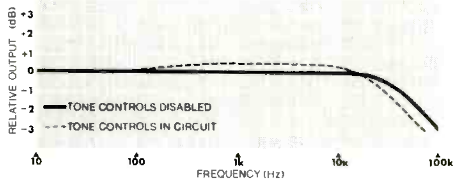

Fig. 7—Frequency response of the CC-2 stereo preamp is plotted here with and without tone controls in the circuit.

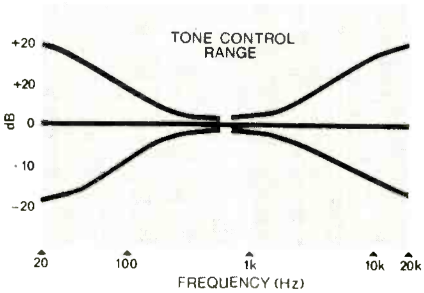

Fig. 8—Tone-control action of the CC-2. ▶

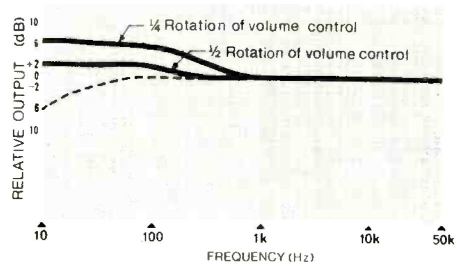

Fig. 9—Filter-action and loudness-compensation curves.

ness-compensation curves, in Fig. 9. With respect to the former, it is simply a 6-dB-per-octave R-C filter. To prevent it from having a deleterious effect upon bass musical content, C/M Labs chose to make the crossover frequency (−3 dB point) at 20 Hz. With such a slight rate of attenuation, however, response at 10 Hz (region of most rumble) is only −9 dB. Thus, it is doubtful if it would materially help a bad rumble situation. The loudness-compensation circuits are moderately effective. As shown in Fig 9, the compensation afforded at 40 dB below maximum setting of volume control (at about ¼ rotation of the control) is about +6 dB at 50 Hz, which does not conform with accepted Fletcher-Munson curves.

Summing up, while the CC-2 preamplifier is good to listen through, it appears to be rather Spartan in design. For example, we miss high-frequency rolloff filters (for scratch and other high-frequency disturbances), provision for tape-head inputs, independent treble and bass controls for each channel, and independent level-set controls for each input. Thus, going the stereo hi-fi path with "separate" components, the CC-2 is certainly adequate. But if one wishes to have more control flexibility, he might be inclined toward a more expensive preamp.

Koss Model ESP-6 Electrostatic Stereophones

MANUFACTURER'S SPECIFICATIONS:

Source Impedance: 4 to 16 ohms; Sensitivity: 90 dB SPL at 1000 Hz ±2 dB referred to .0002 dynes/cm² with 1 volt at the input; Frequency response range, Typical: 27-19,000 ±5 dB; 35-10,000 Hz ±2½ dB. Individual machine-run curve provided with each pair. Isolation from external noise: 40 dB. Total Harmonic Distortion: Less than 1½% at 110 dB SPL. Size of Cup: 4½″ H, 3¾″ W, 2½″ D. Cord: 4-conductor, 3-ft. coiled length; 10-ft. extended length. Cushions: Fluid filled. Plug: Standard tip, ring, and sleeve phone plug. Weight: 27 oz. Price, $100.00.

Fig. 1—Koss ESP-6 stereo headphones, the first electrostatic units to be marketed here.

The most recent offering from this specialist company in the headphone field is the ESP-6 electrostatic model, which brings the advantages of the electrostatic speaker system to the much more compact "wearable" system. Plugging into the output circuit of a usual stereo amplifier, the new headphones provide their own polarizing voltage which is derived from the signal itself, since there is no power required for the polarizing circuitry—only a relativly high voltage.

Because of the high impedance of the "condenser" element of electrostatic headphones, a step-up transformer is required to raise the impedance far above that of the 4- to 16-ohm source. However, since the step-up transformer thus raises the impedance, it also provides a higher-voltage source which may be rectified in a voltage-tripler circuit to provide 240 V. d.c. which serves as the polarizing potential. This voltage is fed to the diaphragms of the "speaker" mechanism through 22-Meg. resistors. The capacitances of the elements themselves serve as the filtering capacitors to produce a relatively constant d.c. voltage. In addition, from a non-filtered tap in the diodes which are the rectifier elements of the d.c. supply, neon indicator bulbs are connected to show the SPL present in the aural cavity. These lamps flash when the SPL reaches 90 dB, and remain on most of the time when the SPL reaches 105 dB.

The story of the development of the electrostatic phones makes good reading. To ensure minimum distortion, it was found that there must be two fixed plates, with the diaphragm placed between them—as is also true with electrostatic loudspeakers. If only one fixed plate is used, there is considerably greater distortion from the plate, the driving force decreases in a non-linear fashion, while it increases also in a non-

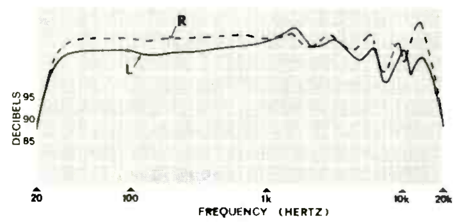

Fig. 2—Frequency response of the Koss ESP-6 headphones.

linear fashion as the diaphragm comes closer to the plate. Because of the need for two fixed plates, with the diaphragm between them, the plates must be perforated so that the radiation can reach the ear. For minimum distortion again, the back wave must be absorbed, which is accomplished by judicious use of polyurethane foam and felt—a process which took a lot of cutting and trying. Similarly, the size and shape of the cavity required a similar amount of cutting and trying to get the optimum performance. A booklet which accompanies the phones tells the story thoroughly, and, as a chronicle of the search for the best possible pair of headphones, it is interesting reading.

(Continued on page 50)

Equipment Profiles (continued)

The headset must be plugged into the ouput of the amplifier with a series resistor in each channel, the maximum recommended value for this resistor being 5 ohms, and a minimum of 2 ohms. This latter value of resistor is mounted in the adapter which is included with the phones, and which is provided with two leads per channel, each tipped with spade lugs. These are to be connected to the speaker terminals on the back of the amplifier, rather than simply plugging the three-circuit plug into the headphone jack on the front of the usual amplifier or receiver. Instead, the plug is inserted into the jack of the adapter.

This will be somewhat of a disadvantage to the non-technical user who expects that he should be able to plug the phones into the front-panel jack, as he would any other. However, most amplifiers and receivers have a series resistor in each channel to avoid offering too much signal to the usual dynamic headphone elements. These resistors typically have a value of about 100 ohms, which is far too much for the ESP phones. The technically-minded user would likely remove the amplifier from its case and connect two 2-ohm resistors across the series resistor in the amplifier so he could then use the front-panel jack in the normal manner. Either of the methods of connection is worthwhile, however, since the listening quality is superb.

One caution must be remembered, however—if you are listening to a mono program which is reproduced only on the right channel, no signal is being fed to the polarizing-voltage circuit, and no sound will be heard. To listen to mono programs, therefore, the mode switch should be set to reproduce the program in both channels, rather than to short the tip and ring of the plug. If the phones are to be used solely for mono, both "hot" leads should be connected to the tip of the plug.

The sound quality from the phones is such that upon putting them on, the listener feels as though he is still hearing the speakers through the air seal. The listening is outstanding, and once tried, it is likely that the shopper will be convinced enough to add the ESP-6 Stereophones to his collection of hi-fi gear.

These attractive phones are supplied in a foam-fitted molded carrying case, which is not the least of the desirable qualities of the ESP-6 headset.

ABZs of FM

LEONARD FELDMAN

Automatic Frequency Control

THE NEED FOR accurate center-of-channel tuning in FM reception (and especially for stereo) has been stressed before in this series. Consider, for a moment, what takes place in a relatively narrow-band i.f. system if the listener is tuned even 50 kHz off of the optimum frequency. Figure 1 shows a discriminator or ratio-detector "S" curve, in which the perfectly linear portion extends about 90 kHz to either side of 10.7 MHz—more than the 75 kHz minimum required, but not very much more. Point "A" on the curve represents center-of-channel tuning, while point "B" represents a point 50 kHz too high, or off-center, to which our unsuspecting listener has tuned. So long as the program being transmitted is relatively low in audio level (quiet music passages, and so on), this amount of detuning will cause no audible defects in the received signal. Suppose, however, that a loud passage of music comes along which causes a full ±75-kHz deviation of the main carrier (and therefore, the same amount of deviation of the 10.7-MHz i.f. signal). Every time the carrier is shifted upward in frequency, the last 35 kHz or so of deviation will encounter a very non-linear portion of the detector "S"-curve, designated by the bracketed length "C" in Fig. 1. Instead of being perfectly sinusoidal, the resultant recovered audio will appear as shown in Fig. 2—severely distorted at one extreme of its excursion. As illustrated in the figure, this amounts to as much as 20 per cent distortion, and would be most unpleasant to the ear.

Assuming that the average listener cannot be taught to tune to exact center-of-channel every time (in the absence of any visual indicator to tell him when the set is properly tuned), there are only two solutions to this problem. The first is to make the i.f. and detector bandwidth so great (say, 300 or 400 kHz for the linear portion of the "S"-curve), that even when a station is carelessly tuned in, there is likely to be at least 75 kHz of linear curve on either side of the tuned point. However, no matter how "wide" the linear portion is, there will still be those listeners who might tune close to *one end* of that linear portion, with the same disastrous results depicted in Fig. 2. The second (and more often practiced) solution is to incorporate a "sensing" circuit which detects errors in tuning and automatically corrects for them. Such a circuit is called Automatic Frequency Control, usually abbreviated AFC.

You may recall that in an earlier discussion of FM broadcasting techniques, we discussed the function of a "reactance-tube modulator." This was a tube (or transistor) circuit which was associated with the basic r.f. oscillator in such a way that it appeared as an additional inductance or capacitance in parallel with the frequency-determining elements of the main oscillator. As varying audio was applied to this circuit, its effective contribution of "L" or "C" varied accordingly, causing the master oscillator to shift back and forth in frequency. Had we applied fixed values of d.c. potential to this circuit instead of audio, we could have shifted the oscillator frequency as well, for the audio information applied may be thought of as continuously varying instantaneous d.c. levels.

Now, every FM tuner or receiver contains a local oscillator, and its frequency determines which incoming r.f. frequency will "beat" with it to produce the desired 10.7-MHz signal for application to the i.f. and detection stages that follow. Alter the local-oscillator frequency and you alter the frequency with which it will beat to produce 10.7 MHz.

Both the ratio detector and the Foster-Seeley discriminator are ideally suited for providing a d.c. correcting voltage to apply to a circuit such as reactance tube. The audio take-off point produces 0 volts of d.c. when the incoming frequency is exactly 10.7 MHz, and produces positive or negative voltages when the frequency is above or

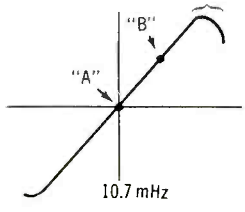

Fig. 1—Linear portion of detector response curve is centered about 10.7 MHz (point "A").

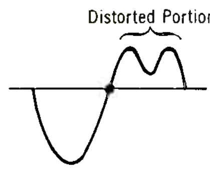

Fig. 2—Distorted audio sine wave caused by detuning a narrow-band i.f. system to point B in Fig. 1.