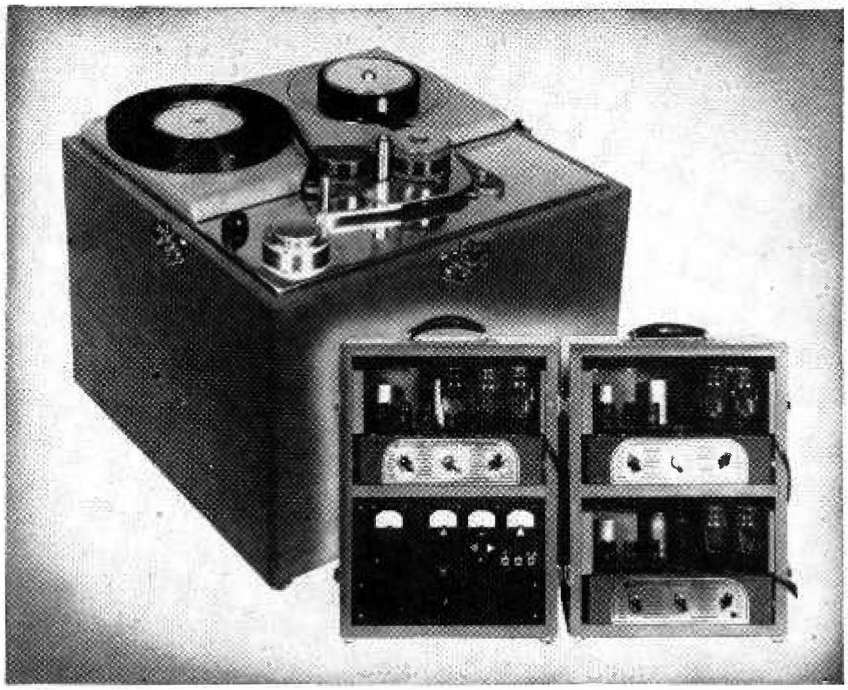

The experimental three-channel stereophonic drive unit and (inset) the amplifiers and mixer. Three microphones and three loudspeakers complete the system

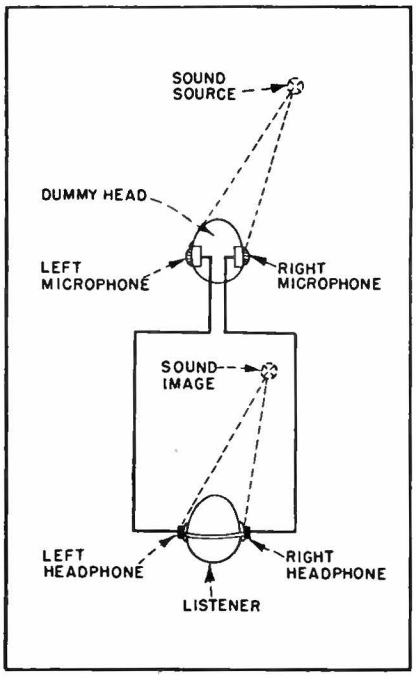

FIG. 1—Simple system for demonstrating binaural sound

STEREOPHONIC

Magnetic tape carrying three simultaneous channels gives a striking illusion of presence when played back through properly oriented speakers. Experiments indicate feasibility of two-channel home system in one cabinet

WHEN A PERSON LISTENS directly to an orchestra, an important factor contributing to naturalness of the sound is binaural hearing. The left ear of the listener picks up a sound that is different in amplitude and phase from the sound picked up by the right ear. The two sounds are combined by the human hearing mechanism in such a way that the listener can judge the direction from which the sound comes, and the psychological effect creates a feeling of presence.

To obtain binaural sound reproduction a two-channel system as illustrated in Fig. 1 can be used. Sound is picked up by microphones placed in the ears of a dummy head. Each microphone is connected to corresponding earpieces of a headset. A person listening to sound through a binaural system has the illusion that the sound originates in the room rather than in the phones. The effect is striking to anyone used to hearing monaural sound from a headset.

Efforts to bring stereophonic sound into practical use have been directed toward entertainment in the theater and concert hall, because of the complexity and cost of such a system. For example, the portable equipment for *Fantasia's* road show employs eleven 62-inch racks of amplifiers plus power supplies and other equipment. It is packed in 45 cases weighing an average of 330 pounds per case, and occupies half a standard freight car.

One field so far neglected is that of home entertainment. Stereophonic reproduction for the home brings up a number of problems which are entirely different from those in the concert hall or theater. For one thing, the listening room in a home is much smaller, and the listener is closer to the loudspeakers. With speakers on each side of the room he cannot back away a distance comparable to the distance between speakers; in fact, the seating arrangement is often such that the listener faces the broader wall. Since the listener is free to move about the room to a considerable extent, the stereophonic illusion should be present throughout the room. Acoustics of the room are generally fixed and little can be done about them, so that the home stereophonic reproducer should ideally be adaptable to various

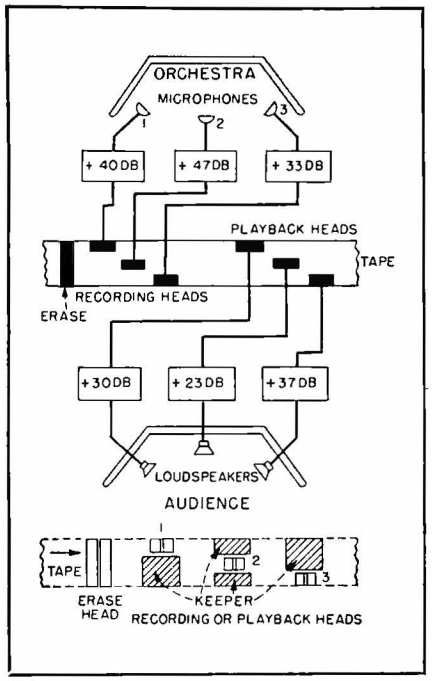

FIG. 2—Block diagram of elements composing three-channel recorder-reproducer

SOUND

shapes and layouts of living rooms.

The economics of a home stereophonic system are also important. A theater sound system can cost many thousands of dollars, and the film for a program of several hours can also be worth several thousand dollars. The home unit, on the other hand, must sell for the price of a high-grade phonograph combination, or somewhere between $250 and $1,000. The records should sell for not more than 1½ to 3 times the present cost of phonograph records for an equivalent playing time.

Experimental Systems

An experimental magnetic-tape recording and playback system recently demonstrated before the New York Section, IRE, by Marvin Camras of Armour Research Foundation, shows promise of approaching most of the economic requirements set forth above. Three channels are provided that are flat within 5 db from 50 to 10,000 cycles. There is less than 4 percent intermodulation distortion and less than 1 percent harmonic distortion at normal levels. The dynamic range is 60 db between maximum modulation level and noise level. Wow and flutter are less than 0.1 percent. At the normal running speed of 1 foot a second a full reel of quarter-inch tape plays for 20 minutes.

The simplified block diagram of Fig. 2 shows the elements of a three-channel system. In actual practice one set of heads serves for both recording and playback, while the recording amplifiers, with readjusted gain, are used in place of the two sets of three illustrated.

Arrangement of the stereophonic heads is presented in the detail at the bottom of Fig. 2. An erase head extends across the entire width of the tape and clears off all three channels. The recording heads are staggered along the length of the tape to permit mechanical and electrical isolation. At the section where one head is recording on its track, the other two tracks are covered by a keeper made of high-permeability alloy. This arrangement protects tracks 1 and 3 when head 2 is recording, and so on.

Because the same heads are also used for playback, when head 1 is reproducing, the adjacent channels are magnetically short circuited by keepers to prevent crosstalk. The other channels are protected in the same way. Without keepers it has been found that heads are sensitive to recordings on channels as far as 0.125 inch or more from the head, the effect being especially pronounced at low frequencies.

Generally the maximum sound intensity picked up by the different microphones during a rendition will be different, necessitating a method for setting gain as indicated in Fig. 2. A test selection is played by the orchestra and the gain of each channel is set at the maximum point that will not produce overload of the recording at any time. Depending on microphone placement and relative loudness of the different instruments, typical settings might be as shown. On playback the gains of the amplifiers are set in inverse ratio to the recording amplification. Some adjustment from the values given might have to be made to compensate for speaker placement, acoustic conditions, and characteristics of the ear.

Comparisons between two- and three-channel systems indicate that a satisfactory simulation of realism is possible with only two channels. A third microphone that is caused to feed equally into both channels may be placed in any convenient location for soloist or announcer. To the listener, the reproduction of this voice appears to come from its customary center-stage location. The third microphone is not, however, mandatory in a home-recording system because pickup from two program microphones gives the illusion that the performer is in a larger room beyond the walls of the listening enclosure.

It has been found that the more conventional and obvious placement of speakers is, at best, difficult in the ordinary home. With reproducing units oriented as shown in Fig. 3, there is some undesirable attenuation of the high frequencies, but reflections from the walls give the effect of virtual sources located at an appreciable distance outside the room. A single enclosure with two speakers similar to the arrangement of Fig. 3A has been designed to hold the complete dual-channel magnetic-tape recorder-reproducer with associated power supplies and amplifiers, as well as a conventional radio-phonograph combination. An artificial center channel can be obtained by having ports in front that open into each of the speaker compartments to give acoustic mixing.—A. A. McK.

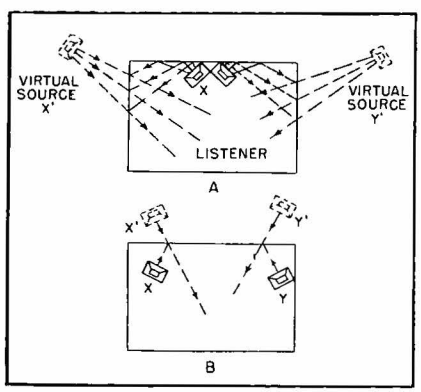

FIG. 3—Reflective speaker system, showing location of virtual sources