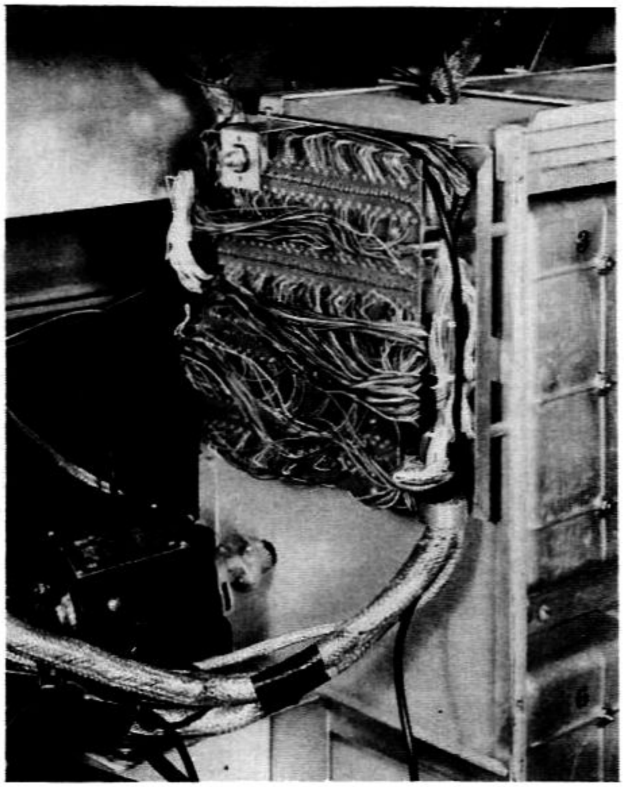

Fig. 11-12. Connection board with printed-circuit filters mounted on rear.

by special dropping resistors at the bass-end entrances of the corresponding stop rods and splitting of the nichrome wires. Figure 11-13 shows the rear of the console with the upper-manual key action picked up and brought into sight. Note the 12-inch speaker secured to the board beneath the manuals in front.

THE WURLITZER VIBRATO

The amplifier system of the organ is not particularly notable, but the vibrato circuit may well be called exciting by many people who have sought a practical way to introduce genuine vibrato — frequency shift — into systems where the original tone source must remain at a constant frequency. We may dismiss the amplifier after noting that one of the stages is used for gating; it normally has cutoff bias which is removed through a time-constant circuit by a series of paralleled contacts under the keys whenever any key is pressed. This eliminate noise of any kind in the absence of a signal.

The heart of the vibrato circuit (aside from the low-frequency oscillator) is shown in Fig. 11-14. The treble input from the reed pickups containing frequencies between 138.6 and 4186 cycles is fed to the grid of a 6SQ7 preamplifier in a standard cathode-biased circuit. (The bass signal is fed through a fairly similar stage directly through the main amplifier system without vibrato.) From the plate circuit of the 6SQ7 it goes through C_1 to the grid of V_2, half of a 6SN7-GT.

V_2 is a phase splitter of the "long-tailed" type, with one signal taken from the cathode circuit, across R_7, and the other from the

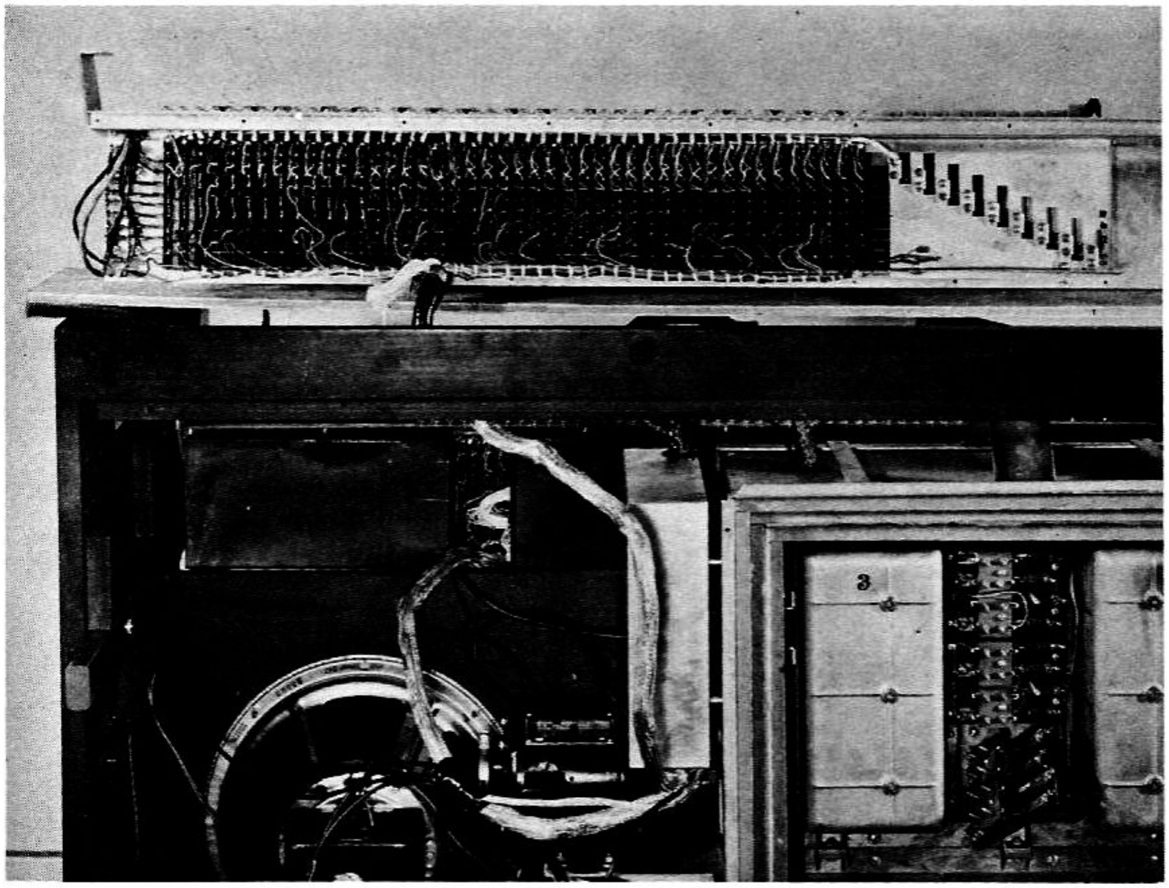

Fig. 11-13. Console rear. The upper-manual action has been raised to make it visible.

plate, the two signals 180 degrees apart in phase. At the plate the signal is divided into two parts, one part through C_3-R_8 and the other through C_4-R_9. The cathode signal is also divided in two paths, one through R_{10}-C_5 and the other through R_{12}-C_7. The plate and cathode signals in each leg are then combined, one set through C_6-R_{11}, and the other through C_8-R_{13}.

The entire purpose of the six legs enumerated above is to act as a phase-shift network, producing two signal outputs which have a constant phase difference of about 90 degrees. These two outputs appear at the points marked X. Their phase relationship to the original V_2 input signal changes, of course, with change in frequency. But they maintain a difference *between themselves* of about 90 degrees between about 500 and 15,000 cycles. It is appropriate to use the language of, for instance, phase modulation transmitters and call them quadrature voltages, for the vibrato of the Wurlitzer 44 is actually a phase-modulation system!

The two quadrature voltages are fed to the grids of V_3 through blocking capacitors C_9 and C_{10}. The two signals are mixed at the plate of V_3 and the mixed output is again a single signal taken from C_{11}.

Vibrato-frequency voltage at either 5.7 or 6.7 cycles is obtained from a low-frequency oscillator and phase inverter; it appears in push pull on the grids of V_3, as indicated in Fig. 11-14. It causes the two triodes to conduct singly. When the phase of the low-frequency signal makes the left grid positive and the right negative, the left triode conducts. When the phase is reversed, the left triode conducts. This causes a continuous change in the phase of the audio signal coming out of V_3 over approximately a 90-degree range.

When the left triode conducts, one signal of given phase goes through. When the right triode conducts the other quadrature signal comes through and there has been approximately a 90-degree phase shift. And the shift is smooth, for the signal emerging from the mixer is the vectorial sum of the two voltages at the plates of the two triodes.

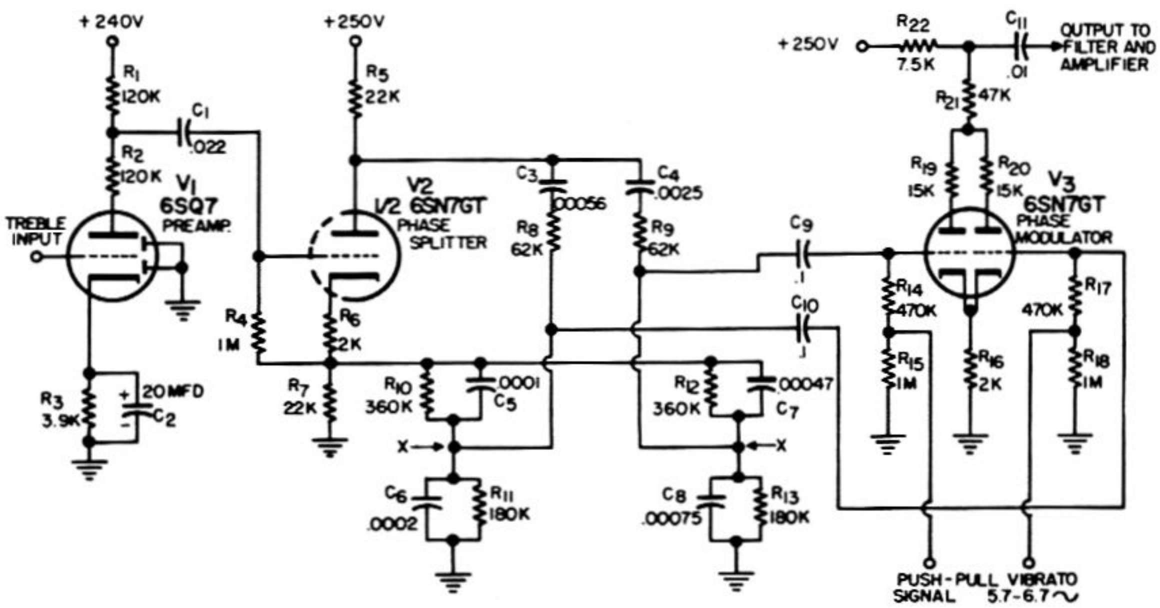

Fig. 11-14. The phase-shifter which produces vibrato.

If both are conducting equally, as is the case at the 0-, 180-, and 360-degree times of the low-frequency push-pull signal, the mixer output is 45 degrees away from either extreme. Thus the phase at any instant is dependent on the relative contributions of the two triodes, which is a function of their relative low-frequency grid signals at that instant. The latter vary in a sine manner, giving a phase swing that is smooth and natural.

Needless to say, phase modulation is equivalent to frequency modulation; it is, so to speak, a reciprocating electronic Doppler effect, as if the classic train blowing its whistle were to come toward and retreat from the listener again and again, with consequent apparent up-and-down change in the pitch of the whistle.

The output of the mixer is connected through C_{11} to a filtering stage which, by using frequency-selective negative feedback, cuts off sharply below 130 cycles so that none of the vibrato-frequency signal can affect the amplifier and speaker.

The oscillator is shown in Fig. 11-15; it is one-half of a 6SL7-GT operating as a standard phase-shift oscillator. The primary control is the two-circuit, three-point VIBRATO SPEED switch. In the FAST position R_2 is selected as the second resistor of the phase-shift network, determining the frequency at about 6.7 cycles. The second section of the switch connects the grid circuit of the other half of the 6SN7-GT, which is a phase splitter, to the arm of the VIBRATO DEPTH switch. The latter determines how much oscillator signal is sent to the phase splitter by tapping at one of three points on a voltage divider carrying oscillator output signal from the plate.

When the VIBRATO SPEED control is at SLOW, R_1 is selected for the phase-shift network; this makes the oscillator frequency about 5.7

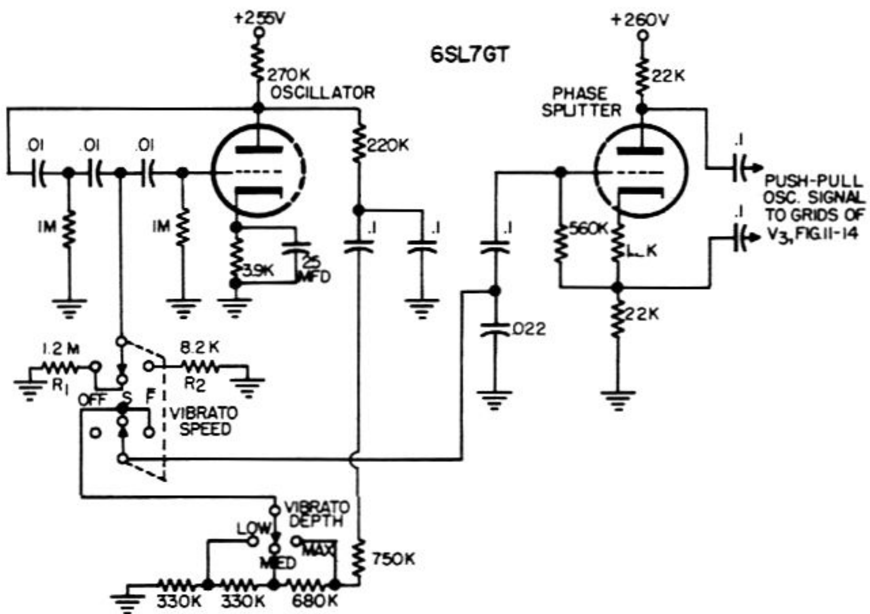

Fig. 11-15. This oscillator and phase-splitter provides switching voltage for vibrato circuit.

cycles. When it is at OFF, the output section of the switch disconnects the phase-splitter grid from the oscillator output.

Since the rate of phase swing and apparent music signal frequency swing depends on the oscillator frequency, the speed switch determines the vibrato rate in the music. And because the oscillator output determines how much total phase shift will occur the DEPTH switch determines how deep or wide the vibrato will be.

This vibrato circuit, it may be remarked, effectively does the same job as the Hammond vibrato scanner described in Chapter 5, but it does the job electrically, without moving parts, in a manner which can only be called elegant. Such a vibrato, with its ease of construction and compactness, does an almost impossible job which has puzzled many people who wished to add automatic vibrato to guitar amplifiers, amplified string instruments, and the like, only to be forced to settle for amplitude tremolo.