High-Fidelity Broadcasting

RADIO-CRAFT welcomes this opportunity to present what is believed to be the first published explanation in simple terms of: (1) why high-fidelity programs are transmitted today over a channel width of 20 kc. in apparent contradiction of the fact that Federal Communications Commission regulations seemingly prohibit a broadcast-channel width exceeding 10 kc.; (2) why it is necessary to transmit up to 10,000 cycles (or 10 kc., which results in a channel width of 20 kc.); and, (3) how the improved transmissions have been effected.

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WITH the announcement of several commercially-available high-fidelity receivers for home use (*See *Radio-Craft.*), an increasing interest is being expressed by radio retailers and consumers concerning the physiological as well as the technical aspects of *high-fidelity* transmission and reception.

It is pertinent, at this time, therefore, to review briefly the significance of "High Fidelity" as it concerns the audio response versus frequency characteristics, assuming that the amplitude distortion characteristics and signal-to-noise ratio are satisfactory.

REVIEWING 1st PRINCIPLES

It is generally accepted that the normal ear can recognize sound vibrations of any frequency from about 20 to 16,000 cycles per second. All ordinary sounds contain one or more *fundamental* frequencies and many *harmonic* frequencies of the fundamentals. The higher-order harmonic frequencies are of decreasing intensity and may even be inaudible, but the lower-order harmonics constitute a distinct portion of the sound—in some instances the major portion—and are termed "useful" harmonics.

In order to assist in "visualizing" the frequency ranges encountered in ordinary sounds, several of the most common musical instruments have been illustrated (Fig. 1) along with their corresponding range of fundamental and of useful harmonic frequencies. It should be noted that the fundamental frequencies in all cases are included below 5,000 cycles per second; whereas in most instances the "useful" harmonic frequencies extend up to and even beyond 10,000 cycles per second. (**Major Edwin H. Armstrong has said that even frequencies as high as 18,000 cycles may be useful in obtaining natural rendition of music.—*Editor*)

It is the presence of the useful harmonic frequencies that enables sounds of different musical instruments which have the same fundamental frequency, or *pitch*, to be distinguished from one another. This is also true of the human voice except that, in this case, the useful harmonic range is not so extensive.

It is obvious, therefore, that it is the harmonic frequencies which constitute the quality, or *timbre*, of sounds, and it is the reproduction of these harmonic frequencies which distinguishes high-fidelity reproduction from ordinary reproduction.

The average radio receiver now found in the home, even when operated with the tone control in the "Fidelity" position, considering the overall response from receiver input to loudspeaker output, reproduces frequencies only up to approx. 4,000 cycles per second. Figure 1 also illustrates which of the common musical instruments lack true tonal quality because of the inability of the receiver to reproduce the higher harmonic frequencies. The darker pictures indicate that only a small portion of the frequency range is lost while the lighter or "ghost" instruments lose considerable or all of their characteristic harmonics.

PROGRESS!

"Using as a demonstration 'Irish Tune from County Derry,' one radio station last night showed how the tone frequency range of broadcasting has been extended from 250 to 2,000 cycles in 1922, to 30 to 10,000 cycles in 1939, replete with overtones and the delicate innuendoes of tonal color and shading which make great music great."

(From a news item, last month, regarding a broadcast in connection with the programs, to increase radio listening, for a week last month, sponsored by the National Assoc. of Broadcasters and the Radio Manufacturers' Assoc.—Editor)

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In anticipation of the present trend towards true high-fidelity reception, the Columbia Broadcasting System for several years has been installing equipment, built to more rigid specifications, or modifying existing equipment so that the equipment facilities are capable of transmitting all frequencies in the range of at least from 40 to 10,000 cycles per second.

At the C.B.S. studios the equipment in use has, for several years, been capable of handling the above range of frequencies from the input of the microphone to the output of the studio channel at Master Control.

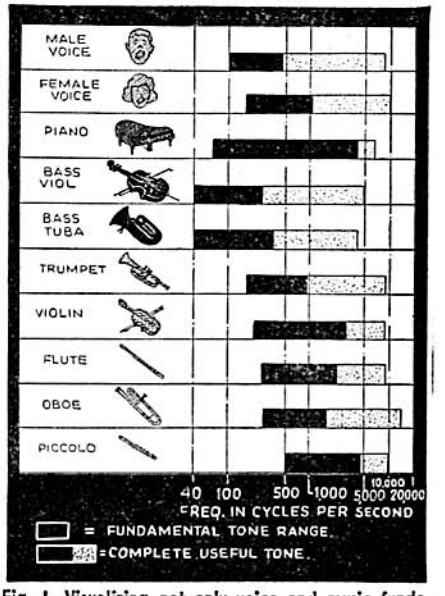

Fig. 1. Visualizing not only voice and music fundamental but also harmonic frequency ranges.

At the WABC transmitter, from the audio-equipment input to the antenna output, the response-frequency characteristic is substantially flat over the above range of frequencies. Specially-engineered lines having similar response-frequency characteristics connect the studios to the transmitter, which results in a flat overall response-frequency characteristic from microphone input at the studios to the antenna output over the range from 40 to 10,000 cycles per second, guaranteeing high-fidelity transmission for those listeners residing in the New York or *primary service* area.

This excellent overall response-frequency characteristic has been brought about by careful engineering, the utilization of high-fidelity equipment all along the line, and operation in accordance with the best modern engineering practices. The microphone and amplifiers must meet rigid specifications with regard to low distortion, high signal-to-noise ratio, and extremely flat response-frequency characteristics. All lines of appreciable length are compensated for

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* "Remote-Controlled High-Fidelity Receiver" (Pacent set), p. 735, June 1939.
"Stewart-Warner High-Fidelity Sets (Chassis Models 91-82, 98-82, 910-82)," pp. 549, 552, March 1939.
"RCA Victor High-Fidelity Models HF-2, HF-4, V-130," pp. 484, 485, 487, Feb. 1939.
"High-Fidelity Goes to Town!" (RCA HF-1 hi-fi set), pg. 154, Sept. 1938.
"RCA Victor Model HF-1 (Symphony) High-Fidelity 8-Tube Superhet," pp. 159A, 159B, Sept. 1938.
"McMurdo Silver Remote-Controlled High-Fidelity Receiver," p. 96, Aug. 1938.

** June 1939 Radio-Craft, p. 711.

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any loss in the response-frequency characteristic by using extended-range equalizers. The installation of feedback in the WABC transmitter played a major role in improving the response-frequency characteristic of the station.

WHAT ABOUT "ADJACENT-CHANNEL INTERFERENCE"?

The transmission of frequencies up to 10,000 cycles per second naturally signifies wider side-band transmission, or, in other words, the transmitter carrier frequency is modulated plus or minus 10 kc. either side of the carrier frequency.

This would seem to imply that, since the station channel assignments (in this country) are separated by only 10 kc., there must result some form of heterodyne interference between 2 stations on adjacent channels. A consideration of the present allocation of stations, as well as of the per cent of energy actually contained in the frequencies above 5,000 cycles per second, soon makes it apparent that when receiving a station *while in its primary service area*, there will result *no adjacent-channel interference.*

As is well known, (1) the high-power stations on any one frequency either have exclusive use of the channel or, if more than one operates on one channel, employ directional antennas, mutually protecting each other's service areas; or, (2) in the case of lower-power stations, they are so geographically located or employ directional antennas, if necessary, so that certain well-defined interference limitations are not exceeded.

Although not so well known, it also is true that definite interference limitations are set up and maintained with regard to stations on adjacent channels, and even, for that matter, with regard to stations separated by 20, 30, or even 40 kc. In other words, the stations in the United States are so situated, geographically, that the signals on adjacent channels of a particular station, are of negligible intensity within the primary service area of the desired station.

Consequently, when located within the primary service area of a station—in any case where the desired signal is much stronger than the signals of adjacent channels—a listener employing a high-fidelity receiver can be assured that the intensity of the signal is sufficiently greater than that of the stations on adjacent channels, so that side-band interference is not present.

When endeavoring to select a weaker signal adjacent to a strong signal, however, the lower frequencies of the strong signal will interfere and be received as high-frequency sounds ("hash," cross-talk, etc.—*Editor*). In a typical transmission, the energy contained in the frequencies above 5,000 cycles per second is less than—roughly—10 per cent of the total energy and, therefore, the high frequencies of the strong adjacent-channel station would not interfere with the low frequencies of the desired station.

When listening to distant stations during the evening or to particularly weak signals, high-fidelity reception is not feasible, and it becomes necessary to cut off the response of the receiver at, say, 5,000 cycles per second. Under this condition, as mentioned above, since the energy content above 5,000 cycles per second is small, adjacent-channel interference on weak signals is not present

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After the wiring was completed but before actually mounting the unit on the panel, tests were made with it in operation to select a frequency clear of local broadcast stations. Once tuned to such a frequency (by means of the screwdriver adjustment of the oscillator trimmer condenser) it was permanently mounted. It happens that it was necessary to do this before mounting the unit as the phono motor blocks access to this adjustment screw in this particular installation.

The use of a microphone was not contemplated in this job. If it had been, the microphone jack could have been removed from the transmitter chassis and mounted on the panel instead.

1 PHONO FOR 3 SETS!

In the apartment where this job was done there are radio sets in 2 of the bedrooms, in addition to the main one in the living room. These are within 30 feet or so of the phonograph and its output is readily picked up on all of them—an interesting advantage offered by the "wireless" system as against wire connections between the phono and radio. One of these bedroom sets provides pushbutton tuning and by pre-setting one of the pushbutton circuits to the frequency of the phonograph oscillator its output is made quickly available at any time that the phonograph is in operation.

In addition to remodeling jobs, there are others where the phonograph equipment is up-to-date but a wireless unit would provide advantages not now enjoyed. It's a thought which Servicemen can logically promote. The "wireless" unit can simply be placed on the turntable panel, or can be mounted inside.

Even in cases where modern record players are in use the addition of a "wireless" unit offers advantages and this is another "angle" which the Serviceman (or dealer) can profitably promote.

This article has been prepared from data supplied by courtesy of Wholesale Radio Service Co.

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even though the stations are transmitting up to 10,000 cycles per second.

CARRIER HETERODYNE

There is, however, one further technical consideration. As the stations are separated by 10 kc., there is always present an inherent 10,000-cycle carrier beat note (or "heterodyne"). If the high-fidelity receivers can reproduce frequencies including 10,000 cycles per second, then this heterodyne beat note can be heard. To counteract this, the receivers must cut off just below 10,000 cycles per second.

The broadcasters have been, and are continually, exerting every effort toward effecting high-fidelity transmission and the programs are produced with this consideration in mind. The listener who avails himself of high-fidelity reception not only obtains the most nearly perfect reproduction, but enables himself to receive the program with the maximum amount of enjoyment and ease.

P.A. AIDS STEEPLEJACKS

When a foreman on the ground recently went hoarse yelling instructions to painters atop WOR's mast the station's engineers set up a P.A. system to project orders nearly 400 ft. upward!

CLOSING DATE OF $4,000 PUBLIC-ADDRESS CONTEST EXTENDED

Complying with many requests from our readers that we extend our Contest over a longer period of time in order to permit them to take advantage of P.A. installations made during the summer months, we have extended the closing date of the Contest from midnight, August 10, 1939, to midnight, September 10, 1939. Unlike other branches of the radio industry, the sound business is at its peak during the summer months.

If you have already made a P.A. installation or if you contemplate making one shortly, take advantage of this extension and shoot-in your description of the job—rental or otherwise—according to the rules of the Contest. See pgs. 80 and 106 for complete details.