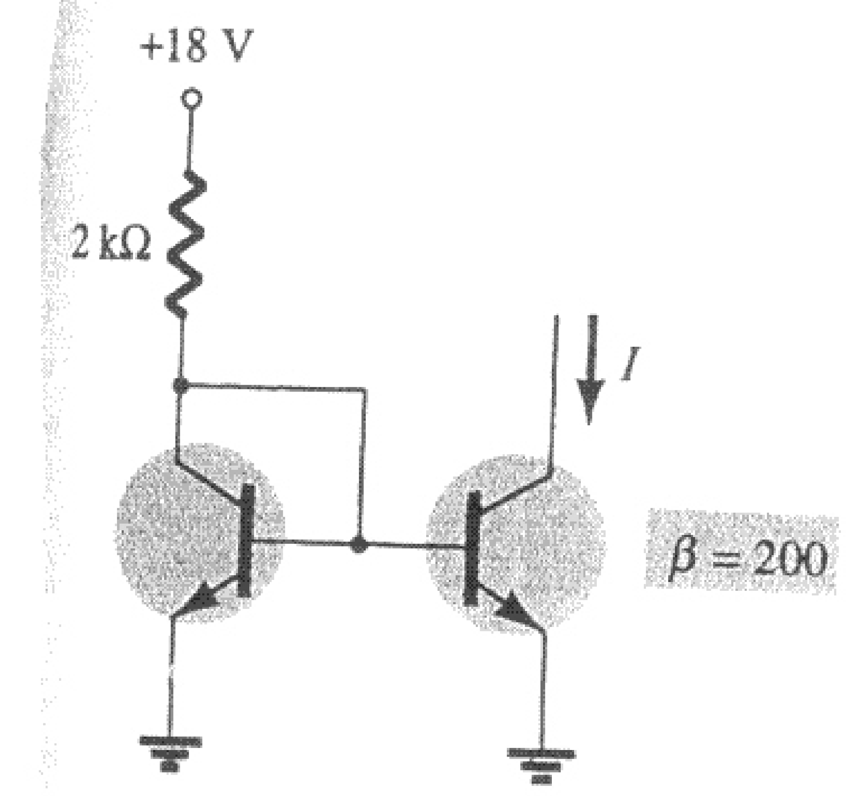

FIG. 4.129
Problem 36.

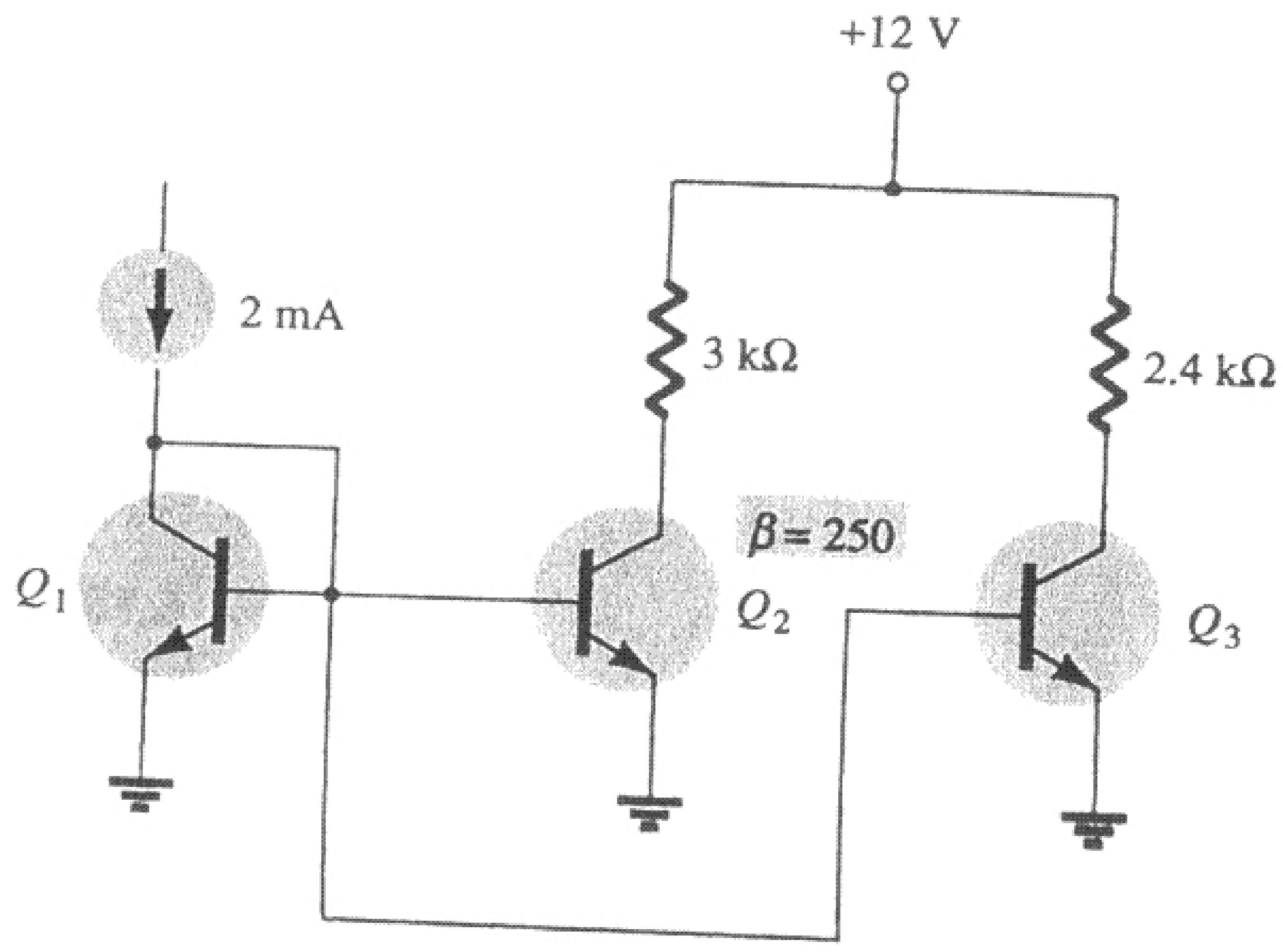

FIG. 4.130
Problem 37.

4.13 Current Source Circuits

38. Calculate the current through the 2.2-kΩ load in the circuit of Fig. 4.131.
39. For the circuit of Fig. 4.132, calculate the current I.
*40. Calculate the current I in the circuit of Fig. 4.133.

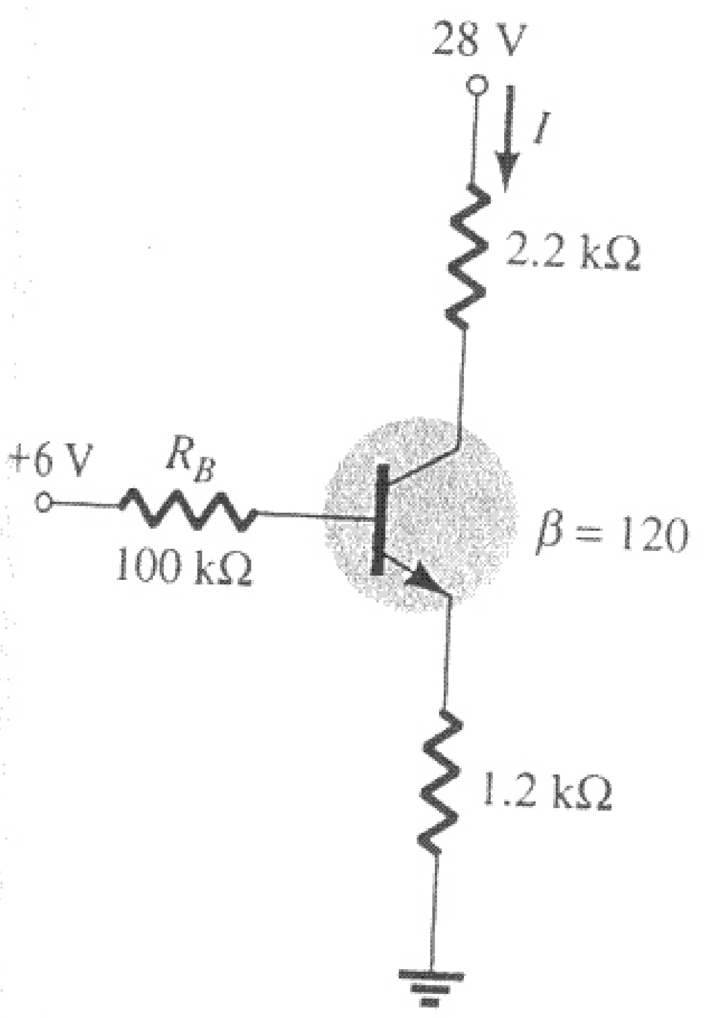

FIG. 4.131
Problem 38.

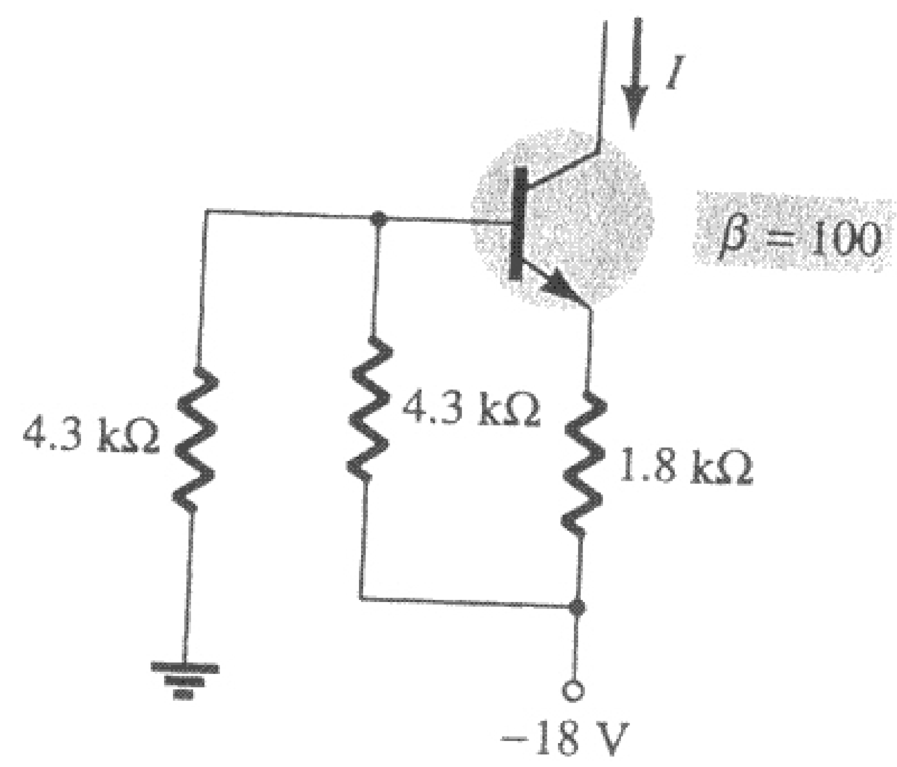

FIG. 4.132
Problem 39.

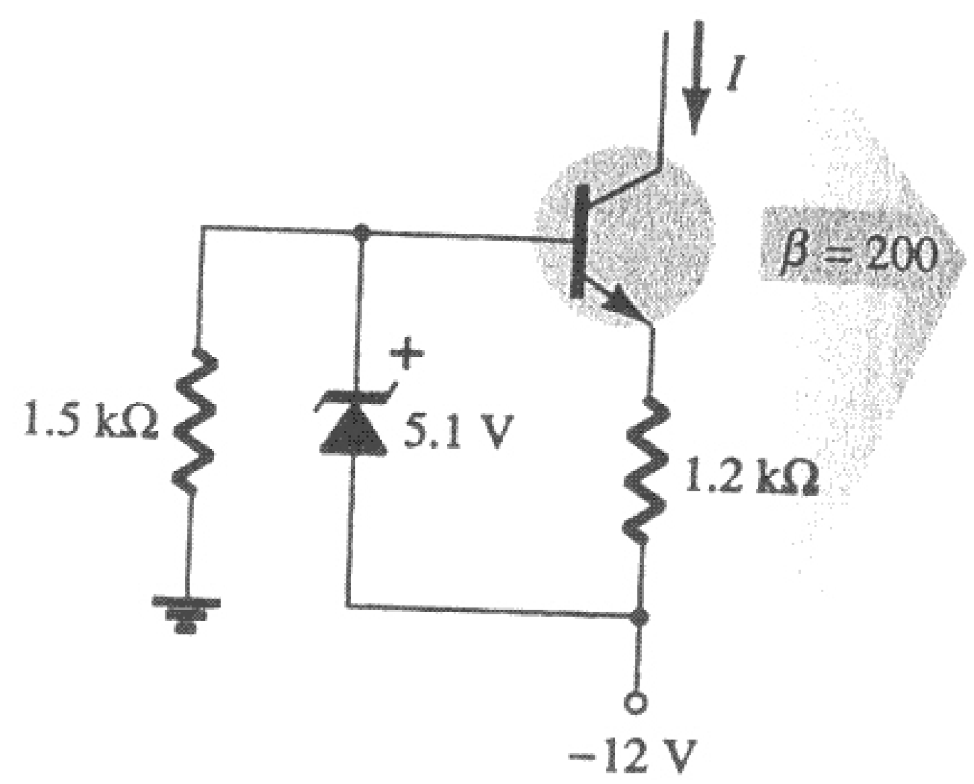

FIG. 4.133
Problem 40.

4.14 *pnp* Transistors

41. Determine V_C, V_{CE}, and I_C for the network of Fig. 4.134.
42. Determine V_C and I_B for the network of Fig. 4.135.
43. Determine I_E and V_C for the network of Fig. 4.136.

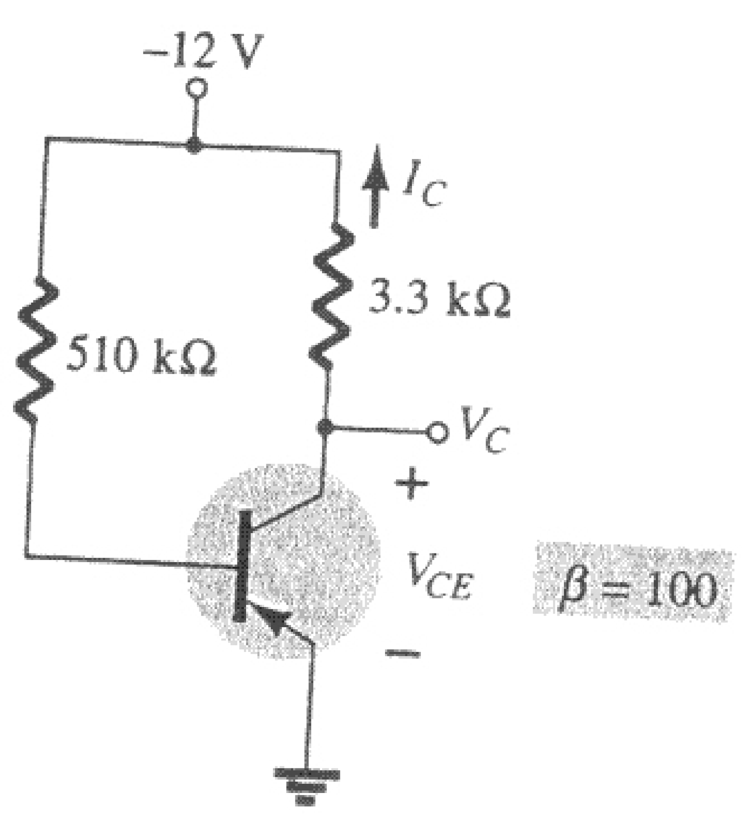

FIG. 4.134
Problem 41.

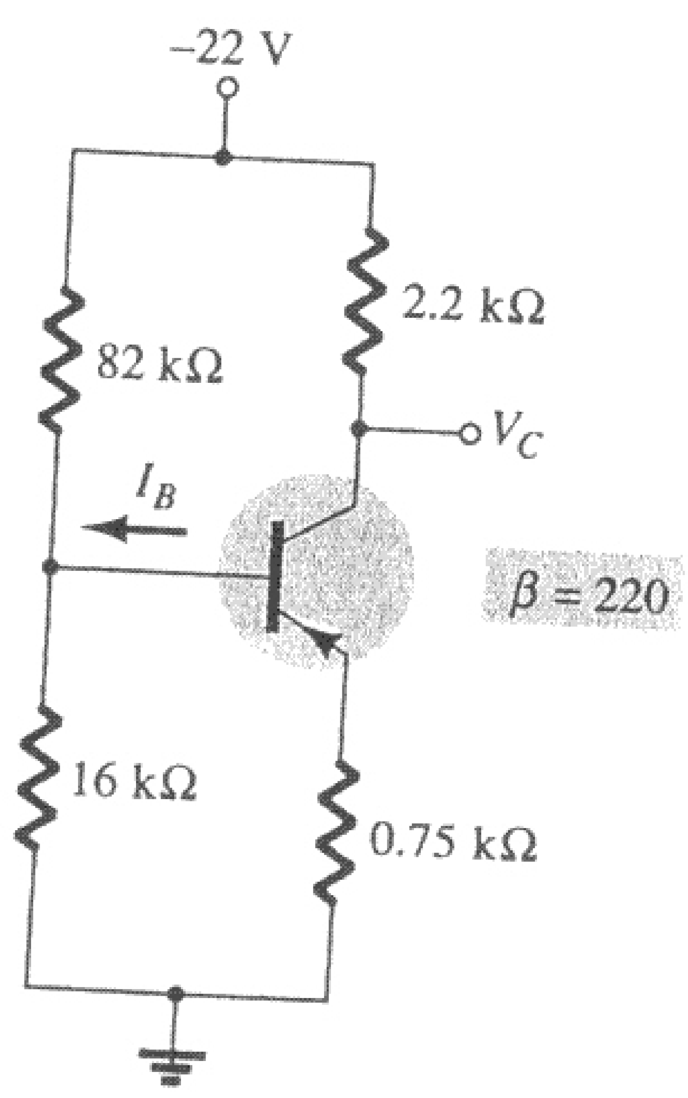

FIG. 4.135
Problem 42.

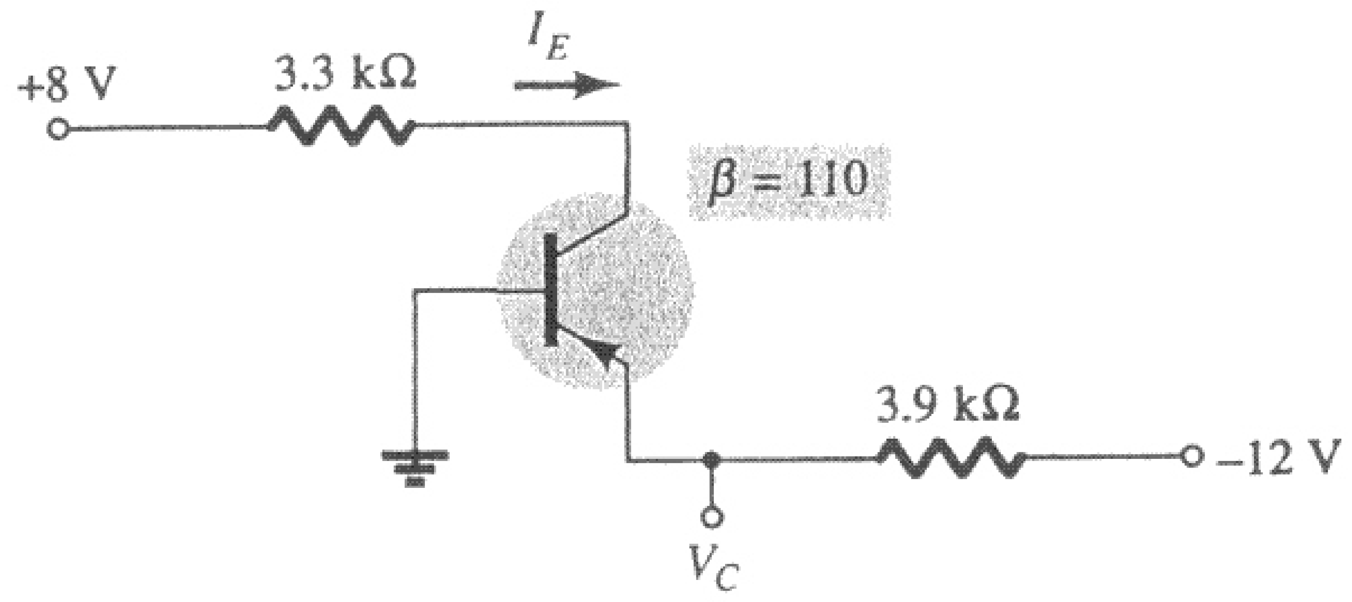

FIG. 4.136
Problem 43.

4.15 Transistor Switching Networks

*44. Using the characteristics of Fig. 4.111, determine the appearance of the output waveform for the network of Fig. 4.137. Include the effects of $V_{CE_{sat}}$, and determine I_B, $I_{B_{max}}$, and $I_{C_{sat}}$ when $V_i = 10$ V. Determine the collector-to-emitter resistance at saturation and cutoff.

*45. Design the transistor inverter of Fig. 4.138 to operate with a saturation current of 8 mA using a transistor with a beta of 100. Use a level of I_B equal to 120% of $I_{B_{max}}$ and standard resistor values.

46. **a.** Using the characteristics of Fig. 3.23c, determine t_{on} and t_{off} at a current of 2 mA. Note the use of log scales and the possible need to refer to Section 9.2.
b. Repeat part (a) at a current of 10 mA. How have t_{on} and t_{off} changed with increase in collector current?
c. For parts (a) and (b), sketch the pulse waveform of Fig. 4.81 and compare results.

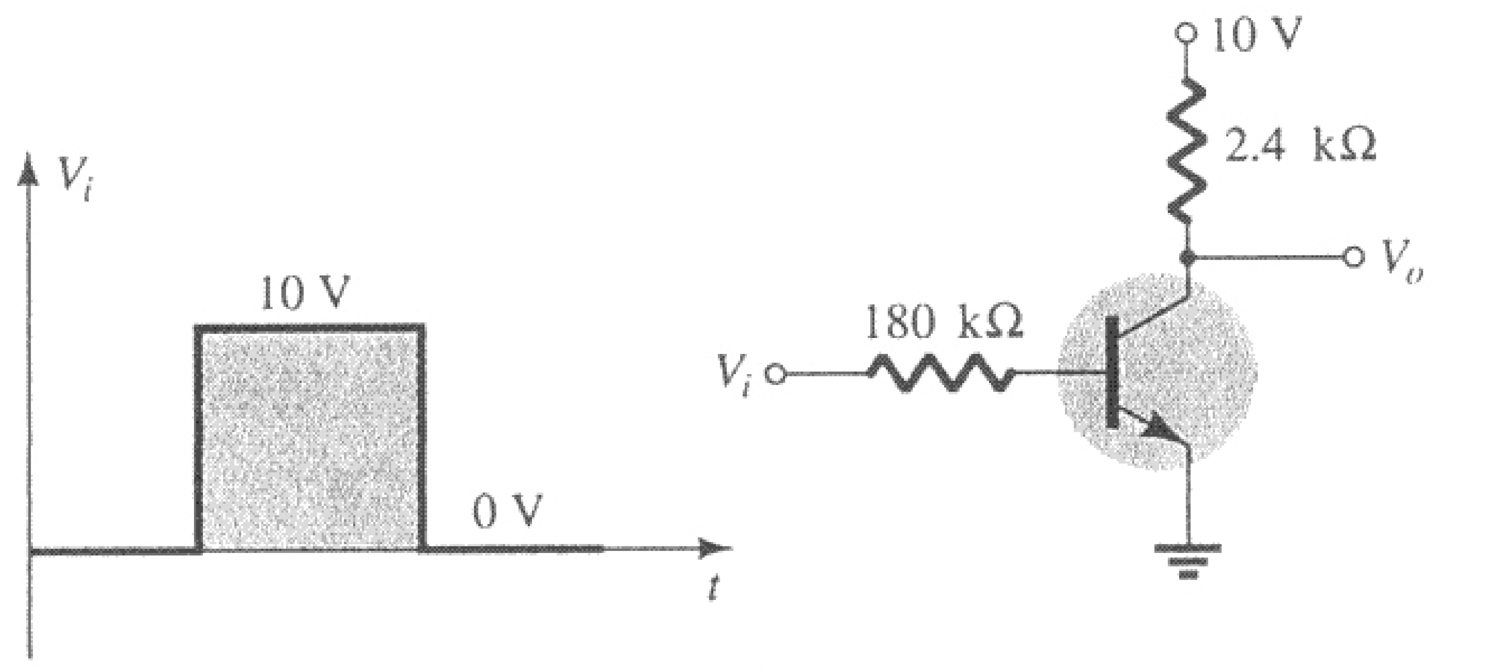

FIG. 4.137
Problem 44.

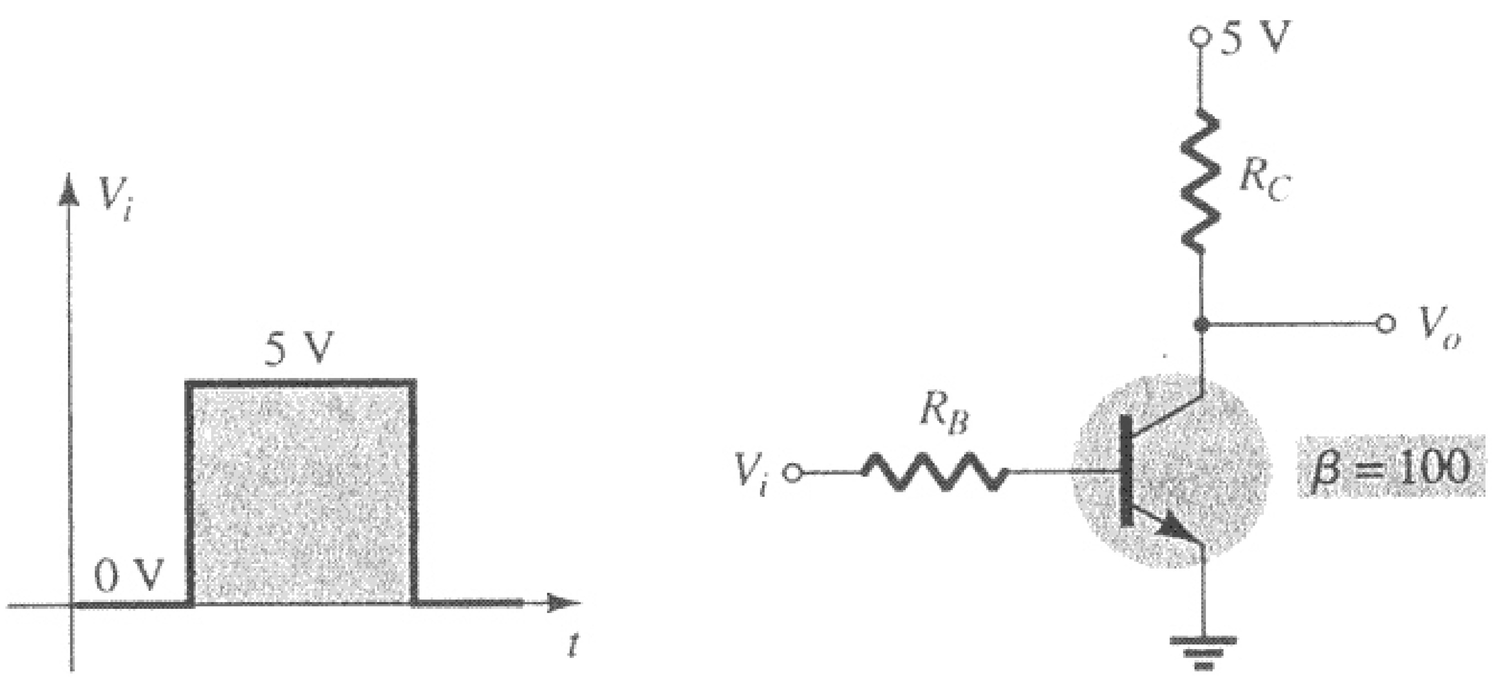

FIG. 4.138
Problem 45.

4.16 Troubleshooting Techniques

*47. The measurements of Fig. 4.139 all reveal that the network is not functioning correctly. List as many reasons as you can for the measurements obtained.

*48. The measurements appearing in Fig. 4.140 reveal that the networks are not operating properly. Be specific in describing why the levels obtained reflect a problem with the expected network behavior. In other words, the levels obtained reflect a very specific problem in each case.

49. For the circuit of Fig. 4.141:
a. Does V_C increase or decrease if R_B is increased?
b. Does I_C increase or decrease if β is reduced?
c. What happens to the saturation current if β is increased?
d. Does the collector current increase or decrease if V_{CC} is reduced?
e. What happens to V_{CE} if the transistor is replaced by one with smaller β?

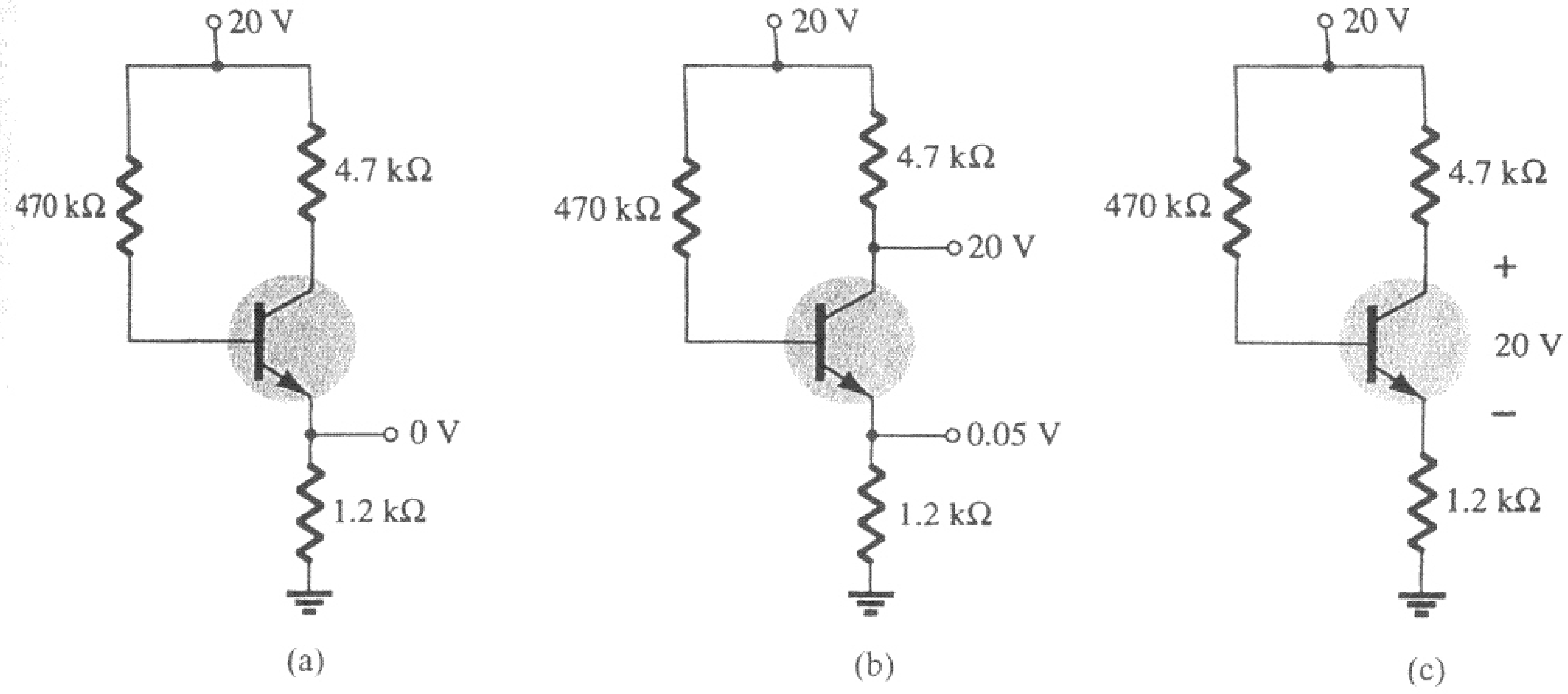

FIG. 4.139
Problem 47.

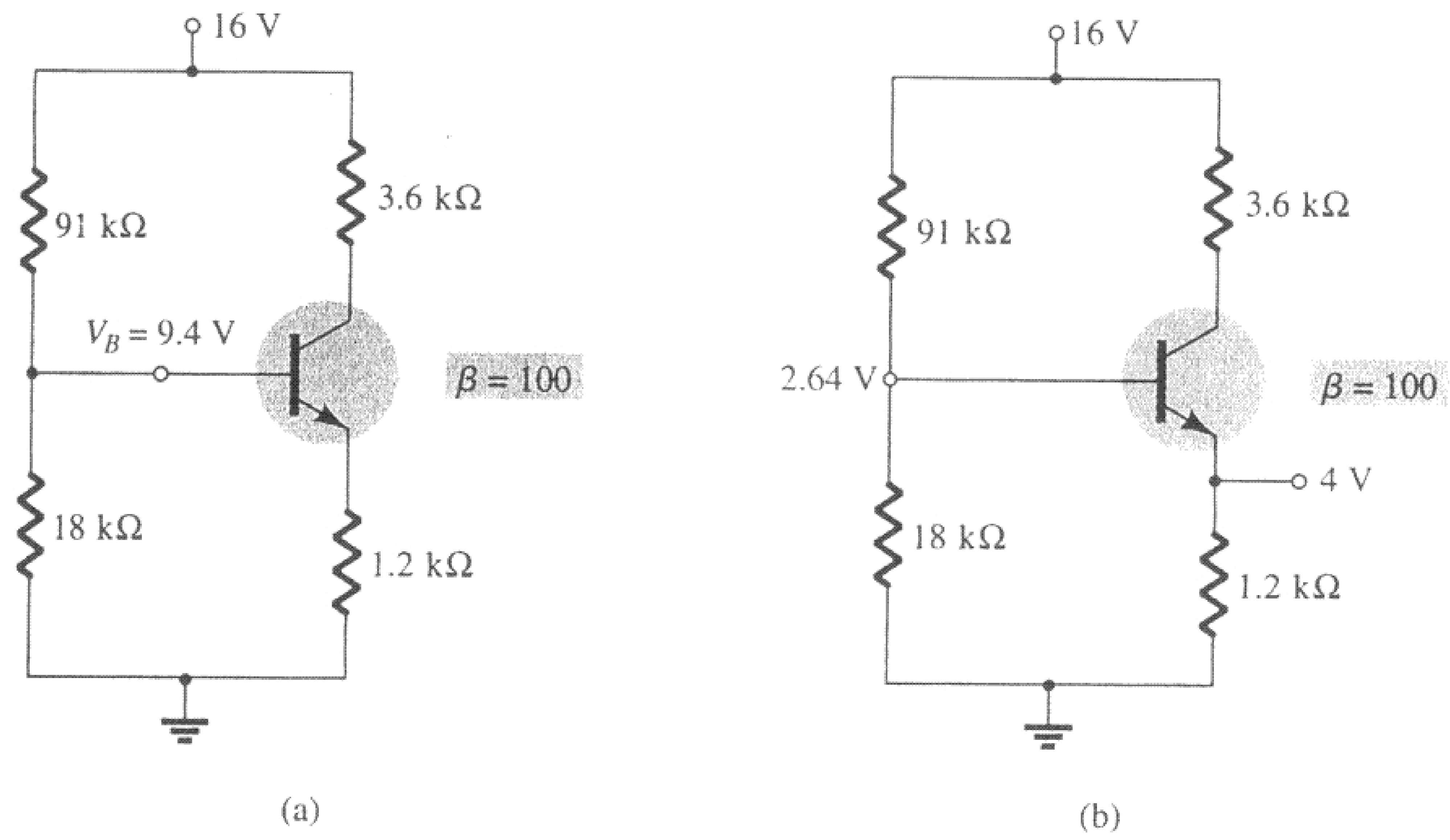

FIG. 4.140
Problem 48.

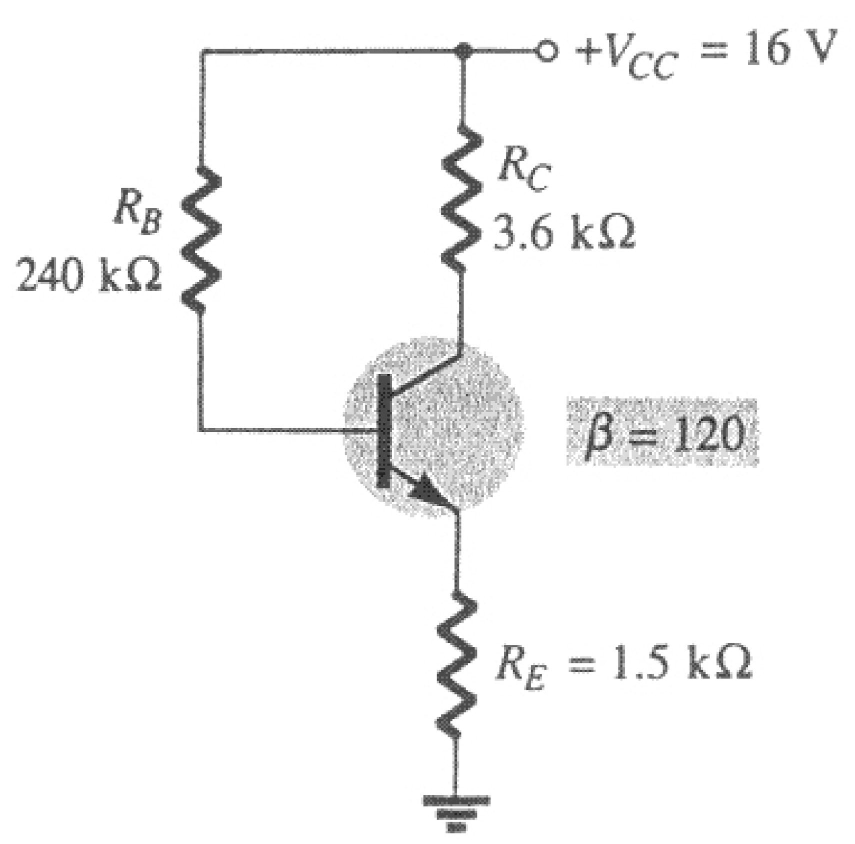

FIG. 4.141
Problem 49.

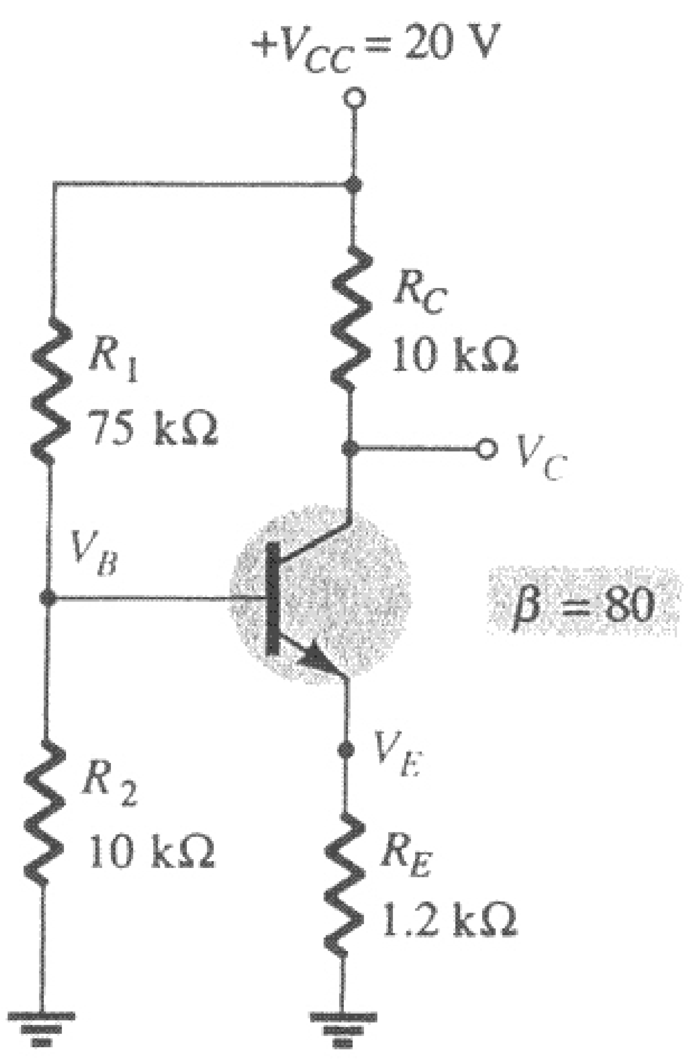

FIG. 4.142
Problem 50.

50. Answer the following questions about the circuit of Fig. 4.142:

a. What happens to the voltage V_C if the transistor is replaced by one having a larger value of β?

b. What happens to the voltage V_{CE} if the ground leg of resistor R_{B_2} opens (does not connect to ground)?

c. What happens to I_C if the supply voltage is low?

d. What voltage V_{CE} would occur if the transistor base–emitter junction fails by becoming open?

e. What voltage V_{CE} would result if the transistor base–emitter junction fails by becoming a short?

*51. Answer the following questions about the circuit of Fig. 4.143:
   a. What happens to the voltage V_C if the resistor R_B is open?
   b. What should happen to V_{CE} if β increases due to temperature?
   c. How will V_E be affected when replacing the collector resistor with one whose resistance is at the lower end of the tolerance range?
   d. If the transistor collector connection becomes open, what will happen to V_E?
   e. What might cause V_{CE} to become nearly 18 V?

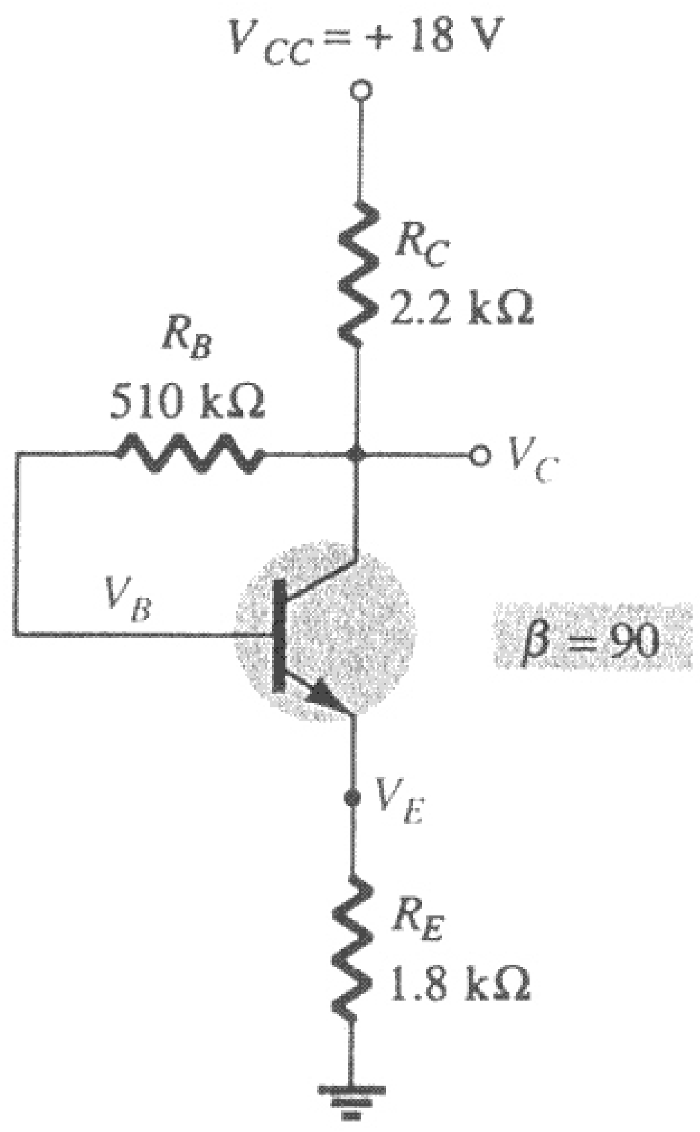

FIG. 4.143
Problem 51.

4.17 Bias Stabilization

52. Determine the following for the network of Fig. 4.108:
   a. $S(I_{CO})$.
   b. $S(V_{BE})$.
   c. $S(\beta)$, using T_1 as the temperature at which the parameter values are specified and $\beta(T_2)$ as 25% more than $\beta(T_1)$.
   d. Determine the net change in I_C if a change in operating conditions results in I_{CO} increasing from 0.2 μA to 10 μA, V_{BE} drops from 0.7 V to 0.5 V, and β increases 25%.

*53. For the network of Fig. 4.112, determine:
   a. $S(I_{CO})$.
   b. $S(V_{BE})$.
   c. $S(\beta)$, using T_1 as the temperature at which the parameter values are specified and $\beta(T_2)$ as 25% more than $\beta(T_1)$.
   d. Determine the net change in I_C if a change in operating conditions results in I_{CO} increasing from 0.2 μA to 10 μA, V_{BE} drops from 0.7 V to 0.5 V, and β increases 25%.

*54. For the network of Fig. 4.115, determine:
   a. $S(I_{CO})$.
   b. $S(V_{BE})$.
   c. $S(\beta)$, using T_1 as the temperature at which the parameter values are specified and $\beta(T_2)$ as 25% more than $\beta(T_1)$.
   d. Determine the net change in I_C if a change in operating conditions results in I_{CO} increasing from 0.2 μA to 10 μA, V_{BE} drops from 0.7 V to 0.5 V, and β increases 25%.

*55. For the network of Fig. 4.128, determine:
   a. $S(I_{CO})$.
   b. $S(V_{BE})$.
   c. $S(\beta)$, using T_1 as the temperature at which the parameter values are specified and $\beta(T_2)$ as 25% more than $\beta(T_1)$.
   d. Determine the net change in I_C if a change in operating conditions results in I_{CO} increasing from 0.2 μA to 10 μA, V_{BE} drops from 0.7 V to 0.5 V, and β increases 25%.

*56. Compare the relative values of stability for Problems 52 through 55. The results for Exercises 52 and 54 can be found in Appendix E. Can any general conclusions be derived from the results?

*57. a. Compare the levels of stability for the fixed-bias configuration of Problem 52.
   b. Compare the levels of stability for the voltage-divider configuration of Problem 54.
   c. Which factors of parts (a) and (b) seem to have the most influence on the stability of the system, or is there no general pattern to the results?