BULLETIN!!

Prepared especially for members of the N.R.I. ALUMNI ASSOCIATION
Headquarters: 3939 Wisconsin Ave., N. W., Washington 16, D. C.

Something New Has Been Added . . . CONAR!

An unfamiliar name? Surely. But you'll be hearing more about CONAR -- and soon.

In keeping with expanded activities in the field of Electronics Kits, NRI recently established the CONAR INSTRUMENTS DIVISION. All products sold under the name "NRI Professional" now carry the CONAR label.

Long before the first radio broadcast in 1920 on station KDKA, NRI kits were already well-known throughout the country. As the first, oldest, and largest Radio-TV-Electronics School, NRI designed and sold more kits than any other organization in the world!

The unsurpassed experience that made NRI the leader is now inherited by CONAR. For the first time, high-quality NRI products -- bearing the name CONAR -- are available to ANYONE.

In addition to Radio-TV test equipment, CONAR will have a complete line of kits for experimenters, hobbyists, ham radio operators, and hi-fi and stereo enthusiasts. Superbly designed to meet rigid specifications, Conar Kits are easy -- FUN -- to build. Only the highest-grade, American-Made components are used.

As you see CONAR products advertised in leading publications, we hope you will come to recognize this name as assurance of quality, dependability, and value -- second to none!

FM Stereo Multiplex

By E. B. Beach, Technical Editor

The FCC has recently approved stereo broadcasting by FM stations. Many stations expect to be on the air with "Stereo" this fall. Here is a brief description of how stereo broadcasting works. Detailed circuitry is not yet available from the manufacturers of stereo equipment, but once you understand the basic theory in back of this type of broadcasting, you should be able to service this type of equipment when it is placed on the market.

Since the time stereo recordings became commercially available, the broadcast industry has been looking for a means of broadcasting stereo sound to its listeners. Many schemes have been tried, such as transmitting one channel on FM and the other on AM, or one channel on one FM station and the other on another FM station. All of these schemes have several inherent disadvantages. First, none of them are compatible. By this we mean that the listener who has, for instance, only FM or only AM is "cheated," since he receives only the left or the right sound channel, and not the entire sound signal. Second, those systems using AM transmission for one channel suffer from poor-quality, noisy sound in one channel, giving decidedly inferior stereo reproduction. Third, all present schemes require two completely separate tuners.

What was needed, and what has finally been approved by the FCC is a system of compatible, FM, stereo multiplex transmission. Multiplex here means that a single FM station broadcasts both the left and right channel signals to the listener. The system is compatible in that a listener who is not equipped with auxiliary equipment necessary for stereo reception will still hear all of the program material. Let's see how this is done.

MATRIX

In the usual two-channel stereo set-up, the left (L) and right (R) signals produced by L and

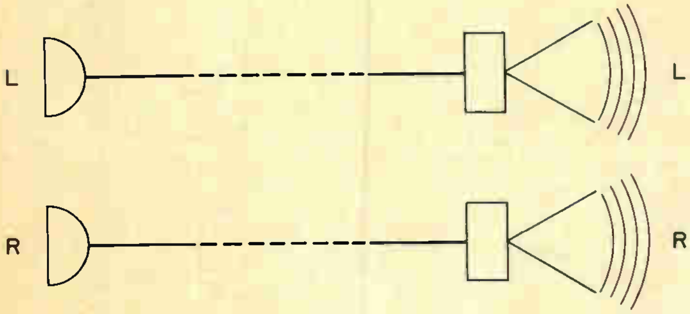

FIG. 1. A typical two-channel stereo set-up.

R microphones are sent individually to corresponding loudspeakers (L and R), as in Fig. 1. Take a look now at Fig. 2A. As long as the sound source (S) is located on a line midway between the L and R microphones, both microphones will have equal outputs, and there will be no directional or stereo effect. In Fig. 2B the source is closer to the L microphone than to the R microphone. Now the output of the L microphone will be greater than the output of the R microphone. Similarly, if the sound source were to the right of the center line, closer to the R microphone, there would be a larger signal in the R channel than in the L channel.

Summarizing: if the R and L signals are equal, the sound source is centrally located. If the R signal is greater than the L signal, the sound source is to the right. If the L signal is greater than the R signal, the sound source is to the left. If we take the outputs to the L and R microphones and add them together we have a signal representing all of the sound picked up by both microphones. Let's call this the L+R or sum signal. If we take the outputs of the L and R microphones and subtract R from L (or L from R) we will have a signal that tells us which channel has the larger signal. Let's call this the L minus R or difference signal.

Referring to Fig. 3 we see a device that performs the addition and subtraction mentioned above. It is called a matrix (MAY-tricks). If we compare Fig. 3 and Fig. 1, we see in Fig. 3 the

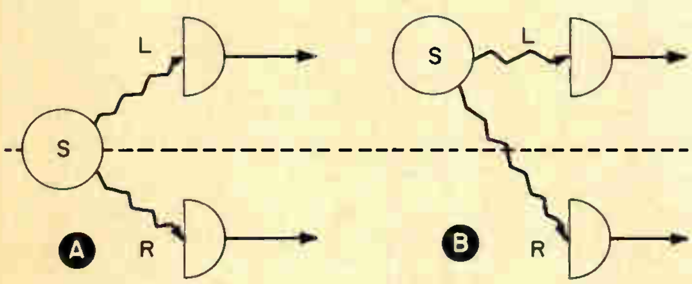

FIG. 2. When the sound source is midway between the two microphones, as at A, they produce equal sounds. If it is closer to one, as at B, that one will produce more sound.

two signals sent along the dotted lines are the sum (L + R) and difference (L - R) signals instead of the L and R signals as in Fig. 1. At the loudspeaker end of Fig. 3, notice that there is another block labeled matrix. This one does the same job of adding and subtracting as the first matrix, but here the signals added and subtracted are the sum and difference signals. Let's see what results when we perform these operations. Adding: $(L + R) + (L - R) = 2L$; subtracting: $(L + R) - (L - R) = 2R$. This matrix recovers the original L and R signals.

STEREO TRANSMISSION

If these two matrix signals could be transmitted by an FM station in such a way that a conventional FM receiver would receive the

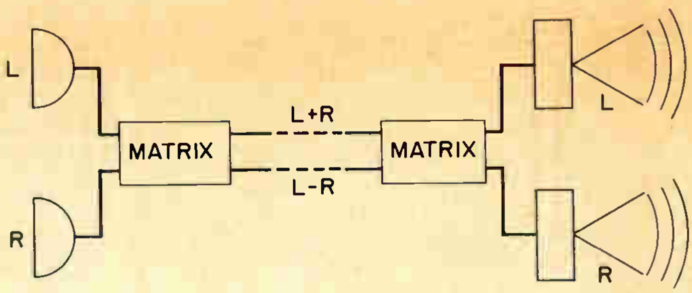

FIG. 3. Using a matrix to produce sum and difference signals, and another matrix to recover the original signals.

L + R signal and a stereo receiver would receive both the L + R and L - R signals, we would meet the requirements of compatibility.

Fig. 4 is a block diagram of a compatible stereo transmitter. The L and R signals, after conventional FM pre-emphasis, are matrixed to produce L + R and L - R signals. The filters included in the block diagram are for limiting the L and R frequencies to the range of 20 cps to 15 kc. The L + R signal passes through a time-delay network, which will be discussed shortly, to a mixer circuit. This mixer could be considered another matrix, which adds all the input signals together linearly. The other two signals added here (19 kc and L - R sidebands) will be explained later.

Because the L + R and L - R signals are both audio signals, they both occupy the same frequency spectrum (20 cps to 15 kc). Obviously we cannot use two different signals in the same frequency band to modulate a single rf carrier; this would result in garbled sound and would be unusable when picked up by the receiver.

If we could take one of these two signals and shift all of the frequency components out of the 20 cps to 15 kc range, the resulting two signals could both modulate the rf carrier without

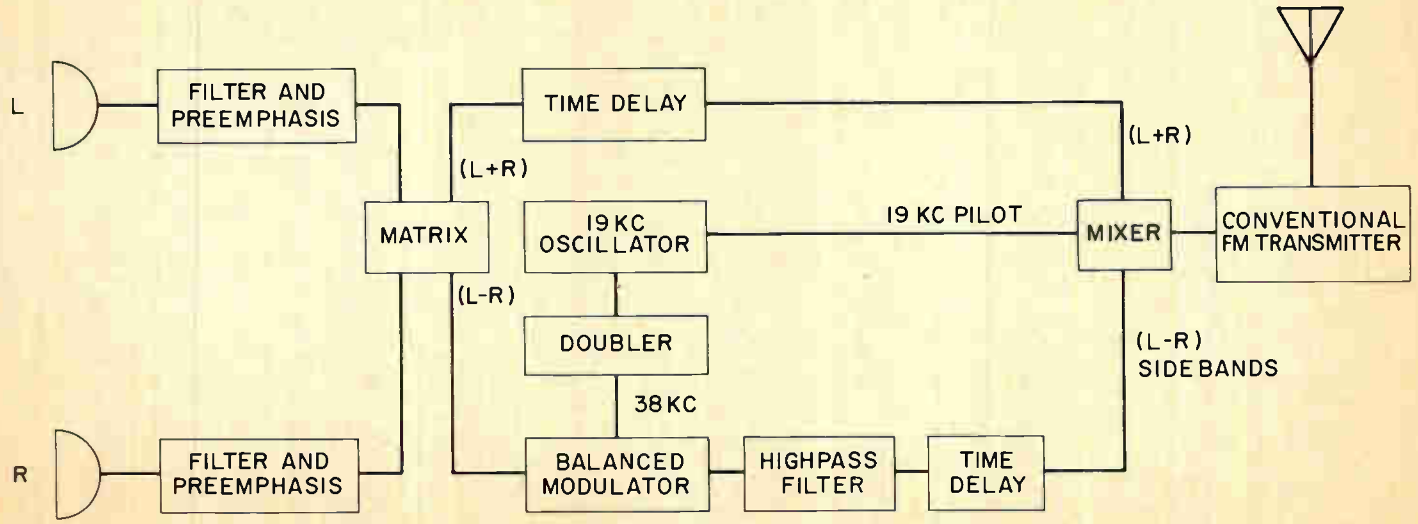

FIG. 4. Block diagram of an FM stereo multiplex transmitter.

interference. We can shift the L - R signals to a different frequency spectrum by using a heterodyning process. Suppose we heterodyne the L - R signal with a 38-kc signal. We know that we will have in the output the original heterodyning frequencies as well as the sum and difference frequencies. For an L - R range of 20 cps to 15 kc, and a heterodyning signal of 38 kc, we would have:

1. (L - R) 20 cps to 15 kc.
2. 38 kc.
3. 38.02 kc to 53 kc.
4. 23 kc to 37.98 kc.

Of these four signals, only signals 3 and 4 are of interest.

The heterodyning stage in Fig. 4 is labelled "Balanced Modulator." One of the features of this device is that it produces the sum and difference signals (3 and 4) but not the heterodyning signal (38 kc), in the output. Notice that signal 1 is much lower in frequency than 3 and 4. This signal can be easily eliminated from the output of the balanced modulator by a simple high-pass filter, leaving as the output signals 3 and 4.

The 38-kc signal may be considered a carrier, which is modulated by the L - R signal. In order not to confuse this low-frequency carrier with rf carriers, it is usually referred to as a "subcarrier." The output signals 3 and 4 are seen to be the upper and lower sidebands of the 38-kc subcarrier. This modulation process, then, produces a double-sideband (upper and lower), suppressed-carrier signal (no 38-kc subcarrier in the output).

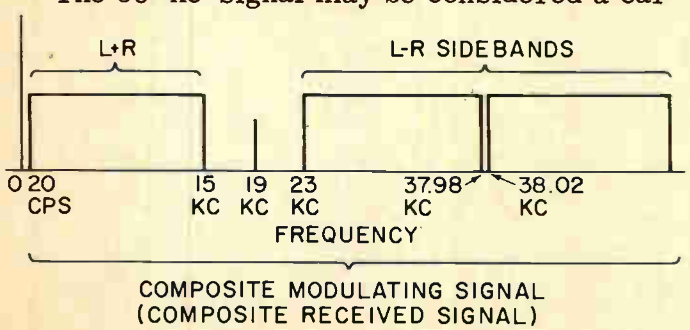

FIG. 5. Frequency spectrum of composite modulating signal.

The 38-kc subcarrier is obtained from a 19-kc oscillator by using a frequency doubler. The 19-kc signal is one of the signals used to modulate the FM transmitter. It is called the "pilot carrier," and will be explained shortly.

The L - R sidebands (Fig. 4) go to the same mixer as the delayed L + R signal and the 19 kc pilot carrier. This composite signal then modulates a conventional FM transmitter. Fig. 5 shows the frequency spectrum of the composite modulating signal. The L - R sidebands are delayed in the modulation process, hence a time-delay network is needed in the L + R signal line.

STEREO RECEPTION

A conventional FM receiver is shown in block diagram form in Fig. 6. It will reproduce only the L + R signal, since the pilot (19 kc) and L - R sidebands (23 kc to 53 kc) are above the audio range. If we insert at point X in Fig. 6 a receiving adapter, we will be able to receive the stereo signals as well. Notice that the receiving adapter must be placed before the de-

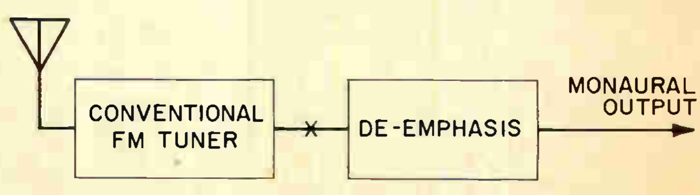

FIG. 6. Block diagram of a conventional FM receiver.

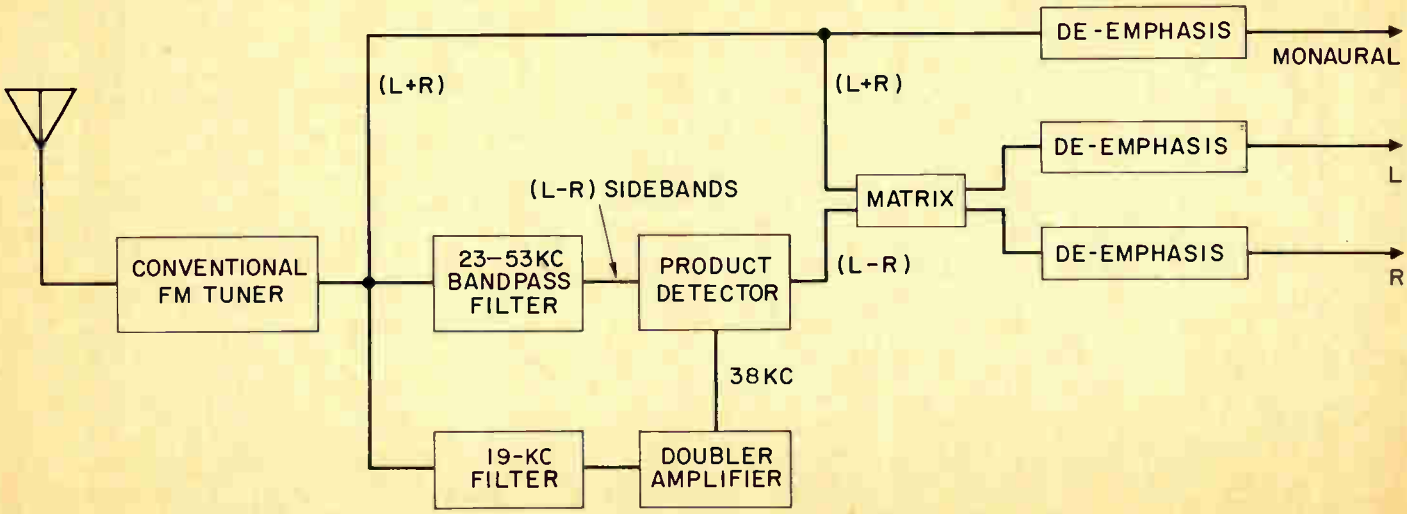

FIG. 7. An FM stereo multiplex receiving adapter.

emphasis network. This is important, since the purpose of the de-emphasis network is to reduce the amplitude of signals above about 8 kc. This means that the 19 kc pilot and 23 to 53 kc L - R sidebands would be lost if they went through the de-emphasis network.

Fig. 7 shows, in block diagram form, the receiving adapter necessary for reception of stereo FM transmissions. The L + R signal goes either directly to a de-emphasis network for monaural reception, or to a matrix. The rest of the output from the conventional FM tuner is used to recover the L - R signal. The L - R sidebands are separated from the composite received signal by a bandpass filter. The 19-kc pilot carrier is separated from the composite received signal by a sharp 19-kc filter. The 19-kc pilot then goes to a frequency doubler, and we have once again our 38-kc subcarrier. This is heterodyned with the L - R sideband in a mixer, which is variously called a "product detector," "synchronous detector," or "balanced demodulator," and the L - R signal is recovered. It is very important that the subcarrier be of exactly the same frequency and phase as the suppressed carrier used to produce the L - R sidebands originally. This is the reason that the 19-kc pilot carrier is transmitted.

The L - R signal is then matrixed with the L + R signal as in Fig. 3, and the original L and R signals result. These signals pass through de-emphasis networks and on to the conventional stereo sound system.