RCA MANUFACTURING COMPANY, INC.

A RADIO CORPORATION OF AMERICA SUBSIDIARY

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RCA RADIOTRON
DIVISION

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APPLICATION NOTE ON A HIGH-GAIN SINGLE-TUBE PHASE INVERTER

To operate two tubes in push pull, it is necessary to furnish the grids of these tubes with signal voltages that are equal in magnitude and 180 degrees out of phase. Practically, this requirement is satisfied when the single-voltage output of a second detector or a-f amplifier is converted into two voltages of proper magnitude and phase by means of either a suitable transformer or a resistance-capacitance network. The resistance-coupled arrangement, called a phase inverter, is often preferable for reasons of economy.

Phase inverters may be divided into two kinds: (1) those requiring two tubes and (2) those requiring only one tube for proper phase inversion. A disadvantage of the two-tube type is the relatively high circuit cost. The disadvantage of the usual single-tube type is the loss in gain due to degeneration in the cathode circuit; in some instances, it is necessary to compensate for this loss by an additional stage of amplification. The single-tube phase inverter described in this Note is non-degenerative and is capable of driving two 6F6's or 6L6's to rated Class A_1 output.

The circuit of the proposed phase inverter is attached. The secondary of the i-f transformer feeds the diode (D_1) of a 6H6 to supply audio voltage; the primary of the transformer feeds the diode (D_2) to supply a.v.c. voltage. The audio voltage that appears across R_2 is fed to the grid of a 6F5 through a coupling condenser (C_2). The output of the 6F5 appears across resistors R_5 and R_6. Because the potentials of points (e) and (f) are equal in magnitude and opposite in polarity with respect to ground, the output tubes operate in push-pull.

In order that the a-c voltages across R_5 and R_6 will be equal in magnitude and 180 degrees out of phase, the capacitance across R_5 must be equal to that across R_6. This requirement places restrictions on the assembly and the physical size of the components. Condenser C_3 should be physically small and should be mounted as far from large grounded objects as space permits. R_1, R_2, R_3, C_1, and C_2 should be mounted close to the sockets of the 6H6 and 6F5 and to the volume control

(R_4); it may be necessary to extend the shaft of the volume control in order that it be placed in the most desirable location. The lead to the cap of the 6F5 should not be shielded.

R_1 and R_3 are filter resistors. They serve to minimize the r-f voltage that can appear across the volume control and to reduce the effects of capacitance from point (a) or (b) to ground. If point (c) or (d) should have a large capacitance to ground, the magnitude and phase of the signal voltage across R_6 will be changed. A shift in magnitude or phase of the voltage across R_6 is manifested by a decrease in power output, especially at high audio frequencies.

In order to determine the effects of stray capacitances on the operation of the phase inverter, a detector-amplifier was constructed as shown in the figure. Those components whose capacitances to ground might adversely affect performance were mounted at least one-half inch from the chassis. A cathode-ray oscillograph was connected to the grids of the output tube in order to determine the magnitude of each grid voltage and the phase angle between them. A modulated r-f signal was applied to the i-f transformer.

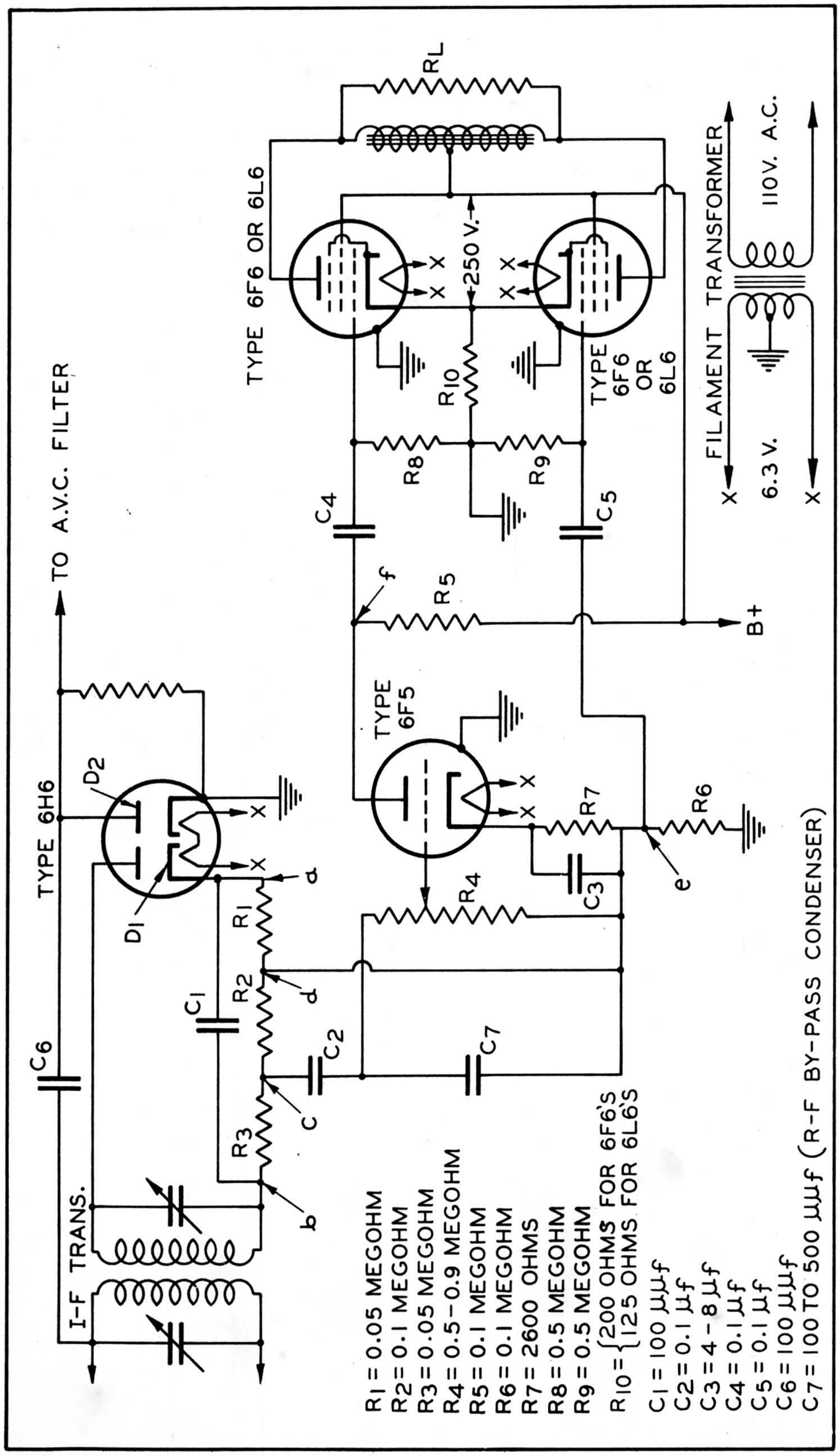
The voltages at the grids of the output tubes were very nearly equal in magnitude and 180 degrees out of phase at 400 cycles. This relationship was indicated on the cathode-ray tube by a single-line trace, which was inclined 45 degrees. At 7,000 cycles, the output was 6 db lower than the output at 400 cycles. The trace on the cathode-ray tube was then a narrow ellipse; the slope of the major axis of this ellipse was slightly different from the slope of the single-line trace observed at 400 cycles. This difference indicated that a relative shift in magnitude and phase of one voltage had taken place. Below 100 cycles, the trace was also a narrow ellipse, the slope of the major axis of the ellipse was nearly the same as that of the straight-line trace observed at 400 cycles. The length of the major axis of the ellipse was slightly less than the length of the straight-line trace. These differences indicated that the phase of one voltage had shifted slightly and that the magnitudes of both voltages were reduced by the same amount. The output was down less than 1 db at 100 cycles compared to the output at 400 cycles. It should be noted, however, that the selectivity of the i-f transformer affected the frequency characteristic of the phase-inverter circuit.

With the volume control set at the maximum-output position, about 20 $\mu\mu f$ of capacitance, in addition to the stray capacitances that were inherent in the system, could be connected from point (b) to ground before the output at 6,000 cycles dropped 2 db below the normal 6,000-cycle output. With normal plate-to-plate load (R_L), rated power output could be obtained at 400 cycles. The voltage applied to the grid of the 6F5 is $R2/(R_1 + R_2 + R_3) \times E_d$, where E_d is the total audio voltage developed by the diode. For the values specified in the figure, $R_2/(R_1 + R_2 + R_3) = 0.5$. Thus, although only 50 per cent of the available audio voltage is used, the high gain of the 6F5 permits the output tubes to be driven to full output.

The phase-inverter circuit described in this Note may be used with any of the recommended Class AB_1 ratings of the 6F6 or 6L6. This circuit can replace the two-tube phase-inverter described in Application Note No. 62 with comparable results.

RCA Cunningham Radiotron RADIO TUBES

SCHEMATIC CIRCUIT OF PHASE INVERTER



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