

## XV. SPEECH COMMUNICATION

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### A. TERMINAL ANALOG SPEECH SYNTHESIZER\*

One type of terminal analog speech synthesizer, called a POVO synthesizer, consists of a number of electronically controlled tuned circuits placed in cascade (1, 2). When the synthesizer is excited by a buzz generator, each tuned circuit produces a resonance that corresponds to a formant of the vowel sound that is being synthesized. Since there are widely different sets of formant frequencies for different vowel sounds, the tuned circuits in the synthesizer must be capable of meeting a reasonably strict set of requirements in order to enable the over-all synthesizer to function properly. The tuned circuit corresponding to the lowest formant frequency has to meet the most stringent specifications. The resonant frequency must be controllable over a range of 10:1 by a voltage or current, and the bandwidth should be approximately 50 cps over the entire range of variation. The control-source-versus-resonant-frequency characteristic must be stable, regardless of aging or replacement of components. The circuit must also have a minimum amount of "thump" (control signal appearing at the output of the circuit) and a maximum signal-to-noise ratio.

Figure XV-1 shows a circuit capable of meeting these requirements. Transistors are employed throughout the circuit, not because a small package is required, but rather because an analysis showed that the design specifications could be more adequately met if transistors are used instead of vacuum tubes. The circuit is essentially a Miller integrator around which is placed a 0.5-henry inductor that is tuned with a 13-mfd capacitor to produce the desired resonant circuit. Variation of the emitter bias currents of the transistors in the attenuator section of the integrator changes the over-all amplification and thus provides for the external control of the resonant frequency. The high-gain section of the integrator is merely a two-stage feedback amplifier which increases the gain so that the necessary 10:1 variation in resonant frequency can be obtained. The input, output, and driver sections provide the necessary isolation between stages and the desired impedance levels.

The various potentiometers  $R_A$ ,  $R_B$ ,  $R_C$ ,  $R_D$  and  $R_E$  enable the circuit to be readjusted when a component is changed and thus render the circuit insensitive to component replacement. The potentiometers  $R_A$  and  $R_B$ , in the attenuator section, are used to match the transistors  $T_3$  and  $T_4$  and hence to reduce the "thump." The

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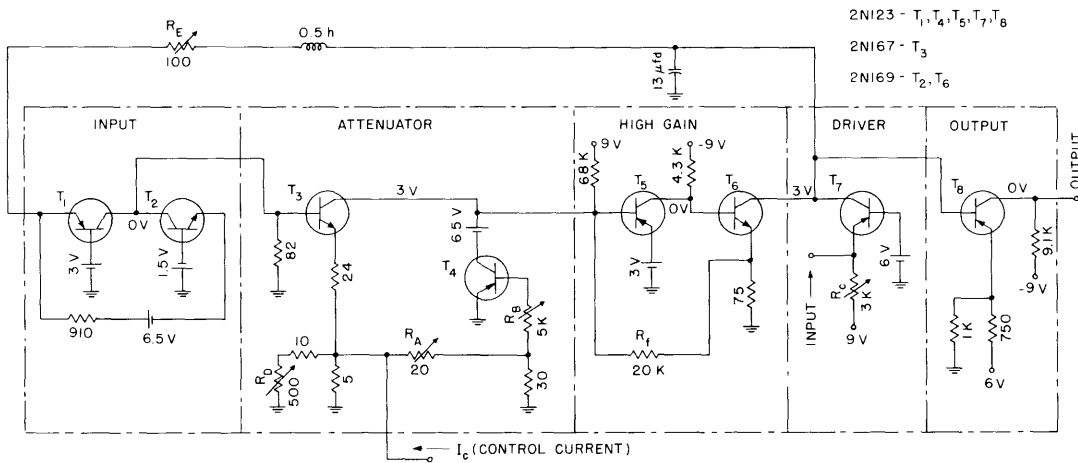


Fig. XV-1. First-formant POVO section.

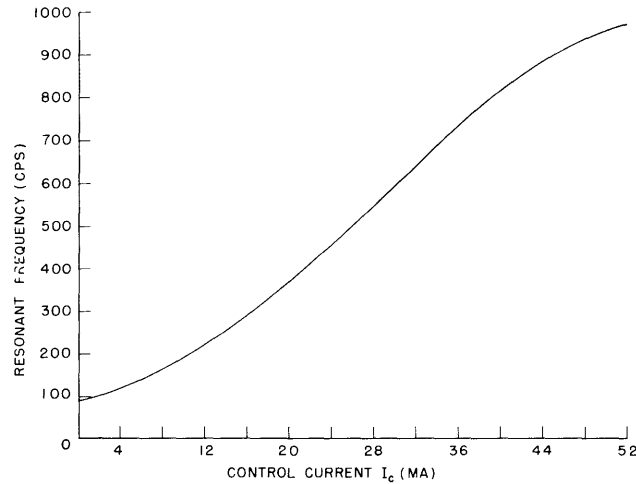


Fig. XV-2. Mean control characteristic for first-formant POVO section.

potentiometers  $R_C$  and  $R_D$  provide for the adjustment of the control characteristic (resonant frequency versus control current), and  $R_E$  controls the bandwidth. Direct-current feedback, which is only possible with transistors, makes the circuit less sensitive to component changes.

Figure XV-2 shows the control characteristic for the circuit of Fig. XV-1. Regardless of the transistors used in the circuit, deviations from this characteristic were less than 4 per cent. The maximum measured amount of "thump" for the circuit was also approximately 4 per cent of the signal amplitude. The bandwidth remained essentially constant for most of the variation in resonant frequency, except for a 7 per cent deviation for high resonant frequencies. This deviation can be eliminated, however, if a

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higher quality capacitor is employed in the tuned circuit. The signal-to-noise ratio of the circuit was measured as approximately 60 db, and was not affected by the particular transistors used in the circuit.

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References

1. K. N. Stevens, Synthesis of speech by electrical analog devices, J. Audio Eng. Soc. 4, 2-8 (1956).
2. J. L. Flanagan, Note on the design of "terminal-analog" speech synthesizers, J. Acoust. Soc. Am. 29, 306-310 (1957).