ELECTRON TUBES

RCA Application Note

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# Compensation of Frequency Drift

In local oscillator circuits of high-frequency receivers, trouble may be encountered with frequency drift during warm-up. This drift falls into two general classes: The first is that due to the oscillator tube and its socket and is characterized by a short-time frequency drift as the tube warms up; the second is that due to the other components of the oscillator circuit and is characterized by a longer-time drift as the chassis comes up to temperature. Both types of drift generally tend to lower the oscillator frequency.

This Note describes a method for substantially compensating the drift due to the warm-up of the tube and socket, and illustrates the application of the method in a receiver. Compensation of the drift attributable to other circuit components is not discussed.

## Short-Time Drift Considerations

The construction of a miniature tube lends itself well to the compensation of that part of the frequency drift due to the tube and socket. Heat is conducted directly from the tube elements through the base pins to the tube socket contacts. Because the socket dielectric material is a poor heat conductor, little heat is lost to the chassis. Consequently, the changes in temperature at the socket terminals are closely related both in time and in relative value to the temperature changes of the tube elements to which the terminals are connected. A capacitor with a negative temperature coefficient mounted directly across two appropriate socket terminals will have a very appreciable temperature rise and, therefore, a small value of capacitance can provide substantial compensation for frequency drift due to the tube and socket.

## Tests Without Frequency-Drift Compensation

A receiver using a 6BE6 as a local oscillator was used in the following tests. The oscillator was operated with its fundamental frequency above the signal in a conventional cathode-feedback circuit as shown in Fig. 1. The oscillator tube socket was a phenolic wafer socket. Tests were made at an oscillator frequency of 110.7 Mc. Because the long-time drift was not under consideration, the tests were made with the receiver chassis out of the cabinet. The observed results follow. For purposes of comparison, the frequency drift values reported are those read from the curves at the ten-minute test point.

(1) The warm-up drift of the unmodified receiver was about 200 kc as shown by curve 1 of Fig. 2.

(2) When a cold 6BE6 was substituted for a hot tube in the set after it was throughly warmed up, the measured drift was about 140 kc as shown by curve 2 of Fig. 2.

(3) After a mica-filled rubber socket was substituted for the phenolic socket, the drift was again measured with a cold 6BE6 inserted in a hot chassis. The drift was reduced to about 100 kc as shown by curve 3 of Fig. 2.

(4) The changes in frequency produced by connecting small capacitors between the grid-socket terminal and the chassis were measured to determine the rate of change of frequency with capacitance. In this manner it was determined that a 100-kc frequency drift corresponded to a change in effective tank capacitance of 0.05 μμf.

Several conclusions may be drawn from the data:

(1) Tests involving the insertion of a cold tube in a hot socket do not necessarily give the drift due to the tube alone. That this is true, is shown by the difference between curves 2 and 3 of Fig. 2.

(2) Phenolic sockets may contribute a significant part of the frequency drift.

(3) The mica-filled rubber socket tested gave reduced drift.

(4) A capacitor having a negative temperature coefficient and connected across the socket terminals will receive heat from the tube in the same manner as the socket. On the basis that a compensation of 100 kc is required, a 3.3-μμf capacitor with a negative temperature coefficient of 0.00075 μμf/μμf/°C across the tank circuit will suffice if its temperature can be raised 20 degrees C during warm-up.

## Tests With Frequency-Drift Compensation

The actual compensation was accomplished by soldering the compensating capacitor across the terminals of a mica-filled rubber socket as shown in Fig. 3. The capacitor is connected between socket pins 3 and 6. This is equivalent electrically to connecting the capacitor between the cathode tap on the coil and ground, as may be seen by reference to Fig. 1. The capacitor leads should be as short as is feasible. This connection was desirable for several reasons. Since the capacitor is

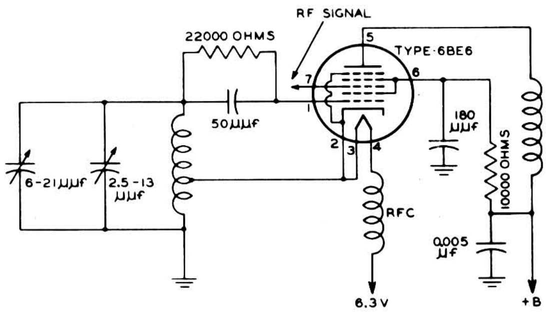


*Fig.1 - Schematic diagram of oscillator circuit.*

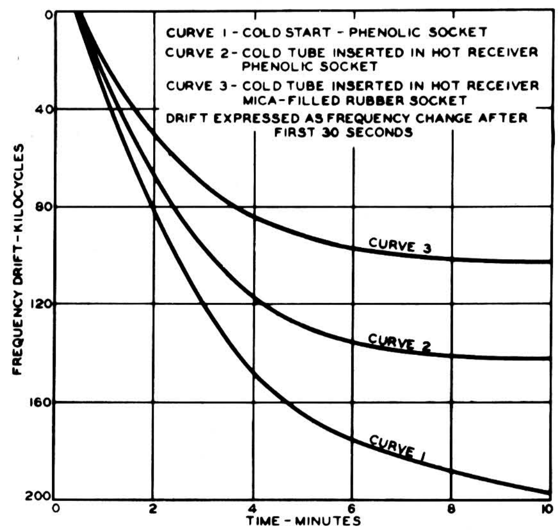


*Fig.2 - Frequency drift of receiver before compensation*

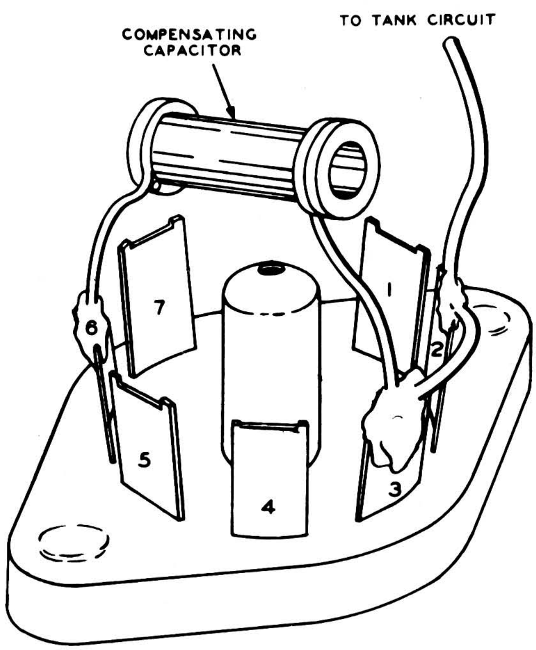


*Fig.3 - Location of the compensating capacitor across the terminals of the socket.*

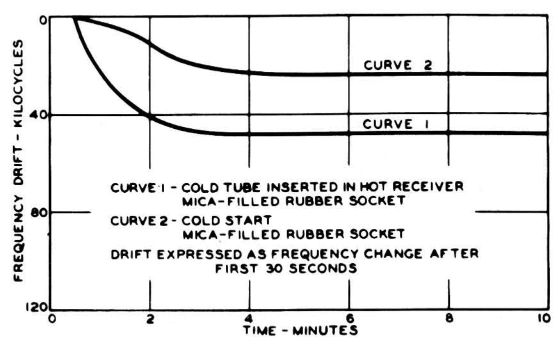


*Fig.4 - Frequency drift of receiver after compensation.*

across only part of the tank circuit, it can have a larger, more convenient value. However, its effect can be made the same as that of a smaller capacitor across the whole tank circuit. Further, the capacitor receives more heat by being connected to the heater terminal instead of the oscillator-grid terminal because the heater terminal runs hotter. An 8.2-μμf capacitor with a negative temperature coefficient of 0.00075 μμf/μμf°C was selected on a trial-and-error basis. The compensating capacitor effectively added less than two μμf across the terminals of the tuning capacitor, a value within the adjustment range of the trimmer capacitor. The frequency drift obtained with this compensating capacitor was about 50 kc as shown in curve 1, Fig. 4 for a cold tube plugged into a hot socket. Curve 3, Fig. 2 gives results before compensation.

The overall frequency drift from a cold start obtained with this compensation was 25 kc as shown in curve 2, Fig. 4. The frequency drift after compensation is greater when a cold tube is inserted in a hot chassis than when both the tube and chassis have a cold start. This difference in frequency drift occurs because the compensating capacitor is not completely cooled by insertion of the cold tube into the hot socket.