Multichannel Audio Mixer-Preamplifier

HAROLD REED*

Circuitry for mixing a number of low-impedance inputs can become complicated when attention is paid to correct impedance matching, and losses are likely to become excessive. The use of a transformer between the network and the succeeding amplifier will eliminate the effect of the losses.

Audio frequency mixers comprising three or four inputs or channels are quite common and present no serious problems in design and construction. With an increasing number of inputs, greater difficulties are encountered. Loss of signal voltage between the input and output of the mixer increases as the number of channels is increased. This alone may not be considered too serious. But when we give our attention to hum and noise figures we realize the importance of large losses in mixer circuits which may result in a signal-to-noise ratio figure so low as to make the overall operation of the mixer unacceptable, even for ordinary non-critical use.

Using individual, low-impedance-to-grid input transformers and a single-stage preamplifier for each input channel can overcome all problems except one. That is, the cost of the unit. With this arrangement, however, several advantages are immediately observed. The low output voltage from each source, say a microphone, is at once given a step up by the input transformers. If we use a 50-ohm-primary to 50,000-ohm-secondary transformer, a type frequently used for this purpose, the voltage step-up is equal to the turns ratio or the square root of the impedance ratio of the transformer. In the example under discussion this amounts to $\sqrt{50,000/50}$, or approximately 33.

Now if we connect a low-impedance microphone with a rating of -55 db, (reference, 0 db = 1 mw/10 dynes/cm²), which gives 0.4 millivolts across the 50-ohm input, then 0.4 mv multiplied by 33 results in about 13 mv across the transformer secondary and available at the grid of the preamplifier input. So, we get off to a good start. However, the use of cheap, poorly constructed transformers can offset, and in some instances to a considerable extent, the advantage of the voltage gain just cited due to greater a.c. hum voltage on the grid which may be picked up by the transformer from nearby a.c. fields. Good-quality, well shielded transformers should be employed. Evidently, then, this is a large item, from the cost standpoint, when we are considering say, a ten-channel mixer which would require ten transformers and ten preamplifiers.

Of the many circuit configurations for input mixers one that offers least loss is the series-parallel arrangement. A circuit for a ten-channel mixer using this type of circuitry is shown in *Fig.* 2. This is for ten, 50-ohm sources. For a total number of inputs other than ten and for different values of input impedance R, the value of R_s, the series resistor and R_o, the output impedance, may be found by two simple equations. $R_s = R(N-3)/N$ and $R_o = 4R(2N-3)/N^2$. It will be seen in *Fig.* 2 that the mixer output

* *3917 Madison St., Hyattsville, Md.*

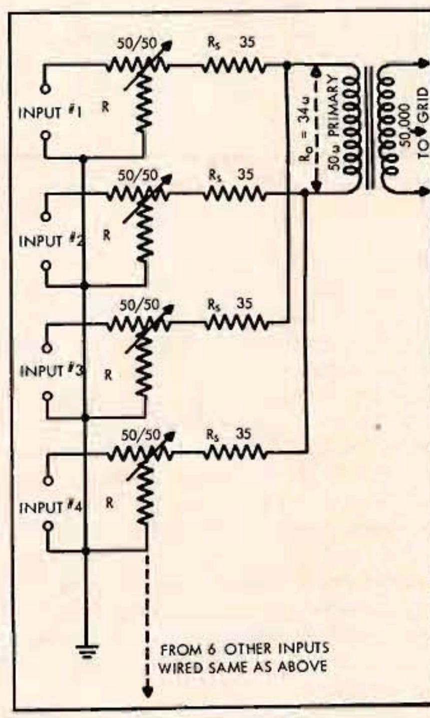

Fig. 2. One type of mixing network—series-parallel—which is often used for several inputs.

series-parallel—which is often used for several inputs.

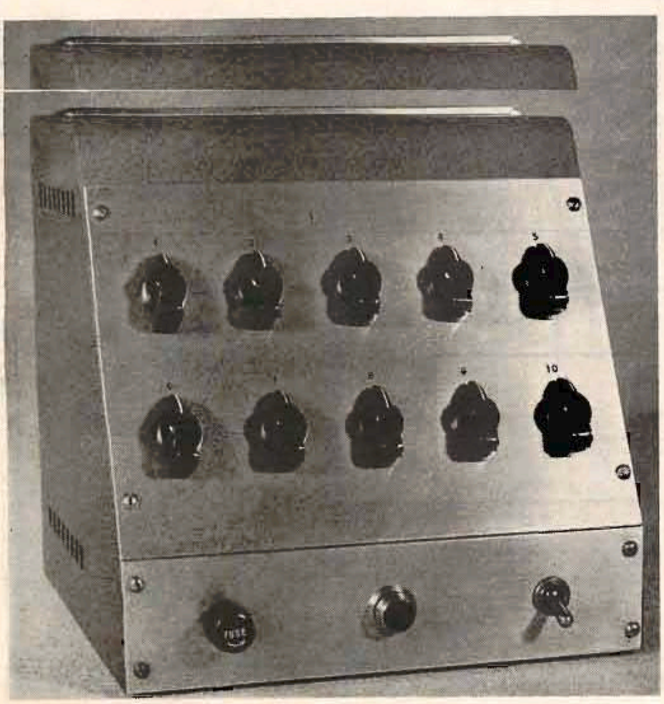

Fig. 1. The author's complete ten-channel mixer and its associated preamplifier can be built in a small sloping-front metal cabinet.

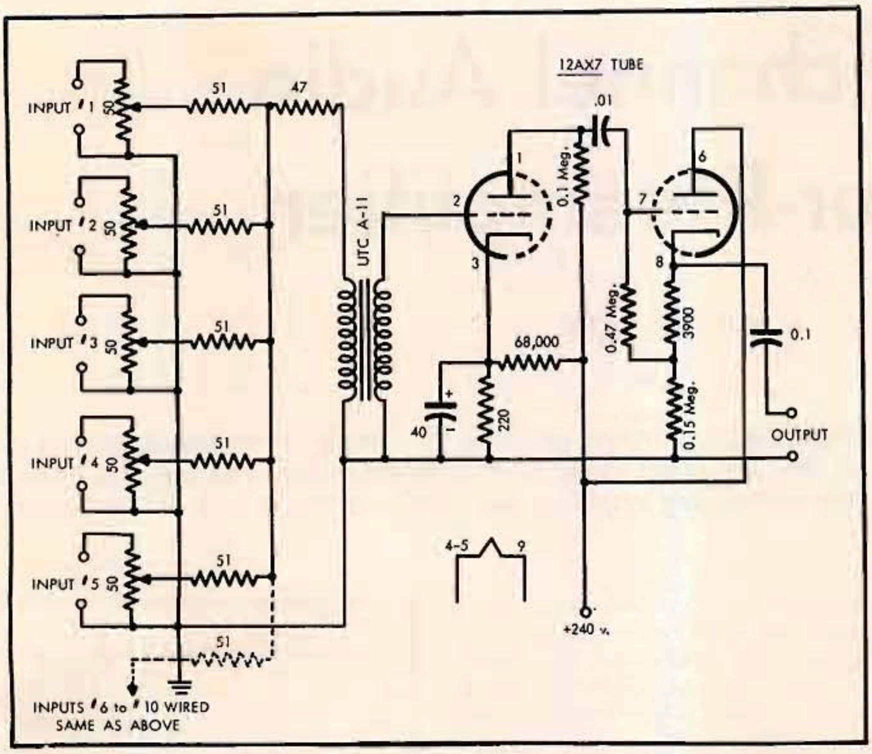

Fig. 3. Inexpensive ten-channel mixing network, using simple potentiometers instead of T-pads.

works into a 50-ohm-to-50,000-ohm transformer. The 50-ohm primary is a close match for the mixer output. The transformer provides a voltage step-up of 33 as mentioned previously. The loss in the mixer circuit is a little over 13 db.

Suppose we round the mixer loss figure off to 14 db and use a microphone with a rating as given previously. A 0.4-millivolt signal to the mixer input will then be down 14 db or reduced to 80 microvolts, since db = 20 times the log of the voltage ratio.) This voltage is applied to the transformer primary. The signal at the secondary will be 2.6 millivolts which may be fed directly to the input grid of an amplifier.

The attenuators, *R*, of the foregoing circuit must be of the constant-impedance, zero-insertion-loss variety. Good attenuators of this type do not come
circuit must be of the constant-imped-
ance, zero-insertion-loss variety. Good attenuators of this type do not come
cheap. Ordinary potentiometers are not suitable. Wirewound T-pad attenuators can be used but will be noisy when varied. However, if the controls are preset for certain levels and not used for extensive "gain riding" they may prove satisfactory and they are relatively inexpensive. One type is the Mallory T series available in fourteen different impedances.

Practical Circuit

A very inexpensive method of constructing a ten-channel mixer will now be considered. The circuit arrangement is given in *Fig*. 3. In this circuit potentiometers are used. They should be of good quality such as the Ohmite "AB" type. The circuit shows 50-ohm controls but, of course, other ohmic values may be substituted. For 10 inputs the mixer loss is about 20 db. Using the same type

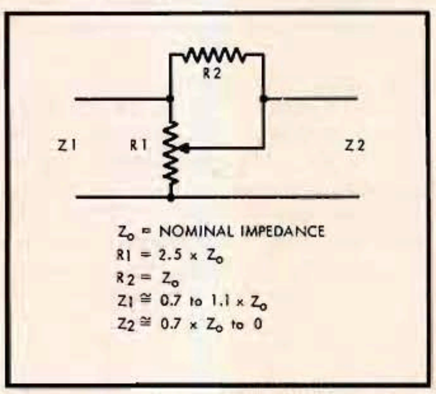

Fig. 4. Alternate arrangement used to maintain input impedances at a more constant value.

Fig. 4. Alternate arrangement used to maintain input impedances at a more constant value.

of microphone as discussed in the foregoing circuit, 0.4 millivolts is applied to the mixer input. With a mixer loss of 20 db the signal is reduced to .04 millivolts at the 50-ohm transformer primary. The transformer voltage gain of 33 provides a 1.3-mv signal to the grid of the preamplifier which is one half of a 12AX7 tube.

The 12AX7 input stage has a voltage gain of 47 which boosts the signal to 61 millivolts at the 12AX7 plate. The other half of the 12AX7 serves as a cathode follower stage which, theoretically provides no voltage gain. However, the signal measured at the cathode follower output was 66 millivolts, which, of course, is a negligible difference over the input signal.

The cathode follower has the advantage of low-impedance output and therefore, the mixer and preamplifier can be operated at a reasonable distance from the main amplifier or recorder. The 66-mv signal is more than sufficient to work into the high-impedance microphone input of an amplifier or tape recorder.

Interaction between the channels amounted to a maximum of just 3 db variation in output for any setting of the controls. This is for the worst condition, that is when feeding a signal to one input and varying the other nine potentiometers from minimum to maximum positions.

For applications where it is preferable to maintain a more constant load impedance on the microphone or other sound source, the circuit of Fig. 4 may be used instead of a simple potentiometer. With this arrangement, the input impedance ranges from about 0.7 to 1.1 times the nominal value. When the arm of the potentiometer is at the top, the input impedance is equal to the nominal value shunted by 2.5 times the nominal value. When the arm is at the bottom, R_2 replaces the load and consequently the input impedance is the same as at the top. In the center, the impedance is equal to twice the load impedance shunted by 2.5 times the load, which is about 1.1 times. This will improve the loading on certain types of microphones.

Any power supply with an output
about 1.1 times. This will improve the loading on certain types of microphones.

Any power supply with an output from 200 to 250 volts can be used for
(*Continued on page 76*)

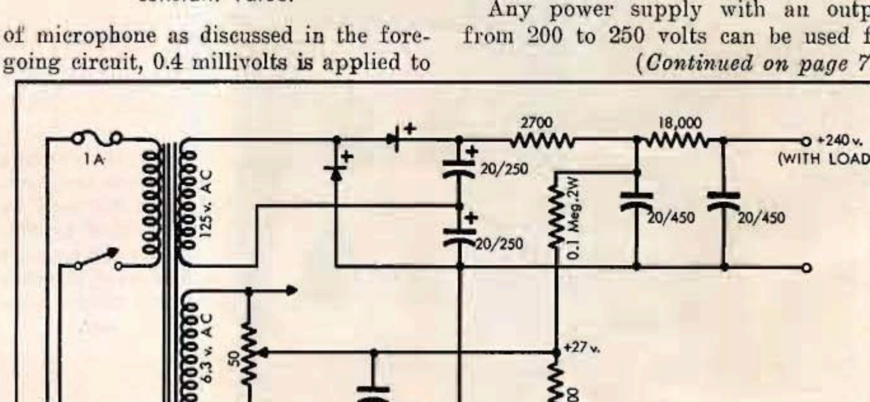

Fig. 5. Power supply used for the amplifier in the mixer.

AUDIO MIXER

(from page 28)

the preamp. A simple half-wave, voltage-doubler, selenium-rectifier type that proved satisfactory in one case was used. A full-wave circuit which will result in a lower ripple component is given in *Fig.* 5. This is highly recommended over the half-wave type.

To reduce hum to a minimum a 50-ohm hum-bucking potentiometer and 27 volts of bias were used in the heater circuit as shown in *Fig.* 5. The power supply was constructed on a small separate chassis and located as far as possible from the preamplifier chassis.

Hum was quite a problem when an open frame power transformer was used and the completed unit was housed in a steel cabinet. Under these conditions critical orientation of the power transformer with respect to the mixer transformer was required to reduce magnetic coupling. It was necessary to use a completely shielded power transformer, a well shielded mixer transformer and to house the unit in an aluminum cabinet with aluminum panel. All leads should be as short and direct as possible.

The mixer shown in *Fig.* 1 was housed in a very small cabinet. Although it resulted in an extremely compact unit, considerable care was required in locating and orienting the transformers. The builder may minimize these problems with the use of a wider cabinet to allow greater spacing between hum-critical component parts.

Although this is probably the most inexpensive, practical circuit for a ten channel mixer it gives satisfactory performance and is suitable for many applications. Æ