

# TECHNICAL GUIDE FOR SERVICE

TROUBLE SHOOTING METHODS IN  
SOLID STATE MAIN AMPLIFIER

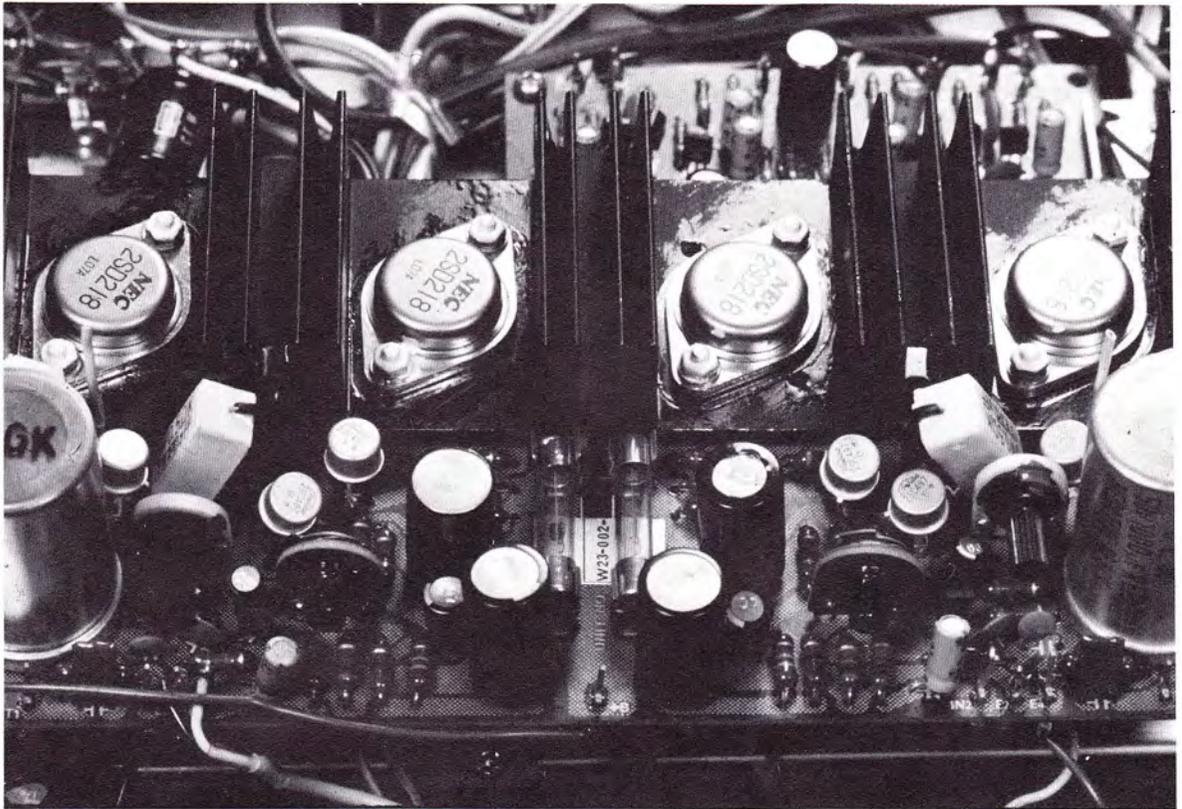
**PIONEER<sup>®</sup>**

SERVICE DEPARTMENT INTERNATIONAL DIVISION

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SOLID STATE MAIN AMPLIFIER

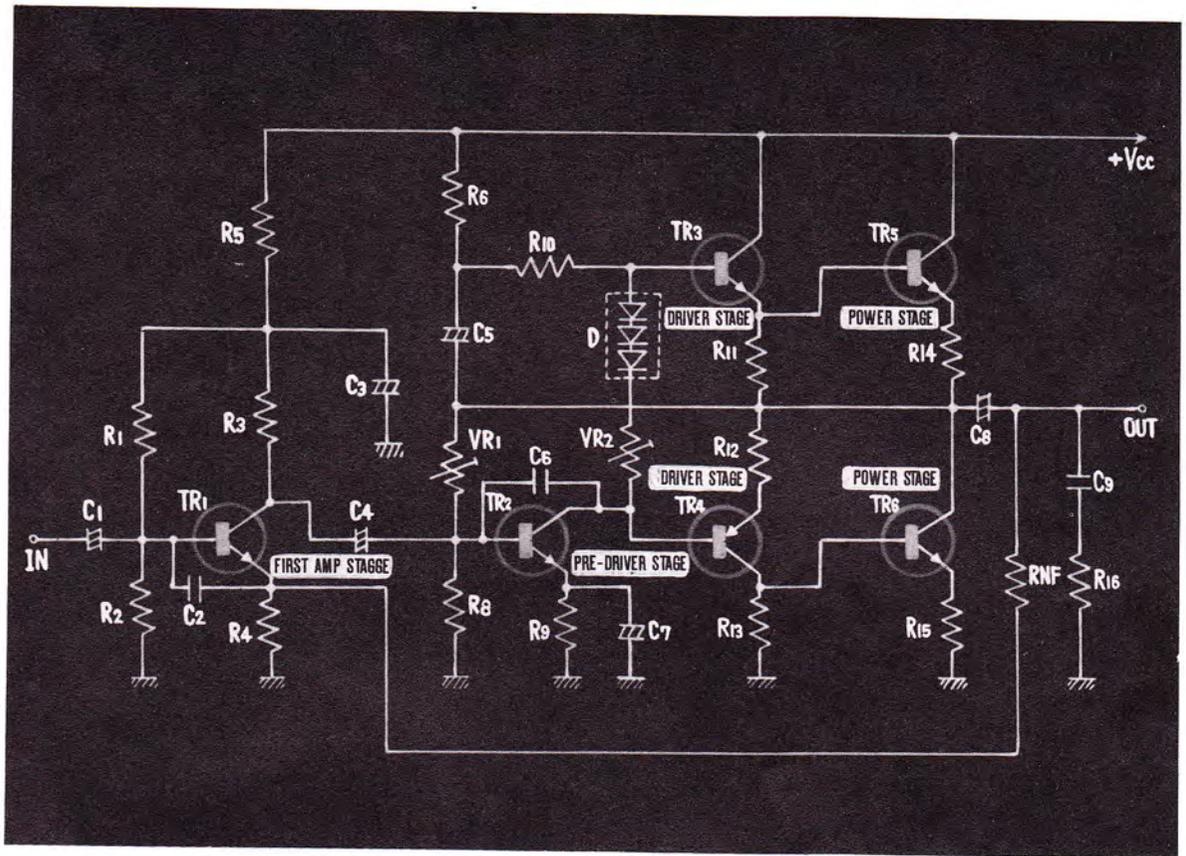
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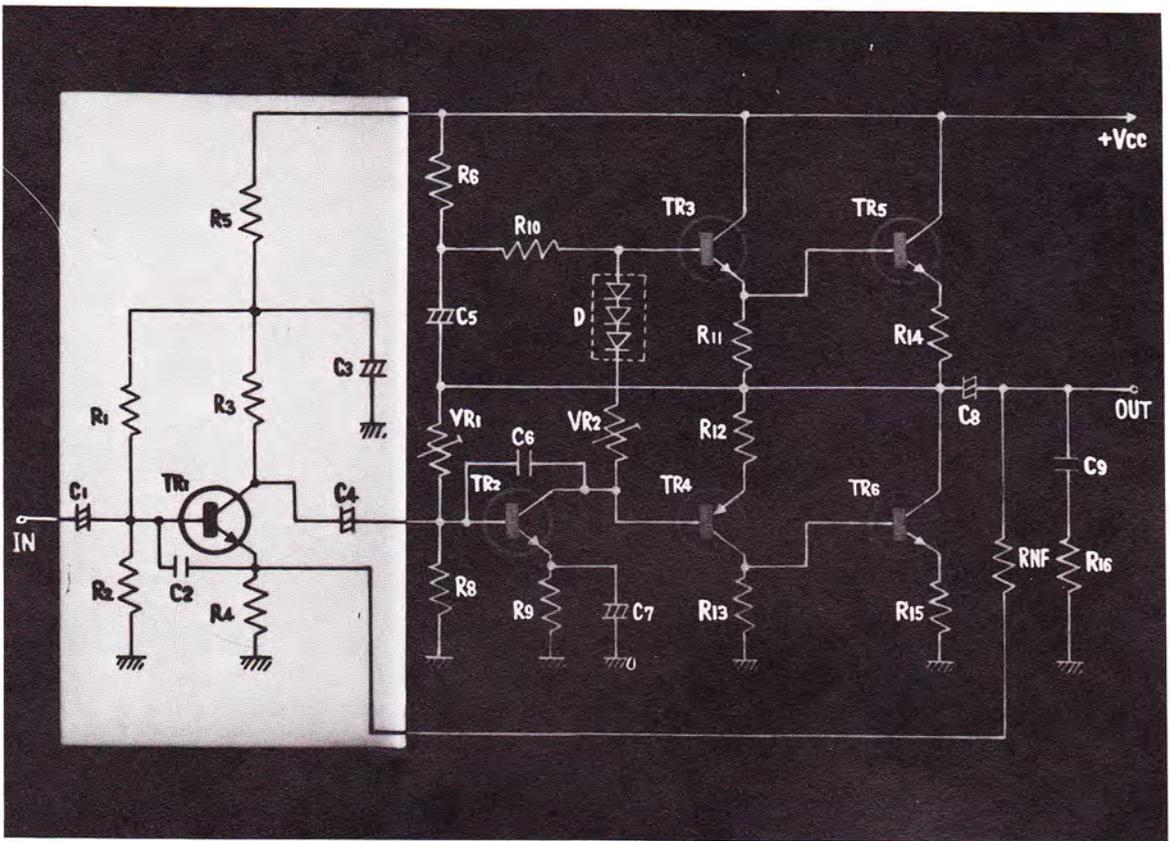


3. WE ARE GOING TO STUDY HOW TO CHECK THE COMPLEMENTARY MAIN AMPLIFIER CIRCUITS WITH THE AID OF THIS SLIDE.

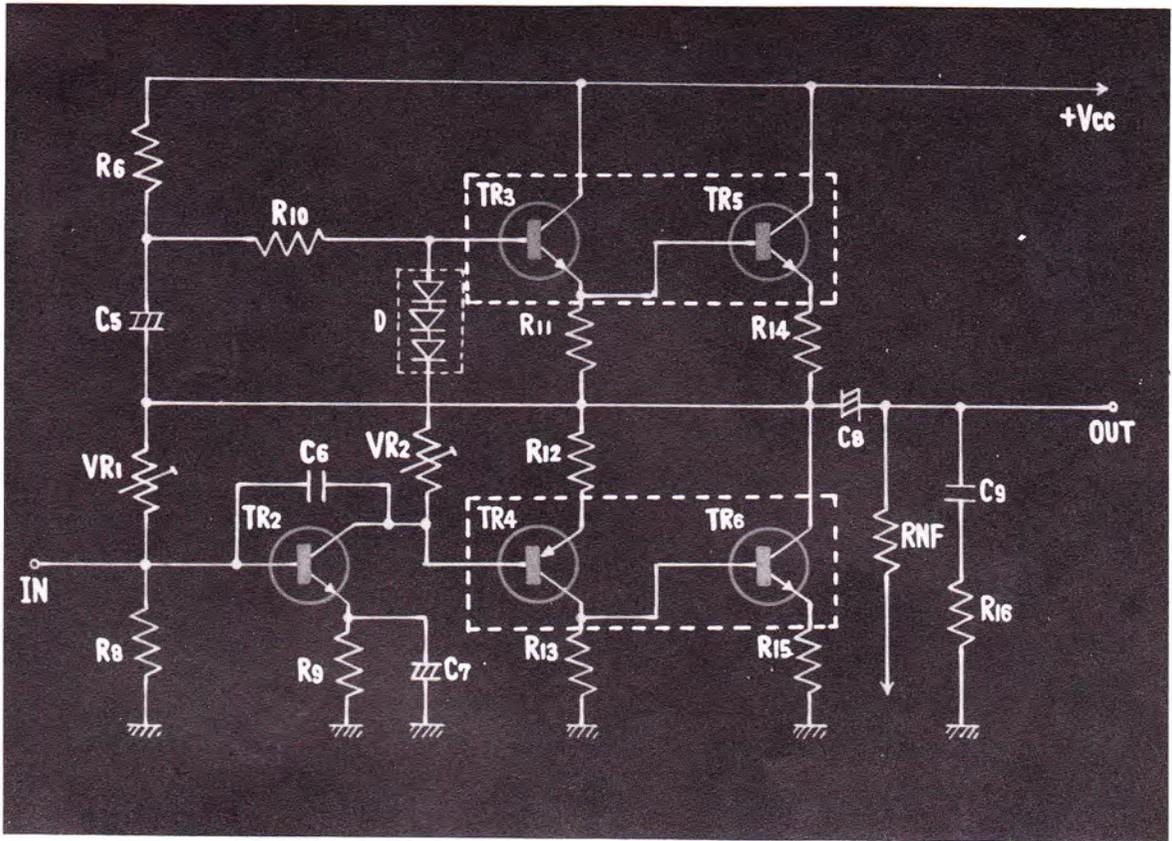




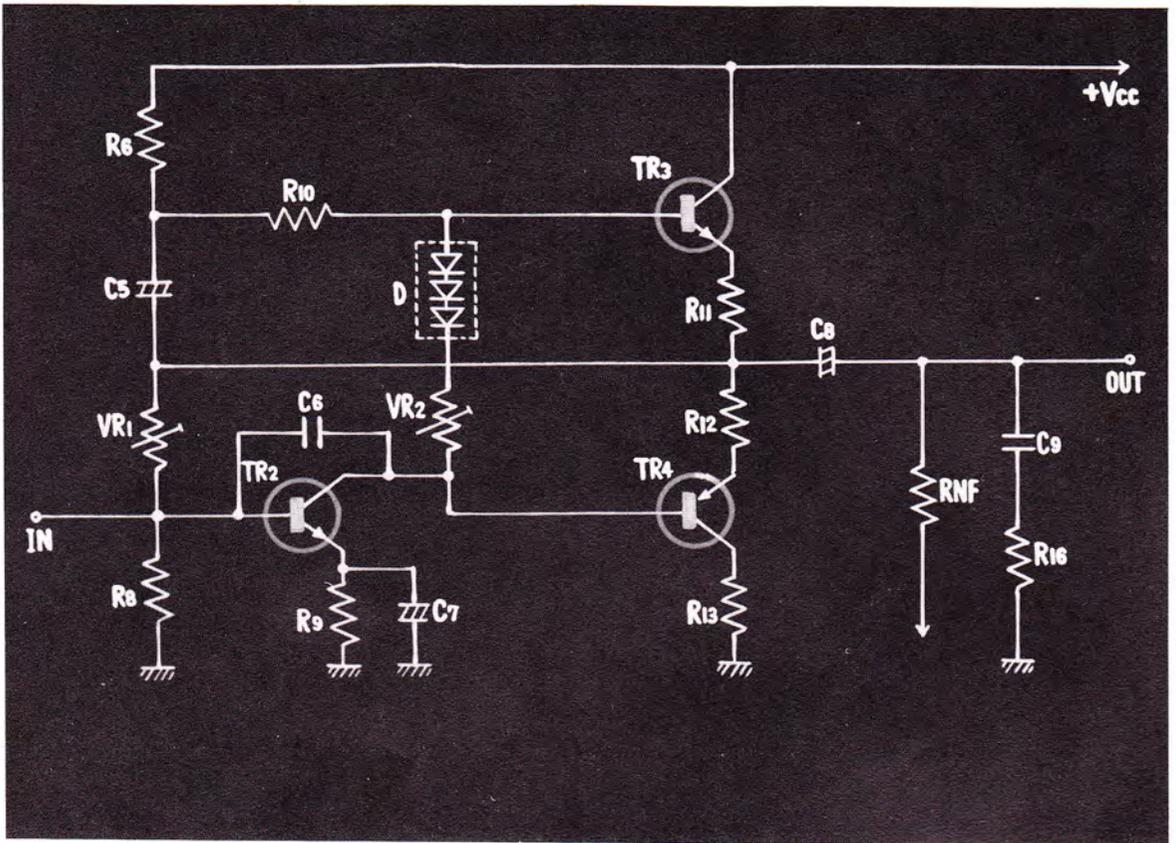
5. ON THIS BASIC DIAGRAM, TRANSISTOR 1 IS FOR THE PRIMARY-STAGE AMPLIFICATION, TRANSISTOR 2 IS FOR THE PRE-DRIVING PURPOSE, TRANSISTORS 3 AND 4 ARE FOR THE DRIVE-STAGE, AND TRANSISTORS 5 AND 6 ARE FOR THE POWER STAGE.



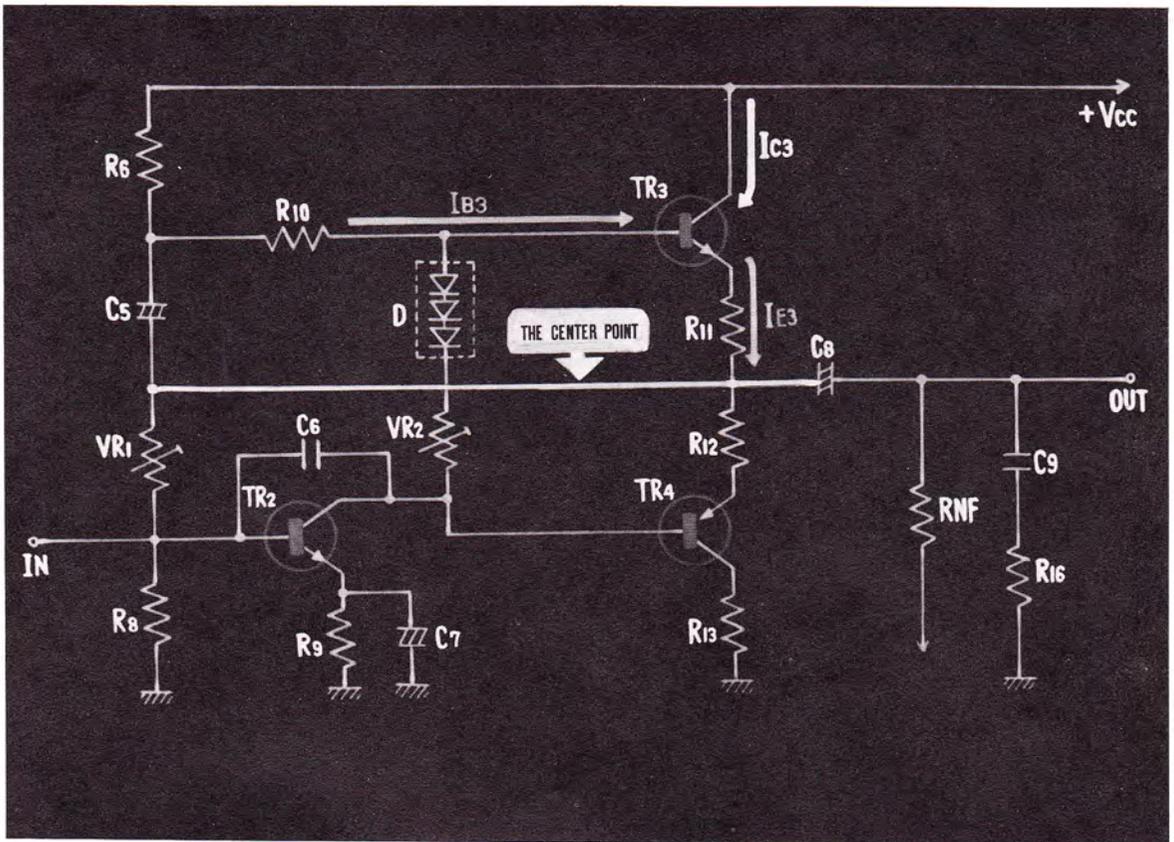
6. HERE, WE WILL OMIT FROM OUR STUDIES THE PRIMARY-STAGE AMPLIFIER SECTION OF TRANSISTOR 1, SINCE IT IS A VERY COMMON CIRCUIT OF CAPACITOR-COUPLED, EMITTER-GROUNDED TYPE.



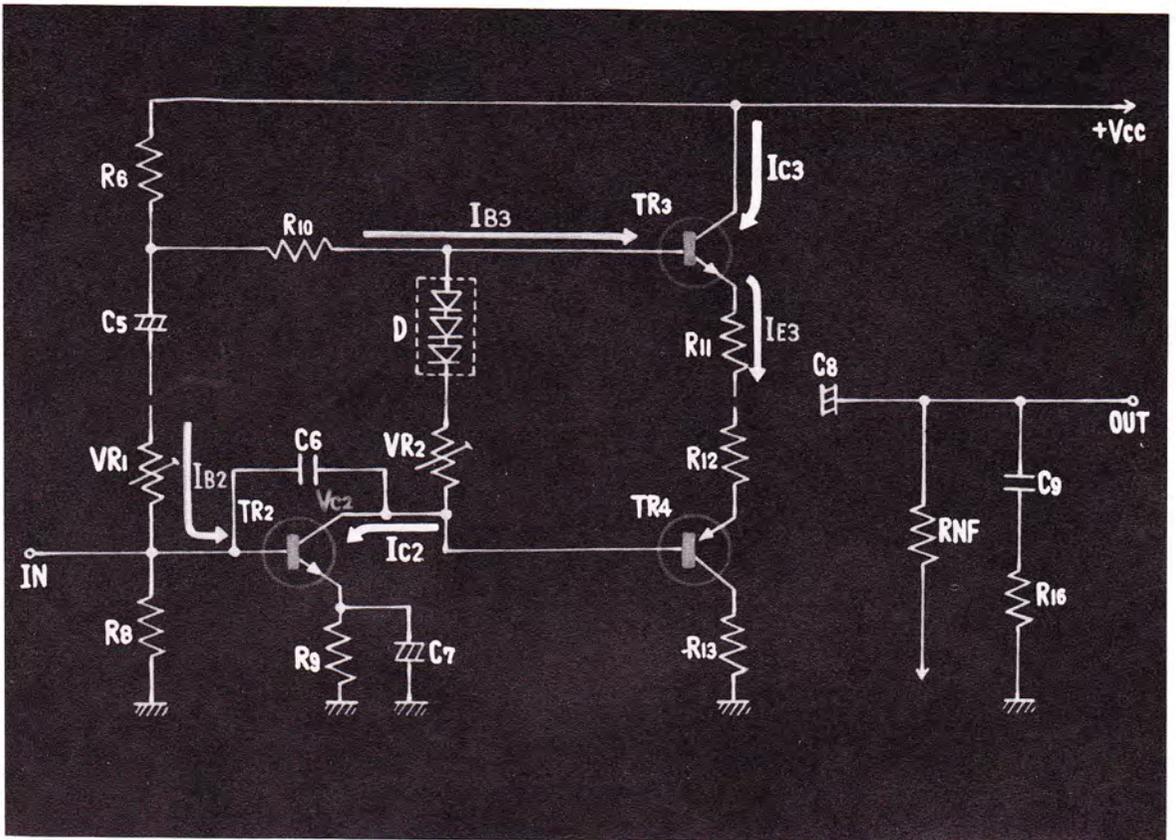
7. TRANSISTORS 3 AND 5 AS WELL AS TRANSISTORS 4 AND 6 ARE OF DARLINGTON-CONNECTION, SO THAT THEY MAY BE CONSIDERED AS N-P-N AND P-N-P TRANSISTORS, RESPECTIVELY.



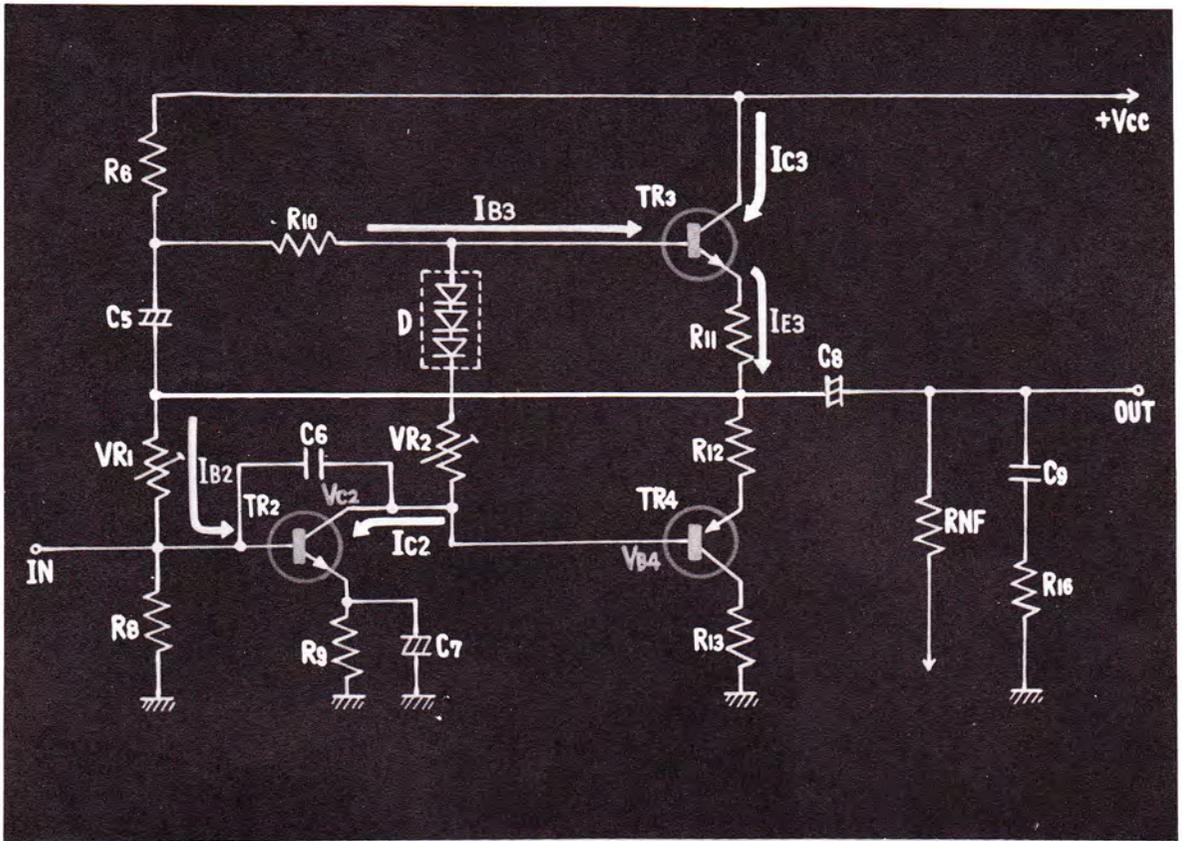
8. SINCE THERE IS NO DIFFERENCE, AT LEAST THE DC FUNCTION IS CONCERNED, WHETHER TRANSISTORS 5 AND 6 ARE CONNECTED OR NOT, LET'S PROCEED WITH OUR SLIDE STUDIES WITH TRANSISTORS 5 AND 6 DISCONNECTED.



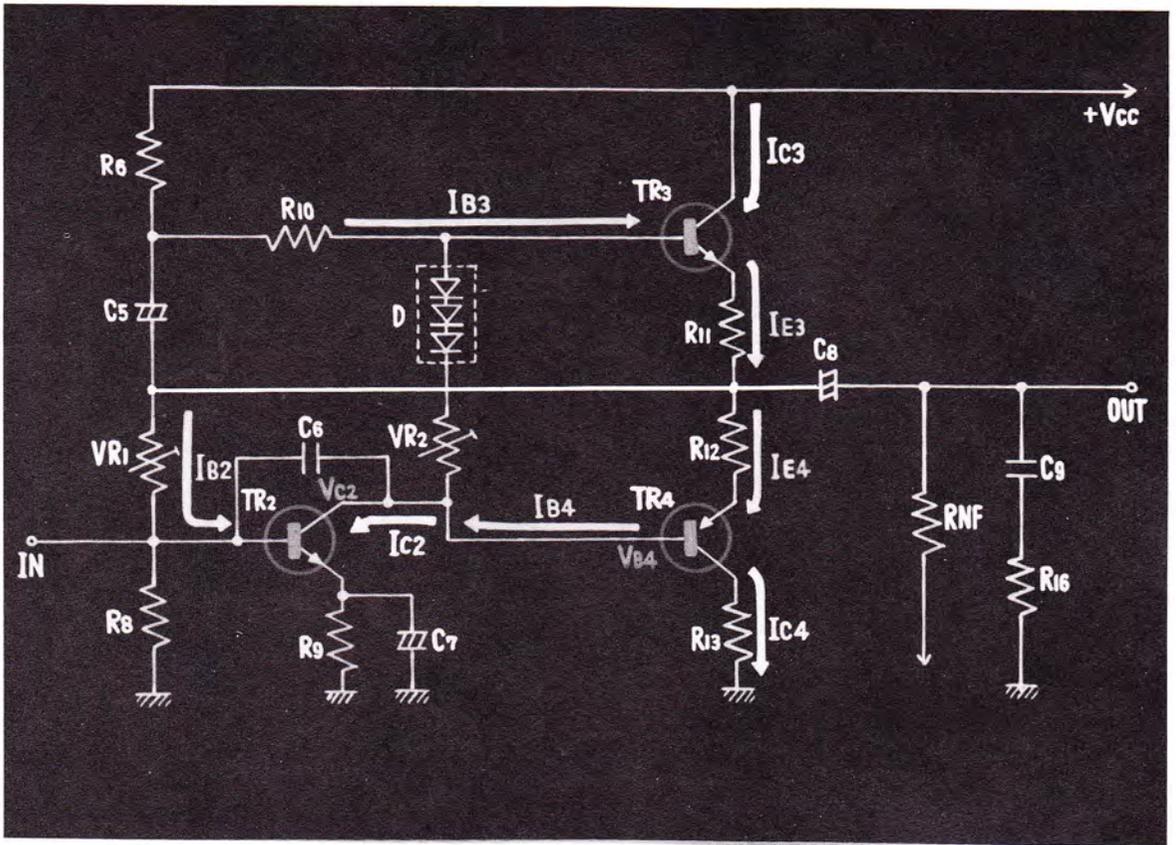
9. NOW LET'S CONSIDER THE DIRECT CURRENT FUNCTION OF THIS CIRCUIT. IF  $V_{CC}$  IS APPLIED, A BIAS VOLTAGE IS GIVEN TO TRANSISTOR 3 BY MEANS OF THE RESISTORS  $R_6$  AND  $R_{10}$ . THEN THE COLLECTOR CURRENT OF TRANSISTOR 3, OR  $I_{C3}$ , FLOWS, AND A VOLTAGE ARISES AT THE CENTER POINT.



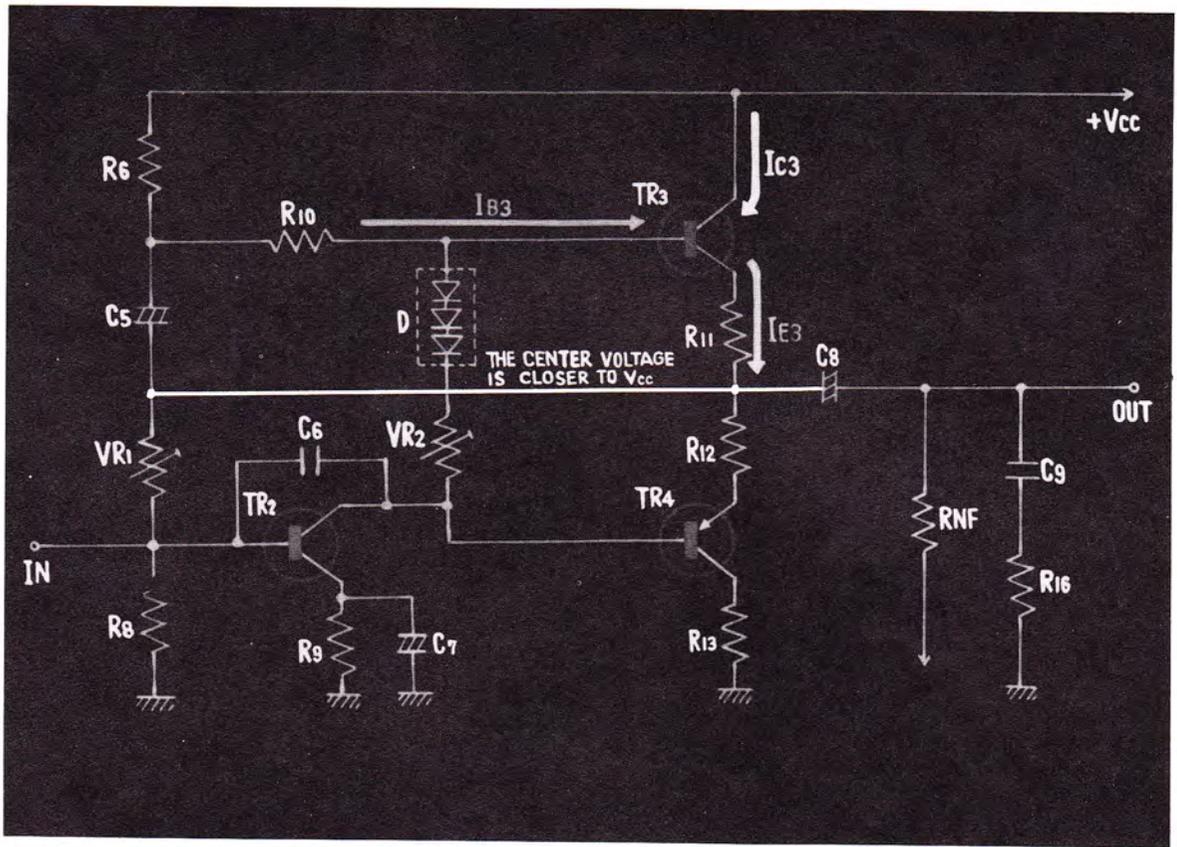
10. A BIAS VOLTAGE IS GIVEN TO TRANSISTOR 2 FROM THE CENTER POINT THROUGH  $VR_1$ , WHICH IS FOR REGULATING THE CENTER VOLTAGE. THEN THE COLLECTOR CURRENT FOR TRANSISTOR 2, OR  $I_{C2}$ , STARTS TO FLOW, AND THE COLLECTOR VOLTAGE, OR  $V_{C2}$ , DROPS.



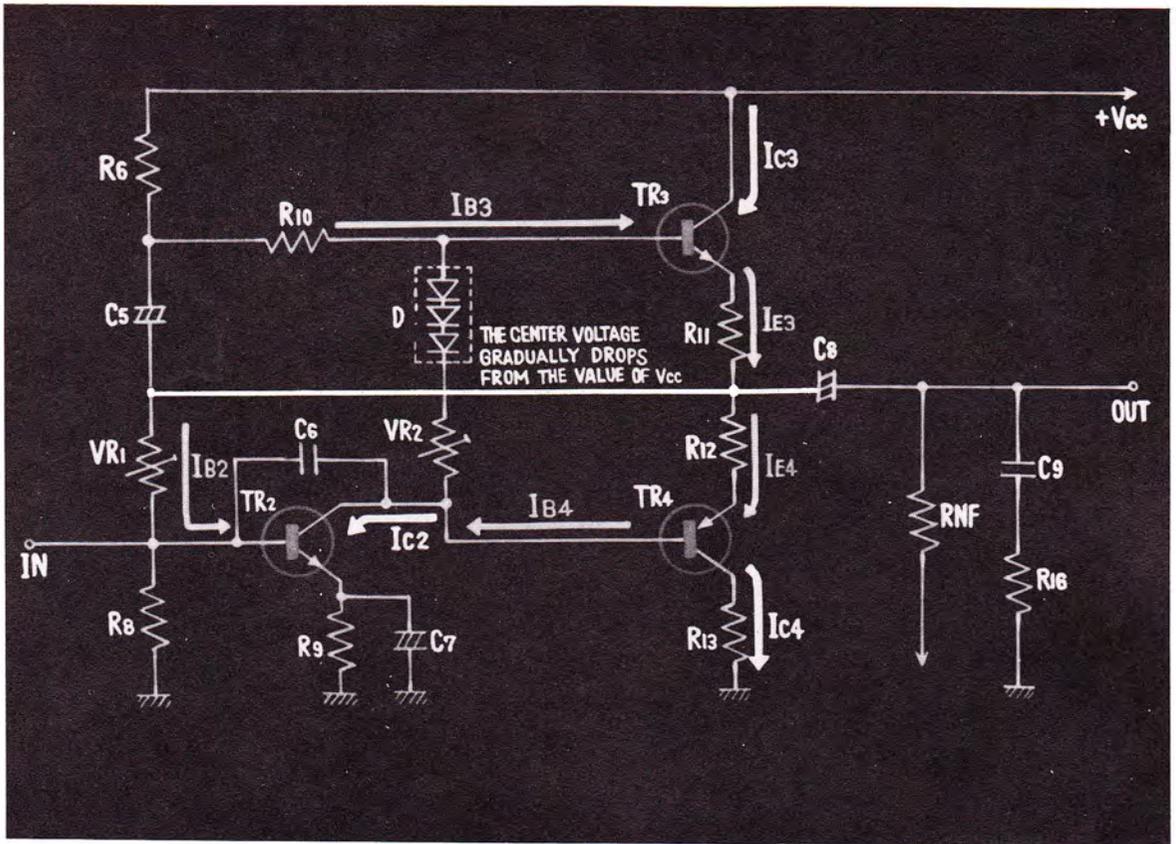
11. THE COLLECTOR OF TRANSISTOR 2 IS DIRECTLY CONNECTED TO THE BASE OF TRANSISTOR 4 SO THAT THE BASE VOLTAGE, OR  $V_{B4}$ , OF TRANSISTOR 4 ALSO DROPS.



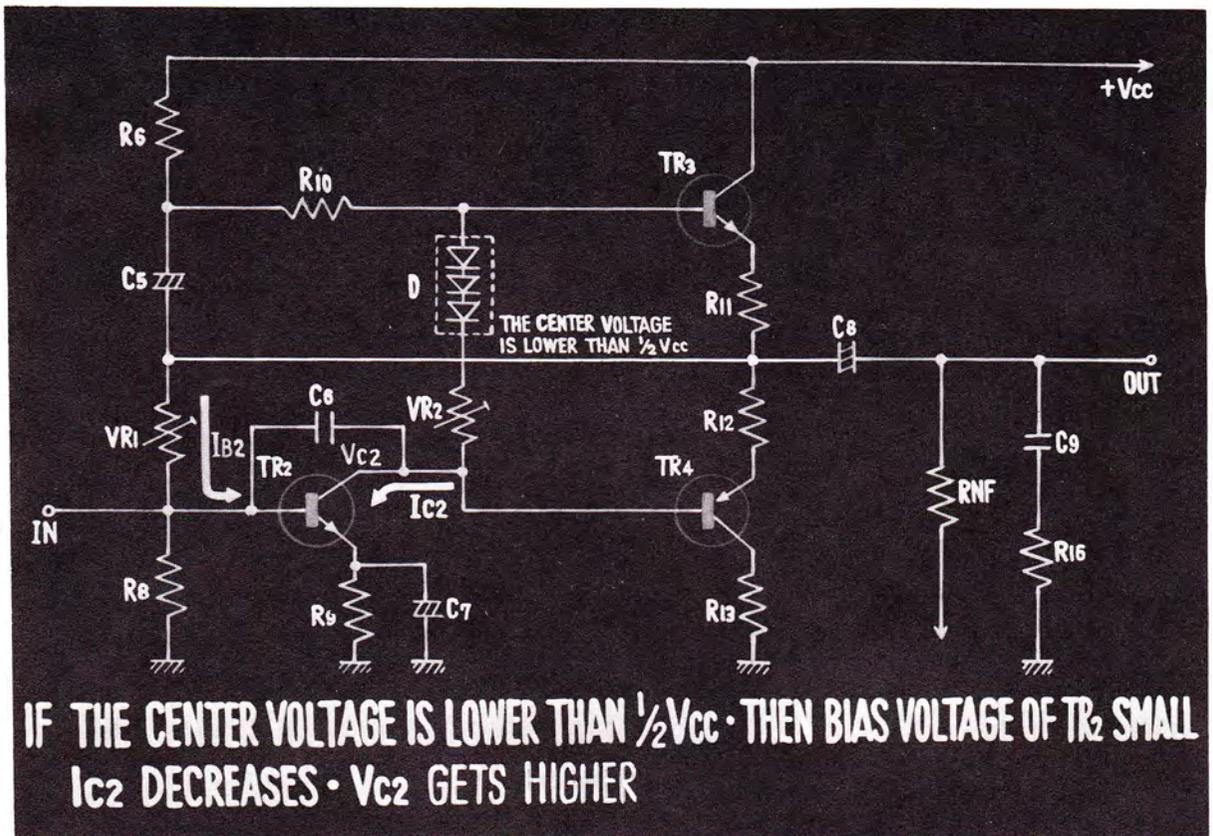
12. SINCE TRANSISTOR 4 IS A P-N-P TYPE, A BIAS VOLTAGE IS IN FACT GIVEN TO TRANSISTOR 4, AND CURRENT THUS FLOWS TO TRANSISTOR 4.



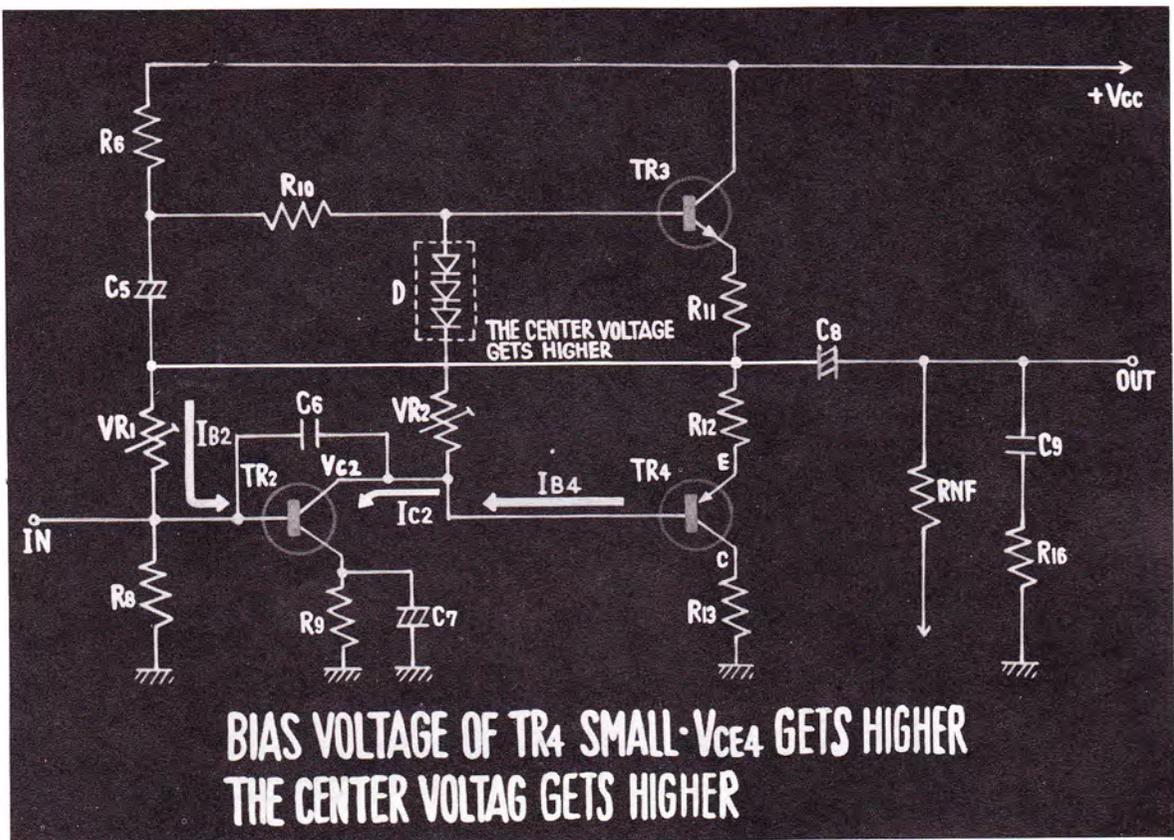
13. THE INSTANT  $V_{cc}$  IS APPLIED, THE VOLTAGE AT THE CENTER POINT BECOMES ALMOST AS HIGH AS  $V_{cc}$  ITSELF, BECAUSE A BIAS VOLTAGE IS GIVEN TO TRANSISTOR 3.



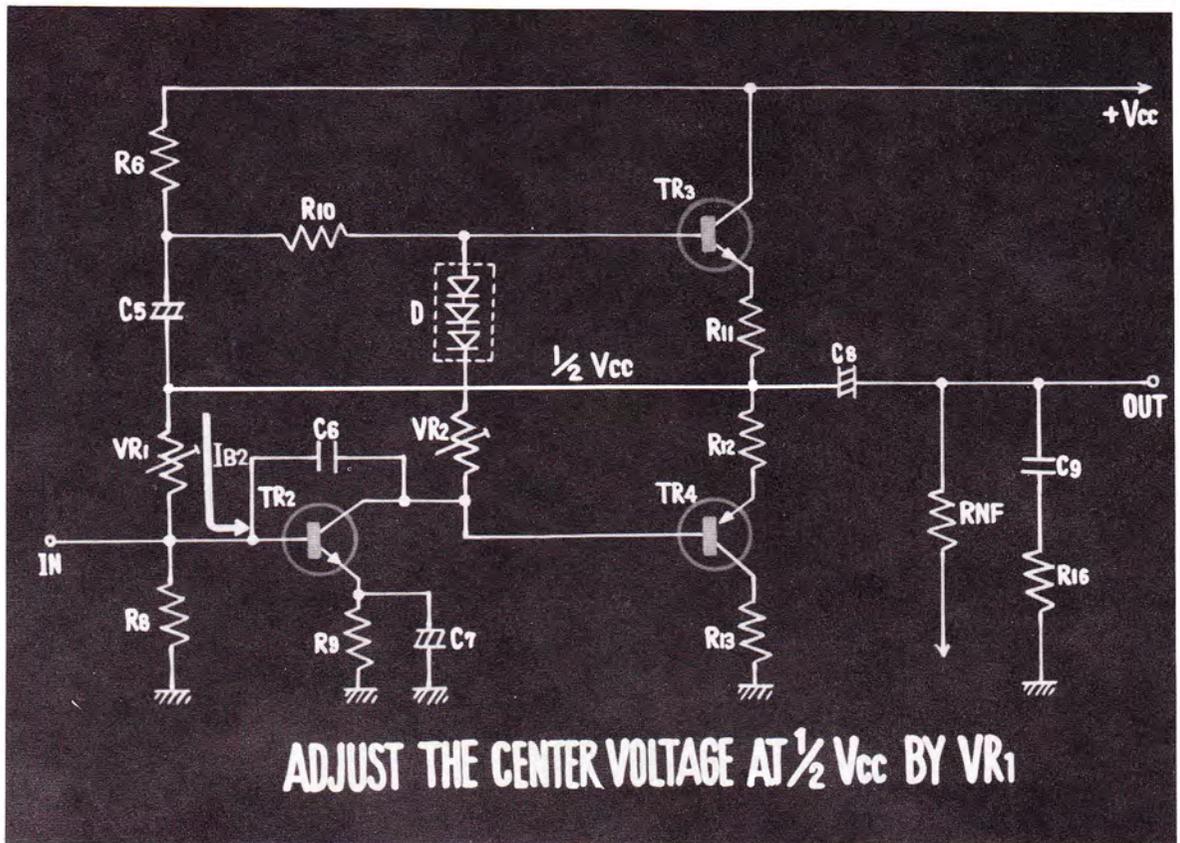
14. BUT AS TRANSISTOR 2 BEGINS TO FUNCTION, AND FURTHER, TRANSISTOR 4 FUNCTIONS, THE VOLTAGE OF THE CENTER POINT GRADUALLY DROPS FROM THE VALUE CLOSE TO  $V_{CC}$ .



15. NOW, LET'S CONSIDER THE CASE WHERE THE CENTER VOLTAGE HAS DECREASED AND HAS BECOME LOWER THAN  $\frac{1}{2}V_{cc}$ . THE BIAS VOLTAGE FOR TRANSISTOR 2 BECOMES INSUFFICIENT, BECAUSE OF THE DIRECT-CURRENT FEEDBACK FROM THE CENTER POINT THROUGH VR<sub>1</sub> TO TRANSISTOR 2. THE COLLECTOR CURRENT, I<sub>c2</sub>, DECREASES AND THE COLLECTOR VOLTAGE V<sub>c2</sub> GETS HIGHER.



16. FOR THIS REASON, THE BIAS VOLTAGE FOR TRANSISTOR 4 BECOMES SMALLER, AND THE VOLTAGE DROP BETWEEN THE COLLECTOR AND THE EMITTER BECOMES LARGER WHICH TENDS TO RAISE THE CENTER VOLTAGE.



17. THUS, THE CENTER VOLTAGE CHANGES AS YOU CHANGE THE BIAS OF TRANSISTOR 2. SO THAT IF THE CENTER VOLTAGE IS SET AT  $\frac{1}{2} V_{cc}$  BY ADJUSTING  $VR_1$ , THEN THE CENTER VOLTAGE CAN ALWAYS BE MAINTAINED AT  $\frac{1}{2} V_{cc}$  BY MEANS OF THE DC FEEDBACK.

UPPER HALF  
TR<sub>3</sub>

LOWER HALF  
TR<sub>4</sub>

18. THE CONDITION UNDER WHICH THE CENTER VOLTAGE BECOMES  $1/2 V_{CC}$  IS WHEN THE DC CURRENT IN UPPER AND LOWER PORTIONS IS THE SAME.

IN OTHER WORDS, IT IS WHEN THE INTERNAL RESISTANCE BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTORS 3 AND 4 IS APPROXIMATELY EQUAL AND WHEN THE BIAS VOLTAGE IS GIVEN IN SUCH A WAY.

NOW THAT YOU HAVE UNDERSTOOD THE DIRECT CURRENT FUNCTION UP TO NOW, LET'S CONSIDER ABOUT THE WAYS OF CHECKING THE CIRCUIT.

BY MEASURING THE  
CENTER VOLTAGE

IS IT.....

HIGHER THAN

$$\frac{1}{2} V_{CC}$$

LOWER THAN

$$\frac{1}{2} V_{CC}$$

19. WHEN CHECKING THE COMPLEMENTARY MAIN AMPLIFIER CIRCUIT, FIRST, MEASURE THE CENTER VOLTAGE, AND THEN, CONSIDER SEPARATELY THE CASES WHERE IT IS HIGHER THAN THE NORMAL VALUE OF  $\frac{1}{2} V_{CC}$  AND WHEN IT IS LOWER.

IN CASE THE  
CENTER VOLTAGE

IS HIGHER  
THAN  $\frac{1}{2}V_{CC}$

$V_{CE3}$  IS LOW

$V_{CE4}$  IS HIGH

20. WHEN THE CENTER VOLTAGE IS HIGHER THAN  $\frac{1}{2}V_{CC}$ , IT MAY BE THAT THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 3, OR  $V_{CE3}$ , IS LOW, OR, ON THE CONTRARY, IT MAY BE THAT THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 4, OR  $V_{CE4}$ , IS HIGH.

IN CASE THE  
CENTER VOLTAGE

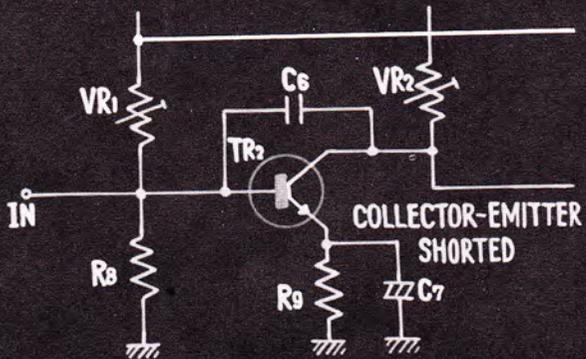
IS LOWER  
THAN  $\frac{1}{2}V_{CC}$

$V_{CE3}$  IS HIGH

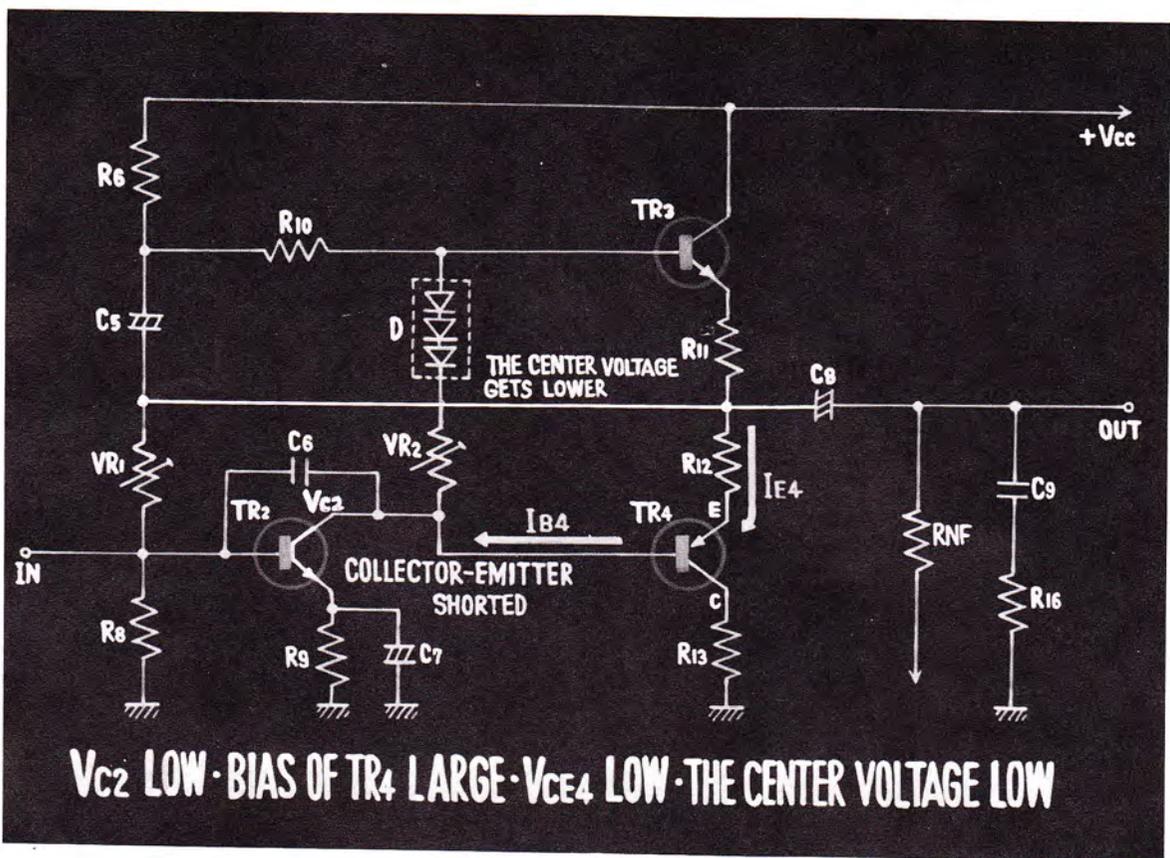
$V_{CE4}$  IS LOW

21. WHEN THE CENTER VOLTAGE IS LOWER THAN  $\frac{1}{2}V_{CC}$ , IT MAY BE THAT THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 3, OR  $V_{CE3}$ , IS HIGH, OR IT MAY BE THAT THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 4, OR  $V_{CE4}$ , IS LOW.

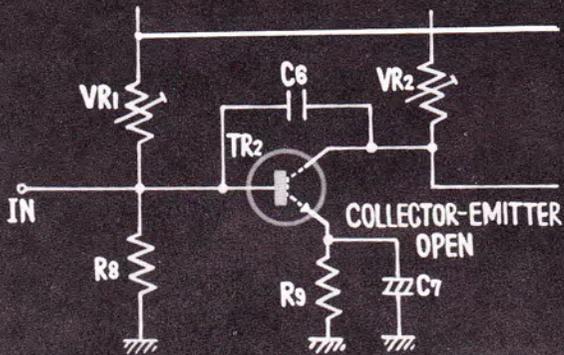
LET'S HYPOTHESIZE ACTUAL TROUBLE SPOTS AND SEE HOW THE CENTER VOLTAGE CHANGES ACCORDINGLY.



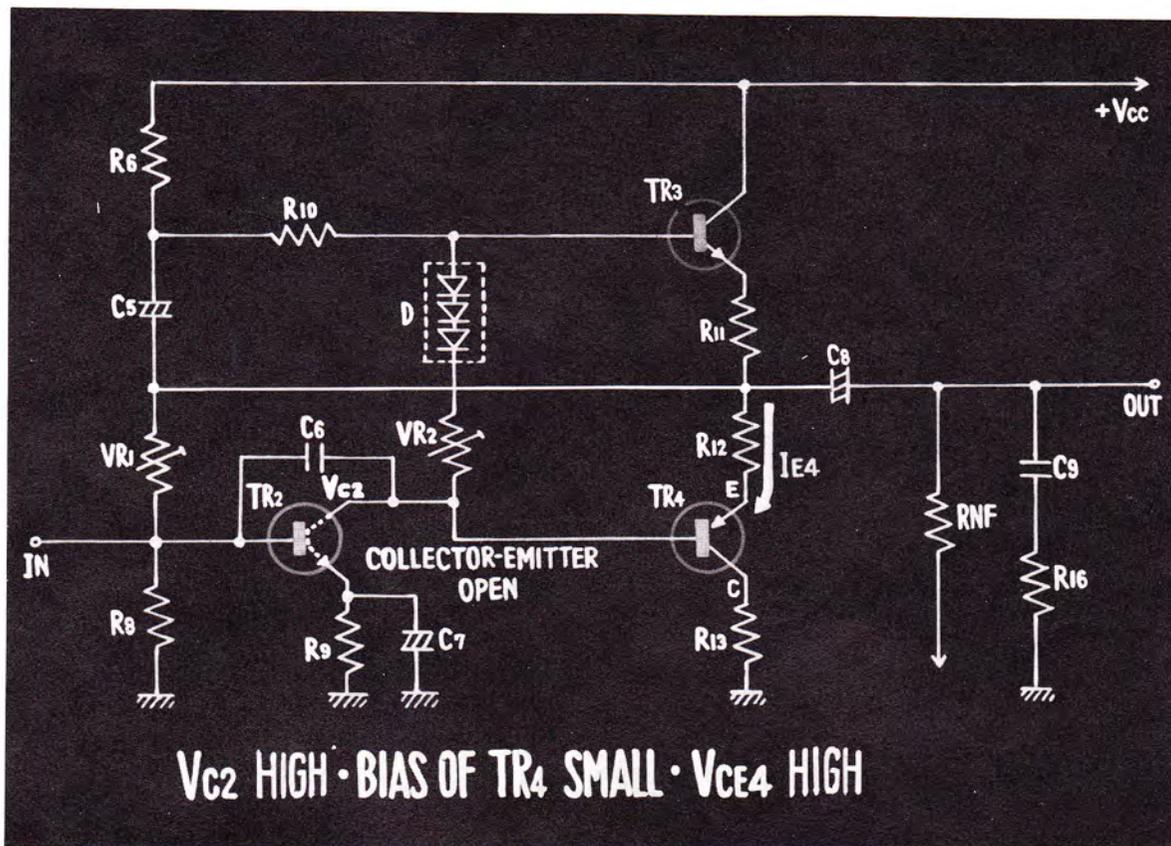
22. LET'S CONSIDER THE CASE WHERE THE COLLECTOR AND THE EMITTER OF TRANSISTOR 2, ARE SHORTED.



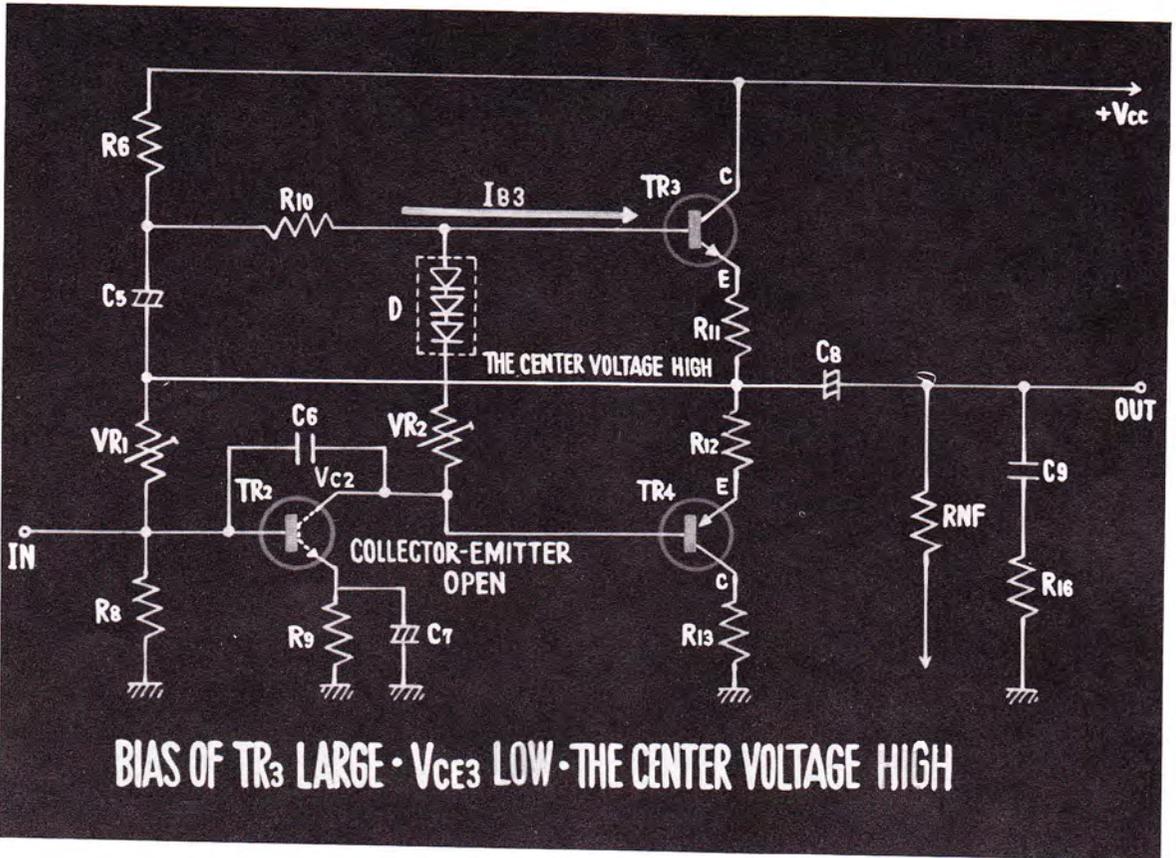
23. WHEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 2 ARE SHORTED, THE COLLECTOR VOLTAGE OF TRANSISTOR 2 BECOMES LOW, THUS THE BIAS VOLTAGE OF TRANSISTOR 4 BECOMES LARGER. THEN, THE VOLTAGE DROP BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 4 GETS SMALLER. THEREFORE, THE CENTER VOLTAGE ALSO GETS LOWER.



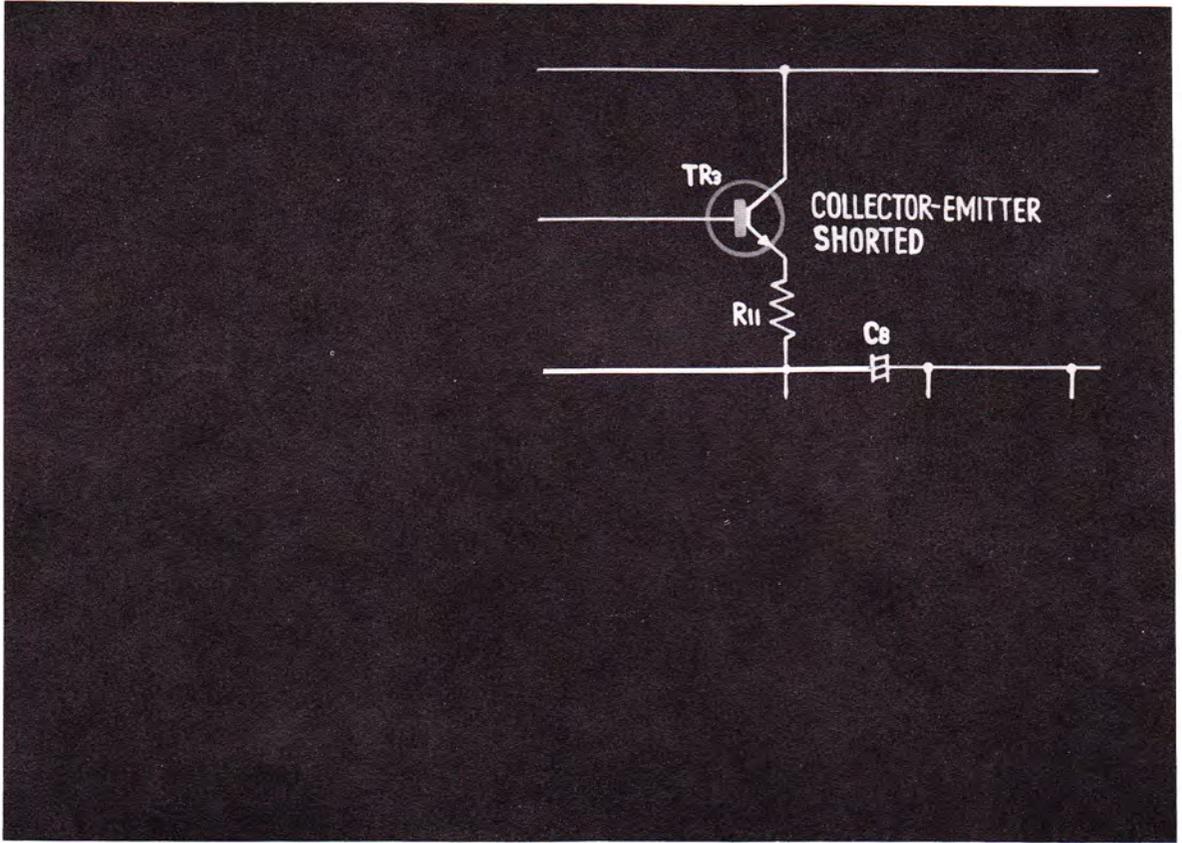
24. WHAT IF THE COLLECTOR AND THE EMITTER IS OPEN?



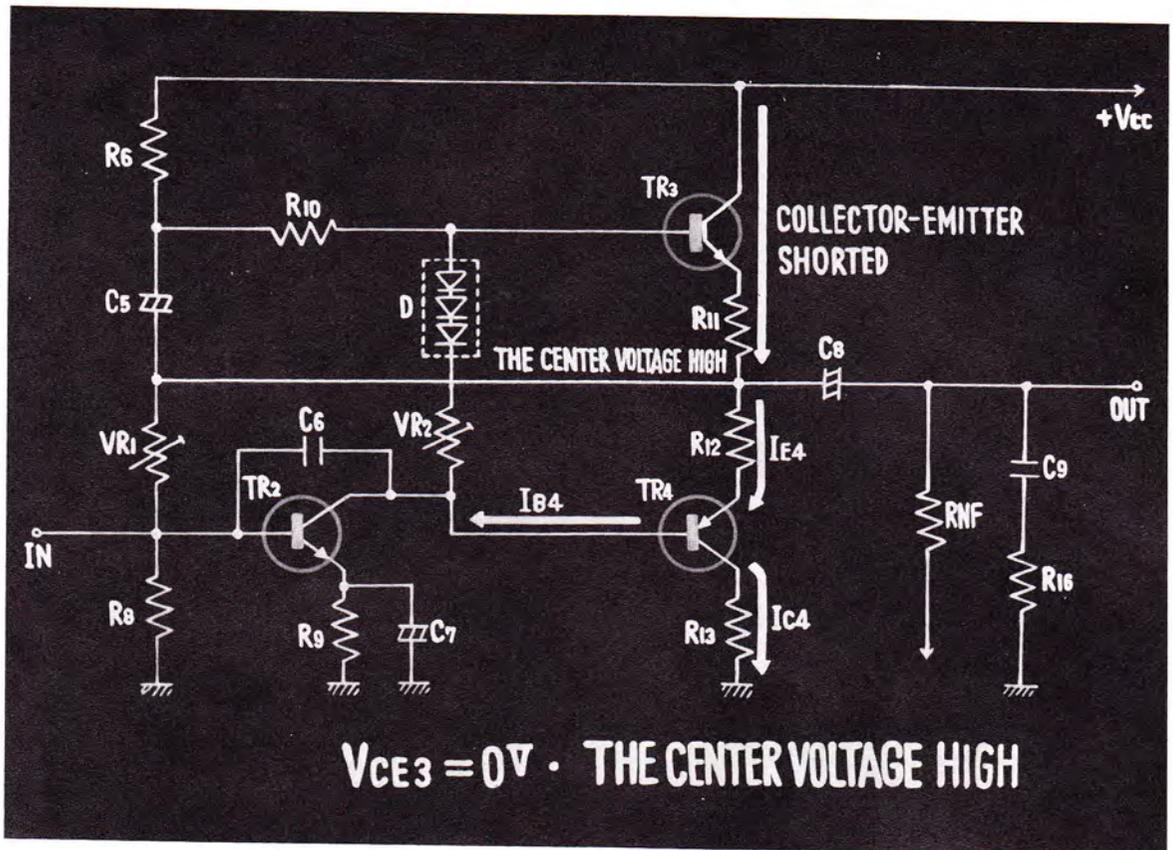
25. WHEN THE COLLECTOR AND THE EMITTER IS OPEN, THE COLLECTOR VOLTAGE OF TRANSISTOR 2 GETS HIGHER. AS A RESULT, THE BIAS FOR TRANSISTOR 4 BECOMES SMALL AND THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER RISES.



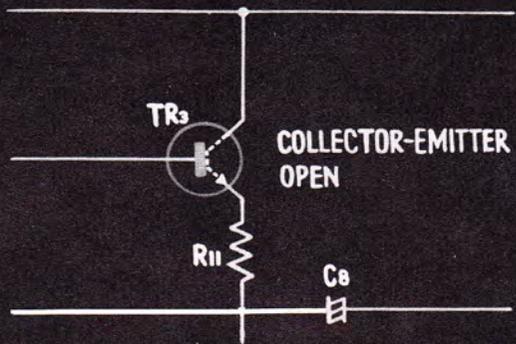
26. ON THE OTHER HAND, THE BIAS IN TRANSISTOR 3 BECOMES LARGER, AND THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER DROPS. AND THE CENTER VOLTAGE BECOMES HIGHER THAN THE NORMAL VALUE OF  $1/2 V_{CC}$ .



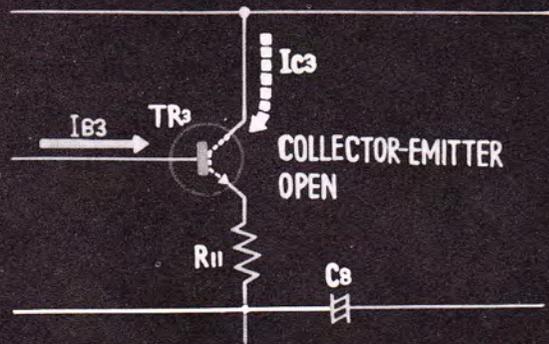
27. WHAT IF THE COLLECTOR AND THE EMITTER OF TRANSISTOR 3 BE-  
COME SHORTED?



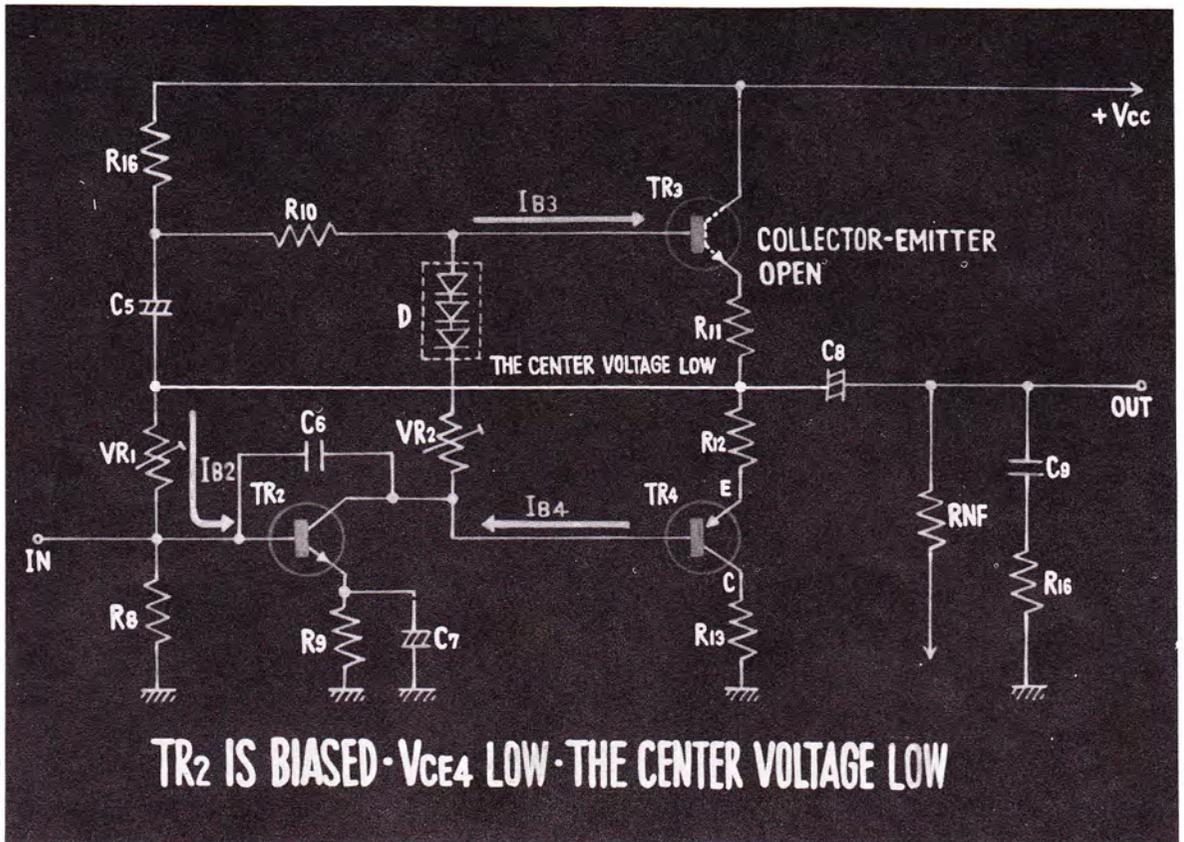
28. WHEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 3 BECOME SHORTED, THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER BECOMES ZERO (0V), AND AS CURRENT FLOWS DIRECTLY TO THE CENTER POINT FROM  $V_{CC}$  THROUGH  $R_{11}$ , THE VOLTAGE AT THE CENTER POINT BECOMES HIGHER. IN THIS CASE, THE BIAS FOR TRANSISTOR 4 BECOMES LARGER, CAUSING AN INCREASE IN THE COLLECTOR CURRENT, THEREFORE, EVERY CAUTION IS NECESSARY TO PREVENT TRANSISTOR 4 FROM BEING DAMAGED.



29. WHAT IF THE COLLECTOR AND THE EMITTER OF TRANSISTOR 3 IS OPEN?

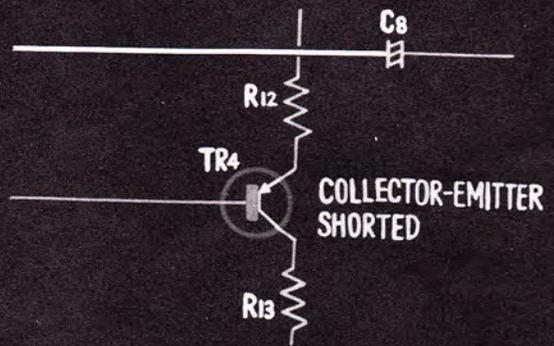


30. IT MAY SEEM THAT WHEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 3 IS OPEN, NO VOLTAGE WOULD APPEAR AT THE CENTER POINT, BECAUSE NO COLLECTOR CURRENT FLOWS TO TRANSISTOR 3 EVEN THOUGH THE BIAS IS GIVEN TO IT.

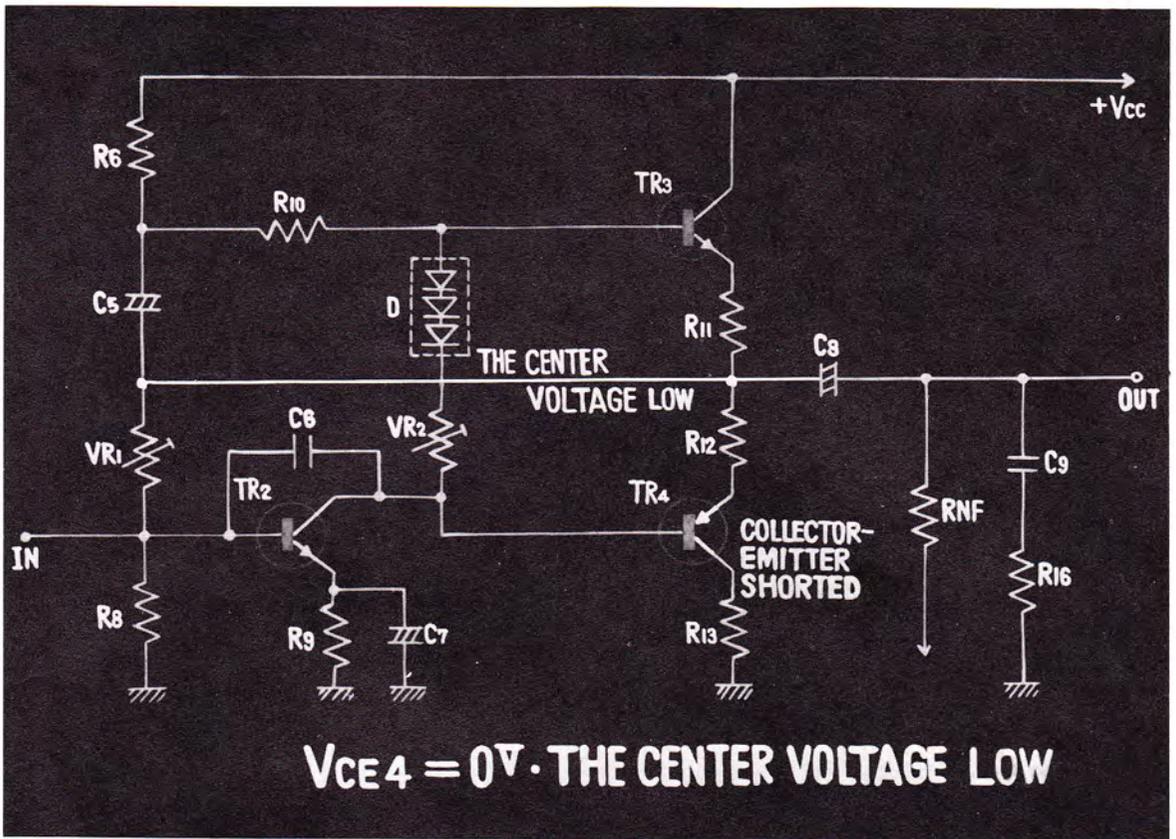


31. ACTUALLY, HOWEVER, VOLTAGE APPEARS AT THE CENTER POINT BY THE BASE CURRENT IN TRANSISTOR 3.

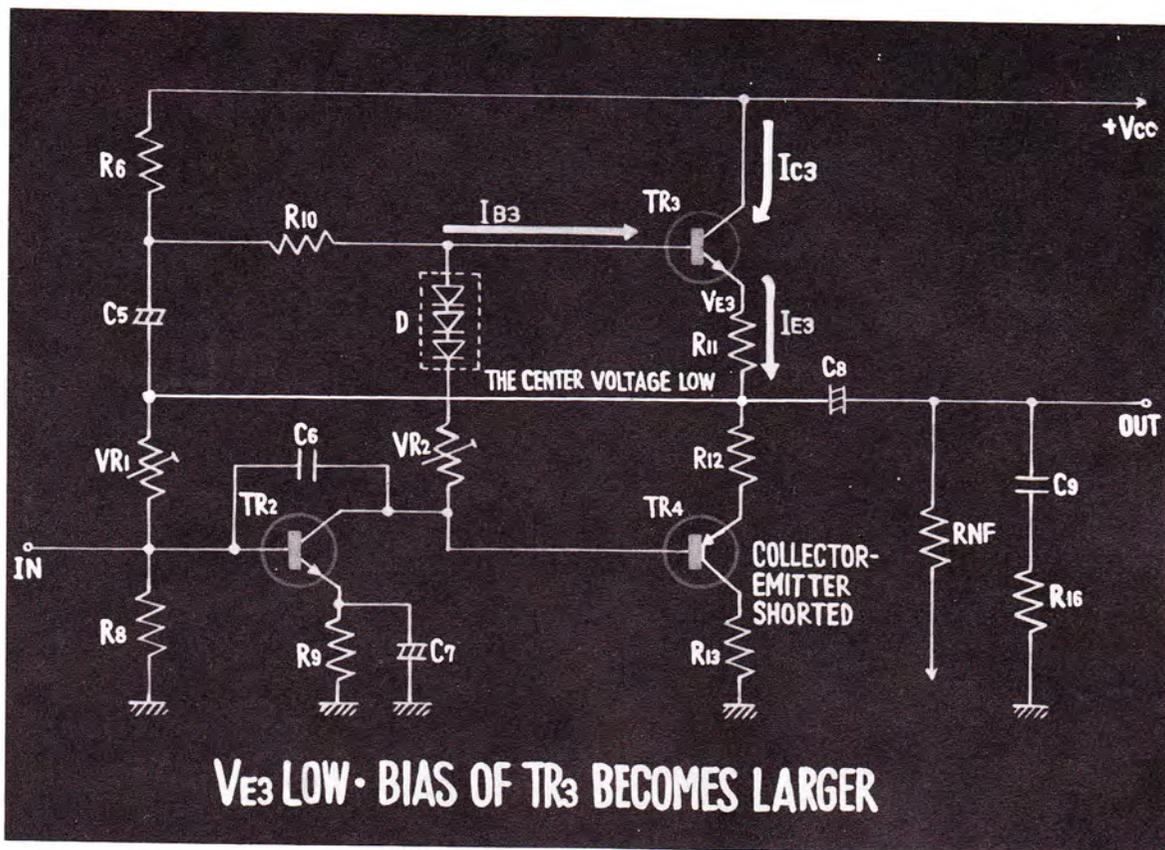
THE BIAS VOLTAGE IS GIVEN TO TRANSISTOR 2, THEN THE CURRENT FLOWS IN TRANSISTOR 2, AND THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 4 DROPS. AS A RESULT THE CENTER VOLTAGE DROPS, TOO.



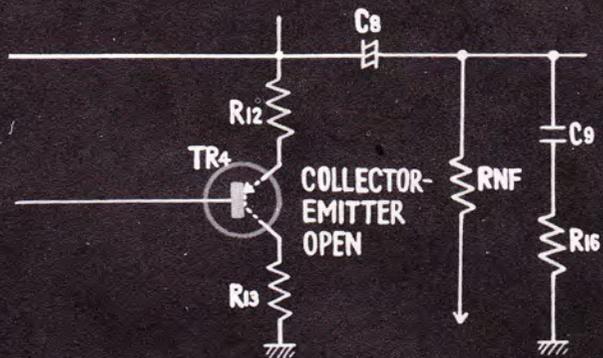
32. WHAT IF THE COLLECTOR AND THE EMITTER OF TRANSISTOR 4 ARE SHORTED?



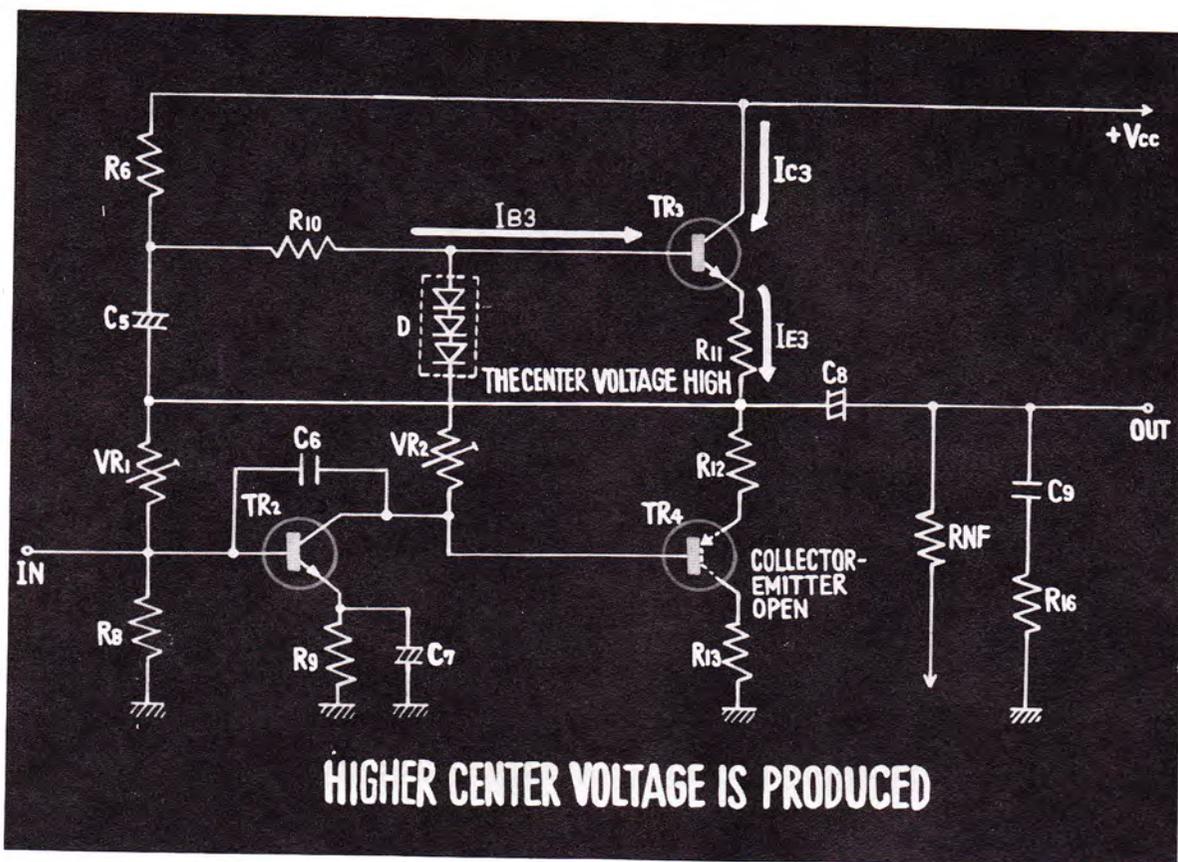
33. WHEN THE COLLECTOR AND THE EMITTER ARE SHORTED, THE VOLTAGE BETWEEN THE COLLECTOR AND THE EMITTER OF TRANSISTOR 4 BECOMES 0V AND THE VOLTAGE AT THE CENTER POINT GETS LOWER.



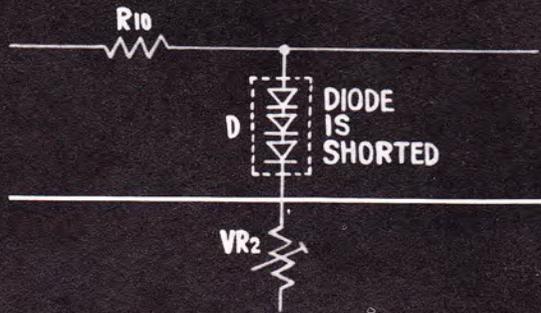
34. IT SHOULD BE EMPHASIZED THAT IN THIS CASE, AS THE COLLECTOR AND THE EMITTER OF TRANSISTOR 4 GET SHORTED THE TRANSISTOR 3 MAY ALSO BE DAMAGED DUE TO INCREASE IN BIAS OF TRANSISTOR 3.



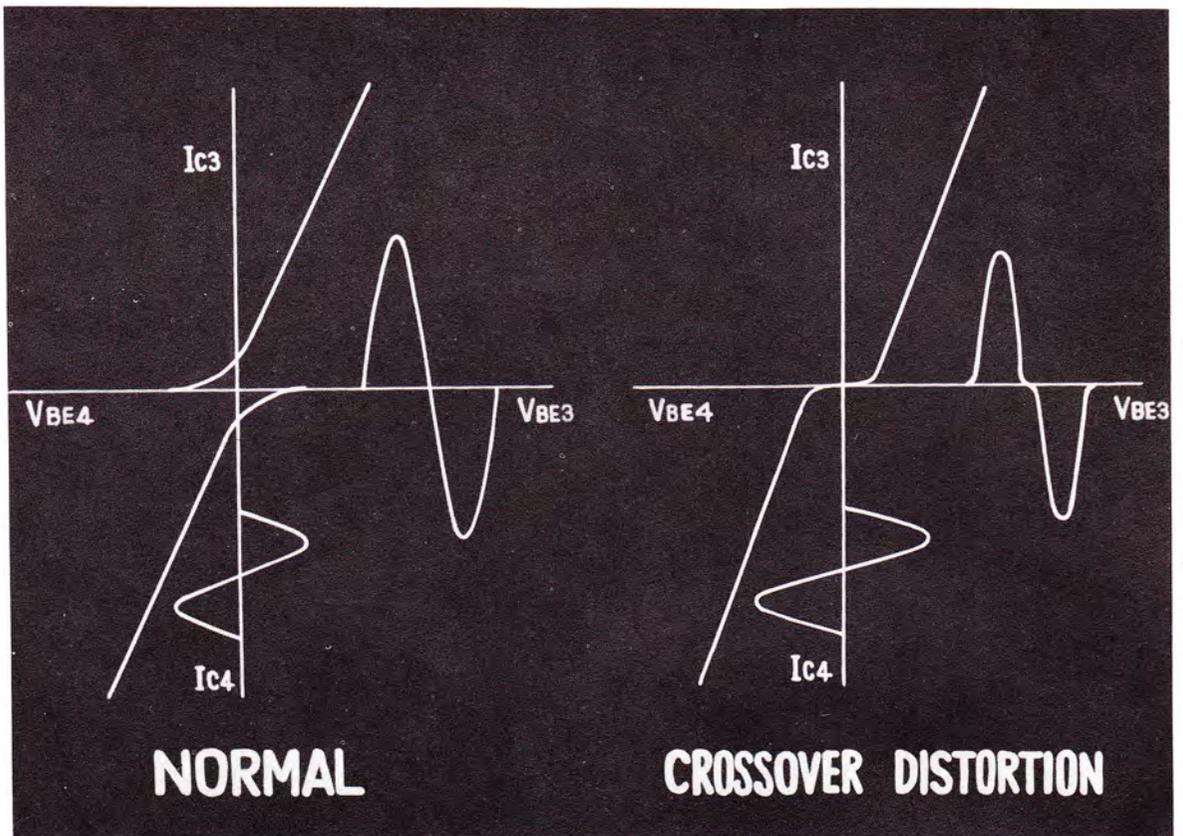
35. WHEN THE COLLECTOR AND EMITTER OF TRANSISTOR 4 BECOME OPEN, WHAT WILL HAPPEN?



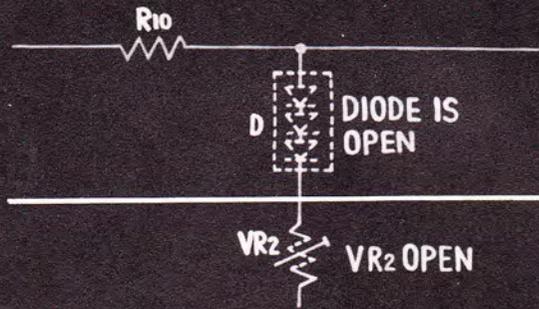
36. IN THIS CASE, NO CURRENT FLOWS BETWEEN THE COLLECTOR AND EMITTER, AND SINCE THE BIAS VOLTAGE IS APPLIED TO TRANSISTOR 3, A HIGH VOLTAGE APPEARS AT THE CENTER POINT.



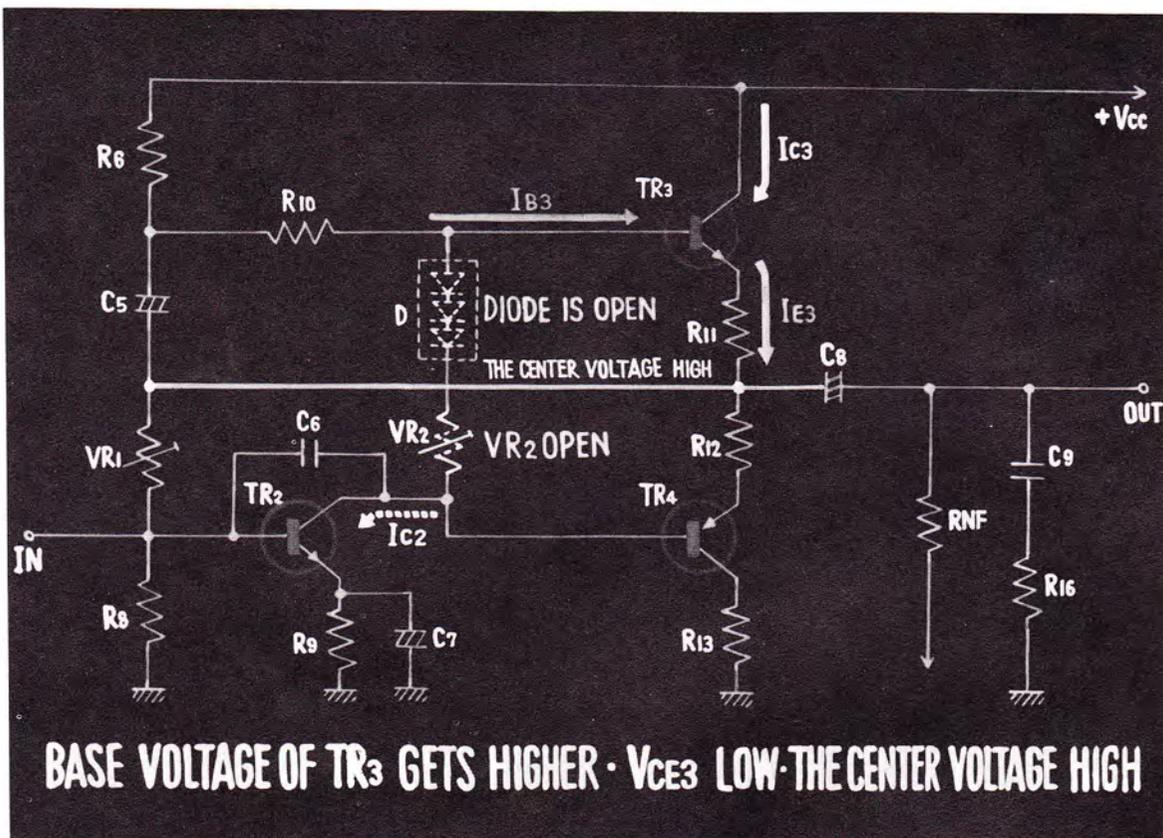
37. WHAT WILL HAPPEN WHEN THE TEMPERATURE COMPENSATING DIODE IS SHORTED?



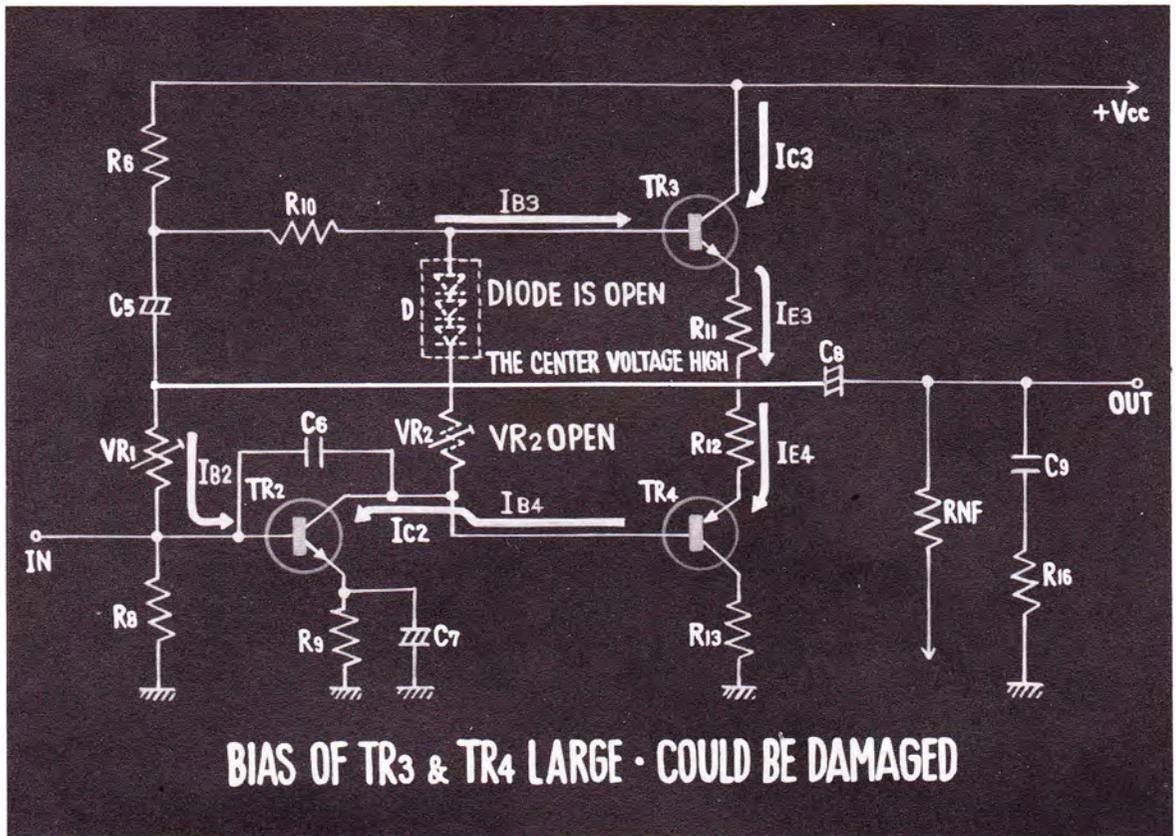
38. WHEN THE DIODE IS SHORTED, THE BIAS VOLTAGE IN THE DRIVE-STAGE AND POWER-STAGE BECOMES SMALL, CAUSING THE FUNCTION POINT SHIFT ONTO THE NON-LINEAR PORTION OF THE  $V_B \cdot I_C$  CHARACTERISTIC.  
 AS A RESULT, THE CROSS-OVER DISTORTION OCCURS.



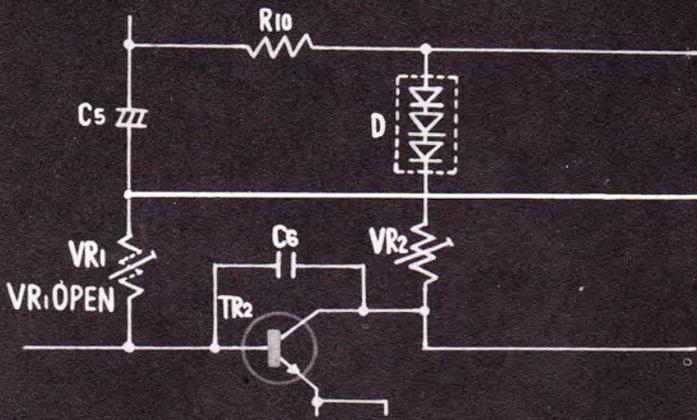
39. THEN, WHAT WILL HAPPEN WHEN THE DIODE OR  $VR_2$  IS OPEN?



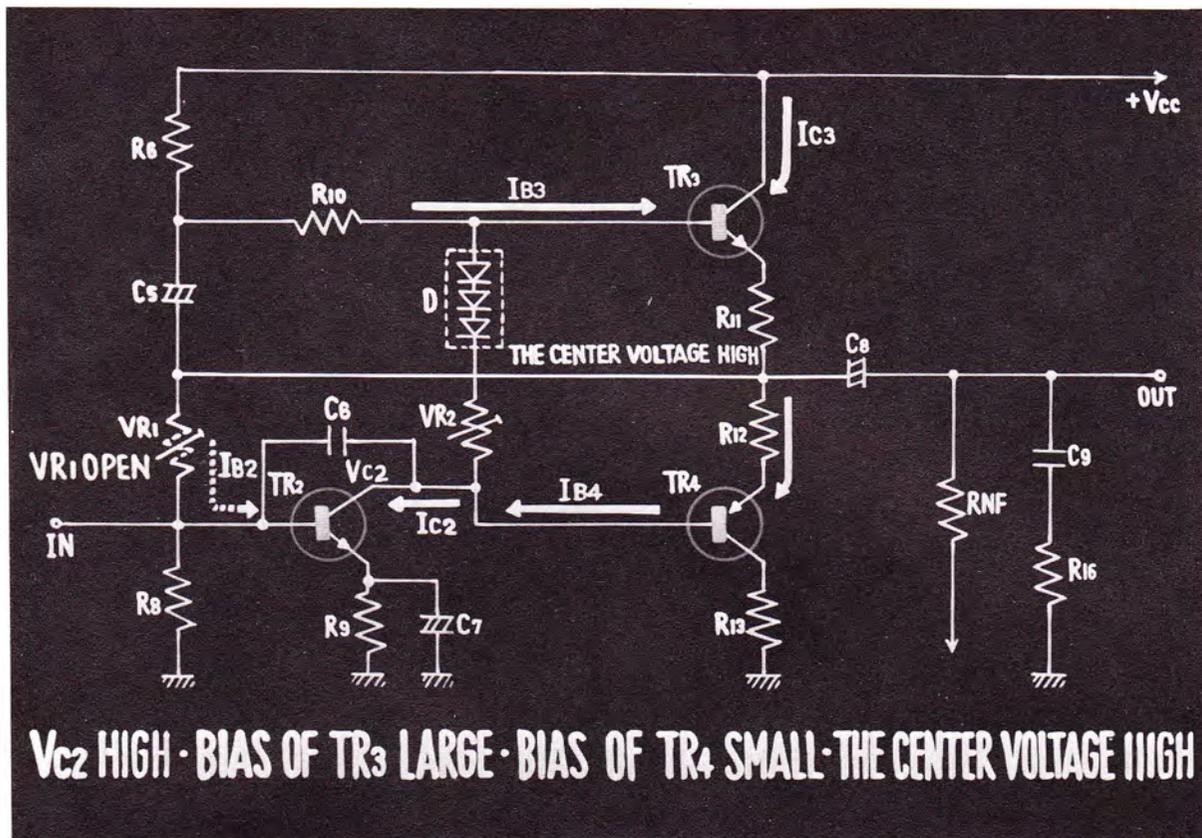
40. IN THIS CASE, THE COLLECTOR CURRENT OF TRANSISTOR 2 DOES NOT FLOW. THEREFORE, AS THE BASE VOLTAGE OF TRANSISTOR 3 INCREASES, THE BIAS VOLTAGE OF TRANSISTOR 3 GETS LARGER. CONSEQUENTLY THE VOLTAGE BETWEEN THE COLLECTOR AND EMITTER BECOMES LOWER, AND THE VOLTAGE AT THE CENTER POINT BECOMES HIGHER THAN  $1/2 V_{CC}$ .



41. HOWEVER, SINCE THE BIAS VOLTAGE IS APPLIED TO TRANSISTOR 2, THE BASE CURRENT OF TRANSISTOR 4 FLOWS INTO THE COLLECTOR OF TRANSISTOR 2, MAKING THE BIAS VOLTAGE OF TRANSISTOR 4 LARGER. IN THIS CASE, EVERY CAUTION IS NECESSARY, BECAUSE A LARGE CURRENT FLOWS INTO TRANSISTORS 3 AND 4, CAUSING THEM TO BREAK DOWN.

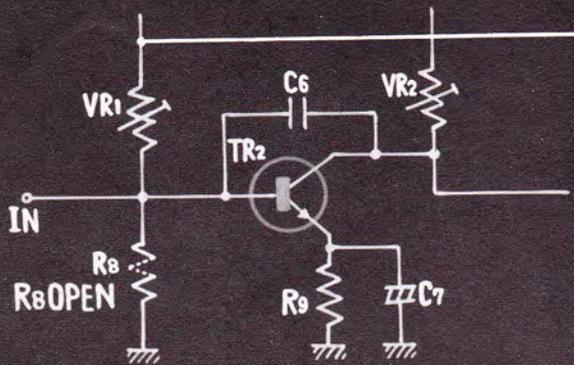


42. WHAT WILL HAPPEN WHEN  $VR_1$  IS OPEN?



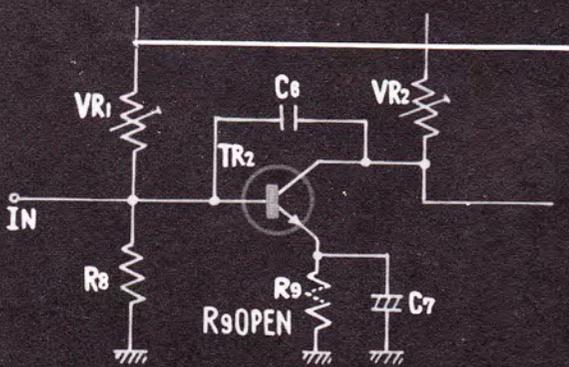
43. IF  $VR_1$  IS OPEN, IT WILL NOT ALLOW TO GIVE BIAS VOLTAGE TO TRANSISTOR 2. THEREFORE, THE COLLECTOR CURRENT OF TRANSISTOR 2 DECREASES, CAUSING THE COLLECTOR VOLTAGE TO INCREASE.

THE BIAS VOLTAGE FOR TRANSISTOR 3 BECOMES LARGER, AND THE BIAS VOLTAGE FOR TRANSISTOR 4 BECOMES SMALLER, THUS THE CENTER VOLTAGE BECOMES HIGHER THAN  $1/2 V_{CC}$ .

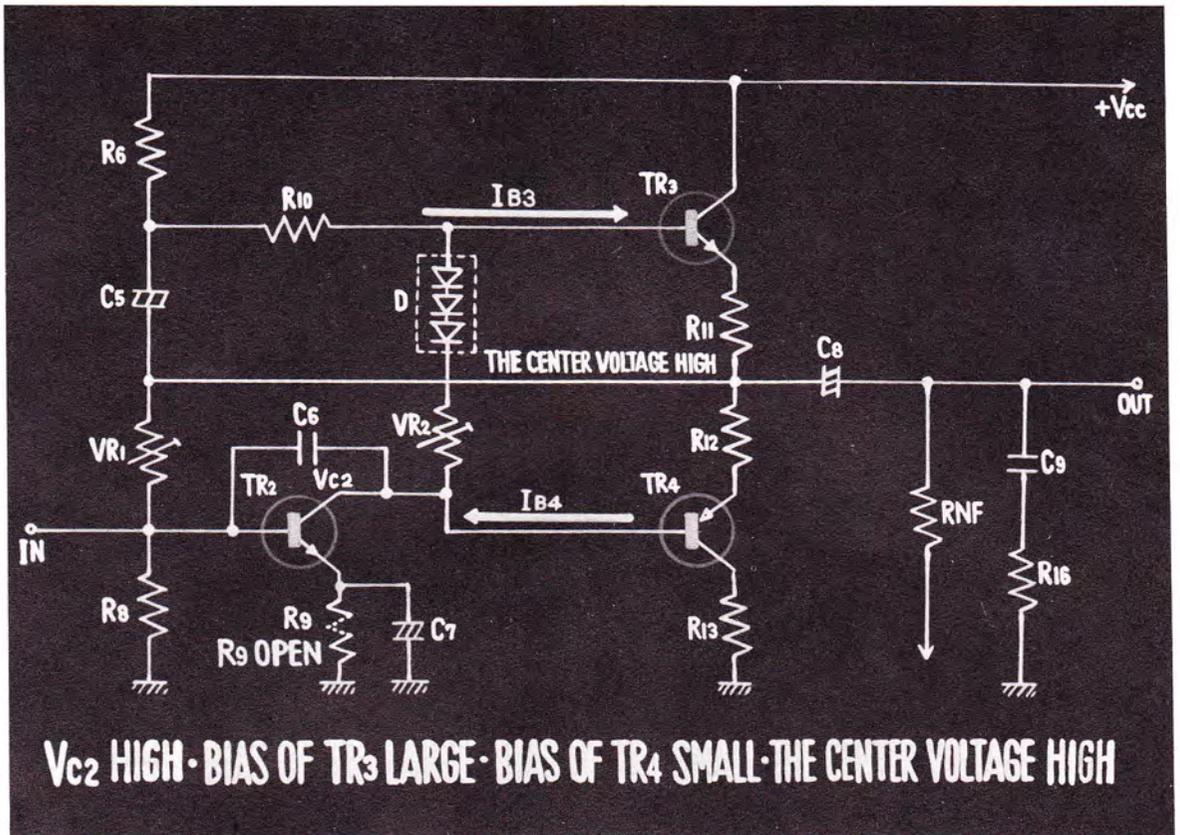


44. WHAT WILL HAPPEN WHEN THE RESISTOR  $R_8$  IS OPEN?

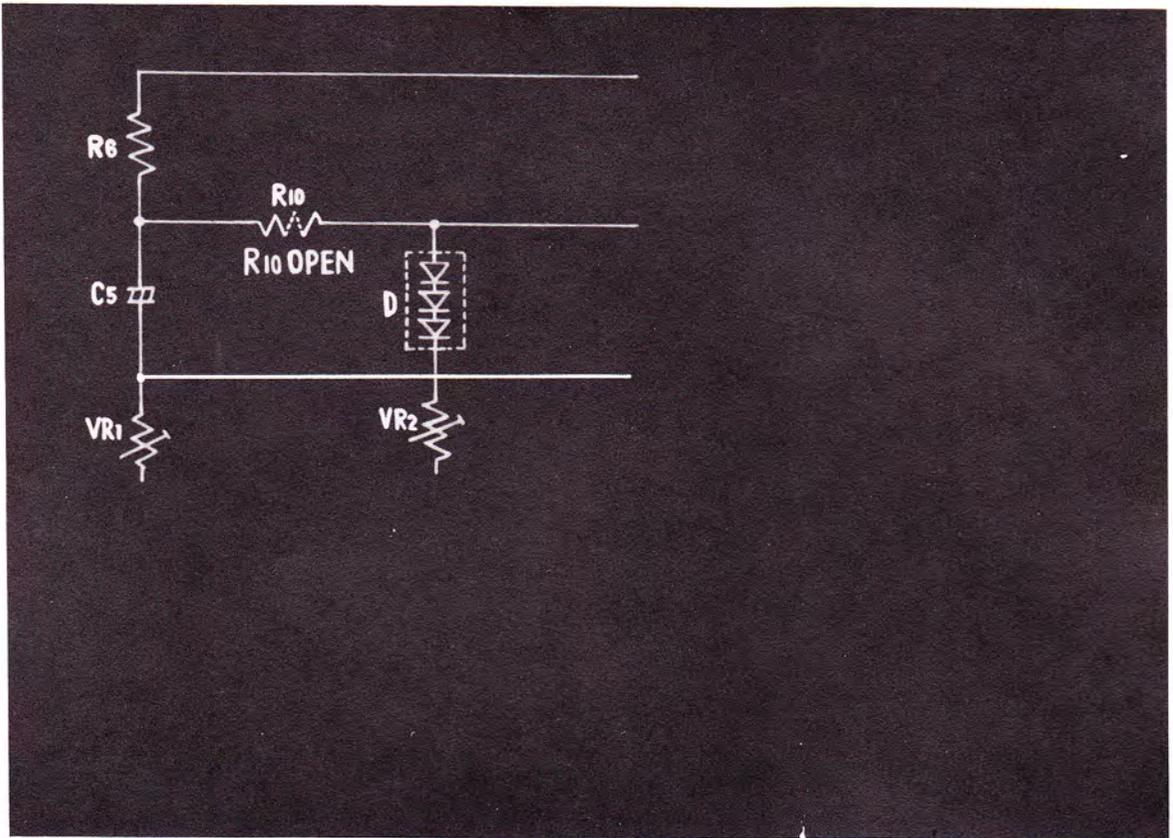




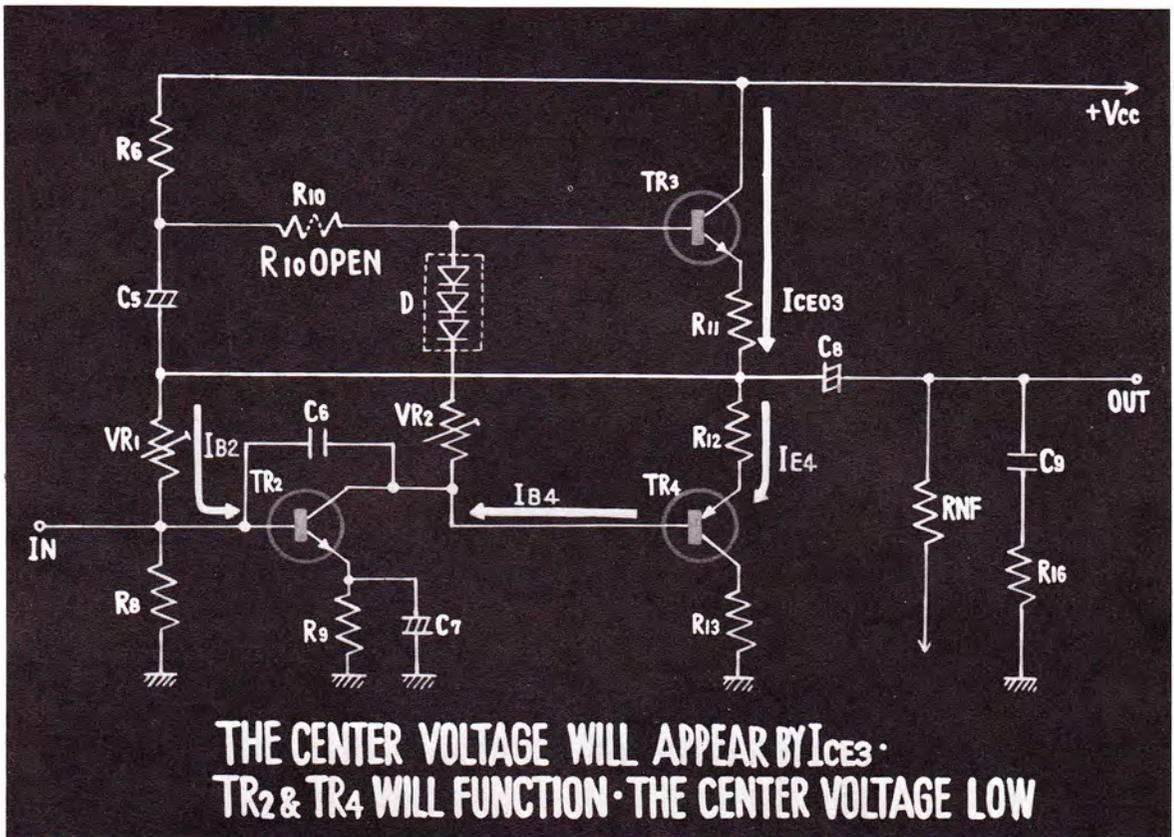
46. WHAT ABOUT THE CASE WHEN THE RESISTOR  $R_9$  IS OPEN?



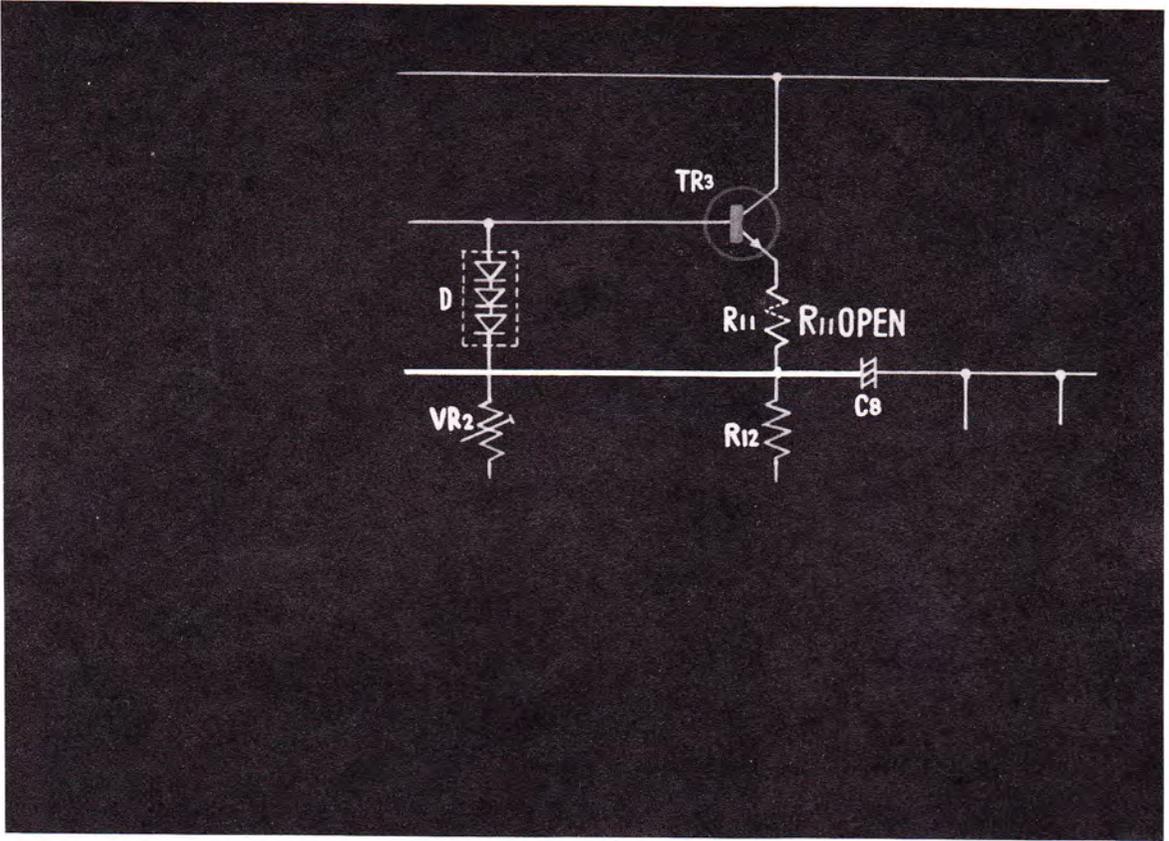
47. IN THIS CASE, NO CURRENT FLOWS INTO TRANSISTOR 2, MAKING ITS COLLECTOR VOLTAGE HIGHER. THE BIAS VOLTAGE OF TRANSISTOR 3 BECOMES LARGER, WHILE THAT OF TRANSISTOR 4 BECOMES SMALLER, AND AS A RESULT THE CENTER VOLTAGE BECOMES HIGHER THAN  $1/2 V_{CC}$ .



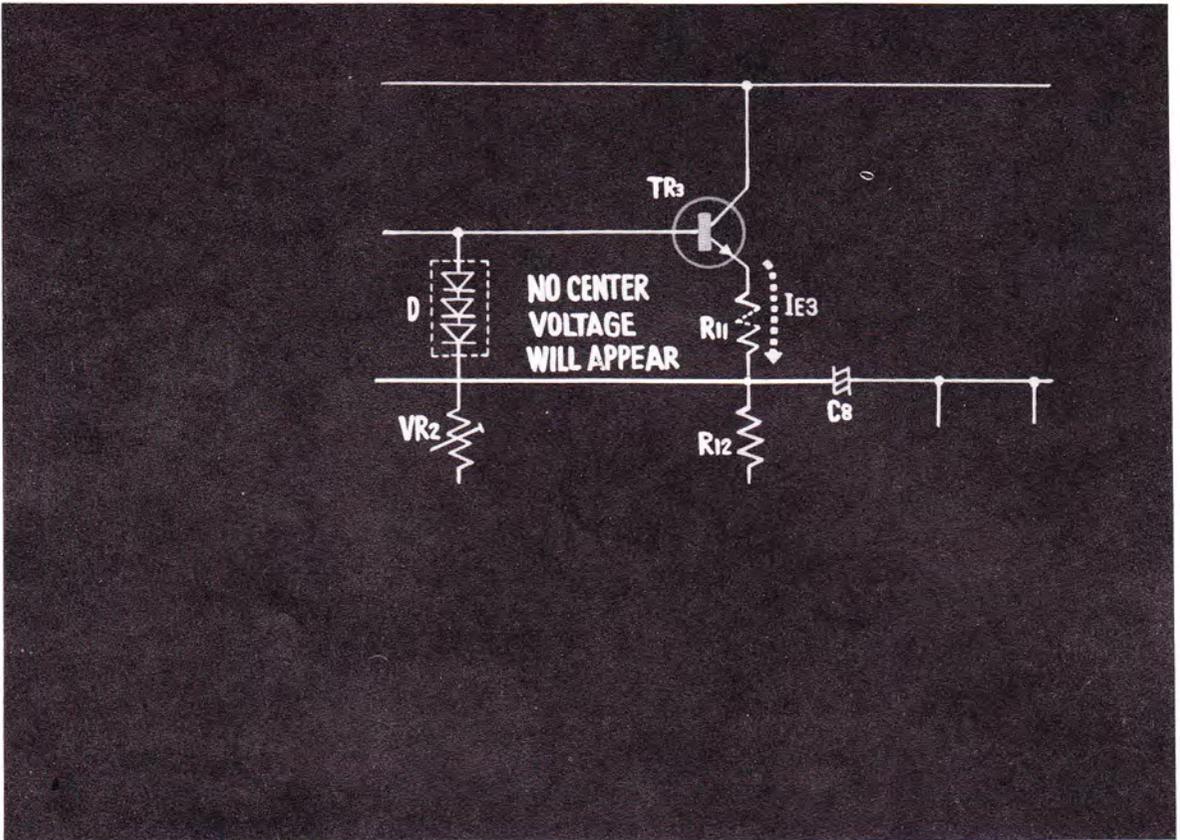
48. WHAT WILL HAPPEN WHEN THE LOAD RESISTOR  $R_{10}$  OF TRANSISTOR 2 IS OPEN?



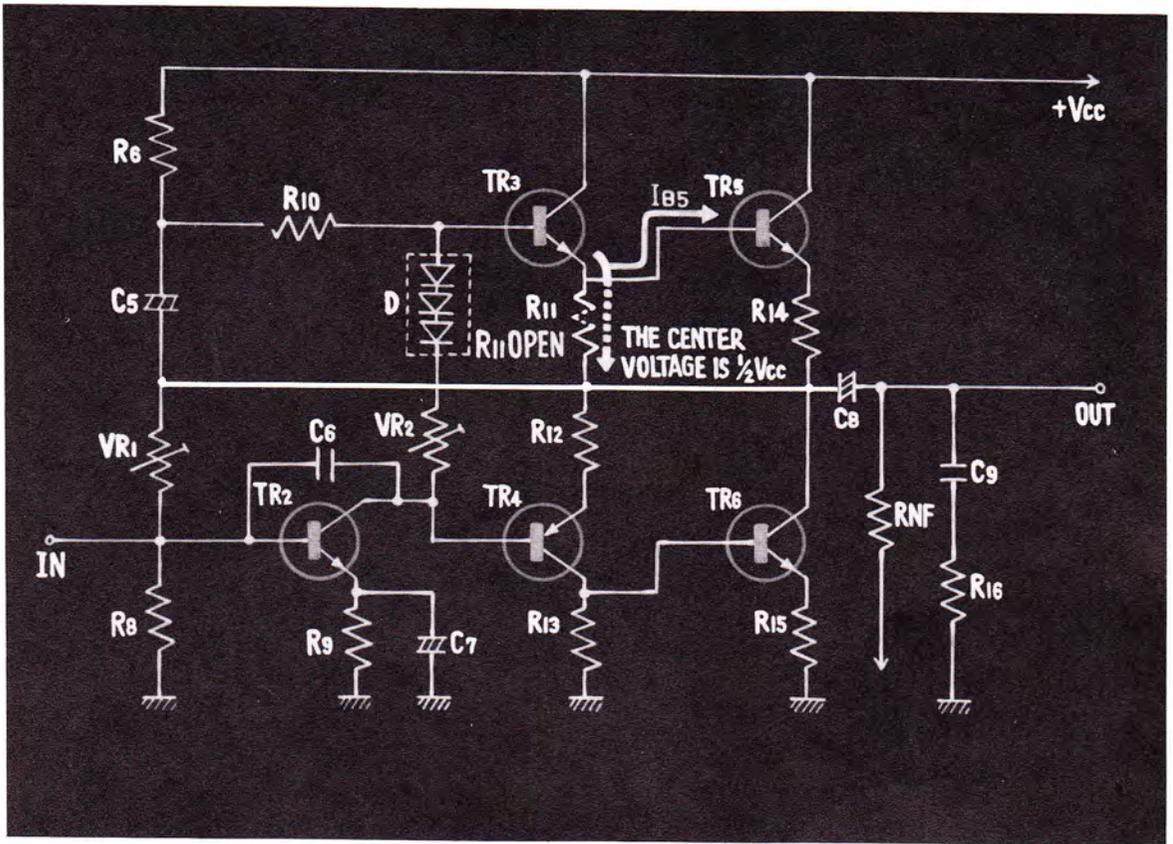
49. IN THIS CASE, IT MAY SEEM THAT NO VOLTAGE IS PRODUCED AT THE CENTER POINT SINCE NO BIAS VOLTAGE IS APPLIED TO TRANSISTOR 3. HOWEVER, ACTUALLY, A VOLTAGE IS PRODUCED AT THE CENTER POINT BECAUSE OF  $I_{CE03}$ , THE COLLECTOR CUT-OFF CURRENT OF TRANSISTOR 3, WHICH IS THE COLLECTOR-EMITTER CURRENT WHEN THE BASE IS OPEN.
- THEREFORE, TRANSISTORS 2 AND 4 WILL FUNCTION IN SUCH A WAY THAT IT WILL REDUCE THE CENTER VOLTAGE TO LOWER THAN  $1/2 V_{CC}$ .



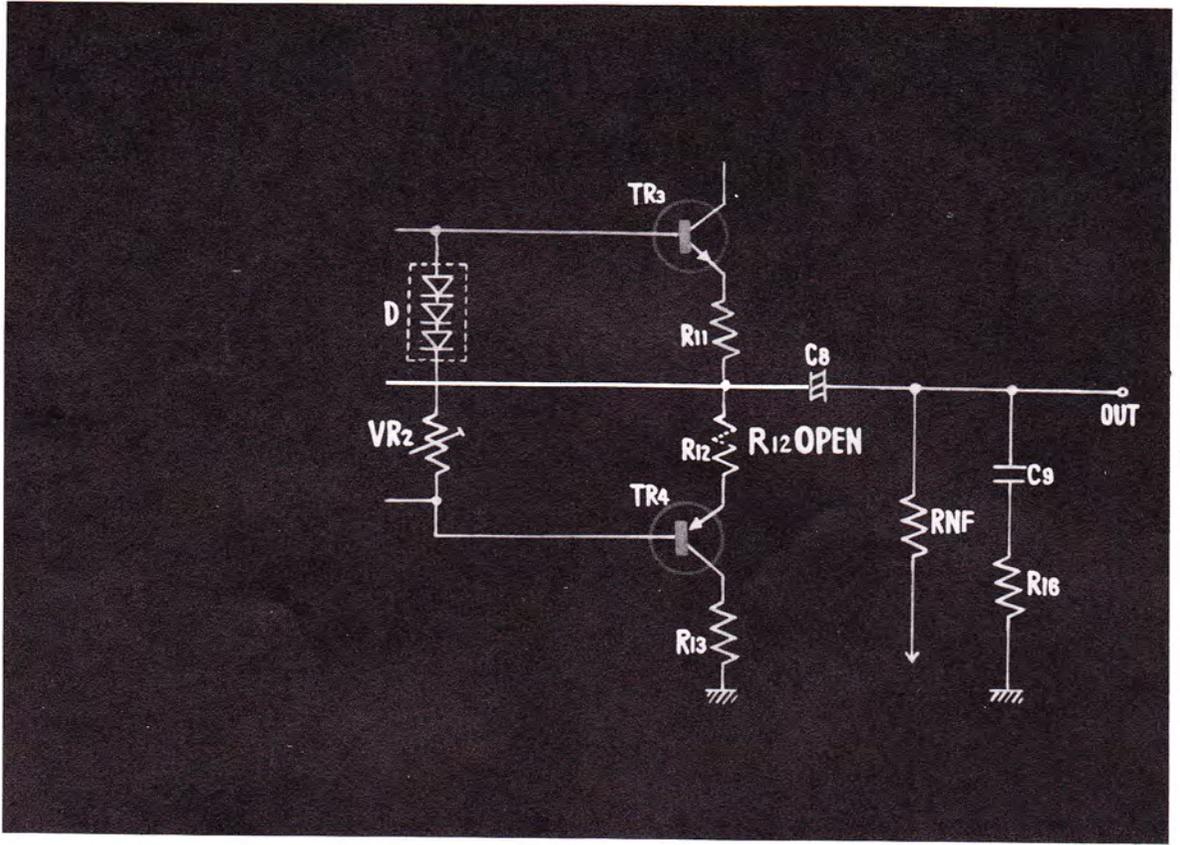
50. WHAT ABOUT THE CASE WHEN THE RESISTOR  $R_{11}$  IS OPEN?



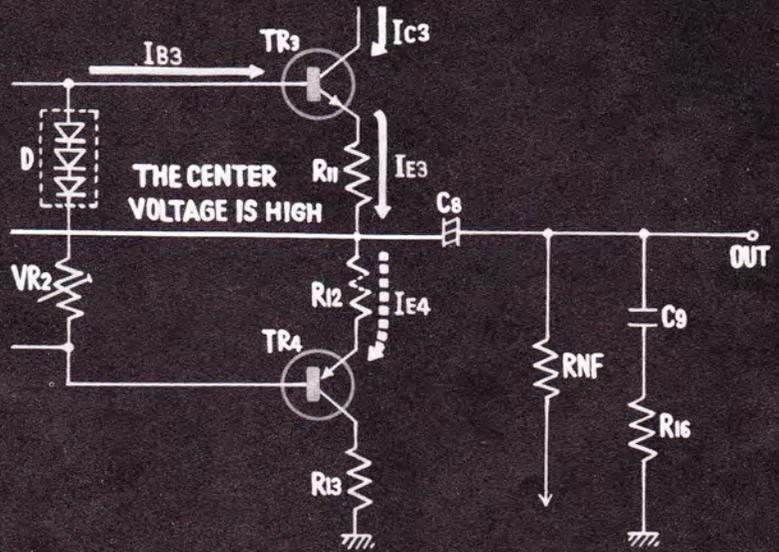
51. WHEN THE RESISTOR  $R_{11}$  IS OPEN IN THIS CIRCUIT WHERE TRANSISTOR 5 IS NOT CONNECTED, THE CENTER VOLTAGE WILL NOT APPEAR.



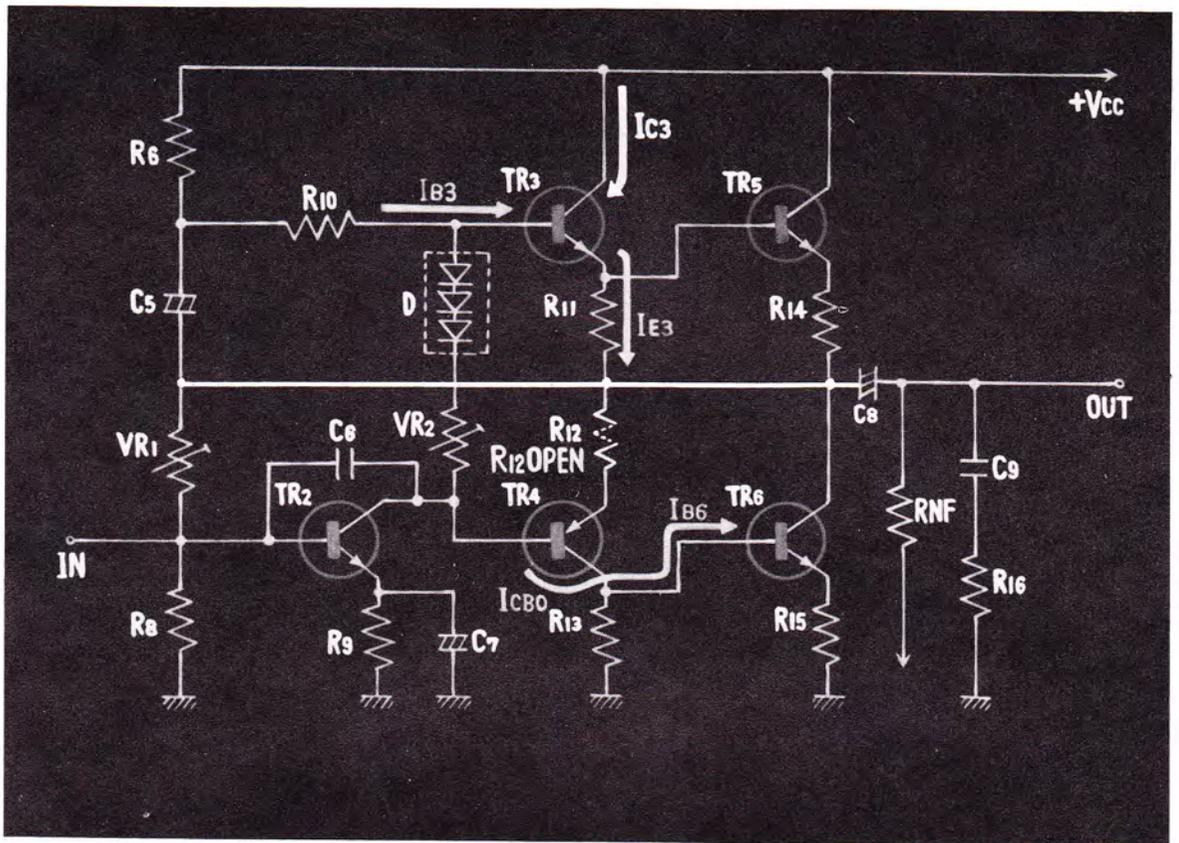
52. HOWEVER, IN ACTUAL CIRCUITS, TRANSISTOR 5 IS ALWAYS CONNECTED. THEREFORE, THE EMITTER VOLTAGE OF TRANSISTOR 3 BECOMES THE BASE CURRENT OF TRANSISTOR 5, MAINTAINING THE CENTER VOLTAGE AT  $1/2 V_{CC}$  OF THE NORMAL VALUE.



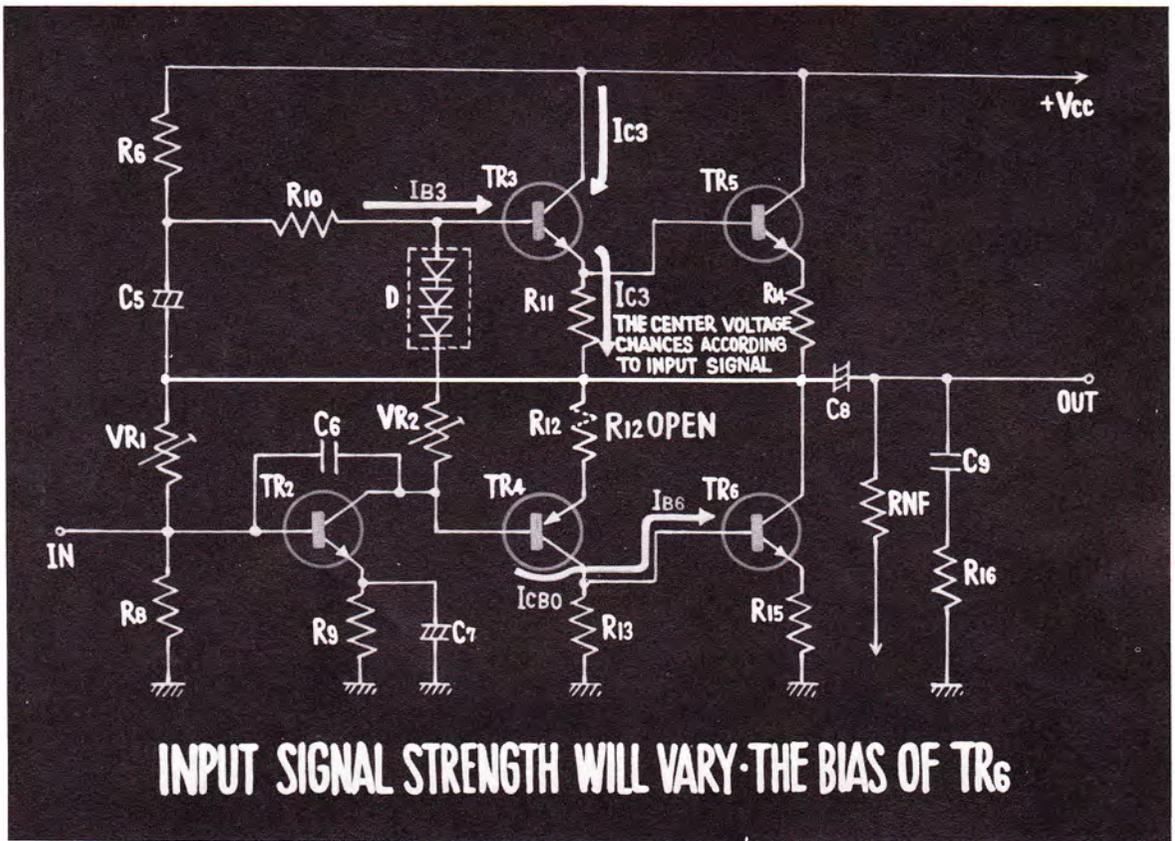
53. WHAT WILL HAPPEN WHEN THE RESISTOR  $R_{12}$  IS OPEN?



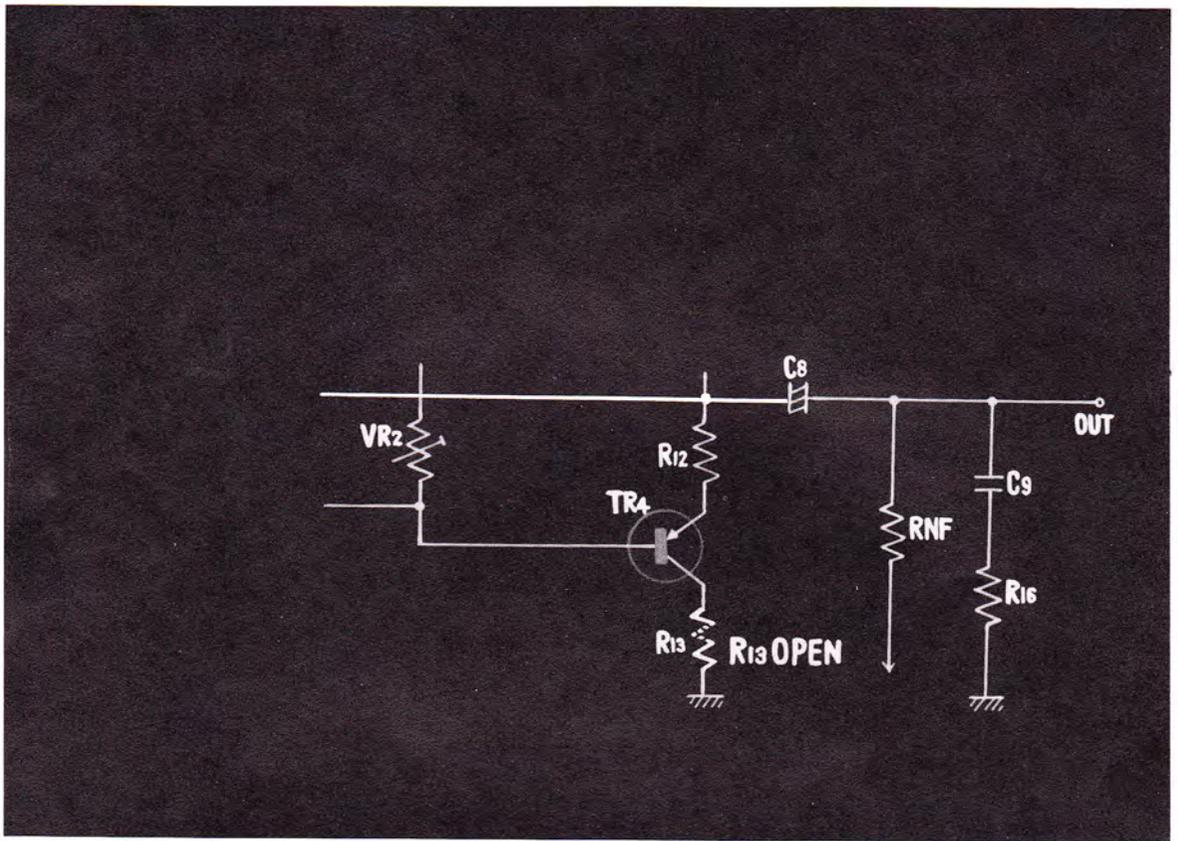
54. WHEN THE RESISTOR  $R_{12}$  IS OPEN, THE EMITTER CURRENT OF TRANSISTOR 4 BECOMES ZERO. SINCE BIAS IS APPLIED TO TRANSISTOR 3, THE CENTER VOLTAGE BECOMES HIGHER.



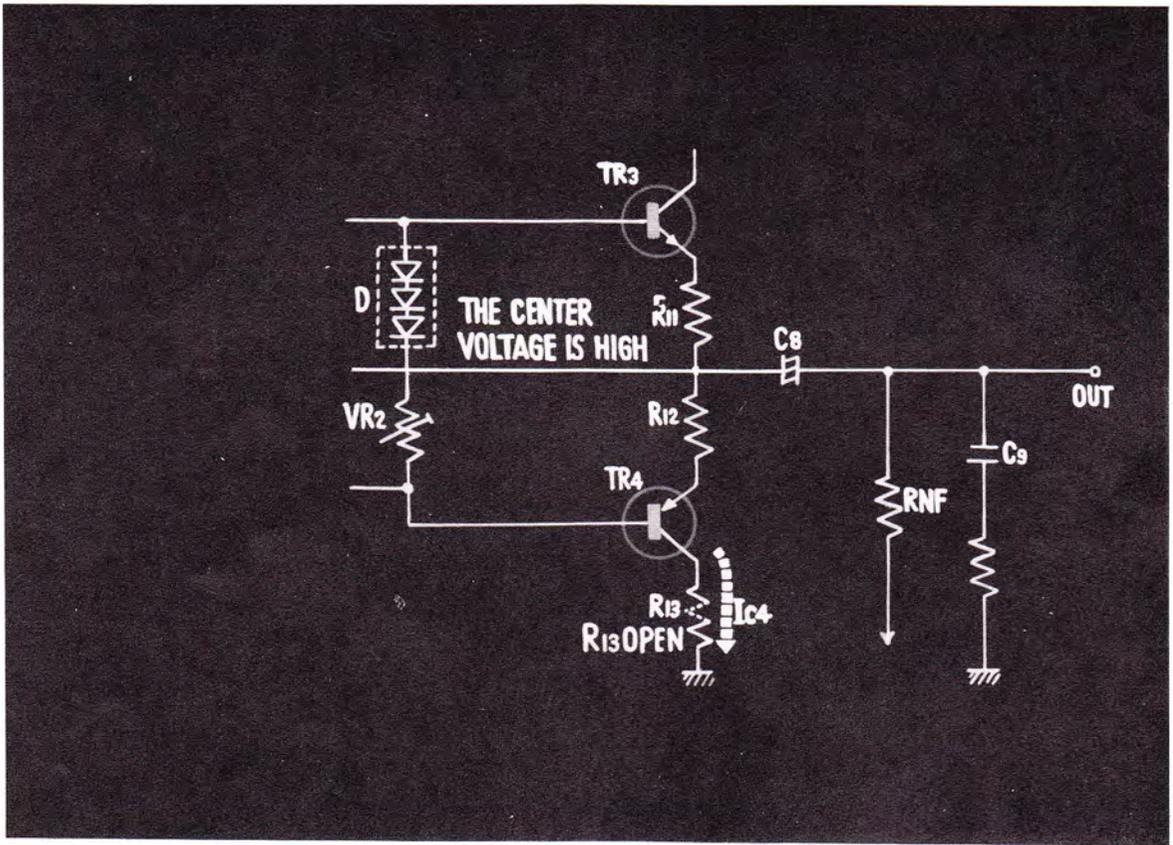
55. IF TRANSISTOR 6 IS CONNECTED IN THIS CIRCUIT, THE COLLECTOR BASE CURRENT  $I_{CEB0}$  WHEN THE EMITTER OF TRANSISTOR 4 IS OPEN BECOMES THE BASE CURRENT OF TRANSISTOR 6. HOWEVER, THIS VALUE OF  $I_{CEB0}$  IS EXTREMELY SMALL, THEREFORE, THIS SERVES AS ALMOST NO BIAS FOR TRANSISTOR 6.



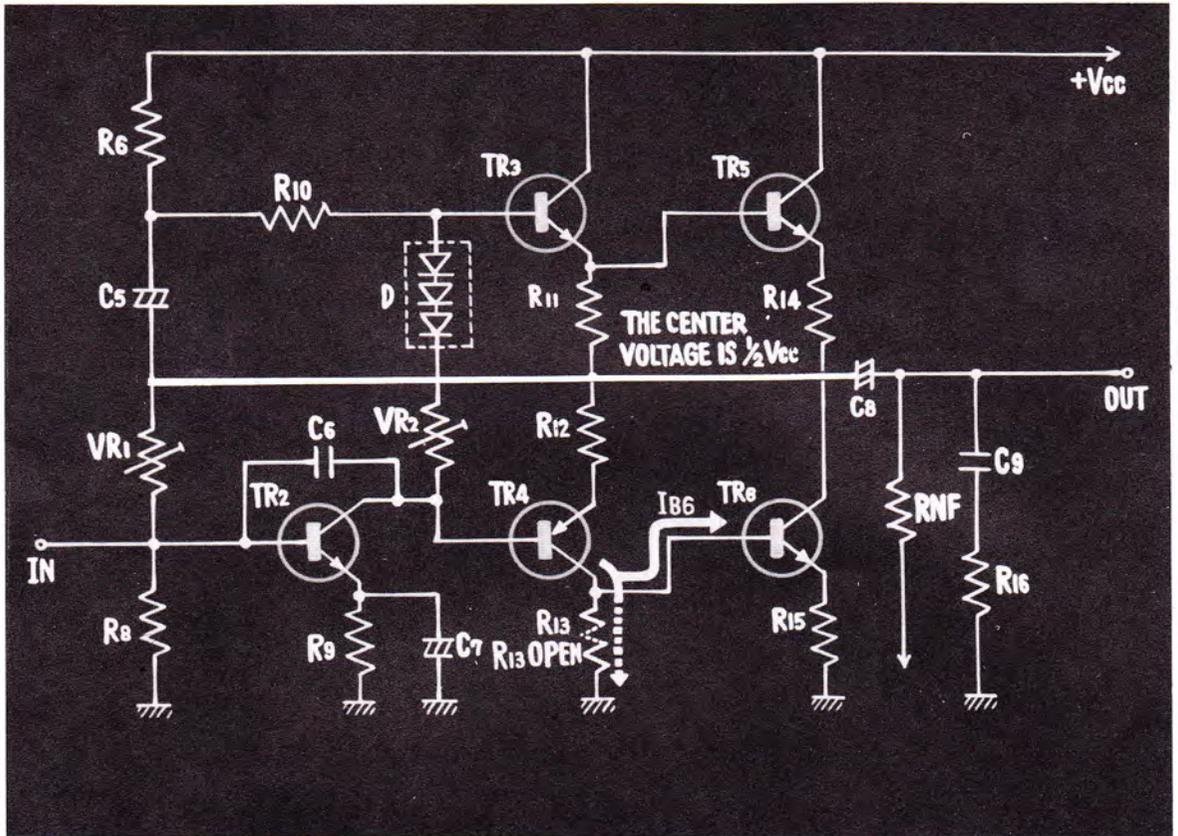
56. THIS  $I_{CEBO}$  OF TRANSISTOR 4 CHANGES DEPENDING UPON THE INPUT SIGNAL. ACCORDINGLY, THE BIAS VOLTAGE OF TRANSISTOR 6 ALSO CHANGES, THE CENTER VOLTAGE VARYING FROM HIGH TO NEAR  $1/2 V_{CC}$  IN ACCORDANCE WITH THE INPUT SIGNAL STRENGTH.



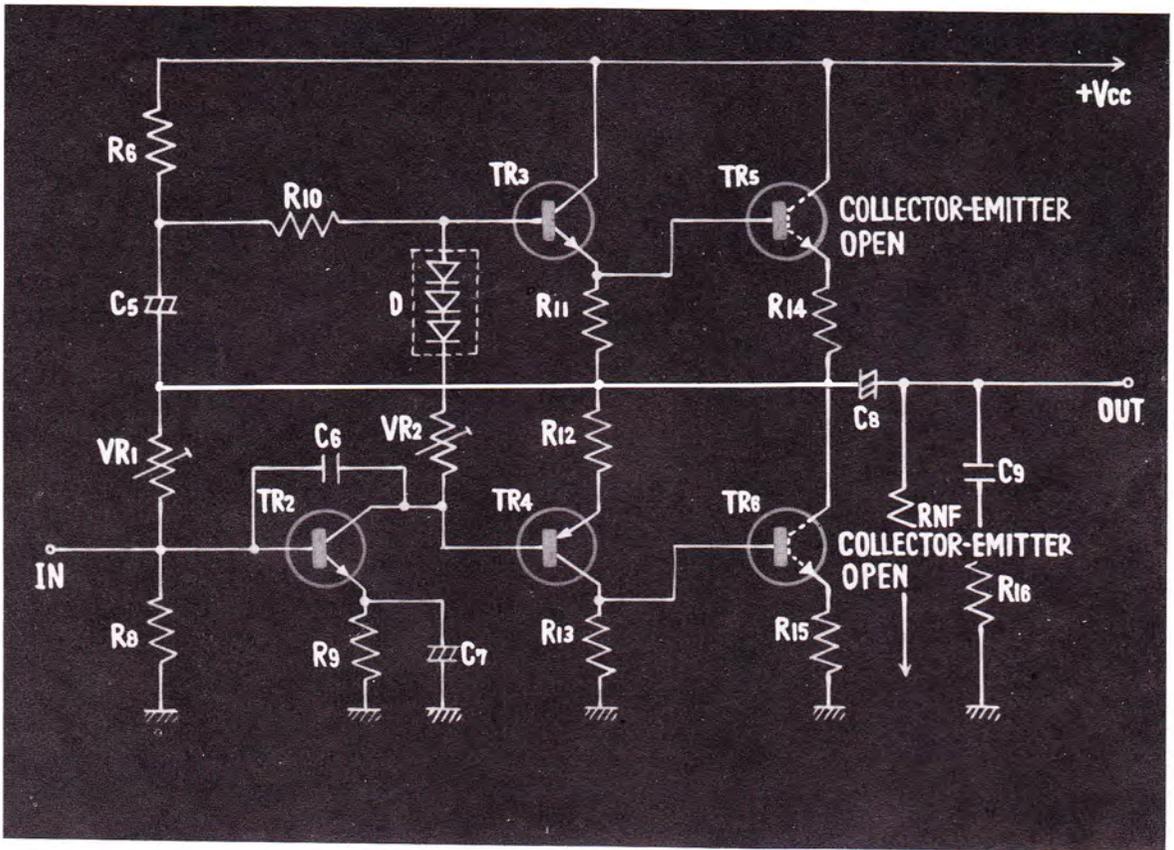
57. NEXT, WHAT ABOUT THE CASE WHEN THE RESISTOR  $R_{13}$  IS OPEN?



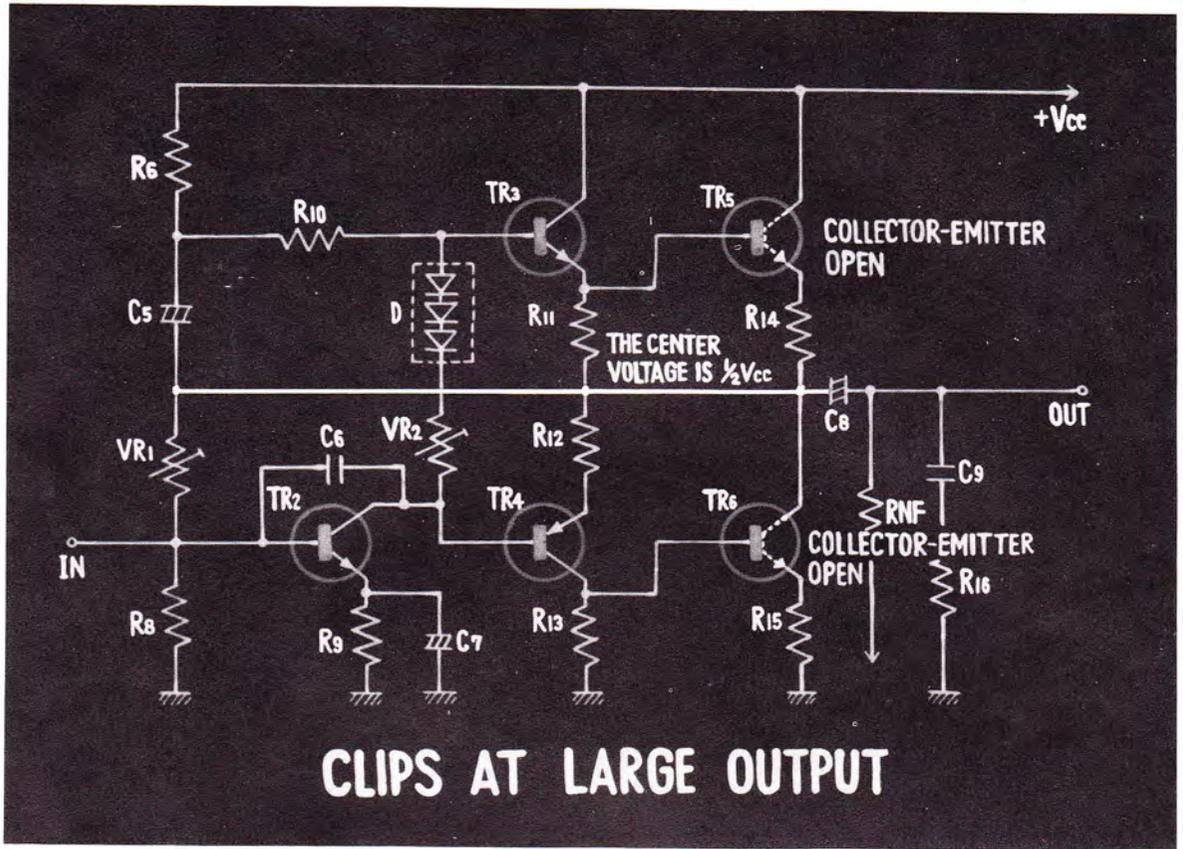
58. WHEN THE RESISTOR  $R_{13}$  IS OPEN AND ALSO IF TRANSISTOR 6 IS NOT CONNECTED, THEN THE COLLECTOR CURRENT OF TRANSISTOR 4 BECOMES ZERO. AS A RESULT, THE CENTER VOLTAGE WILL GET HIGHER.



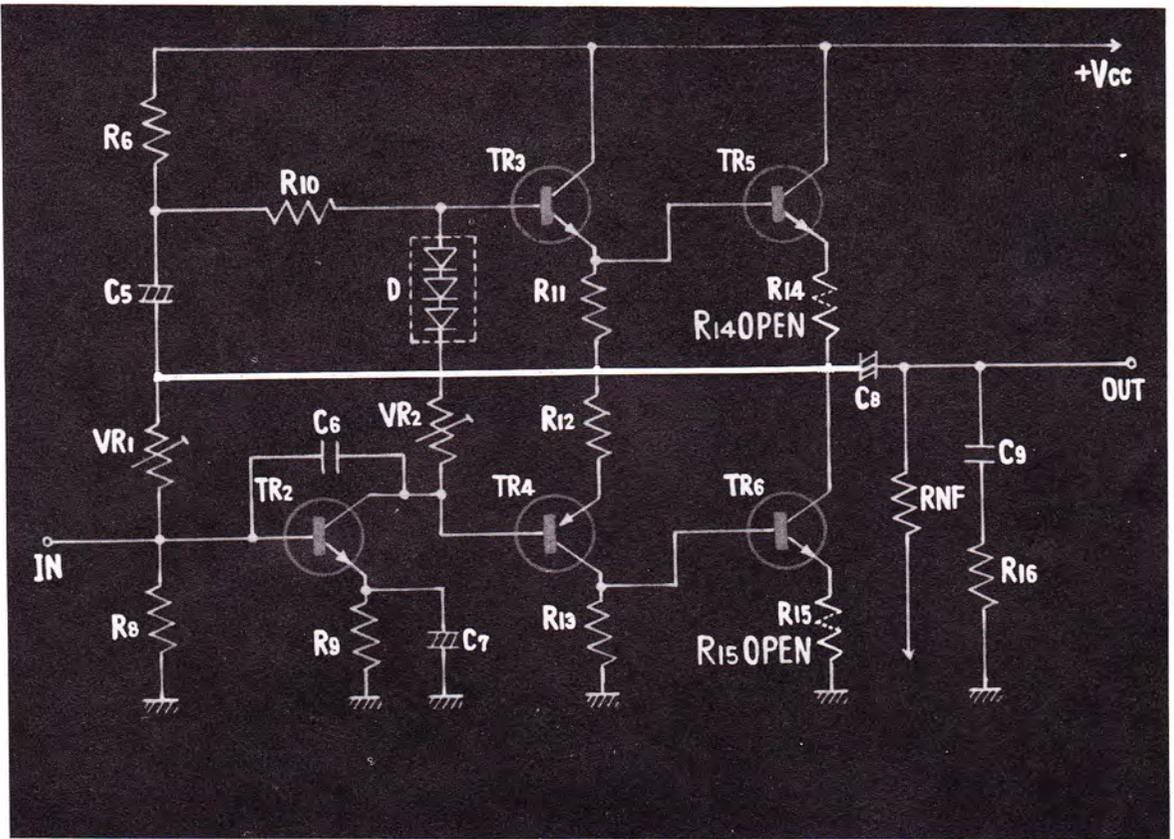
59. IF TRANSISTOR 6 IS CONNECTED IN THE CIRCUIT, THE COLLECTOR CURRENT OF TRANSISTOR 4 BECOMES THE BASE CURRENT OF TRANSISTOR 6, MAINTAINING THE CENTER VOLTAGE AT  $\frac{1}{2} V_{CC}$  OR THE NORMAL VALUE.



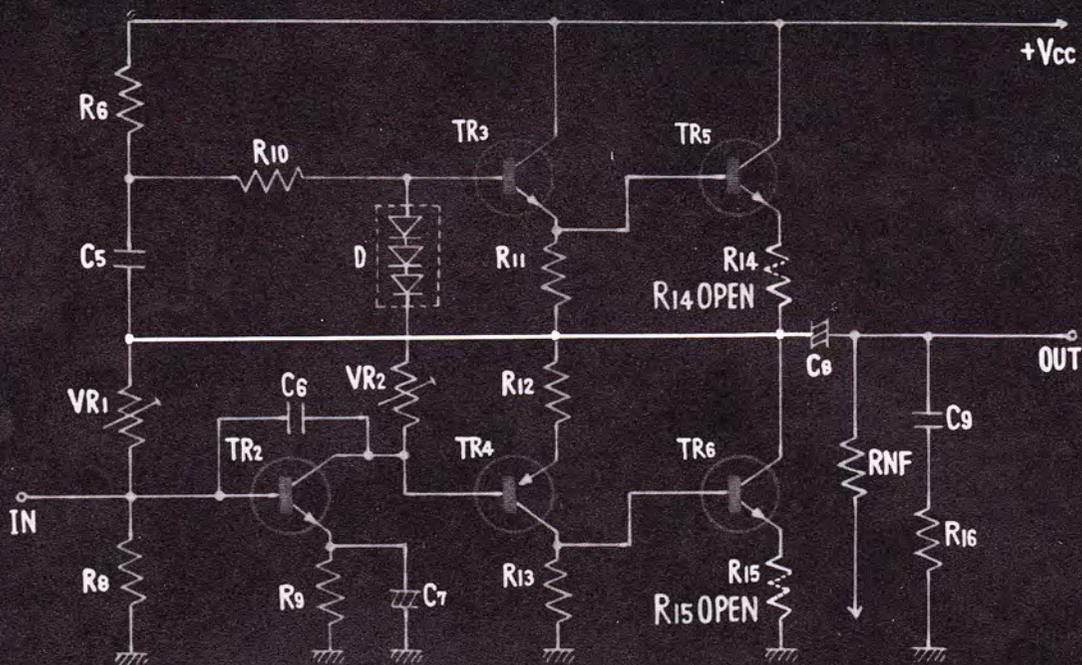
60. WHAT WILL THEN HAPPEN WHEN THE POWER STAGE, TRANSISTOR 5 OR 6 IS OPEN?



61. IN THIS CASE, NO ABNORMALITY OCCURS AT LEAST DC-WISE. THE CENTER VOLTAGE WILL BE KEPT AT A NORMAL VALUE OF  $1/2 V_{CC}$ . FROM THE VIEWPOINT OF AC, THERE IS NO PROBLEM WHEN THE OUTPUT IS VERY SMALL. HOWEVER, LARGE OUTPUT CANNOT BE PRODUCED, DUE TO CLIPPING.

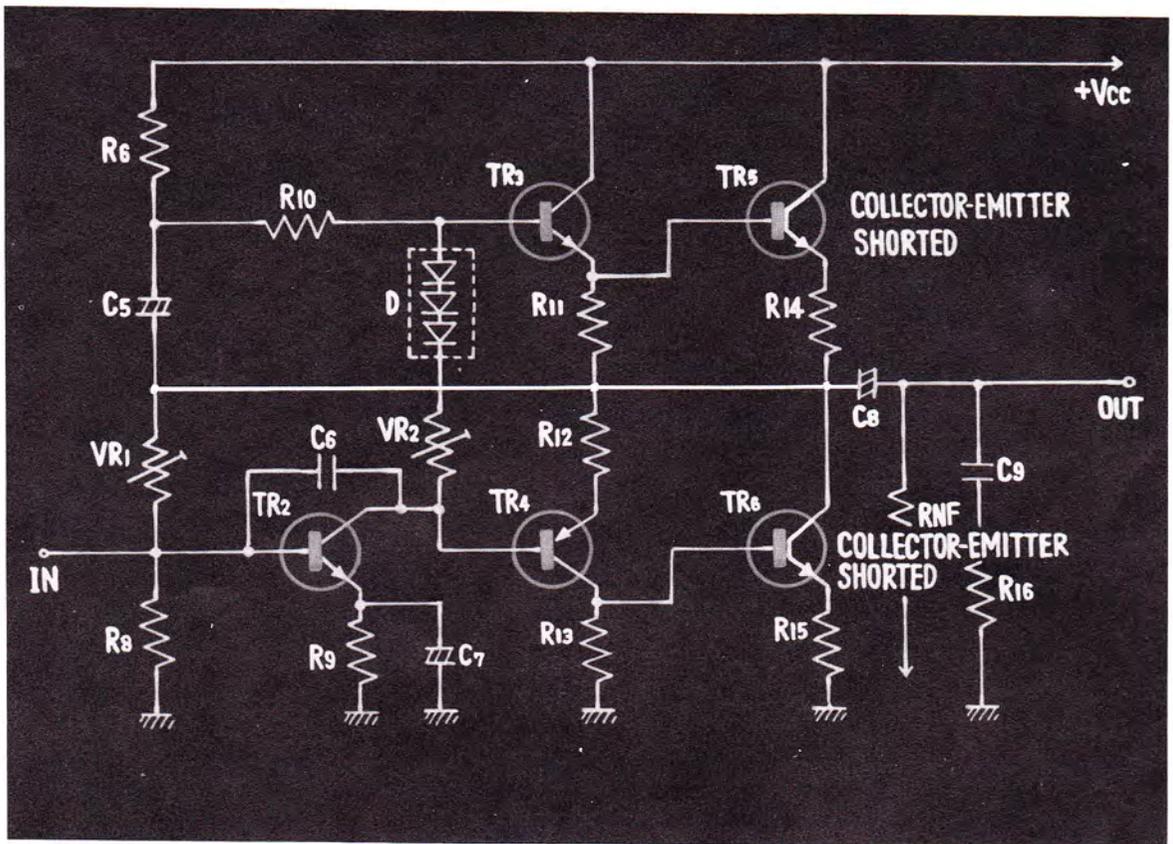


62. WHAT WILL HAPPEN WHEN THE PROTECTIVE RESISTOR  $R_{14}$  OR  $R_{15}$  FOR TRANSISTORS 5 OR 6 BECOMES OPEN?

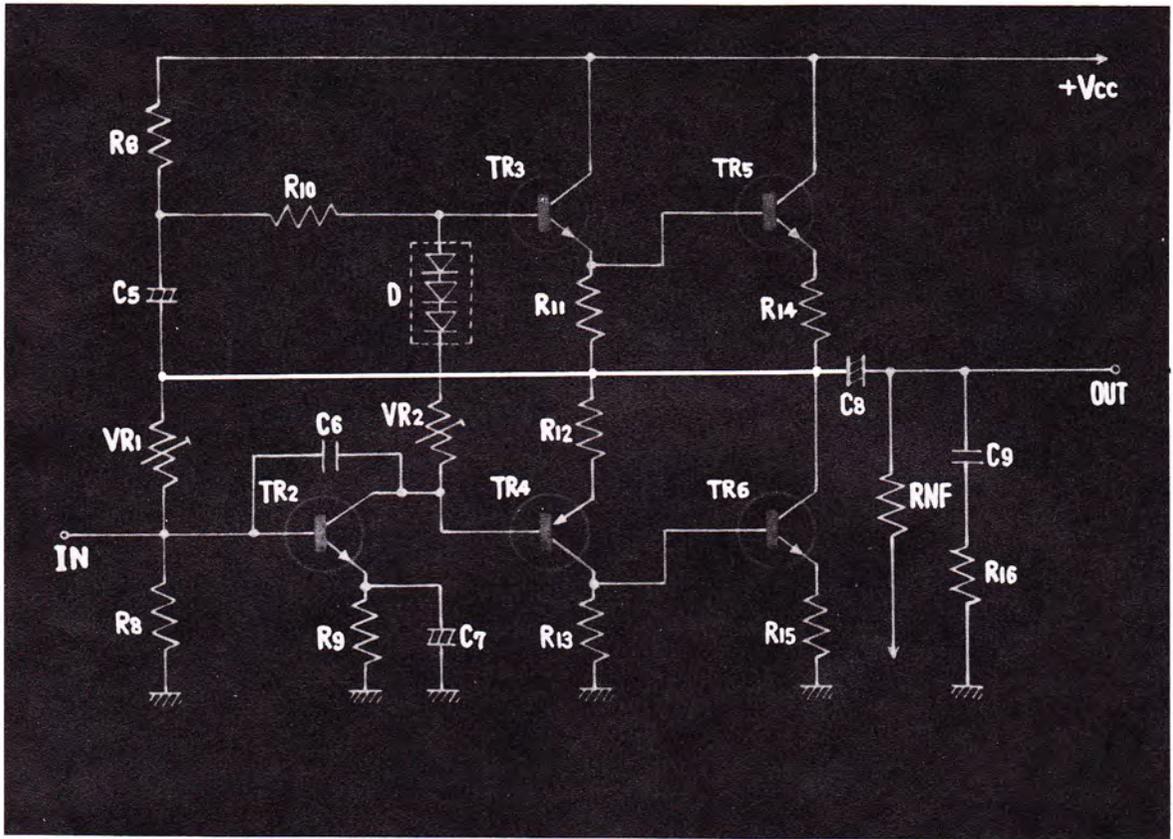


**TR<sub>3</sub> & TR<sub>4</sub> FUNCTION BUT NO LARGE OUTPUT WILL BE PRODUCED**

63. THERE IS HARDLY ANY PROBLEM AS FAR AS THE DC IS CONCERNED, BECAUSE THE SITUATION IS THE SAME AS THE CASE WHEN TRANSISTOR 5 OR 6 IS OPEN. SINCE NO CURRENT FLOWS INTO THE POWER TRANSISTORS, TRANSISTORS 3 AND 4 WILL FUNCTION INSTEAD. HOWEVER, THEY WILL NOT BE CAPABLE OF PRODUCING LARGE OUTPUT.



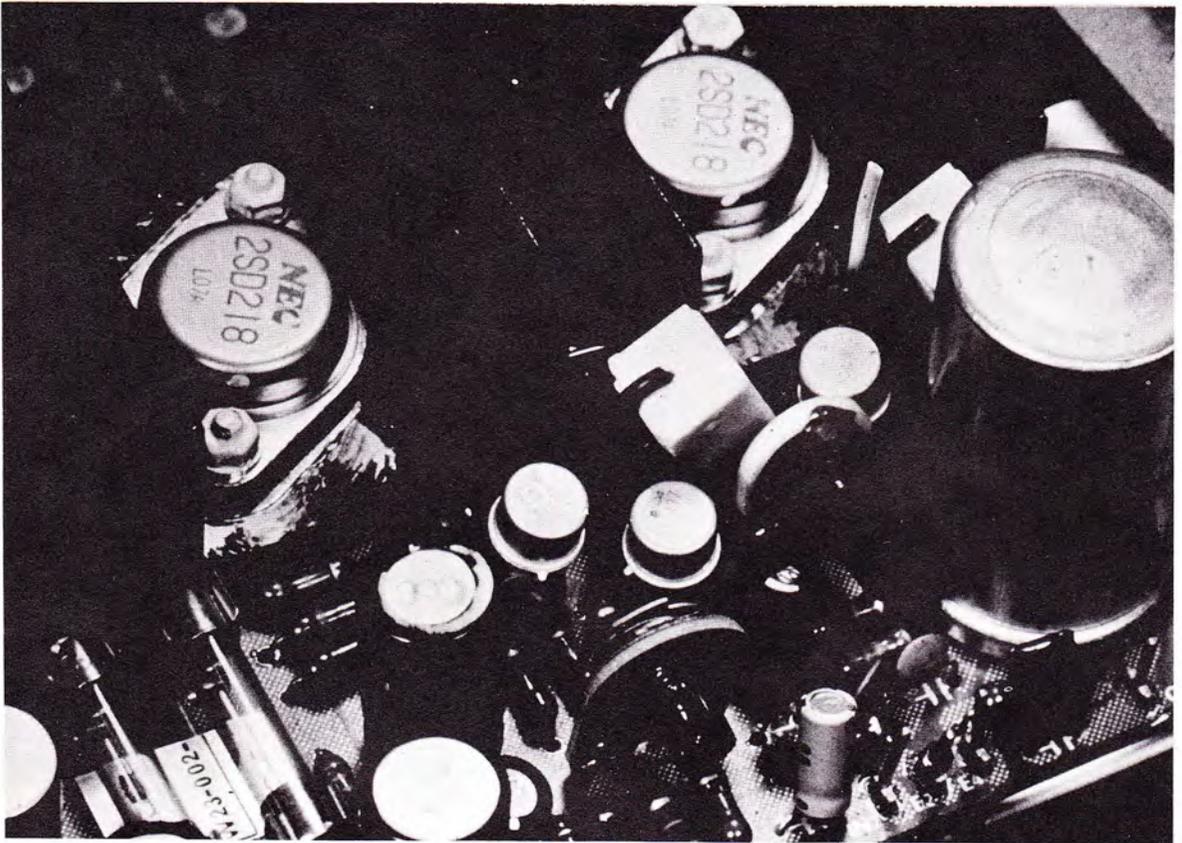
64. HOW ABOUT THE CASE WHEN POWER TRANSISTOR 5 OR 6 IS SHORT-ED? WHEN EITHER ONE OF THE POWER TRANSISTORS IS SHORTED, THE FUSE WILL BLOW IMMEDIATELY, MAKING IT IMPOSSIBLE TO CHECK THE CONDITION BY MEANS OF VOLTAGE.



65. IN THIS INSTANCE, REMOVE THE POWER TRANSISTORS AND CHECK IF THE CENTER VOLTAGE IS SET AT  $1/2 V_{CC}$ .  
IF THE VOLTAGE IS NORMAL, THEN INSTALL A NEW POWER TRANSISTOR.



66. THIS WILL CONCLUDE THE SLIDE STUDY ON HOW TO LOCATE TROUBLES IN THE TRANSISTOR AMPLIFIER CIRCUIT. YOU HAVE SO FAR LEARNED HOW TO CHECK THE CAPACITOR-CONNECTED COMMON-EMITTER TYPE CIRCUIT, DIRECT-COUPLED AMPLIFIER CIRCUIT AND THE COMPLEMENTARY MAIN AMPLIFIER CIRCUIT.



67. WE HOPE YOU WILL GET A CORRECT UNDERSTANDING OF THESE BASIC THEORIES, BECAUSE THEY WILL PROVE TO BE VERY HELPFUL IN YOUR FURTHER STUDY.

**END**

