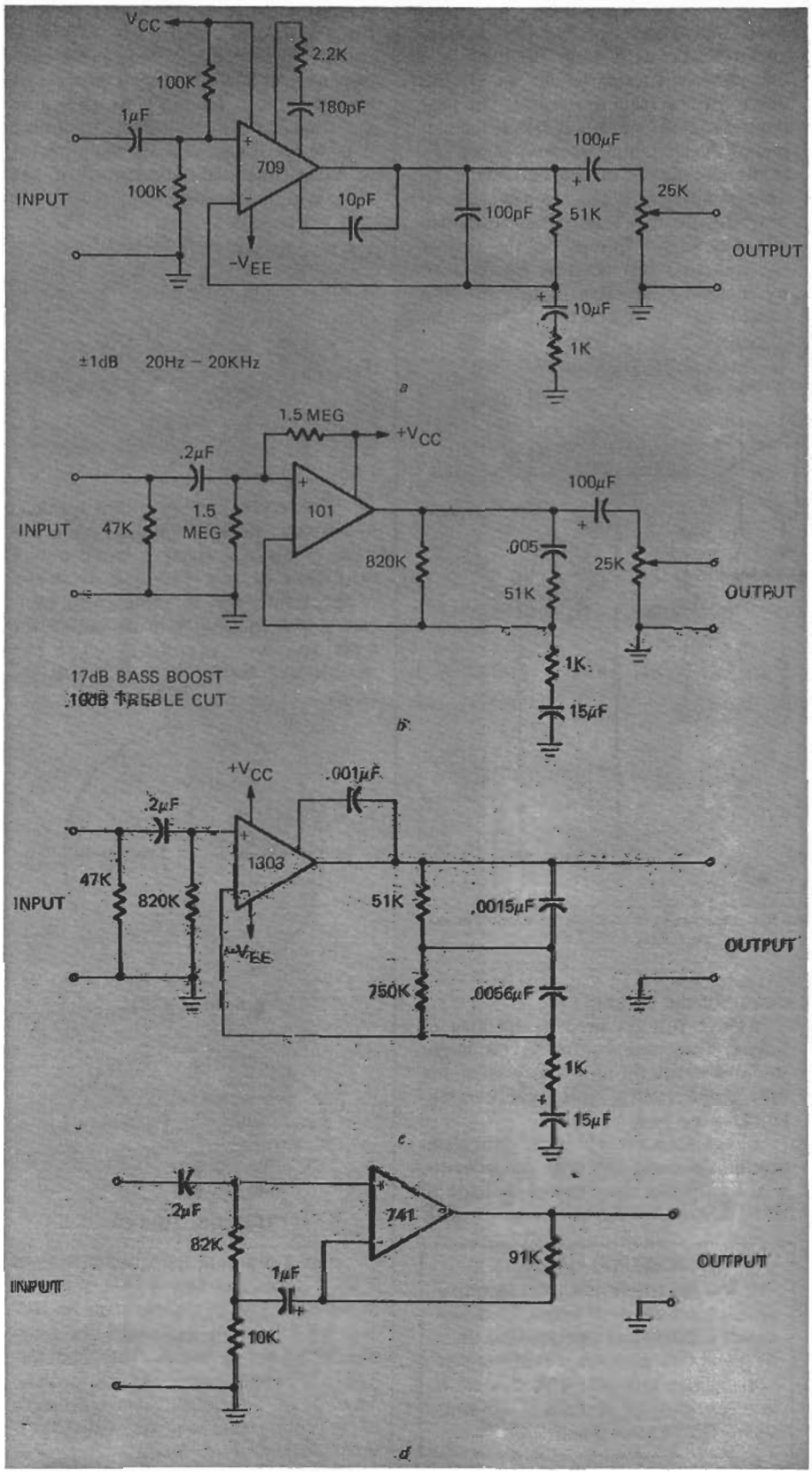
There's a tape head preamp; an RIAA disc record equalizer; a line driver; a mike preamp; a crystal cartridge preamp; a unique tone-control circuit and five others



At this point the gain remains constant till 2 kHz, then drops at 6 dB per octave. Like the RIAA circuit, if you want a non-critical use, substitute a .002-μF capacitor in parallel with a 220,000-ohm resistor as the total feedback network.

To drive an audio line of the standard 600-ohm), use the line driver in Fig. 5. The circuit should be familiar. If you want to increase the output level, make the primary of the output transformer about 150 ohms.

A group of audio op amp circuits appears in Fig. 6. In **a** is shown a microphone preamplifer with a flat response from 20 Hz to 20 kHz; **b** shows a tape-head preamplifier having the required frequency tailoring; **c** illustrates a compensated magnetic cartridge pre-

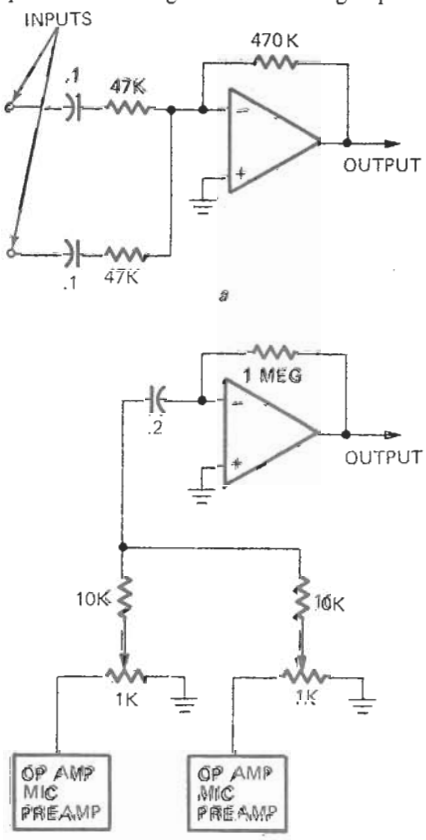


FIG. 7—(above) TWO AUDIO MIXING CIRCUITS. 7-a is a simple audio mixer; 7-b combines a number of the mike amplifiers of Fig. 1.

FIG. 6—(left) OP AMP AUDIO CIRCUITRY. a—mike preamp flat from 20 Hz to 20 kHz; b—an equalized tape head amplifier; c—a compensated magnetic cartridge preamp; d—a high-impedance preamplifier for use with a crystal cartridge.

amplifier, while **d** shows a high input impedance preamp for a crystal cartridge. Note that other than the 709 can be used in audio circuits.

To mix a bunch of audio signals, Fig. 7 shows a couple of approaches. In **a**, a number of inputs can be fed to a single op amp where they will all be combined. In **b**, a large number of op amp mike amplifiers (see elsewhere in this article) can be coupled to an op amp mixer or summer. The summer op amp can be operated with gain, unity gain, or less-than-1 gain, depending on the feedback resistor. The coupling capacitor removes any dc offset that might be present from any of the amplifier op amps.

Unique Tone Control, In the usual bass and treble controls found in audio systems, the maximum benefit is at the ends of the audio spectrum. When using either the bass or treble control, you have no control over just where in the spectrum you want the boost or cut. The circuit shown in Fig. 8 is unique in that you can rig the bass and treble cut and boost controls so that you can not only control how much boost or cut, but pretty much call the turnover frequency. This is a form of graphic equalizer circuit and can be used (for example) to boost only the low frequencies *below* the point at which the speaker falls off. It also makes an excellent "presence" filter, or can be used to set up almost any type of frequency response curve you want without the ringing associated with a number of equalizers.

The circuit uses four filters, each having its own control with the cut filters positioned before the op amp, and the boost filters in the op amp feedback circuit. Each controls the 3-dB frequency of a 6-dB-per-octave slope in accordance with the name of the control. For example; as greater treble boost is brought in, with all other controls flat, the 6-dB-per-octave treble boost curve is brought down in frequency. In this way, you could start the treble boost at 5 kHz and have 12 dB boost at 20 kHz, or start at 500 Hz and get about 36 dB of boost at 20 kHz. You can then bring in the treble cut as desired, and where the two curves meet and pass over each other, the result is a flat curve which can be shifted up and down the spectrum as desired. The bass controls act the same way but at the low end of the spectrum. Because of the low input impedance of the cut filters, an emitter follower is used to drive the op amp. If you run a frequency response test, any slight "bumps" at the end of the spectrum can possibly be reduced by changing the value of the 270-ohm resistor of the filter coming from the output of the op amp.

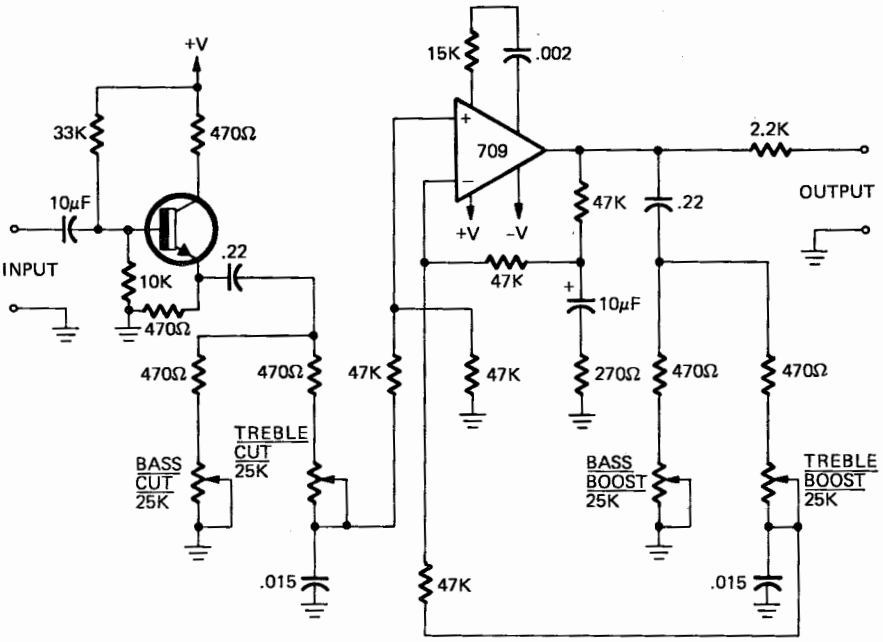


FIG. 8—UNIQUE TONE-CONTROL CIRCUIT gives you four separate tone controls for maximum versitility. Each tone control affects a different part of the response curve.

Once you get used to the idea of having *four* tone controls, you might find this circuit far more useful than any other tone control you have encountered in the past.

Such a circuit would be difficult to mechanize using discrete components, as the amplifier must deliver at least 36 dB of gain across the spectrum. **R-E**

MORE TO COME

We will be presenting three more articles on op-amp uses. One will cover biomedical circuits; the second will describe an assortment of active-filter circuits; and the third is a roundup of "oddball" op-amp uses. Don't miss them.