The Voice of America gives to other nations a full and fair picture of American life, aims and policies, plus factual news of the world and the United States.

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AUDIO ENGINEERING APRIL, 1948
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Audio Engineering April, 1948
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COVER ILLUSTRATION

The communications control console on the desk of the director of news broadcast of the Columbia Broadcasting System in New York City. This unit controls two-way circuits to program origination points throughout the world. These transoceanic communications channels are used prior to actual news broadcasts to arrange the timing of the broadcast, the program content, and other program productive problems.
Three hour high fidelity recording is easy with the MAGNETONE®!

Broadcasting stations will find this magnetic recorder ideal for remote pickup and delayed broadcast work. Especially suited for conference recording, case history study, educational training, opera recording, dispatchers' monitoring, police radio monitoring and many other long period recording usages.

The "MAGNETONE" uses plated brass wire and makes permanent magnetic recordings of unsurpassed quality. Recordings may be "erased" and the wire reused any desired number of times. "Erasure" is automatic as a new recording is made. Life of the magnetic wire is unlimited. Reels of wire in ½, 1, 2 and 3 hour time periods are available. The "MAGNETONE" is portable, durable, in attractive metal or black leatherette case.

Outstanding characteristics of the MODEL BK-303 "MAGNETONE" are its fast rewind, fast forward speed, and constant recording speed which permits any section of a recorded program to be spliced into any other section without impairing the faithful reproduction.

Available with High and Low Impedance Inputs and 500 Ohm Balanced-Line Output

Write today for detailed specifications of the

"MAGNETONE"

The Brush Development Company

[Continued on page 50]
ALTEC LANSING SCIENTISTS DISCLOSE BASIC IMPROVEMENTS IN HIGH QUALITY SOUND REPRODUCTION IN NEW SPEAKERS

NEW 603B MULTICELL DIA-CONE SPEAKER

The new 603B Multicell Dia-cone speaker is as superior to the original 603 Model as the 603 was superior to its competitors. The new 603B has a 30% larger Alnico V permanent magnet; massive circular magnetic circuit; almost 100% increase in acoustic efficiency (25 db increase over the 603).

SPECIFICATIONS

- Angle of Horizontal Distribution: 60°
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- Power Rating: 25 watts
- Voice Coil Impedance: 8 ohms
- Required Amplifier: 4000 watts
- Output Impedance: 6-10 ohms
- Voice Coil Diameter: 3.75
- Weight: 18 lbs.
- Speaker Diameter: 5.25
- Depth: 7.5

NEW MODEL 604B DUPLEX SPEAKER SHOWS REMARKABLE EFFICIENCY AND PERFORMANCE

 Authorities on sound quality—the experts in the broadcasting, recording, and motion picture industries—who considered the previous Altec Lansing Duplex speaker (the 604) as the finest two-way speaker unit that science has produced, were literally thunder-struck when they listened to "views" of the new improved Model 604B. Among outstanding new features are: 1,000 cycle crossover frequency using the new N-1000B network with adjustable high frequency control; an exclusive Altec Lansing development used with the high frequency metal diaphragm to smooth the frequency response beyond 2,000 cycles to 16,000 cycles.

SPECIFICATIONS

- Network Impedance: 16 ohms
- Required Amplifier: 4000 watts
- Output Impedance: 8-16 ohms
- Diameter: 12-3/16"
- Power Rating: 35 watts
- Weight: 40 lbs.

NEW 8" MODEL 400B DIA-CONE SPEAKER

A low-priced high quality unit with a much higher efficiency than any 8" Dia-cone speaker unit. Because of the high efficiency, small space requirements, light weight and superior quality of reproduction, the 400B is ideal for home use, sound reinforcement systems and industrial applications.

SPECIFICATIONS

- Power Rating: 12 watts
- Voice Coil Impedance: 8 ohms
- Required Amplifier: 4000 watts
- Output Impedance: 4-8 ohms
- Voice Coil Diameter: 1.5"
- Speaker Diameter: 8"
- Weight: 4 lbs.

FREQUENCY RESPONSE CURVES PUBLISHED IN ILLUSTRATED BROCHURE

With the announcement of the new line of speakers, Altec Lansing announces that frequency response curves will be published on all its speakers. These curves are guaranteed to be accurate, dependable and true reproductions, made on production run speakers with equipment used by Motion Picture Research Council for establishing speaker system standards in the motion picture industry.
EDITOR’S REPORT

TV OR NOT TV

- IN OUR January issue we announced that we planned to run a short section in this magazine devoted to the operational problems of video engineering. This decision had been reached as a result of conferences with many prominent audio engineers in the broadcast field, where the operational end of video is now being handled by audio men.

However, we have been deluged with letters and phone calls asking that we confine this magazine solely to audio. Apparently most of our readers want no part of video engineering, so until we see a good deal more enthusiasm for video data than now exists, we intend to stick to our present editorial policy. More letters on this topic are invited.

IRE CONVENTION

- THE Institute of Radio Engineers has just concluded its largest national convention and engineering show at the Hotel Commodore and Grand Central Palace in New York City. The program committee is to be congratulated upon the smoothness and efficiency with which the entire convention was handled. Each year this convention and show has grown in magnitude until now it far exceeds anything that most of us had dreamed of ten years ago. Registration this year totalled over 15,000.

Some of the exhibits in the show were a bit skimpy, reflecting the shortages still existing in many manufacturer’s lines, but there was much that was new and interesting. One would never realize from viewing the many excellent exhibits that business isn’t very good with many manufacturers.

Of special interest to the audio engineer were the displays of many manufacturers, among them being the speakers, the program switching console, and the new disc-jockey’s console in the Western Electric exhibit; the many recorders from the tiny Wagner-Nichols instrument which now embosses an hour-long program on a six-inch vinylite disc at 14 rpm to the extremely professional Rangertone Tape Recorder of superlative quality, with intermediate types using discs, wire, and tape; the new phonograph pickups of high quality reproduction; the sonic analyzer of Panoramic which sweeps the entire audio spectrum once per second and presents the information on a c-e-screen with a scale proportional to db; the audio sweep oscillator of Instrument Electronics; the new pocket noise meter of H. H. Scott, along with his demonstrations of the Dynamic Noise Suppressor Amplifier; not to mention the institutional exhibits of RCA and the two lovelies who personally pinned a white carnation on every comer.

The Radio Engineering Show is always the place where the visitor is bound to meet some old friend or associate from across the country; old times and new ideas are discussed; and many a pleasant get-together is consummated. It is surprising, however, to note the over-all seriousness of the IRE Convention—most of the engineers are here for business, and they make the most of the opportunity. The Show is always a beautiful sight, either to the professional or to the non-technical, and the exhibits are calculated to interest every visitor.

AUDIO NEWS

- THE first technical session of the Audio Engineering Society took place on March 11th at the RCA-Victor Recording Studios in New York City. More than two hundred audio engineers crowded into every bit of available space to listen to an excellent talk and demonstration by Dr. Harry F. Olson of RCA Laboratories. Dr. Olson demonstrated a new electronic pickup, using a small diode, which is designed to give high-fidelity reproduction and to provide an output of 0.5 volt across 10,000 ohms. The record pressure can be as little as 15 grams. It is difficult to use much less than this and maintain proper tracking, but the pickup itself does not even require this much pressure. The new Olson duo-cone speaker was also demonstrated, and sounded very well indeed.

The New York Times gave an excellent write-up of the meeting, describing at length, if somewhat inaccurately, the operation of the new pickup. Dr. Olson has promised to prepare a technical paper for Audio Engineering describing this new device, which is expected to be in production sometime this summer.

—J. H. P.
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Where's the manufacturer these days who doesn't need all the competitive and cost advantages he can get? Maybe you have new electrical or mechanical equipment in mind—designs or re-designs that should employ permanent magnets for best results. Maybe you have existing applications that permanent magnets will do better—save you time and money in production, and step up the efficiency of your product.

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Audio Engineering April, 1948
Engineers will welcome these two new additions to the PRESTO line of superior equipment.

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Designed to control program peaks, Type 41A removes the cause of overcutting and distortion in recording and over-modulation in broadcasting. Proper degree of peak limiting permits an appreciable increase of the average signal with consequent improvement of signal to noise ratio. Serves simultaneously as a line amplifier; its 60 db gain adequately compensates for line losses due to pads, equalizers, etc.

**Presto Power Amplifier (Type 89A)**

For recording, or monitoring use, 89A is the perfect high fidelity, medium power unit. 25-watt output, it fills the need for an amplifier between Presto 10-watt and 60-watt units. All stages are push-pull and sufficient feedback is provided to produce a low output impedance and general performance of the type 807 tubes which is superior to that of triodes.

**FULL SPECIFICATIONS OF THESE TWO NEW AMPLIFIERS WILL BE SENT ON REQUEST.**

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AUDIo ENGINEERING APRIL, 1948
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... in Sound on Film and Disc Recordings
... in Production Tests on Radio Transmitters & Receivers

FROM necessity, because of war production, the pre-war very popular Type 732-B Distortion & Noise Meter was dropped from the G-R line. It is now in production again to meet an insistent demand for a meter to supplement the new Type 1932-A which is designed primarily for broadcast and communication applications.

The Type 732-B is equipped with a 400-cycle high-pass L.C. filter so that harmonic content measurements of a 400-cycle signal can be made rapidly. Because of the width of the pass band, unsteady signals, "wows" and other irregularities do not affect the accuracy of measurement.

The ease with which accurate measurements can be made over the distortion range of 0.25 to 30% and noise range of 30 to 70 db below 100% modulation, make it very valuable in these types of production testing:

ON RADIO TRANSMITTERS
- Signal-to-noise ratio
- Distortion vs a-f output
- A-F response
- Noise vs carrier level
- Hum modulation
- Hum level

ON RADIO RECEIVERS
- Distortion & noise vs a-f output
- Whistle output at 2nd and 3rd harmonic of i.f.
- Two-signal cross-talk

The broad pass band characteristic of this meter is particularly useful when making distortion measurements on sound on film or on disc recordings where the fundamental frequency is not constant.

The Type 732-P1 Range Extension Filter is available as an auxiliary unit so that measurements at additional frequencies of 50, 100, 1000, 5000 and 7500 cycles can be made.

TYPE 732-B DISTORTION and NOISE METER . . . . $374.00
(For either 0.5 to 8 Mc or 3 to 60 Mc carrier range, specify which)

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**AMPLIFIERS**

1140A (at right), for either a-c or d-c, is free from noise usually found in this type amplifier. Designed to operate directly from telephone wires without separate isolating coils. Delivers 10 watts from a-c source; 6 from d-c. Meets needs of 85% of subscribers. Most other requirements are met by the 124H (below) or 124J, a-c amplifiers rated at 12-20 watts.

**LOUDSPEAKERS**

The 755A 8-inch direct radiator gives high quality reproduction with exceptional tonal brilliance. 8 watts, 70,000 cycles. For higher power, the 25-watt 756A or 30-watt 728B.

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Specially designed for matching multiple loudspeakers in wired program and sound distribution systems. 25A—4 watts; 26A—16 watts; 27A—64 watts.

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The 633A Microphone permits subscribers to use system for announcements or paging, or to pick up musical programs originating on their own premises. The popular 639 Type Cardioids, too.

**FOR THE PROGRAM CENTER**

In addition to the 1304 Reproducer Set shown—incorporating 2-speed turntable and 9 Type Reproducer, Western Electric offers for the program center a full line of integrated equipment, including microphones, amplifiers, line-coils and associated apparatus. Remember . . . Western Electric recording studios use Western Electric reproducing equipment!

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In the U.S.A. — Graybar Electric Company. In Canada and Newfoundland — Northern Electric Company, Ltd.


**AUDIO ENGINEERING APRIL, 1948**
Two-Channel Two-way-Drive Magnetic Tape Recorder

This recorder is designed to give excellent performance at low tape speed.

As a part of research and development activities carried on for the benefit of manufacturers licensed under its magnetic recording patents, the Armour Research Foundation builds demonstration units to test and demonstrate the performance capabilities of new head designs, recording media and drive systems. These demonstrators are intended to serve as guides for production design, but are not carried to the point where manufacturers can sensibly produce and market exact duplicates. Final product design is left to the manufacturers themselves.

The unit described was constructed in an effort to achieve desirable performance characteristics at a low tape speed. Armour No. 140 magnetic material was selected for the tape because of its good recording characteristics combined with ease of a-c erasing. The magnetic powder has a coercivity of 350 oersteds and a retentivity of approximately 800 gauss. Recently, production tape made by Minnesota Mining and Manufacturing Company has become available, and is suitable for use on this machine.

A tape speed of 8 inches per second was chosen. This was done prior to the RMA recommendation of 7.5 inches per second as the standard speed for home tape recording. A 1200 ft. length of tape .002 inch thick may be used on a 7 inch diameter, 8 millimeter movie reel.

To eliminate the necessity of rewinding, the unit is designed to drive the tape in either direction, and to use one-half the tape width for one direction of motion, and the other half of the tape for the reverse direction. Circuits are switched from one head assembly to the other as the tape direction is reversed. The 7 inch reel of tape thus provides a full hour of entertainment, half an hour in each direction of travel.

The circuits are designed for 500 ohms, 1 milliwatt input and output. Other terminations could of course be provided, and for home use the unit could use the same amplifier for recording and playback, as in current production wire recorders.

Over-all dimensions of the unit are 14-3/4 inches by 14-3/4 inches by 9-3/4 inches high. It weighs 50 pounds.

Mechanical Drive System

The photograph, Fig. 1, shows a general view of the machine with the cover removed. The method of threading for recording or playback is apparent from the photograph. The pressure roller is held against or away from the capstan by means of an over-center spring.

If it is considered necessary to provide high speed transport of the tape, this may be accomplished by removing the tape from the capstan and passing it directly from reel to reel. It is necessary in this case to place a weight on the reel which is to receive tape, in order to provide enough driving torque on the gravity-operated friction clutch below the reel.

Fig. 2. Recorder chassis, showing belt drive.

*Armour Research Foundation, Technology Center, Chicago 16, Ill.


Fig. 5. Schematic diagram of the new two-channel, two-way recorder.
This friction clutch is constructed as follows. A metal disc is secured to the tape reel shaft. On top of this disc is an oiled felt washer. On top of the oiled felt washer is another metal disc, driven by the shaft only through friction of the felt washer. A key projecting upward from this disc drives the tape reel placed on it. With this arrangement, the torque transmitted through the felt washer increases as the weight of the reel increases when taking up tape. This tends to keep the tape tension constant as the take-up diameter increases.

The belting arrangement may be seen in Fig. 2. A reversible motor is used, supported on compliant mounts. It is belt coupled with two belts to the shaft carrying the capstan and flywheel, and with one belt to each of the tape reel shafts. Each tape reel shaft pulley is coupled to its shaft by a one way drive system consisting of a knurled drum fixed to the shaft and a pawl pivoted on the pulley. Also each tape reel shaft is prevented from rotating in a direction to unwind tape by means of another pawl, pivoted from the machine frame and engaging the knurled drum. Engagement of these pawls with the knurled drum is controlled by spring compression which lie in smooth grooves cut into the knurled drum. Friction of these springs in their grooves imparts the necessary motion to the pawls, and prevents mashing of the pawls on the knurled surface. In this manner the felt clutches overdrive the take-up reel and provide a drag on the supply reel for both directions of tape movement.

A 1/75 hp 1800 rpm synchronous motor is used in the model. An induction motor would also be satisfactory and a lower power rating (1/100 hp) would suffice.

The unit comprising the capstan, flywheel, and pulley must be carefully machined to eliminate flutter. In this model, a capstan shaft diameter slightly greater than the capstan diameter is used, so that the entire assembly could be given a finish cut on lathe centers before insertion into the bearings. Sleeve bearings are used, with a single-bail end thrust bearing at the bottom of the capstan shaft. Flutter is less than 0.1 per cent in the model.

The capstan is surfaced with Tygon plastic to provide good frictional characteristics. It was at first attempted to drive the tape without a pressure roller as in a previous one-way-drive model, but the friction of the tape against the head nearest the take-up reel made this impractical. With the pressure roller it might be possible to use a plain metal capstan, but this was not tried on the model.

Practical tolerances on true running of lower plates of the tape reel friction clutches impose an upper limit on the take-up reel overdrive which can be provided, thus limiting high speed transport of tape. Wobble of the clutch members will raise and lower the tape reel. If this is done too rapidly and with too great amplitude, gravity will not maintain a sufficiently constant pressure on the felt washer, and the resulting pulsating take-up torque will produce flutter in the recordings. A minimum initial overdrive of 25 per cent is recommended.

Further mechanical detail is shown in the photograph, Fig. 3.

Circuits and Equalization
Mounting of electrical parts is shown in Fig. 4, and a wiring diagram in Fig. 5. The signal to be recorded must be furnished at a level of about 1 milliwatt at 500 ohms. It passes through a 500 ohm adjustable "T" pad attenuator, a high boost equalizer, a line to grid transformer, a 7N7 cascade amplifier with negative feedback (flat), an output transformer, a 250 ohm "constant current" resistor, and the recording head. An input signal of 0.7 volts at frequencies below 2000 cycles per second results in a recording 10 decibels above

Fig. 3. General mechanical details of recorder.

Fig. 4. Layout of electrical parts of recorder.
below overload. The output transformer also feeds a rectifier-type recording-level meter, which reads zero decibels at 10 decibels below overload. This meter is shunted by a coil and condenser resonated at 40 kilocycles (the erase-bias frequency) to eliminate meter deflection caused by bias voltage feeding back from the recording head.

The erase-bias oscillator is shown in the lower right-hand corner of Fig. 5. A variable resistor in the B supply is used to adjust the erase-bias current to 1.25 amperes.

The playback amplifier consists of a head-to-grid matching transformer, a 1003 triode stage, a 1273 pentode stage, a 7N7 parallel triode stage, an output transformer, and an output attenuator.

Bass boost in the playback amplifier is accomplished in the negative feedback network over the 7N7 and 1273 tubes.

A great deal of care was used to reduce hum. Both wires of the record-pickup heads are switched, with switch decks mounted close together and circuit paths carefully arranged both in the wiring and through the switches to provide hum-bucking action. Open loops in the head circuits and switches caused a great deal of difficulty until the hum-bucking system with matched switching in both leads of each head was evolved. Complete symmetry of the two wires for each head is necessary with low impedance heads. Electrostatic shielding of head leads is not beneficial because of the low impedance.

The constant current response curve is shown in Fig. 6. The playback amplifier response to provide low boost is shown in Fig. 7, and the recording amplifier response to provide high boost is shown in Fig. 8. Fig. 9 is the over-all response curve. Response curves for the two channels are almost identical (within 2 decibels at any frequency).

The signal-to-noise ratio is not alike in the two channels. Our laboratory annealing procedure is imperfect, and we may not have annealed one of the record-pickup heads adequately. On the noisy channel the 1000 cycle signal (2 per cent distortion) to broad band noise ratio is about 40 decibels, and on the quiet channel it is in excess of 45 decibels including hum and amplifier noise. It is intended to replace the noisy head when the current demands for demonstration of the unit to interested licensees have eased somewhat.

Heads

The two head assemblies are identical in design but reversed in mounting (one flipped over with respect to the other) so that one head assembly operates on the lower half of the tape width and the other on the upper half. Each head assembly contains an erase head, a record-pickup head, and two keepers. See Fig. 10. Each keeper prevents the adjacent erase or record-pickup head from acting upon the half of the tape width reserved for action by the other head assembly. These keepers make cross-talk between the channels undetectable. Without them there would be considerable interference, particularly at low frequencies.

The heads and keepers are soldered to a brass support block, which adequately dissipates the heat developed by the
erase heads. Magnetic shield plates complete the head assemblies.

Each erase head is wound with 20 turns of No. 30 Formex coated wire. Each record-pickup head is wound with 100 turns No. 40 Formex coated wire for audio, and has an additional winding of 4 turns of No. 30. This additional winding is connected in series with the erase head to provide high frequency bias.¹

General

Listening tests on this recorder have been very satisfactory. The recordings are remarkably clean.

Many design variations are possible. Cost may be reduced by providing only one way drive, omitting one head assembly and a considerable amount of electrical and mechanical switching. The operator would then be required to turn the reels over to reverse the tape direction.


Fig. 10. Diagram of head assembly.

With some reduction in signal-to-noise ratio, more signal channels could be provided on the present ¼ inch tape. Also, wider tape could be used, providing more channels of the same width and signal-to-noise ratio.

Operation on various channels might be switched electrically as in this model, or by mechanically moving a head, or by a combination of these. A juke box might be built up thus, using wide tapes of any desired length.

On the two channel machine, recordings may be edited by cutting and splicing the tape for only one of the two channels. Editing of each channel without affecting the other channel could be accomplished by dubbing.

The authors gratefully acknowledge that all members of the Foundation’s magnetic recording group have contributed either directly to this machine or to the earlier development of magnetic materials, heads, circuits, equalization schemes, magnetic property testers, x-ray meters, etc., which have made this machine possible.

Notes on Pre-equalization for Phonograph Records

In order to clarify the meaning of pre-equalization and corrective equalization, we will define them as follows:

When the frequency characteristic of the recording system from the air to the track laid down in the record is flat, there is said to be no pre-equalization. Any equalization which may have been necessary to correct deficiencies of any of the components of the recording system is corrective equalization, not pre-equalization. The distortion of the frequency characteristic from flat (from air to record track), which may be desirable to employ for useful reasons, is pre-equalization.

The term “high fidelity” (I.R.E. Standards) has been standardized as a frequency characteristic of a reproducing system which is essentially flat over a very wide range of frequencies and also from certain undesirable distortion. In view of this standardization, this term should not be used for “faithful reproduction” as judged by the ear, since there is considerable evidence indicating that they are different.

There are at least two reasons, one of an acoustic nature and the other a function of the directivity characteristic of loudspeakers, which tend to require the modification of the high fidelity characteristic to enable the ear to hear the reproduced sound as it would have expected to hear the original, had it been present at the performance. This correction is in the nature of a high frequency droop. There are three simple characteristics which the recording system might be designed to have:

(1) Constant amplitude.
(2) Constant velocity.
(3) Constant acceleration.

In general, the middle of the recording range has usually been recorded with approximately constant velocity, and the low and high end compromised from this condition. With a constant velocity characteristic and with a sound source of uniform energy over the whole frequency spectrum, the constant velocity recording yields excessive amplitudes at the low frequencies and excessively small radii of curves within the groove at high frequencies. With this constant energy distribution it would be necessary to record the low frequency end at constant amplitude and the high frequency end above some limiting frequency at constant acceleration, that is at constant radius of curvature within the groove. The droop at the low end is well known in the art.

The droop at the high end has not been necessary because the sound source being recorded have less peak energy in the high frequencies than in the lower and middle ranges. Based on the work of Snow, Dunn, and White, and so far as we know, using the average energy values as a function of frequency, a pre-equalization characteristic was originally determined which over-emphasized the high frequencies to the extent of 16 db at 10,000 cycles. This pre-emphasis of the high end was used in order to allow a high end droop on reproduction, thereby decreasing the disagreeable surface noise of disc recordings.

Later experience has indicated that this amount of pre-emphasis leads to such small radii of curvature on certain sounds that they are not trackable, especially with the improvement of the flatness of the over-all recording system including the microphone and recorder. This is equivalent to saying that the 16 db originally used was not all pre-emphasis as defined earlier, but was partly corrective equalization for equipment deficiencies.

Experience using the flat microphone, flat amplifier, and a flat feedback recorder have shown that the high frequencies are reproduced not only more cleanly but also more intensely when the pre-equalization characteristic is reduced to 6 db at 10,000 cycles as compared with 16 db. The records made with both 16 and with 6 db pre-emphasis were played over the same reproducing system post-equalized for 16 db pre-emphasis.

J. P. Maxfield
J. K. Hilliard

Audio Engineering April, 1948
The use of transmission-measuring sets as a means for simplifying and increasing the accuracy of audio-frequency measurements has become very general. A transmission-measuring set combines in one package the required calibrated attenuators, impedance-matching transformers or pads, isolation coils, power-level indicators and terminating resistors. By means of panel-mounted selector switches which provide for commonly-used source and load impedances, such sets are rendered exceedingly flexible as regards their direct applicability to the majority of audio-measuring problems. The use of a transmission-measuring set not only enormously reduces the setup time, but also greatly increases the repeatability of the results from one setup to the next.

In the broadcasting field the Columbia Broadcasting System pioneered the development and use of completely self-contained transmission-measuring sets for determination of audio-facilities performance. From the original CBS 6-A Transmission-Measuring Set, developed many years ago, the flexibility, accuracy and operating convenience have been steadily improved in a series of models, culminating in the CBS 6-E design described in this article. Several of these models, including the latest, were developed in collaboration with The Daven Company.

Since the development of the CBS 6-D set in 1969, the performance requirements for broadcast audio facilities have become better standardized and increasingly strict. Two of the more influential factors contributing toward this end have been the advent of FM broadcasting and the broadcast audio standardization work of the Radio Manufacturers Association.

Modern Performance and Measuring Requirements

The FCC audio performance requirements for FM stations¹ and the RMA minimum performance standards for audio facilities² set strict limits for the over-all characteristics of complete broadcasting audio systems. Since the audio facilities system itself is generally subdivided into a number of physically separated sections such as studio control consoles, master control facilities, and transmitter audio facilities, it is apparent that each individual section of the audio system must be held to even more rigorous performance standards if the over-all system performance requirements are to be met.

¹See Federal Communications Commission “Standards of Good Engineering Practice for FM Stations.”

In addition to the establishment of minimum performance standards for audio facilities, other postwar advances in the field of audio facilities measurements include RMA standardization³ of source, input and load impedances, input signal level, output signal level, and methods of measurement.

Compliance with present-day audio-performance requirements demands high standards of accuracy for audio-measuring equipment, in order that results will not reflect the limitations of the measuring equipment itself. For example, modern measuring equipment should permit response-frequency measurements which are accurate to within ±0.1 db, and audio input and output level measurements accurate to within ±0.2 db, absolute. It should generate no more than 0.1% harmonic distortion at any audio frequency, and should respond to all harmonic components up to a frequency of at least 45 kc.

It was with such requirements as described above in mind that the development of this transmission-measuring set was undertaken.

Improvements in Design

The many users in the audio field who are already very familiar with earlier transmission sets, such as the CBS 6-D (Daven Type 6-C), will be interested in the operational and constructional fea-
atures and superior electrical performance characteristics which distinguish the CBS 6-E from its predecessors. A front-panel view of the laboratory model of the 6-E Transmission-Measuring Set is shown in Fig. 1. The 6-E set has the same seven-inch panel height of earlier models, but a somewhat greater depth. Some of its new features are summarized as follows:

1. A 10-step, 0.1-db-per-step variable "T" attenuator has been provided in addition to the 1-db-per-step and 10-db-per-step transmission level controls of earlier models.

2. All source impedances are well-balanced, with the source center-tap separately available for grounding where desired. However, equally satisfactory results obtain when either side of the signal source is grounded.

3. Switchable 20-db resistance pads provide isolation between the input terminals of the system under measurements and the source impedance-matching transformer. A mechanical interlock between the source-impedance selector switch and the decade attenuators automatically indexes the latter to show the 20-db loss of the isolation pads.

4. A pair of front-panel distortion-noise jacks provide a convenient sample of load voltage that is independent of load impedance and grounding.

5. Both input and load volume indicators have separate, continuously-variable vernier tracking and calibrating controls. Each control permits adjustments of level over a 10-db range.

6. An extremely high degree of electrical isolation has been provided between the input (transmission) and output (load) sections.

7. An input isolation transformer eliminates the former requirement that the external signal generator have a well-balanced output circuit. Operation is completely satisfactory regardless of the condition of grounding of the signal generator.

8. Electrical performance is considerably improved in a number of respects. Response-frequency characteristics are within ±0.1 db of the 1000-cps value over the entire audio range, input and output power levels are within ±0.2 db of indicated value under all conditions, and source and load impedance are within ±2% of indicated value over the entire frequency range.

The significance of the above features from an operating point of view will be made clear by a description of the 6-E circuit and its application to typical audio measurements.

Circuit

Fig. 2 shows a functional line diagram of the electrical circuits of the CBS 6-E transmission-measuring set. In common with earlier sets, the 6-E is composed of two electrically-isolated sections, the transmission section, and the load section, with separate level indicators (VU meters) for each section. The transmission section provides the required source impedance and signal level at the input of the audio system under measurement. The load section provides the proper load impedance at the output of the audio system, and indicates the load power.

A high degree of electrical isolation is required between the transmission and load sections. In the 6-E set this has been accomplished by maximum physical separation of transmission and load section components and wiring, complete electrical shielding, and full-panel-width separation of the transmission-section jacks and terminals from the load-section jacks and terminals.

Transmission Section

The input jacks (or associated rear-of-panel connecting terminals) of the CBS 6-E set provide a 600-ohm termination for the external audio signal generator. Because of the isolation transformer T1, the operation of the 6-E set is independent of the manner in which the signal generator may be grounded. When the input switch K1 is in the "On" position, the secondary winding of T1 sees a 600-ohm load made up of the 300-ohm source resistor R1 and the 300-ohm impedance of the decade attenuator circuit. The input volume indicator circuit is bridged across the attenuator side of the switch K1, and since in normal operation the reading of the input VU meter VI-1 is kept con-
stant, the desired effect of a zero-
impedance signal generator is obtained at
this point in the circuit. $R_1$ then pro-
vides the required 300-ohm source im-
pedance for the decade attenuators, at
the expense of a 6 db loss in the received
signal level.

The input volume indicator circuit, which has a bridging input impedance of approximately 7500 ohms, includes the frequency-compensating and tracking net-
work $E_1$, the VU meter range attenuator ATT-4 and the building-out resistors $R_3$ and $R_5$. The network $E_1$ has a mid-fre-
quency compensating signal-pedance appearing
Thus the compensating network $E_2$ and the source imped-
ance-matching transformer $T_2$. Thus $E_1$ serves as a level-tracking net-
work so that the signal level read on the VU
meter VI-1 will be equal to that appearing at the source jacks, low, of
course, any attenuation set up in the attenuators ATT-1, ATT-2, and ATT-3.

The capacitor included in $E_1$ equalizes the high-frequency response of the VU
meter VI-1. $R_2$ is a continuously-variable, screw-driver-operated vernier control which permits level-tracking ad-
justments of VI-1 over a 1-db range. Resistors $R_4$ and $R_5$ are normally
shorted out by contacts on the input
volume-indicator jacks. However, when
a patch plug is inserted in the input
volume-indicator jacks, the normal cir-
cuit is lifted, and the VU meter VI-1 may be used as an entirely isolated, auxiliary VU meter. Under this con-
tion the resistors $R_4$ and $R_5$ serve as the VU meter building-out resistors, and
$R_2$ permits a continuously-variable cali-
brating adjustment which is entirely
independent of the normal calibrating control $R_2$.

The 300-ohm decade attenuators ATT-
1, ATT-2, and ATT-3 attenuate the signal appearing at the source jacks by
any desired amount up to a maximum of
111 db. The impedance matching trans-
former $T_2$ effects an impedance match
between the desired source impedances of 600 and 150 ohms and the 300-ohm attenuators. The secondary winding of
$T_2$ is carefully balanced with respect to
its electrical center tap, is well-shielded
electrostatically from the primary wind-
ing, and has very low capacitance to
ground. This type of construction makes
it possible to operate the secondary wind-
ing into a variety of balanced, un-
balanced, or one-side-grounded circuits.

The network $E_2$ serves the double pur-
pose of equalizing the response of $T_2$ at
the extremes of the frequency range and
correcting for impedance mismatches due
to the resistance of the windings of $T_2$.

The appropriate connection of $T_2$ to
the source jacks is effected by a panel-
mounted, eight-position source-impedance switch. In two positions of the source-
impedance switch the 600 or 150 ohm
secondary windings of $T_2$ are connected
directly to the source jacks, and may be
operated with either side of the source
grounded or ungrounded, as desired. The
center-tap of the $T_2$ secondary is con-
ected to a front-panel jack, where it is
readily available for connecting to the
audio system under measurement, or for
grounding to the chassis of the trans-
mission set. In two other positions of
the source-impedance switch internal
terminating resistors $R_6$ of 600 or 150
ohms are switched across the corre-
sponding secondary windings of $T_2$, thus
providing terminated signal circuits of
600 or 150 ohms iterative impedance,
respectively, at the source jacks. These
latter connections are especially useful
when measuring the transmission char-
acteristics of bridging amplifiers and audio
systems with high input impedance.

In the remaining input positions of the
source-impedance switch, 20-db fixed
resistance pads $P$ are automatically
inserted between the 600-ohm secondary
winding of $T_2$ and the source jacks.

These pads provide source impedances of
600, 250, 150 and 30 ohms, respectively,
and serve to isolate the input terminals
of the audio system under measurement
from the impedance-matching trans-
former $T_2$. The pads also make it
possible to determine the required source
impedance of 250 and 30 ohms without
necessitating additional taps on the
secondary winding of $T_2$. The resulting
simplification in the design of $T_2$ pays
dividends in improved performance
characteristics. The center taps of these
pads are connected to the center-
tap of the secondary winding of $T_2$ and
the C.T. jack. If the time should come
when existing audio facilities are entirely
superseded by new equipment having
RMA standard source and load imped-
ances, there will be no further need for the
250 and 30 ohm source impedances
provided in the 6-E design.

**Load Section**

The circuit of the load section is similar in many respects to that of earlier
transmission sets. The six-position load-
impedance switch provides load imped-
ances of 600, 250, 150, 16, 8, or 4 ohms
at the load jacks. The major part of these
impedances are made up of power-type
load resistors. In shunt with these
resistors is the multi-tapped primary
winding of the impedance-matching trans-
former $T_3$. The secondary winding of
$T_3$, which is operated with one side
grounded, supplies signal voltage to the
load-volume-indicator circuit and a pair of
front-panel distortion-noise measuring
jacks. The load volume-indicator cir-
cuit consists of the standard VU
meter VI-2 and the associated VU-
meter attenuator ATT-5, the series
calibrating resistor $R_7$, and the fre-
quency-compensating network, $E_3$.

The loading effect of the load-volume-
indicator circuit and the transformer $T_3$
on the impedance seen at the load
jacks is taken into account in selecting
the exact values of the load resistors so
that the net impedances seen at the load
jacks is within 2% of the absolute values

---

**Fig. 3. Application of CBS6-E Transmission-Meas-
uring Set to a typical audio-measuring set up.**

Only an audio signal generator and a distortion
and noise meter are required in addition to the CBS 6-E
set for any of the measure-
ments generally made of
audio system performance.

The simplicity of the setup from an operational stand-
point considerably enhances the accuracy and repe-
tability of the results.

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indicated by the dial markings on the load-impedance switch.

In a similar manner to that of the input volume-indicator circuit the load VU meter is "normaled" through the load volume-indicator jacks, which latter carry a set of shorting contacts for the building-out resistors $R_7$ and $R_8$. Also similarly to the input volume-indicator circuit, the continuously-variable resistors $R_5$ and $R_6$ act as independent vernier calibrating resistors for the VU meter VI-2 over a 1-dB range, depending upon the respective usage of the latter as a load power indicator or as an auxiliary standard volume-indicator.

The transformer $T_3$ is so connected that the signal voltage delivered to the distortion-noise jacks and the load volume-indicator circuit is independent of the position of the load-impedance switch, for a given power in the load circuit. The voltage appearing at the distortion-noise jacks is also independent of the manner in which the load circuit of the system under measurement may be grounded. This is especially convenient when feeding a distortion and noise meter having an input circuit of the high-impedance, one-side-grounded type. Since it is necessary that the distortion meter be supplied with at least the third harmonic of signal frequencies as high as 15,000 cps, the transformer $T_3$ is designed to pass frequencies up to 45,000 cps with less than 2-dB attenuation.

### Electrical Performance

A few of the outstanding performance characteristics of the CBS G-E set are listed below:

1. The over-all frequency-response characteristic through both transmission and load sections is within ±0.1 db of the 1000-cps response from 50 to 15,000 cps, for all settings of the variable attenuators in the transmission section, and for all positions of the source-impedance and load-impedance controls.

2. The frequency-response characteristics of either the transmission section or the load section considered separately is within ±0.1 db of the 1000-cps response from 50 to 15,000 cps, for all settings of the variable attenuators in the transmission section and for all positions of the source-impedance and load-impedance controls.

3. Assuming that the load-circuit volume indicator has been previously calibrated against a known standard power level at 1000 cps, and that the input-circuit volume indicator has been adjusted to track with the load circuit volume indicator at 1000 cps, the source and load powers indicated by dial markings are within ±0.2 db of the true powers for all positions of the source-impedance and load-impedance controls and all settings of the variable attenuators in transmission section, and for any frequency between 50 and 15,000 cps.

4. The source and load impedances provided by the various positions of the source-impedance and load-impedance controls are essentially resistive in nature and within ±2% of the values indicated by dial markings over the entire frequency range between 50 and 15,000 cps, and for all power levels within the operating range of the transmission set.

### Application

The application of the CBS G-E set to a typical audio measuring setup is shown in Fig. 3. Note that only two other items of measuring equipment are required in addition to the transmission set. The audio signal generator is connected either to the input jacks, as shown, or to the associated input terminals behind the front panel of the transmission set. The input terminals of the audio system under measurement are connected to the source jacks of the G-E set, while the output terminals of the audio system are connected to the load jacks. A distortion meter of the high-impedance input type is connected to the distortion-noise jacks.

In the setup shown in Fig. 3, a balanced, ungrounded, 150-ohm signal source is indicated. When measuring high-gain audio systems the source switch will

### Commercial Disc Recording and Processing in England

A report of a lecture delivered in London by B. E. G. Mittell of E. M. I. Studios, Ltd.

At a meeting of the Radio Section of the Institution of Electrical Engineers held in London in December, 1947, an informal lecture on aspects of commercial disc recording and processing was given by Mr. B. E. G. Mittell, M. I. E. E., Managing Director of E. M. I. Studios, Ltd.

Mr. Mittell stated that at present commercial considerations appeared to confine the disc record to the speed, diameters and groove spacing that were in common usage. The debatable point arises, however, whether the future of the disc record is to be limited in playing-time, in frequency range and in dynamic range. Furthermore, whether it should always be destined to run at an excessive range of linear speed. Non-commercial records already provided interesting departures from the "common usage" link.

Taking countries other than Great Britain into account, there existed a serious degree of divergence within the so-called "common usage," due largely to two causes, namely, the ease with which departures can be made from the classic frequency characteristics; and the use of reproducing points, which, being of a permanent or semi-permanent nature, do not adapt themselves to the shape of the individual record groove. Discussion was particularly invited towards a measure of agreement in Great Britain, and an exchange of views elsewhere.

Demonstrations were given of recorded quality and surface noise successively in the original recording, the metal "mother" and the final "pressing." Recording up to 20 kc/s was demonstrated very effectively to illustrate the lecturer's points.

Eleven speakers took part in the ensuing discussion. It was apparent that there was no fundamental disagreement with the proposals put forward by Mr. Mittell for standardization of groove, stylus and recording characteristics. It was thought that a preliminary committee, on which the principal British record manufacturers were represented, would have no difficulty in reaching tentative agreement, and that their findings might then form the basis of a British Standard.

Attention was given mainly to recording at 78 r.p.m., and it was commented that the proposed recording characteristic suggested by the National Association of Broadcasters of America was essentially a 39 1/3 r.p.m. standard; it could not be said to have met so far with universal acceptance even in the U.S.A.

### Pre-emphasis

Most speakers believed that some degree of pre-emphasis of high frequencies is desirable with present recording materials, but that the amount proposed by the N. A. B. was excessive and would lead to tracing distortion at the modulation levels usually recorded on commercial discs. A rise of 3 db from 3,000 c/s to 6,000 c/s and a further 3 db, from 6,000 to 12,000 c/s was suggested as a suitable compromise.

[Continued on page 57]
Telephone Recording

E. W. SAVAGE*

PART 1 — Problems involved in using this new recording service.

Using the Tele-Mike in telephone recording. Courtesy Miles Reproducer Co.

ON NOVEMBER 28, 1947 the Federal Communications Commission issued its long-awaited order authorizing the general public to make voice recordings of interstate and foreign telephone calls. A primary stipulation of this order is that means must be supplied to notify all parties to a telephone call, when their conversation is being recorded. Such notification will issue from the recording station in the form of a “tone warning signal” automatically injected into the telephone line and repeated at short intervals while the recorder is operating.

Recorders, themselves, will be connected to the telephone lines by plugging into a receptacle which the telephone companies will furnish. Electronic apparatus for generating the tone warning signal may be supplied by either the telephone companies or the recorder manufacturers, so long as the tone signal generated meets specifications set by the Commission.

Originally, the November 28th order was to have become effective January 15, 1948. At the request of the telephone companies, however, the effective date was extended to March 1, to allow further time for engineering and quantity production of the tone signal generator. Adding to this delay is a deceiver later requested by one of the manufacturers. So it may well be late summer or fall of this year before telephone subscribers can get the necessary terminal installations of tone signal generator and recorder-to-telephone-line connection. Technical specifications of this terminal apparatus are discussed later herein.

The important thing, though, is that we are finally, to have telephone recording made generally available. In the past, the only use of recording from message toll circuits which telephone companies have openly “tolerated,” if not “authorized,” has been that by governmental agencies and the Press. The forthcoming widespread, general application of the art is of direct interest to the audio engineer for several reasons.

First, because many of you will be asked for advice in the selection or operation of equipment.

Further, and much more important, there are still many problems which you, as audio engineers, can help solve and thereby make telephone recording much more efficiently usable.

For example, recorders and reproducers should be improved so they will automatically correct for frequency losses, as well as for intensity losses, sustained by speech which is telephoned over message toll circuits.

Also, research in psychoacoustics could very profitably be applied to improve the selection, training and performance of personnel who must type the recorded messages.

It is vitally essential at the outset to realize what is still fundamentally needed in telephone recording and reproducing apparatus, and why it is needed. A perspective is wanted—a perspective of the preconceived ideas, the erroneous notions, the incomplete thinking about telephone recording, which are to be found in some high quarters in the industry. These must be changed if the audio engineer is to be allowed the time and money necessary to develop the improvements which the user of equipment so urgently needs.

In a nutshell, we face the fact that the faithful reproduction of all the fundamental speech sounds requires a considerably wider frequency band than is accommodated by most message toll telephone circuits.

Frequency Attenuation

For the most efficient use of telephone recording, some means—automatic electronic—should be incorporated in the terminal equipment to compensate for circuit transmission losses in frequency characteristics.

No one is more keenly aware of the truth of these statements than the experienced user of telephone recording, who must quickly deliver accurate typed transcripts of telephoned dispatches. The engineer, or professional recordist, too often relegates speech reproduction to a second-rate category—after music. Many regard telephone recording engineering as a cut-and-dried proposition, offering little incentive for new creative thinking. The art is viewed as the offspring issuing from the union of two old arts—each of which, independently, has gotten along pretty well for years—telephony and office dictation recording. But when these two old arts are merged, to provide a new service, new problems arise. These problems must be set down and weighed, if all concerned—manufacturer, engineer, and user—are to derive the maximum in sales, profits and efficiency from the use of the service.

Sales Potential

Since the amount and nature of engineering effort deservedly expended along a given line are related to the sales potential, we may well ask:

1—For what purposes will people use telephone recording?

2—Which will absorb the most machines?

3—What use will absorb the most machines does that use require?

In broad terms, people will buy telephone recorders for three main uses:

1—To record random telephone calls.

2—To record information which is now regularly telephoned, but which at present is noted or summarized only by pencil, or mentally.

3—To communicate written dispatches which now are not telephoned, but which may be slower, or more expensive telegraph, cable, TWX teletypewriter, or airmail.

The first two applications are the easiest to sell, easiest to operate, and require far less perfection of equipment and operating technique than the third. Naturally, they will be the first to be exploited by the manufacturer.

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Primarily, the first two applications are valuable for purposes of reference and convenience, rather than for economy in communication.

In many instances, with these two uses no typewritten transcript is required. If required, it is not always mandatory that the transcript be letter-perfect. The executive, for example, who spoke on a call, can be asked to fill in the missing word here and there, which his secretary could not hear correctly when typing the conversation.

The third application—the use of telephone recording to communicate written dispatches which are now sent through other channels—will, in the writer's opinion, provide the largest long-range sales potential, if equipment and operating technique are sufficiently perfected.

The economic factors are most favorable for the exploitation of this means of communication. Telephone rates are most attractive, competitively, in terms of cost per word transmitted, whether to a suburban or an overseas point. Direct contact can be made with any one of over 50 million telephones throughout the world. There is no delay for terminal pick-up and delivery of the message, as with telegraph and air-mail. The connection established is two-way, which means that a dispatch can be both sent and answered immediately on a single call. However, there are serious technical limitations—in the transmission characteristics of message toll telephone circuits—which restrict the easy application of telephone recording to the general communication of written dispatches.

This statement may be questioned in the light of the tremendous patronage which telephony receives. But it should be emphasized that this traffic is almost wholly of a conversational nature. It is not the transmission of prepared written matter. With conversational telephony, the parties to a call usually have background knowledge of the subject which they are discussing. They exchange idiom units, rather than specific word units, or sound units. And the occasional loss of a word in conversation may not impair the conveyance of an idea. Background knowledge of the subject discussed serves automatically to correct for much of the transmission distortion encountered.

But, in telephoning written dispatches, the text is usually transmitted and received by personnel other than the original sender and the ultimate addressee. These third parties do not always have a thorough background knowledge of the subject matter conveyed. Therefore, they must depend upon accuracy in the communication of each word—each sound.

Here is where the message toll circuit frequently falls down. Many have transmission losses which prevent the accurate delivery of critical speech sounds. Even a "good" circuit accommodating frequencies up to 3,000 cycles per second will transmit the sound "s" with a 60% loss in articulation.

Consequently some means must be employed to counteract these losses and insure correct transmission. At present, it is unnecessary at the sending point for the announcer, or reader, to "tag" those critical speech sounds with special identification as he reads the text, so that they may be correctly received and typed at the recording terminal, despite poor circuits.

This procedure, although not an ideal one, has worked satisfactorily for over 12 years in press installations made by the writer, where accuracy and speed of communication are paramount, and where the quality of circuits employed (during wartime, particularly) left much to be desired.

**Important Points**

With the field shortly to be opened for exploitation, the important questions which arise are: How far will the recorder manufacturers go in acquainting their non-technically minded customers with these "facts of life"—the effects of circuit transmission losses on the accuracy and speed with which recorded dispatches are typed? Will a technique of operation, and specialized personnel training, be delivered along with the equipment? Will research be started, looking toward automatic correction of these circuit losses, by the recording and playback equipment?

It is not too difficult to understand why the manufacturer, whose experience for years has been with office dictation machines, is slow to admit that real problems do still exist in the engineering of a truly efficient telephone recorder.

The important distinction, however, is that with dictating equipment, the manufacturer could control the design and performance of all component parts of the entire sound system—from the lips of the dictating executive to the ears of the transcribing typist ... The input means — speaking-tube to cutting-head, or microphone to amplifier—could be quantity-produced with the necessary uniformity and matched to the rest of the system.

But, with telephone recording, these vital input means are not controlled by the recorder manufacturer. They are telephone company property. And, the various types of microphones (in telephone mouthpieces) encountered in coin-booth, hotel-room, residence and office telephones— together with their age and condition of use—may be found as

<table>
<thead>
<tr>
<th><strong>TABLE I</strong> Contrasted Operating Conditions Telephone Recording vs Studio Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Telephone</strong></td>
</tr>
<tr>
<td>1—Speaker</td>
</tr>
<tr>
<td>2—Pick-up Point</td>
</tr>
<tr>
<td>Often noisy room or one with poor acoustics.</td>
</tr>
<tr>
<td>3—Microphone</td>
</tr>
<tr>
<td>Telephone transmitters widely variable in sensitivity and frequency response.</td>
</tr>
<tr>
<td>4—Input-to-line Level</td>
</tr>
<tr>
<td>Variable intensity of telephone talkers.</td>
</tr>
<tr>
<td>5—Transmission Lines</td>
</tr>
<tr>
<td>Top cut-off usually around 2000 to 2500 c.p.s. Often low intensity level. Interfering line noises.</td>
</tr>
<tr>
<td>6—Recorder</td>
</tr>
<tr>
<td>7—Play-back</td>
</tr>
<tr>
<td>Interrupted by stop, backspace and repeat for typing. Often interfering room noise.</td>
</tr>
<tr>
<td>8—Purpose</td>
</tr>
<tr>
<td>Business communication which must be typed letter-perfect.</td>
</tr>
</tbody>
</table>

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TABLE II
Relative Frequency of Occurrence of Fundamental Speech Sounds and Articulation Loss When Transmitted Over Flat-Response Systems Having the Indicated Circuit Frequency Bandwidths

<table>
<thead>
<tr>
<th>Articulation Loss When Bandwidth (a)</th>
<th>Rela. Freq.</th>
<th>Sound Key Occurrence</th>
<th>c.p.s.</th>
<th>c.p.s.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Key Occurrence</td>
<td>200-2000</td>
<td>200-2000</td>
<td>200-3000</td>
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<td>i tip</td>
<td>7.94</td>
<td>1%</td>
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<td>n</td>
<td>7.24</td>
<td>13%</td>
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<td>7.13</td>
<td>16%</td>
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<td>3%</td>
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<td>3.69</td>
<td>0%</td>
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<td>3.71</td>
<td>1%</td>
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<td>e ten</td>
<td>3.44</td>
<td>3%</td>
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<tr>
<td>th then</td>
<td>3.43</td>
<td>(No figures available)</td>
<td></td>
<td></td>
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<tr>
<td>a top</td>
<td>3.32</td>
<td>3%</td>
<td></td>
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<tr>
<td>z</td>
<td>2.97</td>
<td>22%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>2.78</td>
<td>2%</td>
<td></td>
<td></td>
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<tr>
<td>k</td>
<td>2.71</td>
<td>12%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a tape</td>
<td>2.35</td>
<td>2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v</td>
<td>2.28</td>
<td>14%</td>
<td></td>
<td></td>
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<tr>
<td>v w</td>
<td>2.08</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>2.04</td>
<td>20%</td>
<td></td>
<td></td>
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<tr>
<td>l</td>
<td>1.84</td>
<td>32%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>1.81</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>1.81</td>
<td>3%</td>
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</tr>
<tr>
<td>o tone</td>
<td>1.63</td>
<td>0%</td>
<td></td>
<td></td>
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<tr>
<td>n tool</td>
<td>1.60</td>
<td>3%</td>
<td></td>
<td></td>
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<tr>
<td>i dke</td>
<td>1.59</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>1.26</td>
<td>2%</td>
<td></td>
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<tr>
<td>ng hang</td>
<td>0.96</td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sh shell</td>
<td>0.82</td>
<td>17%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>0.74</td>
<td>14%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>u</td>
<td>0.69</td>
<td>6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>0.60</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ou our</td>
<td>0.59</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>eh ch chalk</td>
<td>0.52</td>
<td>28%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j</td>
<td>0.44</td>
<td>12%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>th thin</td>
<td>0.37</td>
<td>49%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ew fek</td>
<td>0.31</td>
<td>(No figures available)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>oi oil</td>
<td>0.09</td>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>zh azure</td>
<td>0.05</td>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

variable in sensitivity and frequency response as are the circuits which link them to telephone recording machines at some distant point. Under these conditions of operation, the recorder design problem is notably different from that in an ordinary dictating machine.

Accuracy Standards

Another changed condition which the manufacturer bumps into when he steps from the dictating machine field to the telephone recorder field, concerns the accuracy standards of competitive systems. The only practical alternative to the dictating machine was the stenographer taking shorthand notes. And, with all glory to those experts still in the field—the crack court reporters—stenography, as a whole, admittedly has a lower accuracy rating than is achieved by machine dictation.

But with telephone recording, used as a medium for communicating the written word, the reverse is true. Competitive systems of telegraph, teletypewriter and facsimile have already established high accuracy standards with which it is difficult to compete.

In addition, there is also the important consideration of intransit time. The competitive advantages of direct telephone contact between sender and addressee are quickly lost if the typing time of a telephoned dispatch is long drawn-out, and if the transcript, itself, is finally delivered with errors and with blank spaces for missing words.

Further to point up the problems peculiar to telephone recording, it may be of interest to contrast the factors involved with those of studio recording. While most of the differences shown may be well known, their cumulative effect on transmitted intelligibility is emphasized when the two systems are compared. This is done in Table I.

Right at the start with telephone recording, we often run into trouble with the untrained speaker. In many instances, he would still have a poor intelligibility rating even over the finest transmission system. But, at least, someone better qualified can be substituted to read copy, or the careless reader can be taught a few essentials about proper dictation.

With overseas or long-distance calls one will encounter the foreign accent or sectional peculiarities of pronunciation, with which the transcribing typist will find it difficult to cope for a week or so. Thereafter, things should run more smoothly.

A precaution that should be taken wherever possible, especially at stations regularly used as transmitting points, is to make sure that the latest type telephone set is used. If the microphone in the telephone transmitter is sluggish, often caused by accidental dropping of the instrument or excessive humidity, it will obviously impair transmission no matter how good the lines are to which it is connected.

Where the need is for a letter-perfect transcript of a business communication, better methods could be devised for selecting and training personnel with emphasis on detailed analyses of individual hearing acuity, as well as on co-ordination and typing speed.

The general impression one gets is that telephone recording, with all the technical restrictions now inherent in its operation, is pretty much of a plow-horse assigned to do a race-track job. What is devoutly hoped is that the audio engineer can cross-breed electronically into the draft animal those much-needed characteristics of the agile, sensitive thoroughbred.

Articulation Loss

Let us now examine, specifically, the articulation loss sustained by speech sounds when they are transmitted over circuits which have top-frequency cut-offs at 2000, 2500 and 3000 c.p.s., respectively, (assuming that the circuit frequency response above 200 c.p.s. is flat).

"Articulation loss" represents the percentage of times a sound may be incorrectly identified. A loss of 60%, for example, means that out of 10 an error is likely to be made in correctly recognizing the sound which is so rated.

Just which sounds are most seriously affected? How important are they? How often do they occur during the telephoning of a page of written matter?

Fortunately, a great amount of work has already been done to answer these questions—by Godfrey Dewey1 and by Dr. Harvey Fletcher2 and his colleagues of Bell Telephone Laboratories. The information shown separately and in different form in Dr. Fletcher’s “Speech and Hearing” pp. 81-84 inc. and 279-280 inc., has here been combined by the writer in compiling the tables which follow.

Dewey’s tabulations were based on “an extensive study of the frequency of occurrence of words, syllables, and fundamental vowel and consonant sounds in representative written material.

Dr. Fletcher’s graphs were plotted from information obtained in a series of exhaustive reader-listener tests, wherein the fundamental speech sounds were passed through transmission systems of varying frequency bandwidth and identified by listeners with the indicated error.

Table II lists the fundamental speech sounds of English according to the relative frequency of their occurrence in written matter, and shows as well the articulation losses sustained by the sounds when they are transmitted over systems which have the indicated top-frequency cut-offs, (assuming flat response above 200 c.p.s.).


TABLE III
Sounds Having Over 10% Articulation Loss When Top Circuit Frequency Cut-Off is 2000 c.p.s.

<table>
<thead>
<tr>
<th>Sound</th>
<th>Rela. Freq.</th>
<th>Articulation Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>7.24</td>
<td>13%</td>
</tr>
<tr>
<td>s</td>
<td>7.15</td>
<td>29%</td>
</tr>
<tr>
<td>a</td>
<td>5.55</td>
<td>55%</td>
</tr>
<tr>
<td>m</td>
<td>7.15</td>
<td>29%</td>
</tr>
<tr>
<td>k</td>
<td>7.27</td>
<td>14%</td>
</tr>
<tr>
<td>v</td>
<td>2.28</td>
<td>14%</td>
</tr>
<tr>
<td>p</td>
<td>3.69</td>
<td>20%</td>
</tr>
<tr>
<td>h</td>
<td>1.84</td>
<td>36%</td>
</tr>
<tr>
<td>sh</td>
<td>0.82</td>
<td>17%</td>
</tr>
<tr>
<td>ch</td>
<td>0.74</td>
<td>14%</td>
</tr>
<tr>
<td>th</td>
<td>0.59</td>
<td>&quot;</td>
</tr>
<tr>
<td>zh</td>
<td>0.37</td>
<td>49%</td>
</tr>
</tbody>
</table>

Total 33.65 Unweighted Average 25%
spouse between 200 c.p.s. and the top limit.)

With the many thousands of message toll circuits in use today, it is obviously difficult to say exactly what their overall average top-frequency cut-off would be. One will sometimes talk over circuits which would easily pass 3000 c.p.s. and better. But there are also some "split" circuits over which it is difficult to pass even an 1800 c.p.s. tone.

Let us consider the problem, starting with a 2000 c.p.s. cut-off. In Table II the sounds which are subject to 10% or more articiation loss over this kind of circuit, are carried forward to show losses sustained when the cut-off frequency is raised to 2500 c.p.s. and then to 3000 c.p.s. Sounds having less than 10% articulation loss with a 2000 c.p.s. cut-off are not extended to other circuit categories.

Figures for the sound th, as in then, are not included in Dr. Fletcher's curves. The th sound which he does list is the fricative th, as in thin. With the relatively high frequency of occurrence of th as in then, it would be desirable to know whether, too, suffered an articulation loss in excess of 10% in transmission.

Curiously enough, articulation of the sound s falls off as the top-frequency cut-off is raised from 2000 to 2500 to 3000 c.p.s. From 3000 c.p.s. onward, however, the recognition curve swings upward rapidly, and there is practically no loss at 5000 c.p.s.

In Table III we lift out from Table II, for closer study, those sounds having more than 10% articulation loss when passed over a circuit whose top cut-off is at 2000 c.p.s. There are 13 such sounds. Their total frequency of occurrence is 33.6%, which means that every third sound encountered in the reading of a printed page will be one of these shown. Articulation loss is also high in several instances. In fact, the unweighted average loss for the entire group is 25%. (A possibility of error in recognition once out of every four times heard.)

Table IV shows what happens when the top circuit frequency cut-off is raised to 2500 c.p.s. Under such conditions we find that there are 6 sounds which are subject to considerably more than a 10% articulation loss. Their total frequency of occurrence is 17.3%, and their unweighted average loss is 38%. Table V shows that little improvement in recognition of these sounds is achieved by lifting the top frequency cut-off to 3000 c.p.s. In fact, only one sound, ch, as in chalk, is eliminated from the group. The total frequency of occurrence of the remaining sounds is 16.5%, and the unweighted average articulation loss 29%.

With the top cut-off at 5000 c.p.s., three of the sounds: t, s, and z, have practically zero loss, while f still suffers a loss of 12%, and th 22%.

In applying the foregoing information to a circuit which cuts off, say at 3000 c.p.s., it would be erroneous to take the percentages shown and categorically announce that, in every instance, 29%, or 4.8% of the words would be inarticulate. This would mean 45 words out of each 1000 (which the writer has encountered on rare occasions). The point is, that an error of even one-tenth that amount is inadmissible.

Other Factors

The degree of error committed in transcribing is in great measure determined by the typist's background knowledge of the subject matter. Very often, as we all know, an indistinct sound can be correctly identified from the other sounds to which it is joined in a word.

**TABLE IV**

<table>
<thead>
<tr>
<th>Sound</th>
<th>Rel. Freq.</th>
<th>Occurrence</th>
<th>Articulation Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>7.13</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>s</td>
<td>4.55</td>
<td>37%</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>2.97</td>
<td>21%</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>1.84</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>ch</td>
<td>.52</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>th</td>
<td>.37</td>
<td>41%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>17.38</td>
<td>Unweighted-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average 30%</td>
</tr>
</tbody>
</table>

Note: (Excluding th, as in then.)

**TABLE V**

<table>
<thead>
<tr>
<th>Sound</th>
<th>Rel. Freq.</th>
<th>Occurrence</th>
<th>Articulation Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>7.13</td>
<td>18%</td>
<td></td>
</tr>
<tr>
<td>s</td>
<td>4.55</td>
<td>59%</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>2.97</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>1.84</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>th</td>
<td>.37</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>16.86</td>
<td>Unweighted</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average 29%</td>
</tr>
</tbody>
</table>

Note: (Excluding th, as in then.)

For the 100% articulation of all the fundamental speech sounds, a typist would not have to guess, but could correctly type the difficult or unusual word from its component sounds, even though she was unfamiliar with its meaning or peculiar usage.

This brings us to the real engineering problem at issue. Just how are we going to replace at the recording terminal, those frequency components which have been lost during the circuit transmission? Is it really a question of "trying to make water run up hill." That remains for the competent and specialized audio engineer to decide. The writer's position at this point is to state the problem and emphasize its importance, rather than to offer a solution. However, one research staff working along this line is meeting with encouraging results.

Before dismissing the problem as insoluble it might be advisable to examine in greater detail the actual structure of those speech sounds which are most affected by high frequency cut-offs. Even the most poorly rated among them are distinguished by the human ear at least part of the time when transmitted over narrow-band circuits. What happens the rest of the time?

Do recognition errors occur because the ear is not allowed sufficient time for full excitation? Or do some people speak the sounds without certain frequency components (below 2000 c.p.s.) which others use? Certainly, with many of the sounds, there is substantial recognition information in the band below 2000 c.p.s.

Is it possible that recognition could be achieved by electronic means which do not require so long an excitation time as the ear? Could such electronic means be employed first to recognize, and then to trigger off an appropriate synthetic sound source to supply the ear with full information required for accurate recognition?

In the structural analyses of fundamental speech sounds it might also be helpful to explore a new approach. So much of existing literature implies that speech sounds are distinguishable one
Design of Electronic Organs

WINSTON WELLS

PART III

In this instalment, the author presents a detailed discussion of the Hammond organ.

When Edison invented the gramophone, a train of thought was started which has persisted to this day, namely, "Why not record the sound of a musical instrument, giving each note of the scale a separate sound track. Then, a keyboard might be connected, each key controlling the pickup device for its associated sound track. A musician, playing upon the keyboard, would have the resources of the original instrument at his command and, in addition, could couple any number of other instruments, similarly recorded, to the same keyboard."

With the advent of sound on film recording, several inventors constructed instruments in which the sound tracks were cut or photographed upon rotating discs or drums. The moving pattern was used to modulate a beam of light, which was picked up by a photo-electric system. The signal was then amplified and fed into a loudspeaker.

Some of these photo-electric organs were excellent musical instruments, but they required so high a degree of precision in their construction that they never became commercially practicable. There were numerous attempts at using synchronous alternators or phonic wheels for the production of musical signals. Most of these failed for the same reason.

The Hammond Organ

In 1934, Laurens Hammond completed the design of the instrument which bears his name. The Hammond Organ, which uses phonic wheels to generate its signals, was immediately successful. Since its introduction to the public in 1935, it has created a revolution, both in the musical world, and among musical instrument manufacturers.

The reader who is seriously interested in electronic organ design, is urged to secure copies of two of Mr. Hammond's patents, Nos. 1,956,350 and 2,159,305, which describe the Hammond Organ in considerable detail. Each is a master-piece of clear thinking upon this subject, and they give the reader a good picture of the thoroughness with which a comparable project must be planned.

If there is any single reason why this instrument has been so overwhelmingly successful, it lies in the fact that the inventor has given as much consideration to the means for making it as he has given to the musical requirements it was designed to meet.

The Hammond Organ is of interest to us for several reasons, the first of them being that it has made money for its manufacturers. To do this, a product must be well designed, manufactured by efficient methods, properly advertised and distributed through outlets readily accessible to the consumer. A weakness on any one of these points is likely to prove fatal to the entire project.

The pipe-organ business was built upon a class of workers which has practically ceased to exist; highly skilled artisans, who learned their craft through the apprenticeship system. Under this order it was impossible to apply anything resembling modern production techniques, nor could the more recently discovered materials be used to their greatest advantage.

With Mr. Hammond and his staff, came the "new look" in the organ industry. Full mass production methods were introduced. Jobs were broken down into fabrication, assembly and inspection, the first being done largely by machines; the latter two being aided by special jigs and instruments. All equivalent parts were made completely interchangeable, there being no hand fittings of parts required in the assembly of the entire instrument. Practically all of the work was such that it could be done by unskilled and semi-skilled labor.

The manual keys of the new instrument were hollow and made of molded Plaskon. The key action was of aluminum, the low mass of which permitted extremely rapid movement and, at the same time, made for compactness and durability of the mechanism.

Platinum-Iridium Contacts

The manual and pedal contacts were platinum-iridium, making upon palladium bus bars. The contact leaves fitted into punched bakelite spacers; the complete switch assembly was sealed in a metal housing, the contacts requiring no cleaning or adjustments during the life of the instrument.

The tone generator assembly contained ninety-one phonic wheels, gear-driven in pairs from a single synchronous motor. In spite of this being a unit of high precision, all final adjustments could be made after assembly, with the aid of a pair of pliers and a volt-meter.

No wood was used in the entire instrument, except for the pedal-board and bench, and the cabinets for the console.

*307 E. 45th St., New York City.

Fig. 1. Detailed view showing principal controls. Precept keys are reversed in color to avoid confusion with playing keys.
and speaker; the latter two items being fashioned on the assembly line in the manner of radio cabinets.

The overall result was a durable, high-quality instrument which could be sold at about one-fifth the price of its nearest pipe-organ competitor.

This, along with the instrument's portability, compactness, and low current consumption, gave it a potential market at least a thousand per cent greater than could be expected for the pipe organ. For the first time, it became practicable to have an organ in a small private home or an midtown apartment. Many musicians in the entertainment field bought their own instruments, taking them from job to job; they became quite popular in nightclubs and dining rooms.

Because of the Hammond Organ's enormous dynamic range (about 60 db) and its instantaneous attack, it became an extremely valuable instrument in the band and orchestra, lending "bigness" of tone to an otherwise thin ensemble.

It might also be added that the instrument is inherently incapable of getting out of tune, since the intervals of the scale are fixed by the gear ratios in the drive to the plonk wheels, and the generator, as a whole, is driven by a synchronous motor. In most communities, the utility companies hold the frequency of their alternating current to within plus or minus 0.1% of the nominal frequency (usually 60 cycles).

There were some features of the Hammond Organ which the organists received with mixed sentiments. Among these, was a radically new system of registration control, combined with a novel circuit for the synthesis of musical timbre. There were no stop tabs, or anything resembling them; instead, there was a group of nine "draw-bars" for each manual. They were little metal slides terminating in plastic knobs, and they could be pulled out of the console in steps numbered from zero through eight.

One drawbar of each group controlled the strength of the fundamental tone on its associated manual. Another was for the sub-octave, and there was one for the fifth or "quint." The remaining six drawbars controlled the second, third, fourth, fifth, sixth and eighth harmonics of the tone, the seventh harmonic being skipped for a reason which will be explained later.

As a drawbar was pulled out, the strength of its signal increased about three db with each step. Thus it was possible to blend a fundamental and up to six of its harmonics to synthesize a vast number of tone colors.

At the left-hand end of each manual was a group of keys which made available nine preset tone combinations. These were derived through the same process of tone synthesis, and were set up on a recorder board in the rear of the console.

Organists' Opinion

The organists' reaction to this innovation ran the gamut of approval and disdain. In the opinion of some, it represented a major advance in the art of registration control, since it made possible an extraordinarily good tonal balance between the two manuals and the pedals.

Others regarded it as hopelessly awkward and inflexible, since it was difficult to change the setting of the drawbars with accuracy while playing. No one could modify the registration on a preset key in the manner in which he would manually add or take off a stop, when playing the combination pistons of a pipe organ.

By far the greatest objections, however, were directed at the quality of tone produced. While some ears seem to be satisfied by tones containing only the lower order harmonics, it is generally recognized that many musical tones

[Continued on page 39]
Notes on Using High-Power Ultrasoundics

S. YOUNG WHITE

Practical pointers in applying high-power ultrasonics.

THERE is a very considerable interest in the possible health hazards in using high-power ultrasonics, especially in gas-type loads where the energy is often cut in free space, or may escape into air around the apparatus. We wish we could give a clear-cut answer, but we lack long-term experience. In general, we feel there is little danger even in a poorly installed piece of equipment, but absolutely none in a properly designed installation. Since this question is so important, however, let us consider it at some length.

We have been offered some cooperation in investigating the "fly ash" problem in boilers using powdered coal. The small cinder left after the coal burns in the fire chamber of the furnace is carried up into the tubes and forms a deep deposit on them, requiring frequent cleaning. Now certainly agglomeration of dust is one of our least promising fields, so we were interested greatly. However, it turned out that orthokinetic coagulation by random motion of the particles forced on them by a critical choice of frequency would occur in the frequency range of three kc, right down in the audio band, since the fly ash was ten microns or 0.4 mils in diameter.

We need hardly remind sound engineers of the marked annoyance caused by a few watts of such a fixed frequency. The boiler could not be sound-insulated to any appreciable degree, and the effect on the operating personnel would be disagreeable in the extreme. We could not force them to wear ear plugs with such a low cutoff frequency, and we could only hire hard of hearing people with about 60 db down at 3 kc. Since a boiler room is a dangerous place, we would want our personnel to hear warning bells, speech, and so on, so the deaf person is no solution.

The loss of such a potential market is made easy to bear, however, as the collection of large dust particles is in general well in hand. The difficulties with normal methods begin at about 5 micron sizes and below, so we have most of field to work in, the so-called "fines." If flesh is put in an ultrasonic field of about 20,000 watts to the square inch in air, no rupturing of capillaries takes place, due to the very high reflection.

A rather peculiar effect has been noted in rats subjected to a high intensity sound of broad spectrum characteristics. In non-technical language, the lungs became flooded with blood. With much higher intensities, the effect has never been observed with human specimens. After puzzling over this for some time, the writer wishes to offer a possible explanation. The energy probably reached the lung through the open throat, as reflection would be sufficient to prevent direct entry through the chest cavity wall. The sinus, or what passes for a sinus in a rat, would be too long and detailed for efficient energy transfer.

Probably the open throat is a low pass filter with cut-off about 12 kc or so, so it would efficiently carry energy up to 24 kc or so. This energy can be of such frequency as to resonate some lung passages, especially the bronchioles and alveoli, and build up standing waves of greatly enhanced amplitude, causing rupture of the walls of the lungs and consequent flooding with blood.

The writer has certainly been exposed to such energies and considerably more, but no such effect was noted. The difference may well lie in the greatly increased length of the human throat, so the cut-off frequency would be one-fifth or one-tenth that of the rat, and thus introduce sufficient attenuation at the frequencies that would resonate the lung passages so that no damage was observed.

Insulation

Since the mechanical type of damage to humans requires extremely high energy densities, as compared with the mere annoyance caused by energy activating that very sensitive member, the ear, let us see how much would escape through the walls of a totally enclosed chamber in which we have fifty kw or so. Assume steel walls, with air at 20° Centigrade inside and outside. Have the steel wall thickness well away from a significant fraction of a wavelength, say a sixteenth inch or so. The attenuation

Other Effects

If we decide to work around 12 kc, we run into the region where the ear develops a pressure effect. A watt or so in the air will cause nausea and, in some cases, vomiting. A continuous irritation may develop if slightly below this level, and people become quarrelsome and have headaches. So far as the writer knows, there are no further ill effects, and all these stem directly from the ear.

At true ultrasonics, say 20 kc up, there is little or no effect on the ear and we must look for mechanical couplings that produce other phenomena, such as heating and rupturing of capillaries or lung air tubes. Slight heating may occur at points covered by hair, as the tangled network of fur or hair has high absorptive properties. While the ear can be annoyed by a few milliwatts, and very much so by a watt released in a room, it is pretty obvious no mechanical effects can be produced by such low energies.

Fig. 1. Radius of particles of density 1 which have a random excursion of one-half the wave motion.

The writer personally would not like to work in a one kw supersonic field until we know more about it, although much higher energies than this cause no effects that can be noted on a short run. Very many people of middle age or above cannot hear above 6 kc or so, and apparently do not have this pressure or "medio-sonic" region, so it would be quite practical in many cases to assign such personnel to the vicinity of the apparatus.

---

*Consulting Engineer, 52-13 Van Horn St., Elmhurst, L. I., N. Y.
is about 330 times in wave amplitude, and the power ratio is that squared. For each kw to the square inch we have inside our power external to the chamber would be about 10 milliwatts/in². A double wall would make the external field practically undetectable.

We have inquiries for dust precipitation where people would work in the field itself, such as loading a conveyor line with sacks of material that give off hot, some dust that might affect health if breathed for years, or in any case is distinctly unpleasant to breathe. If we cannot definitely keep the workman out of the field it is believed that we had better wait until we have some controlled history of possible after-effects before we undertake this type of application.

In many cases where we have a localized source of dust or fumes, such as a boiling pot of acid or a very high speed packaging machine of dry powder material, it should be feasible to focus the energy on the source of dust, and out in a combination of reflecting and absorption screens to localize the energy and prevent it from coming in direct contact with the operator.

Two other points should be mentioned in this public health field — explosions and toxic products. We have no record of either in gas loads. We do not give off noxious oxygen as the high voltage precipitators do, possibly to combine with the various gases in the load, and there is no record of explosions being produced, although explosive mixes have been investigated. Theoretically an explosion can be produced when the positive pressure portion of the wave reaches "Diesel" pressure, or pressure at which the mix would explode anyway. Since this is usually at extremely high sonic densities to give the five or ten atmospheres pressure necessary, we can design around it on explosive mixes.

**Calculation of a Dust Load**

A common load very suitable for recovery of an aerosol is sulphuric acid mist. The particles range downward from 2 microns in size, and often run 5 grains per cubic foot. Some small installations run as little as a thousand cubic feet per minute of mist to be treated. Here we must take care of a highly corrosive material, and our apparatus must either be acid-proof or protected in some other manner. Let us make some rough calculations as to frequency, amplitude, and efficiency.

The density of sulphuric acid is 1.8 (we will work with round numbers), so 5 grains is equal in volume to 2.7 grains of water. The mass of this amount of water is 3.8 x 10⁴ lb. Since a cubic foot of water weighs 62 lbs, we see that 6 parts per million of the cubic foot of mist are liquid.

Let us assume the significant particles are one micron in size. A one micron sphere of water has a volume of 3.2 times 10⁻¹⁵ cubic micrometers, and there are 1.7 times 10²¹ cubic micrometers in a cubic foot. Dividing, we have 3 times 10¹¹ one micron spheres to the cubic foot, or 1.7 times 10⁸ spheres to the cubic inch. The cube root of this gives us 550 spheres to the linear inch, or a separation in cubic lattice of 1.8 miles.

So we choose a frequency of 20 kc where the particles will partake of half the wave motion of the gas, and with a power density of 60 watts/in² the gas has a motion of about 6 miles. The particle would then have an excursion of 3 miles, much more than the separation of 1.8 miles, and coagulation would occur. See Fig. 1.

Now we can design the chamber in which the gas is to be treated for either resonant operation with a complete standing wave pattern, or operate on reverberation only. Here we would have a confused multiple reflection pattern quite effective in promoting the random type motion of the dust particles, but with high values of wave cancellation.

It is difficult to calculate power and time requirements. In the first place, these particles are repelled by each other, since they all have similar electrical charges. This is often hard to measure or calculate. Since the particles would have combined collision accelerations of the order of 200,000 G probably the effect of the electrical charges can be neglected in the case of a head-on collision, but it is difficult to assign a value that would turn a grazing collision into a miss.

The time factor is of the greatest importance, of course, and depends on the theory of probabilities. The spherical particles are separated by fifty times their own diameter in a cubic lattice. So one particle has a chance of colliding with any one of eight others at the corners of its cube. About 300 planned excursions would cover all possibilities in one plane if a grazing collision is sufficient.

The Germans report about one watt per cubic foot per minute. It is obvious that this is dependent on the particle density. If there were a particle separation of 100 miles, for instance the system would be impractical, as both the length of swing and the number of misses would rise to a high value. An American experimenter says coagulation of steam takes place in a tenth second, but gives no actual data on particle separation vs. power, or wave excursion.

It is emphasized that the collision production requires almost no power itself. Any true aerosol is so small a mass per cubic foot that it is negligible. The power is to swing the gas to the necessary excursion, which incidentally carries the particles with it.

**Distribution**

Particle size distribution is more important in dry particles than liquid ones, we think at the present time, although data is not final. In the sulphuric acid mist case the largest seems to be two microns, instead of the one micron dimension considered.

Particle size distribution is of great importance in practice, and can vary in almost an infinite number of ways. A purely random distribution from, say, two microns down to a tenth or less can possibly be handled by a generator of very high harmonic content. Since the critical frequency at which orthokinetic coagulation occurs is almost an octave wide, a series of harmonics would fill the spectrum very nicely.

If we have two sizes in the mix of greatly different masses, such as a two micron set and another at a tenth micron, we are not sure whether we should coagulate the twos and try to have them scoop up the tenths, or the reverse, or both frequencies at once. We should keep in mind that the collisions produced by the wave motion are only effective until the particle has built up to a factor of 8 times the mass, or twice the diameter. Then with this method of assembling such particles the built up particle has a high charge that attracts other particles of all sizes to it. So our only answer on a mixed load is to try it with a range of frequencies and amplitudes and observe the effect.

**Practical Application to Sulphuric Acid Mist**

Fig. 2 shows a way to apply the generator to such a corrosive load. We might attempt to build the turbo-jet model of materials unaffected by the acid, but this mounting removes the difficulty.

The chamber for the mist is shown. The generator is at the top of the pipe of generous cross section which carries the [Continued on page 57]
PHASE SHIFT OF RC COUPLING CIRCUIT

\[ \theta = \tan^{-1} \frac{X_C}{R} \]

Degrees - Phase Shift

Scale A

Scale B
To Mr. Canby’s widely read column, we add Bertram Stanleigh’s interesting evaluation of recent popular music records.

The proposed outfit is to fill a large blank area between the standard phonograph, (designed for the doke who can’t manage to do more than work the “on-off” switch) and the professional separate-unit materials. If the outfit itself grants curiosity and intelligence to the user, then the very words in which we approach him, through advertising, through descriptive brochures, and most important, through the actual instruction booklet provided with the outfit, must also reflect the fact that we recognize the user’s intelligence and interest even though he may know nothing at all about the innards of a sound system.

Therefore, finally, I suggest that the builder of the type of equipment I have outlined should invest a great deal of time in the preparation of copy. That every possible advantage be taken of the power of simple, direct language to put over the importance and advantages of this new outfit for the intelligent buyer we are after. That the very controls themselves on the machine be labelled and situated intelligently, with the intention of persuading the owner to use them reasonably, intelligently, for their true function—no “magic pointers,” no Buck Rogers effects! The stuff itself is plenty dramatic, but not the right way. At every point, the assumption must be made that the user is willing to learn a bit if we both respect his intelligence and allow for his lack of technical knowledge.

Ads and brochures should be designed to attract the interest of the people we want, and to this end should offer dramatic but honest and accurate accounts of exactly what is available, and what are the very real advantages of the equipment.

Popular Records

WHILE the fidelity of most popular recordings has not increased in the last few months, the quality of the pressings has improved considerably. Surfaces are quieter, and the spots and blisters have disappeared. The millennium has not yet been reached, but the situation has improved to such an extent that it is now possible to hear both soloist and accompaniment above the hissing and clickings on all major labels. Owners of record changers will be particularly pleased to learn that edges are smoother and less likely to chip.

Shellac and greater care in manufacturing are responsible for this improvement. The lowered price and greater availability of the former has allowed record producers to include more of it in their biscuits. Manufacturing costs have certainly not gone down, but a slight recession in the record business has slowed production to a point where rush methods are no longer prevalent and more careful inspection is possible.

Capitol is still producing the best product. Its discs have the most quiet surfaces, but its platter edges are still sometimes irregular. Columbia’s edges, in those designed for two-post, blade-type changers, do not always work smoothly on the Capelhart. Their laminated pressings sound better than ever. Decca and Victor have made a sizable improvement. Decca, particularly, has improved the noise-to-music ratio of its pressings.

Here are some interesting new singles:

**Capitol**

Lover—Brazil. Les Paul, guitar

Termed the new sound, this record is a

**41 East 50th St., New York 22, N. Y.**  

(Continued on page 11)

AUDIO ENGINEERING APRIL, 1948
Entirely New Design now brings you
New FLEXIBILITY, New BEAUTY, New LOW COST

NEW EY CENTURY
CRYSTAL, DYNAMIC, CARBON MICROPHONES

Complete Adaptability Permits Widest Use in
Public Address, Paging, Recording, Communications

The CENTURY series heralds a new era of brilliantly engineered and superbly styled low-cost microphones. Designed for utmost flexibility, it is available in a choice of three generating elements: crystal, dynamic, or carbon. Each provides excellent reproduction and high output. Each gives you exclusive E-V quality features. Each is top value!

Size is 3" x 2½" x 1½". Crystal model weighs only 6 ounces. Highest purity diecast metal case, finished in lustrous gray-brown. The incomparable CENTURY can be used in a variety of ways, as shown. It is the perfect answer for all economical installations. Get full details now! Send for Bulletin No. 137.

<table>
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</tr>
</tbody>
</table>

*with slide-to-talk shorting switch
**with slide-to-talk relay control switch and hang-up hook

Model 415. New, modern, reclining Desk Stand. Microphone mounts at 15° tilt. List Price $1.50
Model 340. Suspension Bracket. Fits 5/8"-27 thread adapter. List Price $0.85

Authorized Distributors Everywhere

NO FINER CHOICE THAN

Electro-Voice


Audio Engineering April, 1948
SINGLE-TUBE A-F OSCILLATOR

- A unique circuit for a simple audio oscillator is described in the March issue of Wireless World by K. C. Johnson. The oscillator is of the RC feedback type, but differs from the conventional circuit in that a single variable element is used as the frequency-determining control.

The circuit, shown below, also utilizes an automatic gain control arrangement to stabilize the output voltage. Basically, the oscillator is a two-stage amplifier with cathode coupling. Since the grid swings of the two tubes are opposite and very nearly equal, even harmonics are practically eliminated. The plate loads are small, however, so the $I_{P-E2}$ characteristics of each tube are not linearized and the overall slope can be reduced by the application of grid bias without increasing the distortion appreciably.

The bias, which serves to reduce the gain, is obtained with a grid leak and capacitor in the usual way, but in order to reduce the phase distortion and assist the symmetry of the two stages, most of the leak is made common to both grids. It must be remembered that this arrangement has a long time-constant, and several seconds are required for it to charge up when the oscillator is switched on, so that oscillations do not start as soon as the tube is warmed up.

With the constants shown, the two ranges are from $\frac{1}{3}$ to $800$ cps, and $700$ to $16,000$ cps, with the output being flat within 1 db throughout the two ranges.

By adding other capacitors, it is possible to increase the range of the oscillator so that with four bands, complete coverage can be had from 5 to 120,000 cps.

THEATRE SOUND RE-ENFORCEMENT SYSTEM

- Relatively few high-quality sound systems are in existence, and when a new one is installed it is usually of great interest to sound engineers. No exception is the description of the system recently completed in the Roxy Theatre, New York, by Altec Service Corporation, and described in the February issue of J. Soc. Mod. Pict. Eng. by C. E. Talley of the theatre and R. W. Kautzky of the installing company.

Ideally, a theatre patron should not be aware of the use of sound re-enforcement. Good illusion demands that the sound should appear to come from its actual source, but it is difficult to locate the speakers on the stage itself. They must usually be located at the sides of the proscenium arch, and as far forward as possible to keep out of the microphone fields.

The Roxy Theatre has an auditorium volume of over 1,500,000 cu. ft., is about 185 feet wide, 150 feet long, and 85 feet high, and seats approximately 6000 people. The requirements dictated a flexibility of use between the sound projection system and the PA system for special effects.

Thirty-two microphone circuits, each with its own preamplifier, are provided for orchestra and stage pickup. These are grouped into four sections with separate sub-master controls, and a master for the four. Four additional microphones are used in the organ chamber, with separate controls and a master. In order to provide the dramatic effect of stereophonic sound originiation, the output can be "panned" from the right to the left speaker groups at will. Switching flexibility permits feeding the picture sound system onto the side speakers for special effects.

The details of the entire design are too elaborate for description here, but the console itself is extremely modern, and comparatively simple to operate. It utilizes a new arrangement of controls of the radial type, so placed that the operator can handle the entire system efficiently and easily. A study of this article is recommended to advanced sound engineers as typical of a modern installation.

COMMERCIAL VIDEO

Royal V. Howard, NAB Director of Engineering, addressed the San Francisco Radio Executives Club recently, reviewing the general television scene with particular emphasis on video's commercial applications and future possibilities.

The address was arranged by Philip G. Lasky, General Manager of KSFO. Howard was granted a leave as KSFO Engineering Director to take the NAB post last May.
PREPARATION OF RECORDING LACQUER

Quite apart from the chemistry of good recording lacquer are the mechanics of tailoring it to the coating process and to the requirements of the disc itself.

Control of coating uniformity and elimination of objectionable outer-edge ridge demand, among other things, laboratory-accurate viscosity control. The correct amounts of solvent must be mixed into daily supplies of new lacquer. Electric agitators then so thoroughly stir this mixture that uniform viscosity is assured throughout the entire system. There is thus no possibility of hard or soft spots on any Soundcraft disc.

Because the high viscosity of fine-grain lacquer retards natural dispersal of air bubbles, forced debubbling methods are necessary. Soundcraft combines two methods, each of which alone is usually considered adequate. First, the lacquer is subjected to vacuum; second, it is allowed to rest. This double debubbling removes not only the visible bubbles, but also the noise-making invisible ones.

Commercial lacquer ingredients often contain hard foreign particles dangerous to styli. While the larger of such particles are commonly removed by conventional cloth and paper filter presses, Soundcraft uses two additional stages of filtering—first, coarse porous stone filters, then fine ones right at the point of coating—to trap microscopic particles even as small as one micron.

Elaborate preparation to be sure, but what better way to assure a good recording every time?

*No. 5 of a series  *Watch this space for succeeding ads on how Soundcraft discs are made.
NEW PRODUCTS

THE AUDIO RULE

Shown for the first time at the recent Radio Engineering Show, the new Audio Rule attracted considerable attention from engineers. This rule is a compilation of many of the data that the engineer uses in his daily work, and gives direct indications of the resistor values used for the construction of T and bridged-T pads for 600-ohm circuits. In addition, construction data for grid potentiometers, bridging pads, and matching pads between 17 common impedances is furnished, and the values between impedances, voltage, and ohms are shown. The reverse of the rule consists of a circular slide rule with one scale divided into ohms, which aids in the many calculations encountered in audio work. Also shown are the power and watts and the voltages existing across 600 ohms for various levels from +1 to +50 db.

The Audio Rule is solidly constructed of celluloid, and is furnished with a leather carrying case of pocket size. Audio Equipment Sales, 923 Eighth Ave., New York 18, N. Y.

WIREMASTER RECORDER

The Wiremaster recorder was designed to meet the exacting requirements of broadcast stations and professional recordists. Not only does the Wiremaster fulfill these rigid specifications, but according to the enthusiastic owners of Wiremaster recorders, it actually surpasses the expectations of these critical users! The on wire frequency response is rated essentially flat from 40 to 10,000 c.p.s., limited in this respect only by the capabilities and quality of recording wire available at present. Up to 62 minutes of highest quality wire recording on a single spool allows 2 minutes for cueing a full hour radio show. Specially machined and assembled like a fine watch, the Wiremaster has many advantages not found in other recorders, regardless of price. The wire will not break, no matter how often or how abruptly the motor is switched from "play" to "rewind." May be replayed or erased countless times without affecting the quality of recording. Wire-transporting mechanism utilizes two heavy motors, instead of a single motor ordinarily used in other types. Features include specially designed 10-tube high-fidelity amplifier, dual tone controls for separate bass and treble equalization, mixing and fader controls for two microphones, one phonograph input and built-in radio. Dual recording level indicators and independent speaker volume control for monitoring add to ease of operation. Separate speaker jack permits simple connection to a studio speaker. Output jack permits dubbing of all or portions of wire content onto transcription discs.

Plays standard records up to 12" size at 78 rpm for reference or simultaneous sound-effects mixing while recording on wire. Separate Jensen 8" high fidelity speaker may be placed some distance away from Wiremaster, yet conveniently fits into recorder compartment for complete, self-contained portability.

The Wiremaster is housed in an attractive carrying case and is ruggedly constructed to withstand more than average use. Operation is from 110-120 volts 60 cycles a.c.

Complete information and prices may be obtained from Wiremaster's New York distributor, The Terminal Radio Corp., 85 Cortlandt St., New York 7, N. Y.

HYPER-MAG SPEAKER

A new Hyper-Mag Loud Speaker featuring a New Parabolic Projector coupled with the Hyper-Mag Magnet has been announced by Radio-Music Corporation, Fort Chester, New York. The center dome with its parabolic projector gives broad high frequency distribution, and the special magnet design provides a high quality, efficient unit for FM and wired music installations. The eight-inch Speaker offers linearity of response from 100 to beyond 10,000 cycles and at extremely low distortion.

New Bulletin 81 available upon request to the manufacturer.

CONVERTIBLE MIKE

Described as the "Velvet Voice" beauty, a new, convertible type Crystal Microphone has just been introduced by the Astatic Corporation, Conneaut, Ohio. Made with a detachable "quick-lock" base, this microphone may be used as a hand or desk mike or mounted on floor stand.

The "Velvet Voice" is made with bright chrome grille, gold finish housing and

handle, and dark brown enameled base. It is supplied in two models: No. 200, with smooth, even frequency response characteristics from 30 to 10,000 c.p.s. No. 241, with smaller range but with rising characteristics between 1500 and 5500 c.p.s. for added brilliance in the speech range. Either model supplied with or without switch, as illustrated.

RCA RECORDER CONSOLE

A custom-built RCA professional recorder console and control turret, which was recently shipped to Radio Station WKJG, Fort Wayne, Ind., incorporates two recorders (RCA Type 74-A) which may be operated simultaneously. Switching facilities permit use of either recorder by itself or both at the same time. Either one of the two program busses on the cutting units may be monitored during operation. The necessary amplifiers, filters, equalizers, and associated equipment are built into the console, eliminating the need for extra racks.

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AUDIO ENGINEERING APRIL, 1948

www.americanradiohistory.com
Efficiency Applications Value
by using these New RACON Speakers and Horn Units

New Special PM Horn Unit, having Alnico V magnet ring, completely watertight, housed in heavy aluminum spinning. Provides extremely high efficiency reproduction with minimum input. Handling capacity 35 watts continuous, 60 w. peak.

New Small Re-Entrant Horns, extremely efficient for factory inter-com and paging systems, for sound trucks, R.R. yards and all other industrial installations where high noise levels are prevalent. Watertight, corrosion-proof easily installed. Two new models—type RE-1, complete with Baby Unit, handles 25 watts, covers 500-6000 cps.; type RE-12, complete with Dwarf Unit, handles 10 watts, freq. response of 600-8000 cps.

New Radial Re-Entrant Speaker, excellent for all types of industrial sound installations. Provides superlative and complete 360° speech intelligibility by efficiently over-riding factory high noise levels. Frequency response 500-6000 cps. Handling capacity 25 watts continuous 35 w. peak. Has mounting bracket. Size 12” wide by 15” high.

Other RACON products now available:

- PM Horn Driving Units, 10 types
- Straight Trumpets, 7 types
- Fanfare & High Freq. Speakers, 3 types
- Radial Horns and Speakers, 3 types
- Armored Cone Projectors, 4 types
- Also—cellular and auditorium horns, inter-com, paging, monitor, and dwarf speakers, cone speaker boottoms, etc., besides all basic accessories such as swivel brackets, mounting units, cone bearings, multiple horn throat combinations, etc.

To the more than 60 different type and size speakers and horn units that already comprise the RACON line—these new models have been added. There is a RACON speaker and horn unit ideal for every conceivable sound system application.

RACON has not only the most complete line, but also the most preferred line. For over 20 years leading Soundmen have recognized and specified them because of dependability, efficiency and low-cost, and because the reproducers are trouble proof.

Ask your Jobber, or—Write today for full details

RACON ELEC. CO., INC., 52 E. 19th St., N. Y. 3, N. Y.

RACON

Audio Engineering April, 1948
Telephone Recording

from the other primarily by virtue of the differences in which their sound energy is distributed in various frequency bands. This does not seem to be the whole answer. If it were, then there would not be such difficulty in making synthetic speech sound natural.

Of considerable significance, it would appear, are the orders of sequence and timing with which the respective frequency components of a speech sound are initiated, or reach their peak amplitude or decay. In synthesizing musical tones these factors have been found to be quite important. They may be equally important in the formation of speech sounds.

Suppose the necessary electronic means—whatever they may be—could be provided in telephone recorders or reproducers to provide broadband results from narrow-band circuits. Could the cost of such extra equipment be justified to the customer?

It is the writer’s opinion that even if such extra aids resulted in doubling the cost of the units to which they were applied, they would be welcomed by the customer because of the time and money they would save.

Assume a cost to the customer of $300 for his present transcribing unit, its useful life at 3 years, with 200 working days yearly, 6 hours per day. Written off at this rate, one transcribing unit costs $3.84 per hour.

Doubling the cost of the transcriber would mean an increased expense to the customer of $1 an hour. An improved operator efficiency of less than 5% with the new equipment would more than pay for its cost.

Manufacturers who have switched from the straight acoustical transcriber to the electronic type find that greatly improved operator efficiency results from the wider frequency response, electronic amplification and tone control.

The whole question of the transcribing efficiency rating of equipment—both in telephone and office dictation recording—will become increasingly important as competition in these fields stiffens.

As will be seen in a later article, the physical and mechanical characteristics of the equipment and the recording medium used, influence transcribing efficiency to a great degree—the form and shape of the medium, and the method and speed used to propel it.

Most of the emphasis of this article has been on frequency distortion. The writer would not imply that he is overlooking other forms of distortion encountered in telephonic transmission.

A later article of this series deals in part with amplitude distortion and shows circuit diagrams of several types of automatic volume control systems used in telephone recorders.

Specifications

Reference was made to the specifications of the tone signal generator and the recorder-to-telephone-line connection which the Federal Communications Commission stipulates must be used when a telephone call is recorded. Unfortunately at the time of this writing, the Commission has not yet finally approved the design of this apparatus as submitted by the telephone companies. Accordingly, publication of circuit diagrams must be postponed until the Commission’s approval has been secured. In the interim, a listing of the specifications to be met, must suffice. They are:

Number of tones....... 1
Length of each tone. 20/100 of a second, with a tolerance of ±10%.
Pitch of tone....... 1400 cycles per second with a tolerance of ±10%.

It’s Tops!

Surveys show that AUDIO ENGINEERING is preferred over all other technical magazines read by the best informed in the sound field—the broadcast engineers. Each issue brings you outstanding articles on five or more of the following subjects:

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- Sound on Film
- Recording
- Phono Reproduction
- Public Address
- Industrial Sound equipment and applications
- Acoustic treatment of studios, rooms, auditoriums etc.

In addition, each month Audio Engineering presents latest improvements in sound reproducing equipment design, test methods, and technical news from here and abroad. The editorial staff includes top authorities in the sound field.

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High-Power Ultrasonics
[from page 27]

Supersonic energy into the chamber. By locating the generator above the chamber gravity separation of the mist will favor us. A valve or damper shown cut-off the pipe when the generator is not operating. Since the turbo-jet unit requires considerable air or steam pressure to run it, a diaphragm actuator opens the pipe only when pressure is on, and since the operation of the turbo-jet causes a strong current of air or steam to flow down the pipe, it will keep the mist from contact with the generator. The usual lead lining is a good reflector for ultrasonics, so installation should be quite economical. Some baffles would distribute the sonic energy through the chamber to insure equal treatment to all the gas.

This is the sort of problem ultrasonics will do rather well. With an over-all efficiency of the order of 40% we would need about 2 kw of steam per 1,000 cfm of gas treated. The cost of the apparatus would be reasonable, and the installation very simple. Corrosion is no problem, except in the chamber itself, where it would be handled in the usual manner of lead lining or the like. Since this gives a solid type wall, no special precaution would be necessary to protect the public from escape of the energy. The amount of mist collected should be about 99.9%.

Disc Recording
[from page 19]

There was general agreement that an extended high-frequency response was worthwhile, provided that distortion components in both recording and reproducing systems could be reduced to a satisfactorily low level. Even when the response of the reproducer, or of the ear of the listener, was restricted, the subtle improvement resulting from the recording of high, even ultrasonic, frequencies could be detected. It was thought that this might be explained on the basis of improved transient response.

“Peaking” of the high-frequency response to give a spurious brilliance was deplored, and it was emphasized that rising characteristics had to be handled with extreme care. The rise should not begin much before 5,000 c/s, and trouble had been experienced through over-modulation by second and third harmonic modulation by the apparatus described.
Get the RMC VERTICAL-LATERAL COMBINATION

INCLUDING 2 ARMS . . . VERTICAL HEAD . . . LATERAL HEAD . . . AND EL-3 EQUALIZER

Specially Priced: $174.00 net,
F.O.B. Port Chester, N. Y.
90-DAY UNCONDITIONAL GUARANTEE

A new low price made possible by an ever-Increasing demand with resultant volume production.

Use the new EL-3 EQUALIZER with both Vertical and Lateral recordings. Use one arm for Vertical only and one arm for Lateral only or on one turntable or separate tables. Connect both to the new EL-3 EQUALIZER and obtain the same of perfection in reproduction from your records and transcriptions. By simply switching the new EL-3 EQUALIZER from Vertical equalization to Lateral changes from one arm to the other, at the same time, correct equalization is thrown in.

Write for Speaker Bulletin EL-3-4 Sold through local jobber.

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- One Amperite Velocity Microphone will pick up an entire symphony orchestra.

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AMPERITE Company, Inc.
561 BROADWAY NEW YORK 12, N. Y.

Audio Engineering April, 1948
automatic record changers meant that "permanent" tips were essential. Fears of trouble through breakage were largely unfounded. With a cantilever-sprung mounting, giving vertical compliance, sapphire tips could be dropped several inches on to a disc without risk of fracture; alternatively, a simple automatic lowering mechanism could provide the necessary protection.

**Popular Recordings**

series of multiple recordings and dubbings. An echo chamber has been used on some of the cuttings. Although it is difficult to say how many dubbings were involved, the various voices are clearly separated, and there is no noticeable distortion. The final cutting does up to about 10,000 rps. The music is pleasant.

**There Ought to be a Society.**

Harry Roy Orch. Joy Nichols, vocal.....London
Betty Garrett, vocal, Harold Mooney Orch....MGM
Janette Davis, vocal, Archie Bleyer, Orch.

**Sabre Dance Boggie.**

Fredly Martin and his Orch..............Victor

**Sabre Dance.**

Wooly Herman and his Orch..............Columbia
Both popular arrangements from Khachaturian's *Gagye Ballet Suite* are vastly unlike the original. Herman's version is more exciting because its jumps with the whole orchestra. The Fredly Martin side features the piano on a separate mike. Both recordings are clear but lacking in high. The piano is particularly well recorded on the Martin platter.

**Le Disque Use.**

Edith Piaf, chanteuse..............Vox

The title means worn disc, and it is highly appropriate. A dubbing from the original French master, it has annoying distortion and every known variety of surface noise. The song is amusing and the performance first rate, but noise and distortion cover so much of the audible range that normal attenuation will not help. This should be the classic test record for a dynamic noise suppressor.

---

**Electronic Organs**

require the presence of the entire series of harmonics within the audible range for their faithful synthesis.

The inclusion of, at least, the seventh, ninth and eleventh harmonics would have added much to the tonal resources of the Hammond Organ but, to have done so, would have increased the expense of the instrument beyond the limits imposed by its market. It would have been necessary to use additional tone generators, since these partials cannot be derived from the equally tempered scale, as are the ones used in this system of tonal synthesis. Thus, in addition to the cost, the bulk and weight of the organ would be greatly increased and its field of utility severely limited.

The tone of this instrument has been further criticized on the basis that the third, fifth and sixth harmonics should not be "borrowed" from the equally tempered scale, since their true pitch coincides with the diatonic scale. Admittedly, a tone is more pleasing when its partials conform to the natural scale, but the difference is slight and, again, the field of usefulness of the instrument would be limited by the cost and bulk of equipment necessary to effect this change.

(Continued on page 40)

---

**Ingenious New Technical Methods**

To Help You Simplify Shop Work

**Metal Turning Made Easy with New Simplified Tool!**

A new tool called "Tru-Turn" makes possible the conversion of drill presses, wood-turning lathes, or grinder stands into tools that will turn and cut-off steel, bronze, copper and aluminum measuring ¼", 3/8" and ½". Its built-in micrometer permits adjustments that give tool-room accuracy to 1/1000 inch.

Small tool shops as well as all types of repair shops and garages find the "Tru-Turn" ideal for cutting long pieces of bar stock into desired lengths. Also, home craftsmen are able to produce accurate, highly finished precision-machined parts from metal even without previous training.

Accurate, precision work is also easier to do when tension is relieved by chewing gum. The act of chewing gum seems to make the work go easier, faster—thus helping on-the-job efficiency. For these reasons Wrigley's Spearmint Chewing Gum is being made available more and more by plant owners everywhere.

You can get complete information from Millholand Screw Products Corp., 132 West 13th Street Indianapolis 2, Ind.

AC-55
Realism from Records

All of the electronic equipment for distortionless reproduction of phonograph records, including the latest model of the *Dynamic Noise Suppressor, is combined in this single compact unit—the new Type-210-A Laboratory Amplifier.

Circuits similar to those in use in leading broadcast stations reduce record scratch and rumble to negligible proportions. The amplifier may also be used with standard tuners or other signal sources.

Outstanding features are the latest type *Dynamic Noise Suppressor circuit, equalized preamplifier for magnetic pickups, de operation of low-level tubes, extended frequency range, output stage of new design combining high power and efficiency with low distortion, flexible tone control system for independent boosting or attenuating either high or low frequency response, self-contained power supply unit, unusually compact design and high quality workmanship. Once you have seen and heard the Type 210-A nothing else will satisfy you.

The Type 210-A is priced at only $250.00, F.O.B. Cambridge, Mass., including a variable reluctance pickup cartridge, and tax. It is available for early deliveries.

Send your order or write for complete specifications today.

Engineering Representatives
CHICAGO: 3924 Superior St., Oak Park, III.

Early Models

The earliest (Model A) Hammond organs were totally lacking in ensemble, the effect being that of a pipe organ played with but a single stop upon each manual. In 1937, the Model B console was made available; this organ containing an auxiliary tone generator whose notes were set off pitch from those of the main generator by a predetermined amount. When blended with the tone of the main generator, a celeste effect was produced, lending a certain degree of ensemble and greatly enhancing the tone as a whole.

The early Hammond Organs were equipped with a varying amplitude tremulant, instead of one in which the frequency of the note is varied. It was, essentially, a motor-driven gain control in the audio circuit, and was particularly objectionable in its effect.

The tremulant is used sparingly in church and concert work, but is absolutely essential to most of that done in the entertainment field. A wide frequency vibrato is necessary to the production of the "sweet" tones used in playing popular music, and it was here that the shortcomings were felt the most. (A frequency vibrato also makes possible a smoother broadcast or recording, since the effect of standing waves in the studio is greatly reduced.)

The instrument was finally equipped with a most ingenious and effective vibrato circuit, utilizing a periodic phase shift in the signal to produce a variation in pitch.

Since the organ is sometimes played in rooms having a very low reverberation time, the manufacturers provide an artificial reverberation unit. This device is extremely compact, and is fitted into the speaker cabinet, along with the power amplifier. The unit is adjustable, both as to reverberation time and the ratio of echo signal to the original signal from the console.

In spite of the criticism which it has received from some quarters and, granting that part of it is justifiable, there is no doubt that the Hammond Organ represents the greatest single advance ever made in organ design. And the ideology behind this instrument has opened the door to a new era in musical instrument manufacturing.

In the next installment of this series, we shall discuss the theory of operation, as well as the mechanical and electrical design of the Hammond Organ.

Classical Recordings

[From page 30]

The instruction booklet, I feel strongly, should be almost a small textbook—not stuffy and academic, never indulging in long words, unless explained by short ones, but a personal, direct-to-you account of the machine with a simple back-
ground of information as to why, and how. Possibly this booklet should be charged for extra. It could well be advertised as available on its own for a small sum—a fine sales device! In any case, the right language, with good diagrams or pictures, it will become a vital part of the outfit itself and an absolute necessity in order to carry out the purposes of the design.

I shall be so bold therefore as to invent a few paragraphs of such a booklet, describing an aspect of the equipment covered last month, the compensation provisions:

**Bass Control Switch**

You will notice that your amplifier is equipped with a two-position switch marked

---

**RECORD LIBRARY**

In this spot a continuing list of records of interest will be presented. This list specifically does not suggest the "best" recordings or versions. It will draw predominantly but not entirely from postwar releases. All records are theoretically available, directly or on order: if trouble is experienced in finding them Audio Engineering will be glad to cooperate. Records are recommended on a composite of musical values, performance, engineering: sometimes one, sometimes another predominates but records unusually lacking in any of the three will not be considered. Number of records in album is in parenthesis.

*High-quality "semi-pop" music wellrecorded.*

**Bizet** Symphonia in C Major
N. Y. Philharmonic, Rodzinski

C MMM 597 (4)

**Britten** Young Person's Guide to the Orchestra
Liverpool Philharmonic, Sargent

C MMM 703 (3)

**Delibes** Sylvia Ballet music.
BBC Theatre Orch. Robinson

Decca London EDA 5 (2)

**Fitz** Symphony in E Flat
Boyd Neel Orch. Neel

K 1680 (1)

Gould, Interplay (ballet music.)
Robin Hood Dell Orch. Gould

C MX 289 (2)

Handel-Beecham, The Great Elapement.
London Philharmonic, Beecham

V DM 1093 (3)

**Fried** Le Bal Martiniquais. (2-piano).
Robert and Gaby Casadesu

C 11831-D (1)

**Mendelssohn-Rosenthal** Gaite Parisienne.
Boston Pops Orch. Fiedler

V DM 1147 (4)

**Piacoloff** Classical Symphony
Philadelphia Orch. Ormandy

C MX 287 (2)

**Saus** Johann, Polkas.
Boston Pops Orch. Fiedler

V DM 1049 (3 10”)

**Tchaikovsky** Nutcracker Suite.
André Kostelanetz & His Orch.

C DM 714 (3)

**Thompson, Virgil** The Plow that Broke the Plains.
Hollywood Bowl Orch. Stekowsky

V DM 1116 (2)

---

**PICKERING PERFORMANCE**

The Pickering Pickup

--- incorporates all of the requirements for the finest possible reproduction of lateral records and transcriptions. It is extremely rugged and absolutely stable, ensuring long trouble-free service with minimum record wear.

---

**TECHNICAL SPECIFICATIONS**

- Perfectly polished diamond stylus with .0025" radius; other radii available on special order at no extra cost

- Correctly offset head gives negligible tracking error

- Extremely rugged—may be scrapped across records or dropped from full height without damage to pickup

- Tracking pressure adjusted at factory to 16-18 grams

- No measurable effects of temperature, humidity, or age

- Equalized output level — 60 db

- Frequency response flat within 1 db from 30 to 15,000 cycles per second

---

**MODEL 163A EQUALIZER**

The Pickering Equalizer is made to a tolerance of ±1 db, and provides five different lateral characteristics which equalize properly all types of records and transcriptions. It is designed for use with 250 to 600 ohm input circuits at a level of —60 db. Hum pickup is less than —120 db.

The Model 161M Pickering Pickup with the 163A Equalizer is so free from distortion of all kinds that it may be used as a standard for measurement.

Write for Technical Bulletin 84

---

**Pickering & Company, Inc.**

29 West 57th Street
New York 19, N. Y.

---

"GIVES MORE BASS" and "GIVES LESS BASS." This is provided for two reasons. One is to allow for individual taste regarding bass, and to adjust for variations in room acoustics, but more important, the Bass Control allows you to compensate for important differences in the way records are made by various companies.

All records must be made so that the lower tones are relatively weaker than the higher tones. This is because, as you can figure for yourself, the slower the vibrations of a sound (the lower the pitch) the order they must be on the record in order to produce a given amount of sound energy. There are practical limits to the width of the record groove's movement from side to side. Ingeniously enough, manufacturers weaken the bass, as recorded, and count upon this weakness to be made up in the phonograph itself, where electrical circuits are arranged to strengthen the bass tones proportionately—thus restoring the original balance.

Unfortunately, there aren't yet any accepted standards as to how much the bass should be weakened to give best results in recording. Opinions differ, and so do the records you buy. Therefore, we have provided you with two types of bass response, as above, which between them will provide good compensation for most of the records you will play.

In general, European-made records provide stronger bass than American records. Therefore, in playing European records, try the "GIVES LESS BASS" position. For most American-made records, in which the bass is somewhat weaker, use the "GIVES MORE BASS" position. In all cases your ear will tell you which position is best.

[Continued on page 42]
Granted that the average person will have to read that several times. But, granted I hope, that it is reasonably interesting in the reading. Of course the principles are greatly simplified; the problem is to simplify without distorting the facts any more than necessary.

The actual matter of turnover point is dodged here in favor of a more generalized description—but the idea is clearly included, and to my mind most certainly should be. Other aspects of the instruction booklet should be treated similarly, in considerable detail, without fear in the explanation, yet taking very little for granted—except the all-important intelligent curiosity.

It remains to suggest merely that in order to fulfill the basic idea of flexibility and expansion for which the proposed outfit is best suited, a number of accessories should be available, notably the radio tuner, FM, AM, the record changer; possibly other gadgets such as a tape or disc recorder (no wire for me!) The policy here would seem fairly obvious. Supply regular existing brands in these items, adapted to fit into the standardized plug-together system already envisioned. The extra charge would be directly absorbed in this adapting, and would obviously be justified in the buyer’s mind. Thus a changer, an AM, FM or FM-AM tuner, so fixed up, could be plugged instantly into the existing system—extending both its usefulness and the beauty of its basic construction. In some cases the “adapting” might mean no more than the installation of a simple plug at a trifling cost—yet right there is the very thing your customer does not want to have to do, for himself. That is our basic idea.

RECENT RECORDINGS

Mozart, Eine Kleine Nachtmusik, K. 525. (a) Pro Musica Orchestra, Otto Klemperer. (b) London Philharmonic, Sir Thomas Beecham.

Vox 169 (2 plastic) Victor DM 1163 (3)

Will there ever be a clean, undistorted, wide-range recording of this music? Not these! The Victor set must be an oldfashioned one, no highs, much distortion of string tone. Some fancy luggings-up by Sir Thomas, with a too-big orchestra relieved by un-called-for solo violins, etc. Effect not too bad, nevertheless.

The Vox set is most interesting. It was first issued on black plastic: rather low level, no highs, very dead acoustically, but undistorted. Vox reissued it, same numbers, same album—on red plastic. Vox publicity told me it was re-recorded; it is the same recording, dubbed, put through an echo chamber, boosted in the highs (middle). An interesting comparison, especially as to startling difference that echo makes. The new version is superlatively more brilliant, pleases most listeners—but there is very considerable distortion not present in the more subdued original.


Decca London K 1601 (1)

A most extraordinary bit of recording and singing. This boy is an extremely gifted musician, and has the clearest, most perfect diction for the microphone I’ve heard in recorded vocal music. The nurse (adult) is a triumph at singing compared with him. The bass is excellent too, as Boris, and the two illustrate what can be done with wide-range, distortionless vocal recording. Fine orchestral background.

Brahms, Gypsy Songs (Zigeunerlieder). Lotte Lehmann, Paul Ulanowsky, piano.

Victor DM 1188 (2; 10")

Lehmann transfers to Victor. These are solo-voice versions, arranged by Brahms, of original 4-part works. Lehmann sings them delightfully in spite of increasing vocal difficulties. Victor does her proud—

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THE ELECTRO
MOTIVE Mfg. Co. Inc.
Willimantic, Connecticut

AUDIO ENGINEERING/April, 1948
not quite the crispness of her last Columbia major offering (Schubert Schoene Muellerin) but a better roundness, better piano.

Brahms, Symphony No. 2, New York Philharmonic, Rodzinski.

Columbia MM 725 (3)

Brahms gives the hi-fi accentuation treatment. Wide range, rather dead, with a great deal of accent on individual instruments, picked up apparently close-to. Not too suitable to the Brahms style of music, but gives interesting glimpses of what goes on inside a complex symphony. Performance begins a bit ploddingly, picks up as it goes along.

Tchaikowsky, Symphony No. 1, Indianapolis Symphony Orch., Fabian Switsky, Victor DM 1189 (3)

This seems to me about the best recording technically to come from Victor since war, as well as musically a very fine performance of its kind. The recording is typical of the best that the Victor "point of view" can offer—lacking, as always, in the highs and so disappointing to some, yet more than making up for that lack in the fine resonance in the excellent solo instruments and the equally good ensemble sound. The music, early Tchaikowsky, is a highly competent symphony, a bit choppy now and then, and will be welcome to many merely because it is not overly familiar, as is so much Tchaikovsky.

St. Matthew Passion; excerpts.

The Jacques Orchestra, the Bach Choir, Reginald Jacques conducting; Elsie Suddaby, Kathleen Ferrier, Eric Greene, William Parker.

Decca London EDA 43 (7)

Ffer is good here, allowing for both interesting perspective and for brilliant tone color and clear enunciation of words. The performance is very British—honest, hearty, simple, and yet so means the most vibrant virtuoso sort, and with not a few flaws, which, however, don't really do much harm. Orchestra, soloists very close, chorus far in background. The British type of clear, accurate (mostly) solo voice makes Bach a lot easier to appreciate—because you can hear the tune! (Our singers use so much vibrato and overtone coloring that frequently one literally cannot tell what pitch is intended.) An interesting example, side 12, of results of Decca 'no monitoring' policy—a passage for chorus that is grandly conceived, with broken-down grooves. They could have pulled this down just a bit.

Stevinsky, Pastoral for Violin and Wind Quartet; Russian Maiden's Song.

Joseph Szurget, violin; Stevinsky, pianist and conductor; woodwind soloists.

Columbia 72495-D (1)

Pastoral is a remarkably interesting recording. Very close-to pickup of violin, wide range, boosted highs, high level. In some ways an ugly and unbalanced sound, but still an extraordinary recording sensation. You can hear Szurget breathe quite audibly—first time I've got this on a record, though it is the plaque of FM pickups a la AM! Music is charmingly lyric, most attractive, very short. The Maiden is less interesting, sorrowful, a bit dull as I hear it.

CBS Measuring Set

[from page 19]

usually be turned to the network positions, in this case, the 150-ohm position. This inserts a 20-dB pad at the output of the transmission set, as described, and automatically, by means of a mechanical

AUDIO ENGINEERING APRIL, 1948
Here at last is a binder using modern postwar materials at prewar prices. Designed to provide instantaneous reference to your monthly copies of Audio Engineering. An unusually fine library finish that will stand up under constant use.

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AUDIO ENGINEERING APRIL, 1948
linkage, adds 20 db to the dial reading of the 10-db-per-step (10X) attenuator. This arrangement is especially useful when the audio system under measurement does not terminate the signal source in a constant resistive impedance (microphone preamplifiers are a typical example). Other conditions of source grounding can be readily effected, for example, either of the input terminals can be directly grounded, or the center-tap of the balanced source can be grounded merely by inserting a shorted patch-plug in the center-tap and ground jacks.

A one-ended grounded condition of the output terminals of the audio system is indicated in Fig. 3, but any condition of load circuit grounding will work equally well, with no effect upon the signal amplitude appearing at the distortion-noise jacks, or upon the load volume indicator. Since, in the example shown, a 150-ohm load is required, the load impedance switch of the transmission set is turned to the 150-ohm position. Assuming the input volume-indicator and load volume-indicator range attenuators are on the same range setting (+40 dbm, for example) and that the decade attenuator dials on the 0-E set have been adjusted so that both input and load volume-indicators show reference deflection, the gain of the audio system is read directly by the sum of the readings shown on the three attenuators. This gain indicated by the reading of the decade attenuator is the true insertion gain of the audio system, and is independent of the input impedance of the audio system.

Frequency-response measurements of the audio system are made by holding one of the volume-indicators at reference deflection over the entire frequency range, and recording the variations of the other. In the majority of applications it makes no significant difference which volume-indicator reading is held constant, but if output level compression of the audio system is appreciable, it is the output volume-indicator reading which should be held at the desired level.

The signal appearing at the distortion-noise jacks provides ample calibrating voltage for a typical, high-impedance-input distortion-noise meter, even for a load power as low as +04 dbm. Noise measurements can be readily made with the CBS 6-E by turning the input key ($K_1$ of Fig. 2) to its terminated-input position. This removes the signal and properly terminates the equipment.

**Conclusion**

The CBS 6-E Transmission-Measuring Set provides substantially improved performance and operating flexibility over that of earlier transmission sets. Its performance meets the new high standards of accuracy required in present-day audio measurements.

The development of the CBS 6-E...
Transmission-Measuring Set was carried out under the general direction of Howard A. Chinn, Chief Audio-Video Engineer of the Columbia Broadcasting System. Electrical components development and mechanical design were under the direction of J. P. Smith, Jr., Chief Engineer of The Daven Company. A similar unit (Daven Type 10-A) will be manufactured by the Daven Company.

Letters

[From page 5]

The discussion started several years ago regarding surveys on the public's attitude toward high fidelity still goes on and on, but not by the public. It is carried on mostly by engineers wishing for perfection, naive idealists insisting the the public must eventually accept fidelity so perfect that it is indistinguishable from the original. This is of course desirable as an engineering achievement but it is not the answer to program enjoyment. For the enjoyment of music is a personal, intimate experience like poetry or a warm shower, and varies from individual to individual. Why must we, as the perfectionists desire, have only the bald original where the penny-trumpet and the brasses pierce the brain? The neuro-response to frequency varies with individuals, and greater subjective pleasure may be had over the original by permitting the listener to emphasize or de-emphasize such frequencies in accordance with his emotional preferences. Also permitting him to do several other things to the program, some of which will be suggested in the following paragraphs.

A perfect-fidelity system is only a canned system made perfect. This is said with sincere respect for the labor that has made it so, and for the undeniable satisfaction that it gives. But high fidelity, per se, can create nothing by itself. It is imitation raised to the nth order. Therefore it is regarded as synthetic and is taken far too casually. To maintain high fidelity the listener must not tamper with the tone controls, except that they be set for highest fidelity. The reproduced program, realistic though it be, is immutable in its musical construction since it is identical with the original. But give the listener the opportunity (when he desires) to change that construction, and his attention becomes acute. He is no longer a casual listener. He will experience a heightened participation in the program. He will attempt to identify himself with the surge and movement of the music. And this is vastly more important than perfect fidelity which is incompatible with his temperament.

Arguments that the public does not
especially desire extended high frequencies are not held by this writer. It is a peculiar portion of the highs that is usually found objectionable. With present-day designs the listener desiring to attenuate the 1500 to 3000-cycle range, has no alternative but also to eliminate all frequencies above this. No wonder manufacturers are confused and hope that a period of ear-reconditioning to wide range will eventually win a greater acceptance of it! But they will have to provide more than this if acceptance is to be hurried.

A New Creative Outlook

I therefore plead for a new creative outlook towards reproduced forms of music. Our audio systems must become instruments of individuality. They should be capable of making the owner a collaborator in the performance. Once the program enters the aerial, or as the record rotates under the needle, the listener should, if he chooses, be able to alter the frequency relationships, intensities, spatial illusions, timbre and coloration, etc. The different strands of a musical mixture should be made to stand out in individual distinction through their separable tone coloration. For instance, in the "Ride of the Valkyries," at certain passages three different themes are simultaneously present, the clear precision of the violins, the agitated flutterings of the woodwinds and a stentorian motif in the bassoons. This complex, polyphonic arrangement can be channeled and localized in the listening room, making for a quality of reproduction that is acute with dramatic intensity and effects. In the absence of stereoophonic pickup and transmission at the source, such segregation and spatial effects are today possible at the receiver by means of frequency channelization of the output, by the use of filters, by multiple loudspeakers and locations. We can add echo effects to increase the apparent dimensions of the hall in which the original performance was held. We can alter timbre and achieve a gradation of color and sound intensities. Dynamic range can be added to a crescendo. Unfortunately the writer cannot suggest means for varying tempo. For the time being our new-audio-listener will have to remain content and endure a "languendo" movement no matter how his fingers may itch for an absent "presto" switch-button. But all other possible buttons shall be at his finger tips so that he may add his own interpretation according to his own feelings.

Saul J. White
80 No. Keesico Ave.
White Plains, N. Y.

[Mr. White's views, which he has so interestingly presented, do not altogether coincide with ours. But we feel that his letter will stimulate thought along aesthetic lines, so often neglected by engineers.—Ed.]
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Frequency Range 30 CY to 17 KC

This gain set has been designed for the accurate and rapid measurement of the transmission characteristics of audio systems and their components. It is a direct reading instrument, entirely eliminating laborious calculations and complex set-ups. This unit is arranged so that the meters and their associated range controls can be independently used as VU meters in program monitoring.

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*Patent Pending

This unit was developed in cooperation with the General Engineering Department of the Columbia Broadcasting System.
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VELOCITY MICROPHONE

Bantam Size!

Because this man is talking into the new miniature KB-2C, his audiences hear him ... and see him! Hear him—because the KB-2C has "big mike" quality. See him—because the KB-2C is one of the smallest high-quality microphones yet designed. It's ideal for conventions and night clubs. And it's ideal for general station and other indoor uses.

Using highly efficient magnetic material ... and a magnet structure that's a part of the microphone case itself, here's a microphone that's as "light as a feather"—and so small it fits into your pocket. Its directional characteristics provide a symmetrical figure eight ... with surprisingly uniform frequency response between 80 and 8,000 cps. Hum level, -108 dbm. Effective output level, -56 dbm. Three output impedances provided; 30, 150, and 250 ohms, in accordance with RMA standards.

Plenty of operating conveniences, too. You can tilt the KB-2C backward and forward on its swivel through an angle of about 30 degrees. You can select your bass response by means of a screwdriver-type switch located under the swivel pivot. You can disconnect the cable right at the microphone. For desk positions, use RCA's type KS-2A low-height stand. For other services, use any standard floor stand or collapsible stand.

More about the 12-ounce KB-2C from your RCA Broadcast Sales Engineer. Or write Dept. 7-D

RCA TYPE KB-2C
80 to 8,000 cycles
Price $50.00

The KB-2C shown here is actual size.

Directional characteristics of a typical KB-2C microphone.

Open Circuit Frequency Response of a typical KB-2C microphone.

BROADCAST EQUIPMENT
RADIO CORPORATION OF AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: R.C.A. VICTOR Company Limited, Montreal.

www.americanradiohistory.com