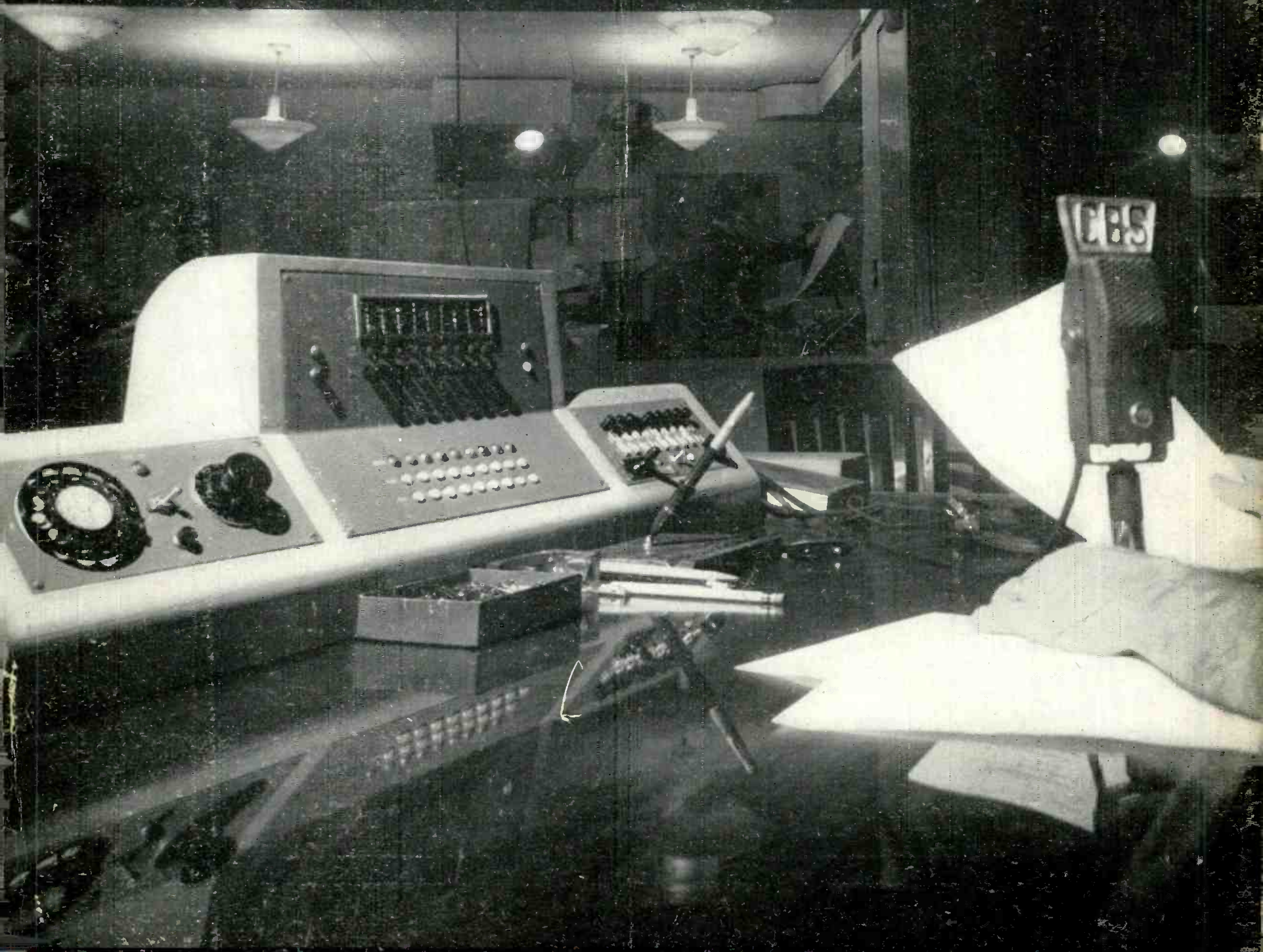
AUDIO ENGINEERING

APRIL
1948



THE JOURNAL FOR SOUND ENGINEERS

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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.

Broadcast in twenty-three languages, these programs blanket Europe, Latin America and the Far East, with a potential radio audience of more than 150,000,000 persons.

Of the thirty-two hours of daily broadcast, approximately one-fourth of the time is devoted to news, one-half to additional comment and informational programs, and the remainder to music and entertainment.

A substantial part of these daily programs is recorded and, due to the excellent quality of these transcriptions, such recorded portions cannot be distinguished from the *live* transmissions.

Today, as from the beginning, the recorded parts of these broadcasts are on AUDIODISCS.

AUDIO DEVICES, INC., 444 Madison Avenue, New York 22, N.Y.

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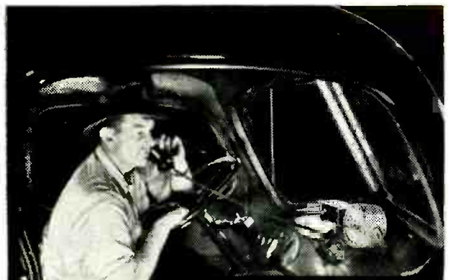


View of truck cab showing driver "on the road" in communication with headquarters station.

The Lock-In Tube In Action

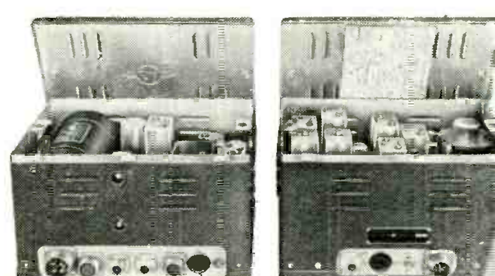
For Electric Department
Public Service Electric and Gas Company

Headquarters station in communication with any of the many Public Service units ready for prompt trouble-shooting.

THROUGH an ingenious system of radio communication, the Electric Distribution Department of the Public Service Electric and Gas Company (New Jersey) is able to service a given area swiftly and efficiently.

With 153 vehicles in operation (at the present time), equipped with two-way radio units, Public Service can direct any one of these mobile units to the scene of an electrical breakdown in a matter of minutes!

This elaborate repair system can't afford to risk communication failures. Sylvania Lock-In tubes are used in these Link Radio Corporation sets because no matter how rough the way, they'll *stay* in their sockets. Tubes have few welded joints and *no* soldered ones—the elements can't warp or weave. Short, direct connections . . . less loss; getter located on top . . . leakage reduced by separation of getter material from leads. See Sylvania Distributors or write Radio Division, Emporium, Pa.



Transmitter and Receiving Units used in Public Service mobile equipment, manufactured by Link Radio Corp., New York.

The famous Lock-In tube's superiority makes it the ideal choice for equipment on the road, in the air, on the rails, marine radar, FM and television.

SYLVANIA ELECTRIC

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS

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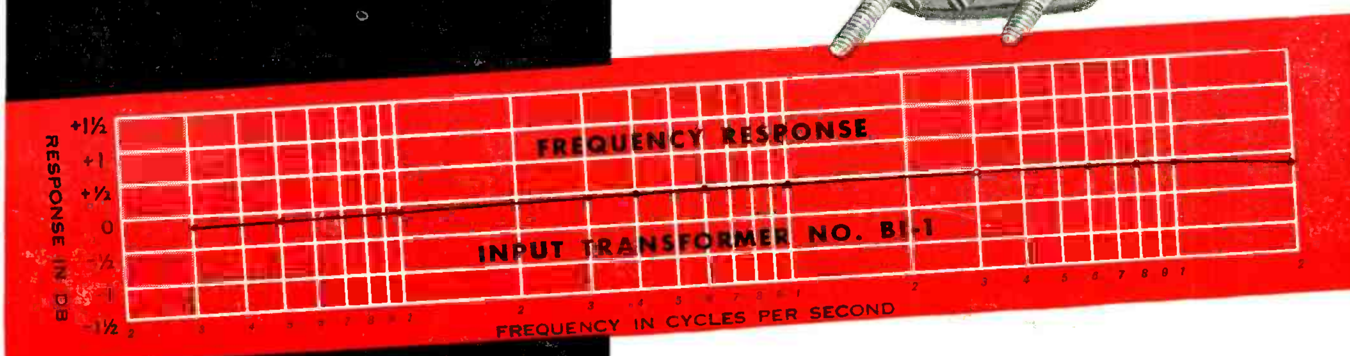

INPUT TRANSFORMERS

Catalog No.	Application	Impedance Primary—Secondary	Max. Power Level
BI-1	Line to Single or P.P. Grids..........	*Pri.—600/150 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.
BI-2	Line to Single or P.P. Grids..........	*Pri.—600/150 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.
BI-3	Line bridging to P.P. Grids..........	*Pri.—8,000/6,000 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.
BI-4	Line to line...........	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT..	+20 dbm.
BI-5	Line to line...........	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT..	+30 dbm.
BI-6	Interstage—P.P. Plates to Single or P.P. Grids..	*Pri.—20,000 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.

OUTPUT TRANSFORMERS

Catalog No.	Application	Impedance Primary—Secondary	Max. Power Level
BO-1	Single Plate to Line....	Pri.—15,000 ohms at 0 to 10 ma d-c........ *Sec.—600/150 ohms CT..	+20 dbm.
BO-2	P.P. Plates to Line.....	*Pri.—20,000 ohms CT.... *Sec.—600/150 ohms CT	+30 dbm.
BO-3	P.P. Plates to Line.....	Pri.—5,000 ohms CT..... *Sec.—600/150 ohms CT..	+40 dbm.
‡BO-4	P.P. Plates to Line.....	Pri.—7,500 ohms CT..... *Sec.—600/150 ohms CT..	+43 dbm.
BO-5	P.P. Plates to Line.....	Pri.—10,000 ohms CT.... *Sec.—600/150 ohms CT; 16/8/4 ohms......	+37 dbm.

‡Has tertiary winding to provide 15% inverse feedback.
*Split and balanced windings.

Characteristic of C.T.'s New Full Frequency Range Input and Output Transformers

They provide response within ±½ db over the full range from 30 to 15,000 cycles . . . and response within ±1 db up to 20,000 cycles. That's tested performance . . . not *just* a curve.

Their percentage of distortion is exceptionally low over the full range . . . at low as well as high frequencies.

They're *Sealed in Steel* to protect the delicate, fine wire coil windings against corrosion by atmospheric moisture. The drawn steel cases are compact and streamlined . . . help achieve a clean, uncluttered appearance for any gear.

Input units have hum-bucking core construction and additional inner cases of special alloy for hum shielding of –70 dbm or better.

For 250-watt, 1-KW, and 5-KW Transmitters

Matched sets of Driver and Modulation Transformers, and Modulation Reactors, Response within ±1 db over the Full Frequency Range of 30 to 15,000 cycles. Distortion very low . . . well within FCC limits for transmitters.

Distributorships for this new stock line are now being established. For full information, see your radio parts jobber or write direct.

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AUDIO ENGINEERING

Successor to RADIO

Established 1917

CONTENTS APRIL, 1948

Vol. 32, No. 4

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.

AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at 28 Renne Ave., Pittsfield, Massachusetts, by Radio Magazines, Inc., J. H. Potts, President; S. R. Cowan, Sec'y-Treas. Executive and Editorial Offices at 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States, U. S. Possessions and Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U. S. A. Entered as Second Class Matter at the Post Office, Pittsfield, Massachusetts, under the Act of March 3, 1879.

Letters

Toward A New Audio

To me, my radio reproduces music with greater thrill than is imparted by the original flesh-and-blood orchestra. It can make a singer's voice more beautiful than nature made it. That is why I think it is the finest reproducing system in the world. A lyric tenor assumes a diaphragmous quality. He approaches the mellowness of a baritone without a shift of key. A rural twang will have a low frequency sounding-board added to it, and the sibilants will fairly spit out at one through the loudspeaker. That is how I like my reproduction, and that is why I think my audio system is unsurpassable. It is not a linear system, but it is capable of reaching the extremes of the audible spectrum. It is not fidelity or realism that sends a thrill through my spine as I listen. It is something vastly more important to me personally than similitude to the original performance. It is reproduction that enhances that portion of the frequency spectrum that gives me psych-delight, and lessens that which irritates, even in the original.

My reproducing system is the most unlinear one in the world. It is unflat, plus or minus something awful. And by manipulation of controls I can make it even worse. It can be all lows or all highs, or a combination of both, with the middle range attenuated as much as 30 db. I just can't stand much of that blatant, nerve-scrapping middle register. You can have it . . . it's much too fat for me. I like my middle register lean. But I can obtain acoustic output to 16 kc, and as for the low end, I believe that if the Great Bell of Moscow weighing 180 tons hadn't cracked that I could place it acoustically in the center of my livingroom. Let a drum be struck and the blow against a tightly-stretched skin rolls through the house. As for the highs, castanets, tambourines, triangles and the snare-brush waltz down into my ear canal, either the right or left canal, as I choose! This is because I can shift the spatial feeling by switching my tweeters either for in-phase or out-of-phase operation. This is not realistic reproduction . . . this is private intimacy. Needle scratch is ever present, but because I attenuate the upper portion of the middle register, my needle scratch becomes almost enjoyable. What a tone to that scratch! It is like steam gently escaping from a fine nozzle. Nothing rough or harsh about *my* scratch. It is silky, soft and silvery. It is random noise with practically no upper limit but with a definite lower limit. This is quite the reverse of conventional practices for reducing scratch.

[*Continued on page 46*]

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-r 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.

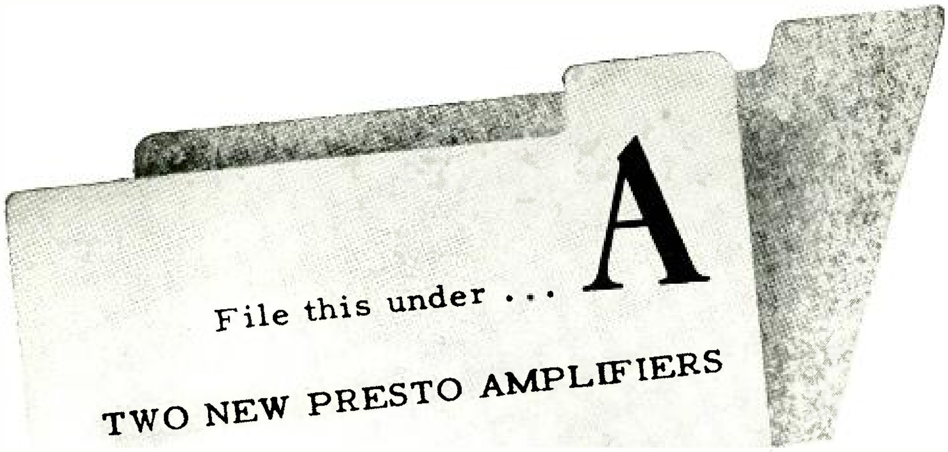
The Radio Engineering Show is always the place where the visitor is bound to meet some old friend or associate from across the country; old times and new ideas are discussed; and many a pleasant get-together is consummated. It is surprising, however, to note the over-all seriousness of the IRE Convention—most 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.

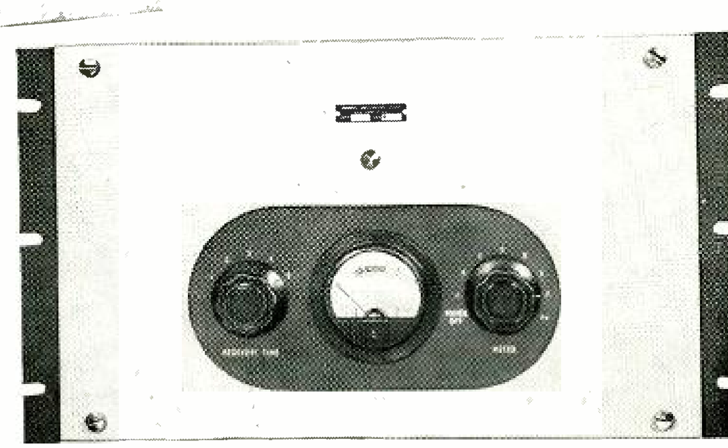
—*J. H. P.*



Engineers will welcome these two new additions to the PRESTO line of superior equipment.

Presto Peak Limiting Amplifier (*Type 41A*)

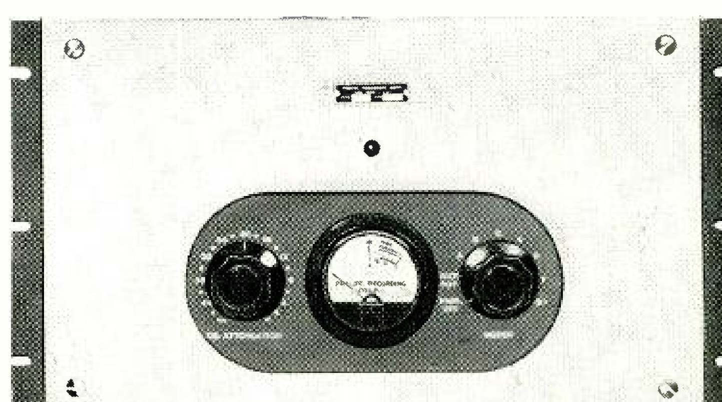
DESIGNED to control program peaks, Type 41A removes the cause of overcutting and distortion in recording and over-modulation in broadcasting. Proper degree of peak limiting permits an appreciable increase of the average signal with consequent improvement of signal to noise ratio. Serves simultaneously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



Type 41A. Chassis construction is for vertical mounting in standard racks. Removable front panel gives access to all circuits. Meter and selector switch indicate amount of limiting taking place and current readings of all tubes.

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.



Type 89A. Chassis construction is for vertical rack mounting. Removable front panel for easy access to all circuits. Meter and selector switch provide convenient indication of output level at 1000 cps and current readings of all tubes.

FULL SPECIFICATIONS OF THESE TWO NEW AMPLIFIERS WILL BE SENT ON REQUEST.
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WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT & DISCS

for A-F DISTORTION and NOISE MEASUREMENTS

. . . 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 { power / r-f levels / frequency / percentage modulation }
- 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 particulary 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)

TYPE 732-P1 RANGE EXTENSION FILTER $209.00

WE HAVE A FEW IN STOCK. ORDER NOW FOR PROMPT SHIPMENT

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

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To deliver WIRED MUSIC at its finest . . .

Western Electric's complete line!

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, 70-13,000 cycles. For higher power, the 20-watt 756A or 30-watt 728B.

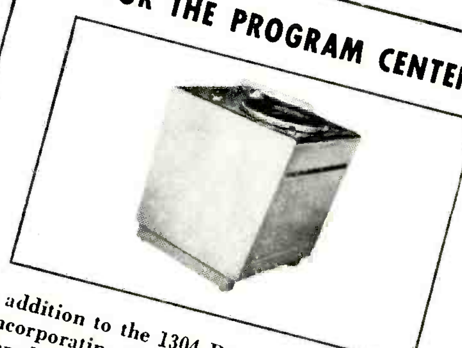
AUTOTRANSFORMERS

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

MICROPHONES

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 . . . the two major wired music program studios use Western Electric *recording* equipment. Get the most out of these fine recordings with Western Electric *reproducing* equipment!

WITH Western Electric's complete line of equipment—engineered to provide quality reproduction and dependable, trouble-free operation—an ideal system can be planned for any requirement.

Your local Graybar Representative will be glad to give you details. Or write Graybar Electric Co., 420 Lexington Ave., New York 17, N. Y.

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Western Electric

— QUALITY COUNTS —

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Fig. 1. View of the recorder with cover removed.

R. E. ZENNER*
and
R. B. VAILE, JR.*

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 [1,2] 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.

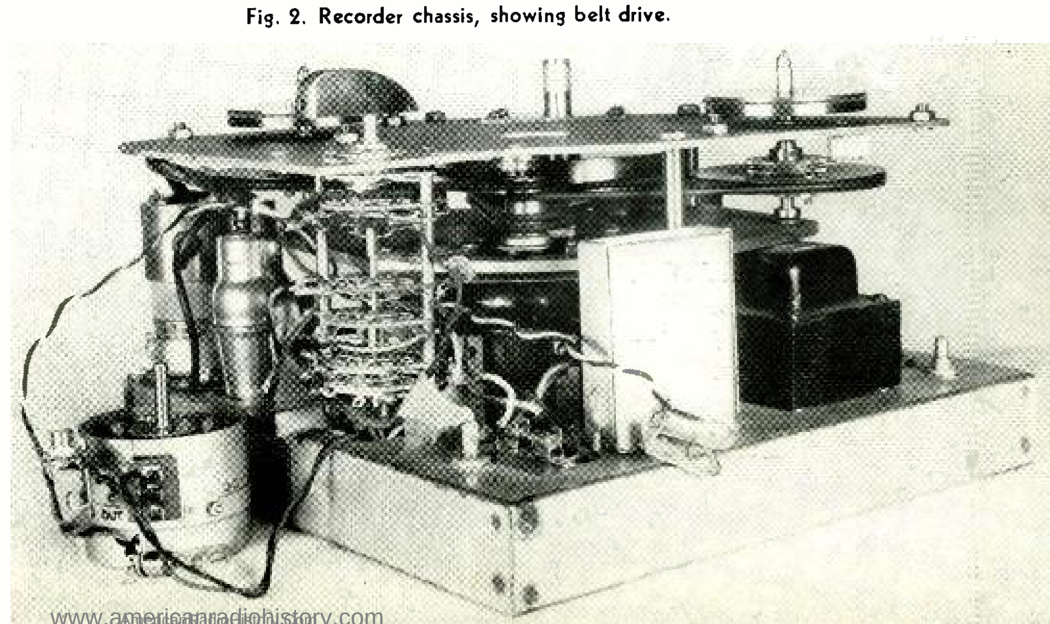
Over-all dimensions of the unit are 14-¾ inches by 14-¾ inches by 9-¼ inches high. It weighs 50 pounds.

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.*

[1]Marvin Camras, "Magnetic Sound for Motion Pictures," *Journal of the Society of Motion Picture Engineers*, Vol. 48, No. 1 (January, 1947), Pp. 14-28.

[2]Marvin Camras, "Magnetic Recording Tapes," presented before the American Institute of Electrical Engineers, January 29, 1948.

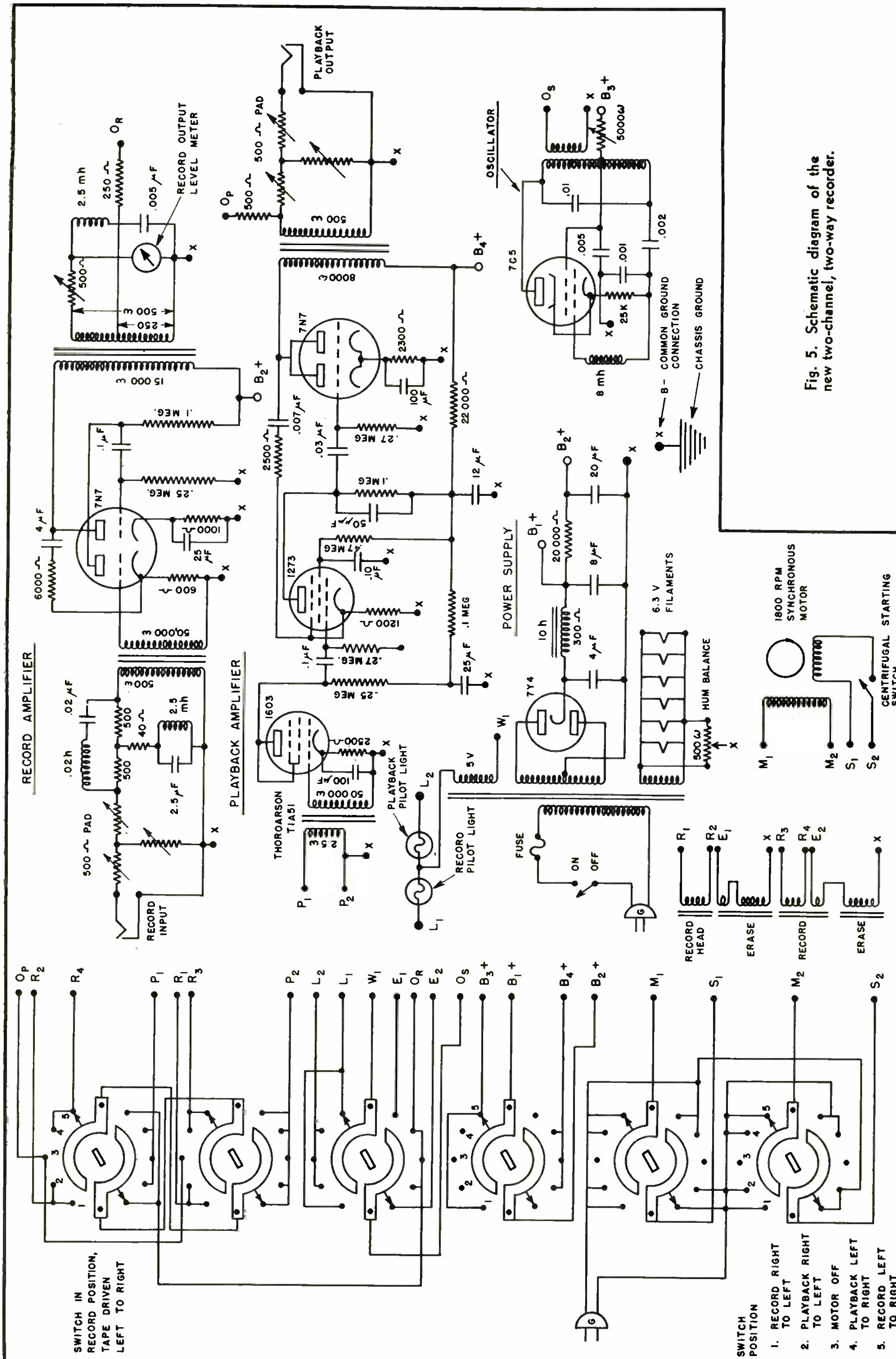


Fig. 5. Schematic diagram of the new two-channel, two-way recorder.

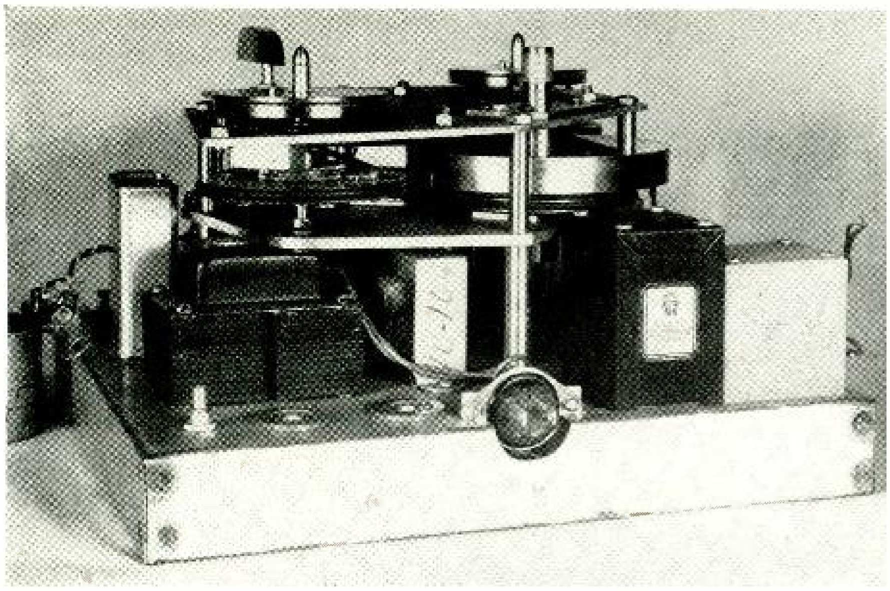


Fig. 3. General mechanical details of recorder.

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 single turn springs 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 rasping 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-ball 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.

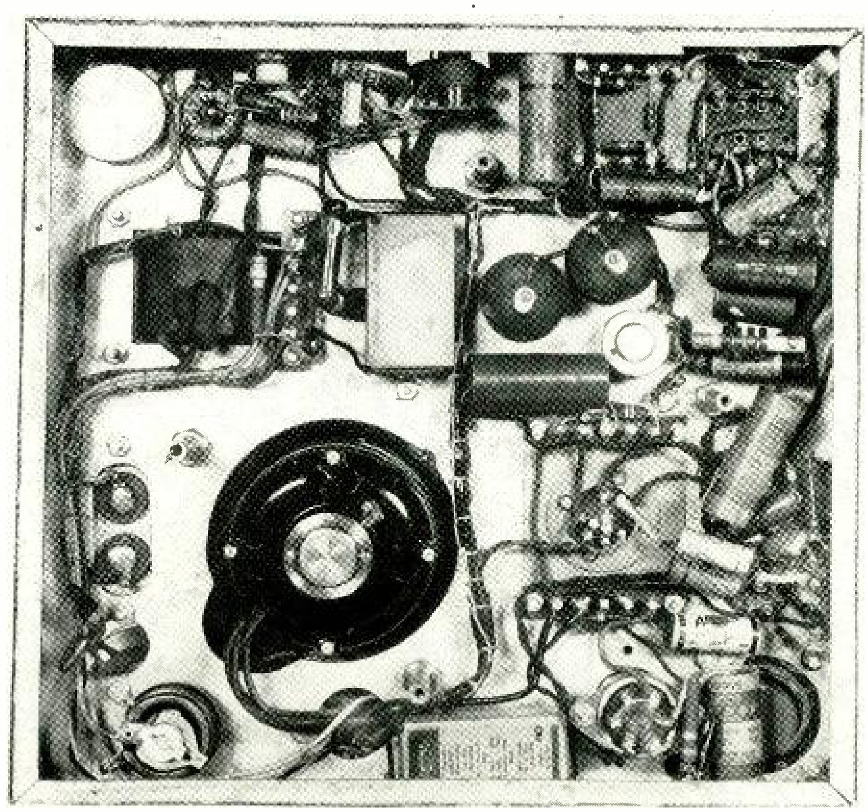
Practical tolerances on true running of lower plates of the tape reel friction clutches impose an upper limit on the take-up reel overdrive which can be provided, thus limiting high speed transport of tape. Wobble of the clutch members will raise and lower the tape reel. If this is done too rapidly and 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

Fig. 4. Layout of electrical parts of recorder.



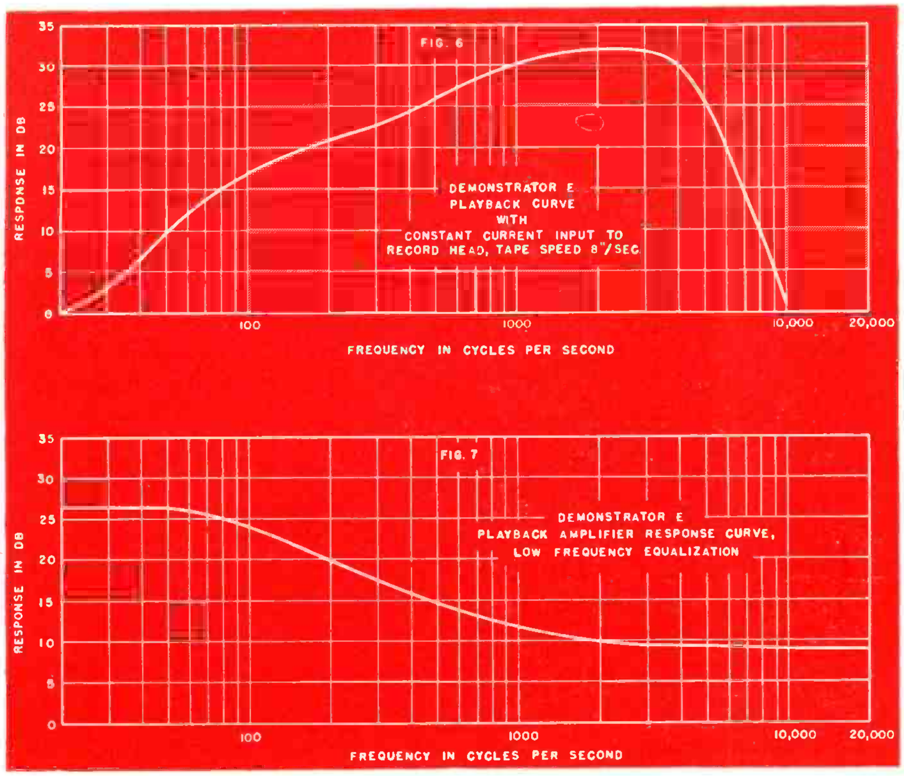


Fig. 6. (top). Constant current frequency response curve.
Fig. 7. Negative feedback provides bass boost shown.

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 1603 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*.[3] 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.

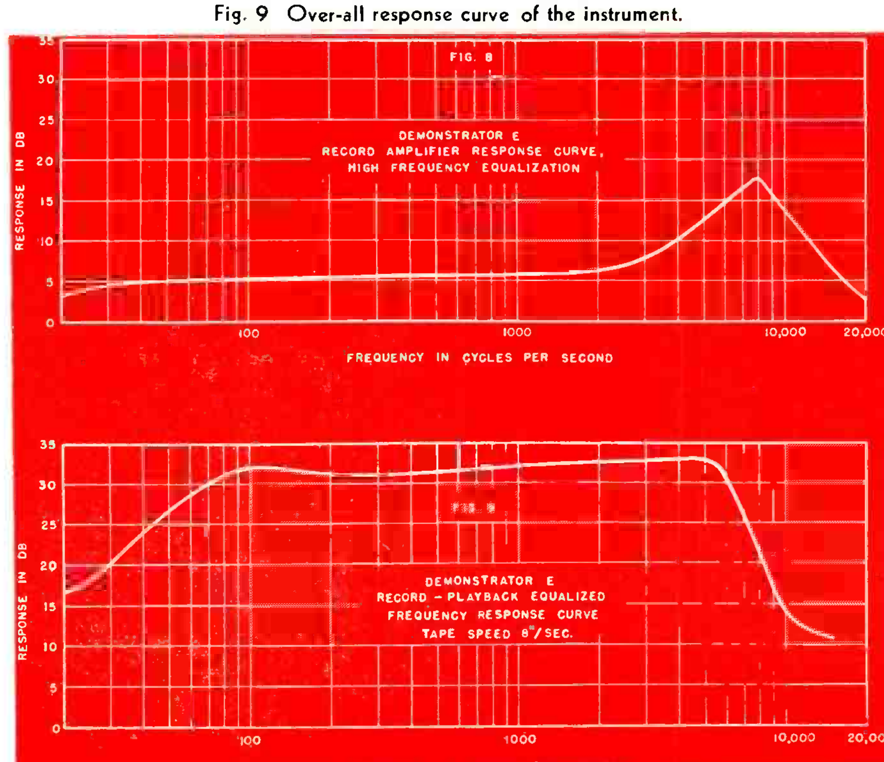
Heads

The two head assemblies are identical in design but reversed in mounting (one flopped 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

[3]Marvin Camras, "Theoretical Response from a Magnetic Wire Record," *Proc. I. R. E. and Waves and Electrons*, Vol. 34, No. 8 (August, 1946), P. 597.

Fig. 8. (top). High frequency emphasis is provided in the recorder.
Fig. 9 Over-all response curve of the instrument.



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.[4]

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. High impedance heads could be used, reducing cost by eliminating transformers, with some loss of signal from the heads. Circuit design might be patterned after the current production home wire recorders.

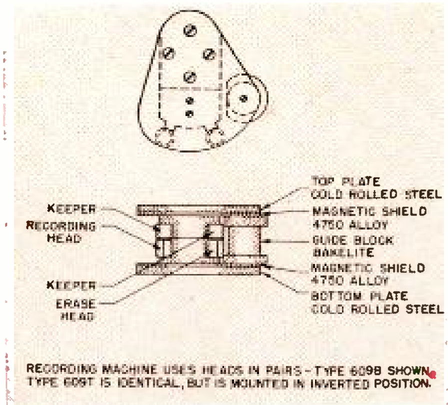


Fig. 10. Diagram of head assembly.

If extended high frequency response were required, it could be provided by increasing tape speed.

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, wow meters, etc., which have made this machine possible.

[4] Lynn C. Holmes, Donald L. Clark, "Supersonic Bias for Magnetic Recording," *Electronics*, July, 1945, Pp. 126-36.

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 amplitude 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 sources 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, expecially 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

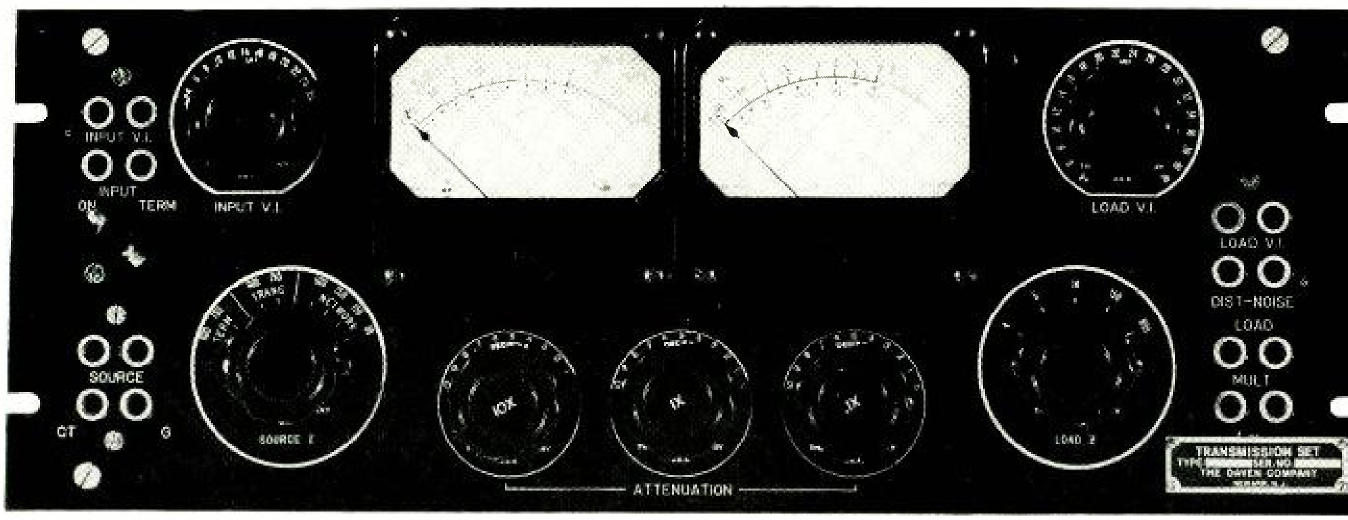


Fig. 1. Front-panel view of CBS 6-E Transmission-Measuring Set, laboratory model. Full-panel-width separation of the source and load jacks provides a high degree of isolation between input and output circuits. The three ATTENUATION controls provide a total attenuation of 111 db in 0.1-db steps. The SOURCE-Z and LOAD-Z controls permit convenient selection of the most commonly required source and load impedances. Standard VU meters are used as power-level indicators.

CBS Transmission Measuring Set

DONALD F. MAXWELL*

Describing a new instrument designed for precision audio-frequency testing in broadcast service.

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 1939, 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 stations[1] and the RMA minimum performance standards for audio facilities[2] 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.

In addition to the establishment of minimum performance standards for audio facilities, other postwar advances in the field of audio facilities measurements include RMA standardization[2] 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-

[1] See Federal Communications Commission "Standards of Good Engineering Practice for FM Stations."
[2] See RMA Standards Proposal No. 186, January 15, 1947.

**Engineering Dept. Columbia Broadcasting System New York City.*

tures 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 1-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 a 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. A sectionalized type of mechanical design simplifies maintenance and reduces stray coupling between circuits.
9. 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 clearer by a description of the 6-E circuit and its application to typical audio measurements.

Circuit

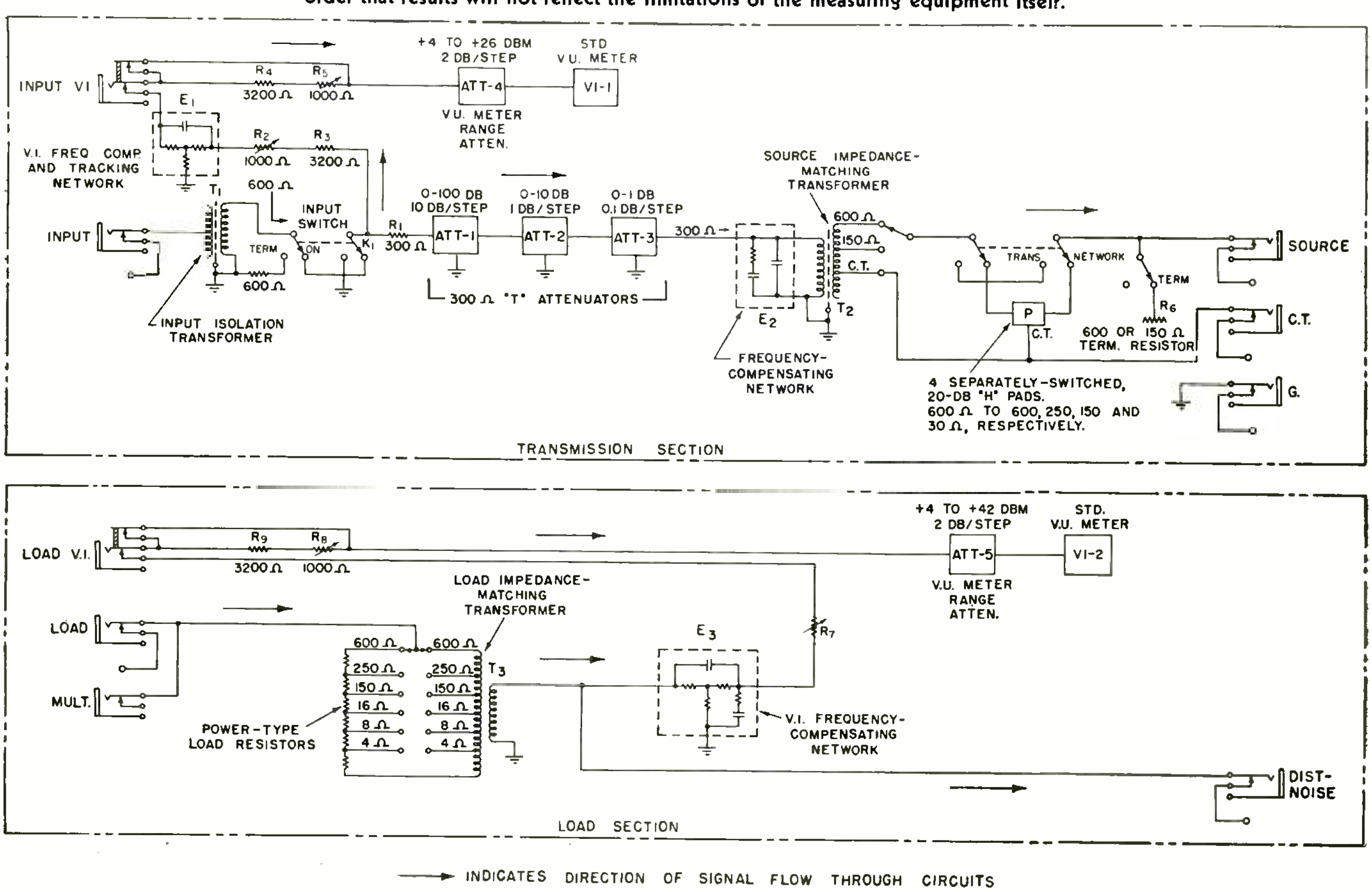
Fig. 2 shows a functional line diagram of the electrical circuits of the CBS 6-E transmission-measuring set. In common with earlier sets, the 6-E is composed of two electrically-isolated sections, the transmission section, and the load section, with separate level indicators (VU meters) for each section. 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 T_1, the operation of the 6-E set is independent of the manner in which the signal generator may be grounded. When the input switch K_1 is in the "On" position, the secondary winding of T_1 sees a 600-ohm load made up of the 300-ohm source resistor R_1 and the 300-ohm impedance of the decade attenuator circuit. The input volume indicator circuit is bridged across the attenuator side of the switch K_1, and since in normal operation the reading of the input VU meter VI-1 is kept con-

Fig. 2. Functional line diagram of CBS 6-E Transmission-Measuring Set. In one unit are contained all of the calibrated attenuators, impedance-matching transformers, isolation coils, power-level indicators and terminating impedances required for the measurement of audio facilities performance. Present-day standards of performance for audio facilities necessitate a very high degree of accuracy in the measuring equipment in order that results will not reflect the limitations of the measuring equipment itself.



stant, the desired effect of a zero-impedance signal generator is obtained at this point in the circuit. R_1 then provides the required 300-ohm source impedance 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 network E_1, the VU meter range attenuator ATT-4 and the building-out resistors R_2 and R_3. The network E_1 has a mid-frequency attenuation equal to the combined transmission loss introduced by the source resistor R_1, the frequency compensating network E_2 and the source impedance-matching transformer T_2. Thus E_1 serves as a level-tracking network so that the signal level read on the VU meter VI-1 will be equal to that appearing at the source jacks, less, 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 adjustments 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 circuit is lifted, and the VU meter VI-1 may be used as an entirely isolated, auxiliary VU meter. Under this condition the resistors R_4 and R_5 serve as the VU meter building-out resistors, and R_5 permits a continuously-variable calibrating 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 transformer 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 winding, and has very low capacitance to ground. This type of construction makes it possible to operate the secondary winding into a variety of balanced, unbalanced, or one-side-grounded circuits. The network E_2 serves the double purpose 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 connected 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 transmission set. In two other positions of the source-impedance switch internal terminating resistors R_6 of 600 or 150 ohms are switched across the corresponding 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 characteristics of bridging amplifiers and audio systems with high input impedance.

In the remaining four 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 transformer T_2. The pads also make it possible to obtain 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 impedances, 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 impedances 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 transformer 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 circuit consists of the standard VU meter VI-2 and the associated VU-meter attenuator ATT-5, the series calibrating resistor *R7*, and the frequency-compensating network, *E3*. 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

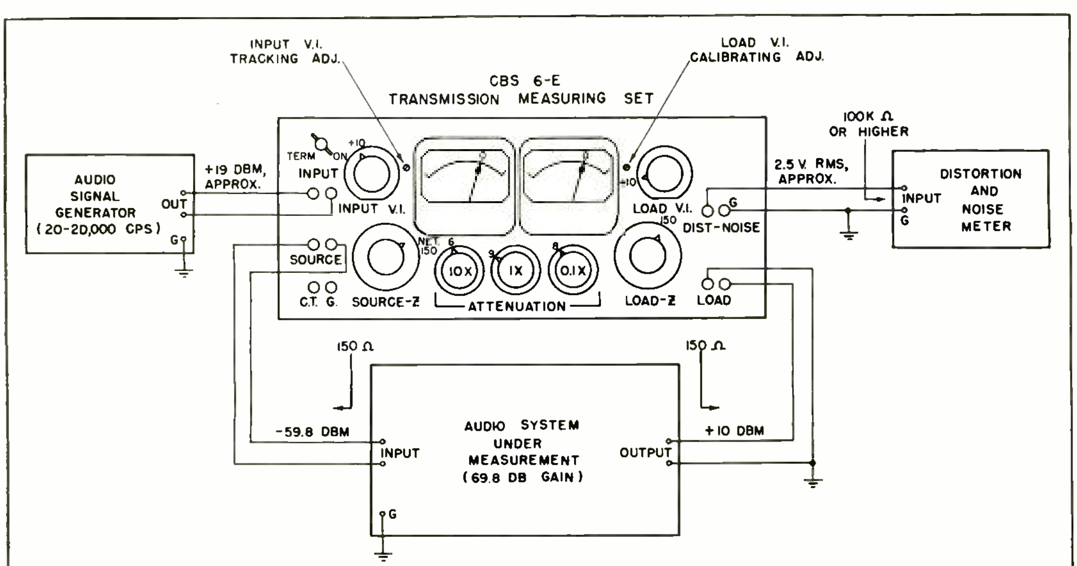


Fig. 3. Application of CBS 6-E Transmission-Measuring Set to a typical audio-measuring setup. Only an audio signal generator and a distortion and noise meter are required in addition to the CBS 6-E set for any of the measurements generally made of audio system performance. The simplicity of the setup from an operational standpoint considerably enhances the accuracy and repeatability of the results.

indicated by the dial marking 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_8 and R_9. Also similarly to the input volume-indicator circuit, the continuously-variable resistors R_7 and R_8 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 6-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 50-15,000 cps, for all settings of the variable attenuators in the transmission section and for all positions of the source-impedance or 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 $\pm 2\%$ 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 6-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 6-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

[*Continued on page 43*]

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 $33^1/_3$ 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 37*]

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 demurrer 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 use will absorb the most machines?
3—What unusual technical performance 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 move by 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.

*Box 408, New Canaan, Conn.

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 typed 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 *idea 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 accurate transmission. At present, it is necessary 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 were 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 I

Contrasted Operating Conditions Telephone Recording vs Studio Recording

Telephone	Studio
1—Speaker Usually untrained for best diction.—Frequently speaks with sectional dialect.	**1—Speaker** Professional—trained announcer—pronunciation fairly standardized nation-wide.
2—Pick-up Point Often noisy room or one with poor acoustics.	**2—Pick-up Point** Sound-proof studio.
3—Microphone Telephone transmitters widely variable in sensitivity and frequency response.	**3—Microphone** High quality in sensitivity and frequency response.
4—Input-to-line Level Variable intensity of telephone talkers.	**4—Input-to-line Level** Monitored and controlled by engineer.
5—Transmission Lines Top cut-off usually around 2000 to 2500 c.p.s. Often low intensity level. Interfering line noises.	**5—Transmission Lines** Good at least to 5000 c.p.s. Equalized and quiet.
6—Recorder Competitively priced at from $300-$400. Operation by non-technical office personnel. Where disc used, embossed.	**6—Recorder** Superior equipment. Operated by professional engineer.—Groove cut, rather than embossed.
7—Play-back Interrupted by stop, backspace and repeat for typing. Often interfering room noise.	**7—Play-back** Continuous, uninterrupted. Usually with no distracting interference by room noise.
8—Purpose Business communication which must be typed letter-perfect.	**8—Purpose** Entertainment. Sufficient if listener gets the "sense" of program—not imperative he get every word letter-perfect.

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

Sound	Key	Rela. Freq. Occurrence	Articulation Loss When Bandwidth is: 200-2000 c.p.s.	200-2500 c.p.s.	200-3000 c.p.s.
i	tip	7.94	1%		
n		7.24	13%	7%	4%
t		7.13	29%	23%	18%
r		6.88	1%		
o	ton	5.02	5%		
s		4.55	55%	57%	59%
d		4.31	9%		
á	tap	4.17	3%		
ē	eat	3.89	0		
l		3.74	1%		
e	ten	3.44	3%		
th	then	3.43	(No figures available		
a	top	3.33	3%		
z		2.97	22%	21%	20%
m		2.78	2%		
k		2.71	12%	4%	2%
ā	tape	2.35	2%		
v		2.28	14%	8%	5%
w		2.08	0		
p		2.04	20%	7%	2%
f		1.84	36%	22%	15%
b		1.81	3%		
h		1.81	5%		
ō	tone	1.63	0		
ū	tool	1.60	3%		
ī	dike	1.59	0		
ô	talk	1.26	2%		
ng	hang	.96	0		
sh	shell	.82	17%	4%	1%
g		.74	14%	5%	3%
u	took	.69	6%		
y		.60	3%		
ou	our	.59	0		
ch	chalk	.52	28%	16%	7%
j		.44	12%	7%	4%
th	thin	.37	49%	41%	34%
ew	few	.31	(No figures available)		
oi	oil	.09	"	"	"
zh	azure	.05	"	"	"

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 diction.

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 6 times 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 Dewey[1] and by Dr. Harvey Fletcher[2] 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 279-289 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 re-

[1]Dewey, Godfrey, "Relative Frequency of English Speech Sounds," 1923 Harvard University Press, Cambridge, Mass.

[2]Fletcher, Harvey, "Speech and Hearing," 1929, D. Van Nostrand Co.-Braunworth & Co. Press, Brooklyn, N. Y.

TABLE III

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

Sound	Rela. Freq. Occurrence	Articulation Loss
n	7.24	13%
t	7.13	29%
s	4.55	55%
z	2.97	22%
k	2.71	12%
v	2.28	14%
p	2.04	20%
f	1.84	36%
sh	.82	17%
g	.74	14%
ch	.52	28%
j	.44	12%
th	.37	49%
Total	33.65	Unweighted Average 25%

Note: (Excluding *th*, as in then.)

sponse 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 articulation 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 it, 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 33.65,—which means that every third sound encountered in the reading of a printed page will be one of those 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 17.38, and their unweighted average loss is 30%.

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 16.86, 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% x 16.86%—or 4.8%—of the words typed would be incorrect. This would mean 48 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

Sounds Having Over 10% Articulation Loss When Top Circuit Frequency Cut-Off is 2500 c.p.s.

Sound	Rela. Freq. Occurrence	Articulation Loss
t	7.13	23%
s	4.55	57%
z	2.97	21%
f	1.84	22%
ch	.52	16%
th	.37	41%
Total	17.38	Unweighted Average 30%

Note: (Excluding *th*, as in then.)

Common sense tells us what the word should be.

But, in countless other instances, the typist finds no dependable experience to fall back on, correctly to identify the sound in question. Here is where the dangerous game of guessing begins. Two illustrations of guessing will illustrate the danger.

At one of the tensest moments in Britain's history, just before her entry into World War II, a news story was telephoned from London containing the sentence: "Big Ben was ticking the peace away."

Delivered by the typist in New York it read: "Big men were kicking the peace away." (Perhaps a more accurate statement of fact.)

On another occasion at the dedication of Shenandoah National Park, one of the oratorical dignitaries reached a high point with the phrase: "the wilderness to be inviolate."

This was typed out from a recording as: "the wilderness, the bee and violet."

Note that in each case it was error in identifying the critical sound *t* which started the trouble.

The important consideration is, that, given a transmission bandwidth sufficient 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.

TABLE V

Sounds Having Over 10% Articulation Loss When Top Circuit Frequency Cut-Off is 3000 c.p.s.

Sound	Rela. Freq. Occurrence	Articulation Loss
t	7.13	18%
s	4.55	59%
z	2.97	20%
f	1.84	15%
th	.37	34%
Total	16.86	Unweighted Average 29%

Note: (Excluding *th*, as in then.)

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-off. 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 is 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

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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.

*307 E. 44th St., New York City.

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 2,159,505, which describe the Hammond Organ in considerable detail. Each is a masterpiece 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.

Fig. 1. Detailed view showing principal controls. Precept keys are reversed in color to avoid confusion with playing keys.

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 voltmeter.

No wood was used in the entire instrument, except for the pedalboard and bench, and the cabinets for the console

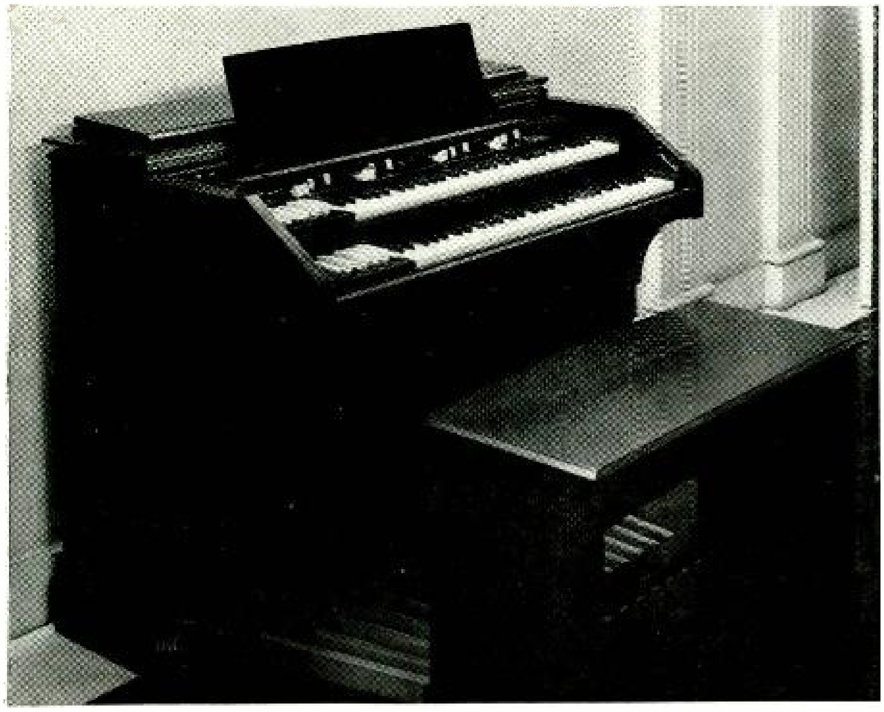


Fig. 3. The model CV Hammond console. It is similar in electrical design to the model BV console but has special features which adapt it better to church use.

and speaker; the latter two items being fashioned on the assembly line in the manner of radio cabinets.

The over-all 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 a 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 phonic 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. Nor could one modify the registration on a preset key in the manner in which he would manually add or take off a stop, when using 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]

Fig. 2. Model BV Hammond Console. The models B, BV, and BVC are identical in appearance but differ in electrical design. This instrument is widely used in homes.

Notes on Using High-Power Ultrasonics

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 out 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 coagulation of dust is one of our most 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 o' 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."

**Consulting Engineer, 52-12 Van Horn St., Elmhurst, L. I., N. Y.*

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.

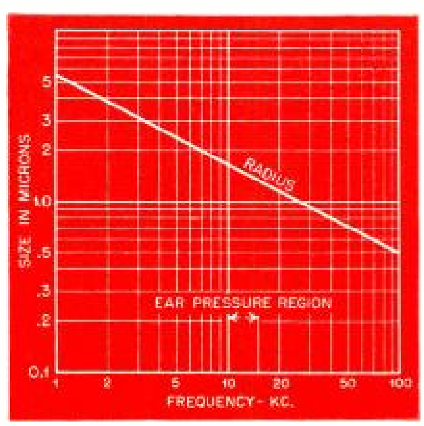


Fig. 1. Radius of particles of density 1 which have a random excursion of one-half the wave motion.

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.

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 actuating 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 0° 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 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/in^2. 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 bothersome 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 nascent 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 10^{-4} 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 10^4 microinches, and there are 1.7 times 10^{21} cubical microinches in a cubic foot. Dividing, we have 3 times 10^{11} one micron spheres to the cubic foot, or 1.7 times 10^8 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 mils.

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 50 watts/in^2 the gas has a motion of about 6 mils. The particle would then have an excursion of 3 mils, much more than the separation of 1.8 mils, and coagulation would occur. See *Fig. 1*.

Now we can design the chamber in which the gas is to be treated for either

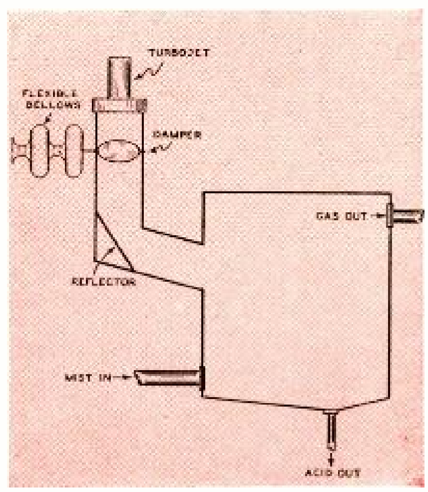


Fig. 2. Chamber for treating sulphuric acid mist by ultrasonics.

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 mils, 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 unit 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 37]

AUDIO DESIGN NOTES

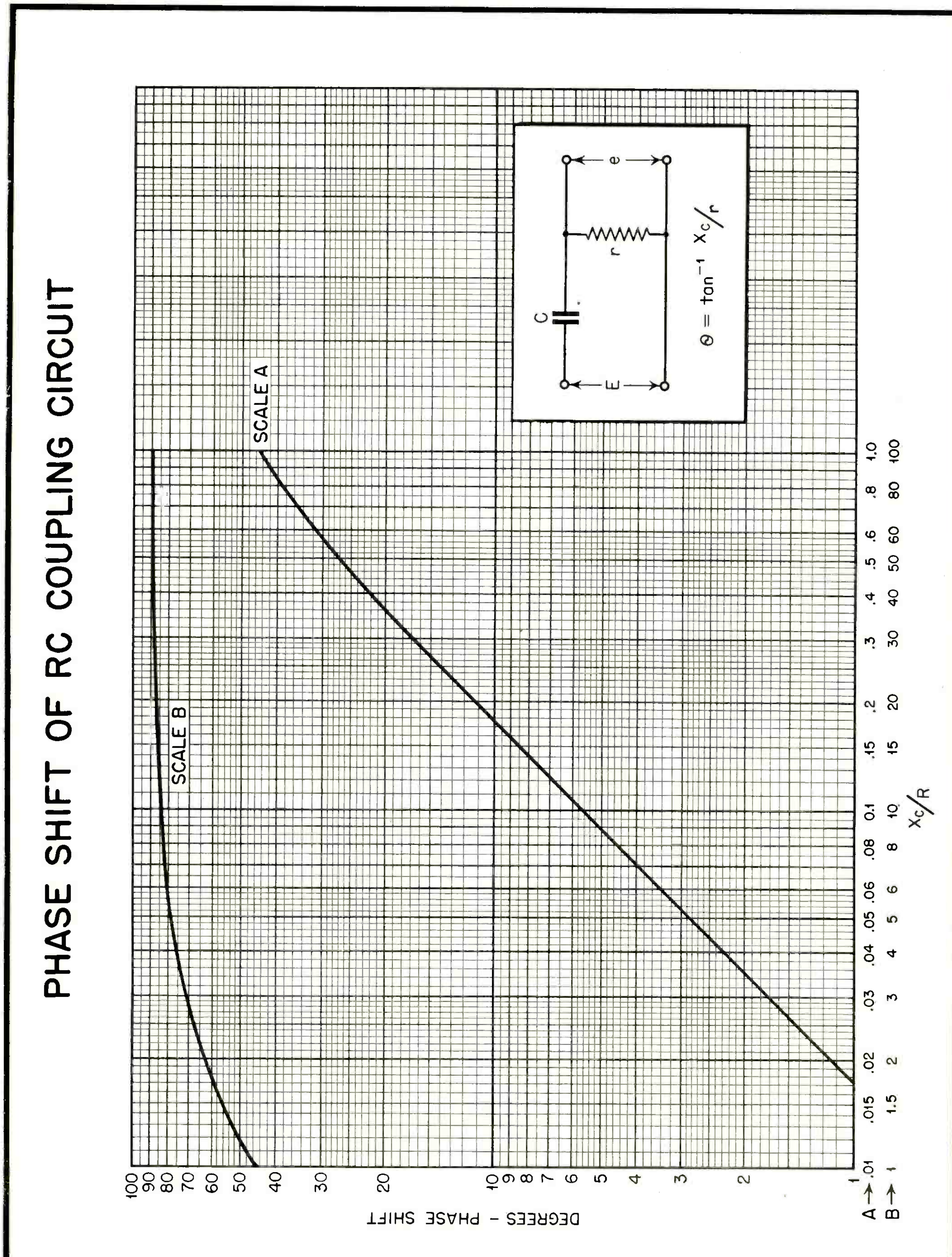
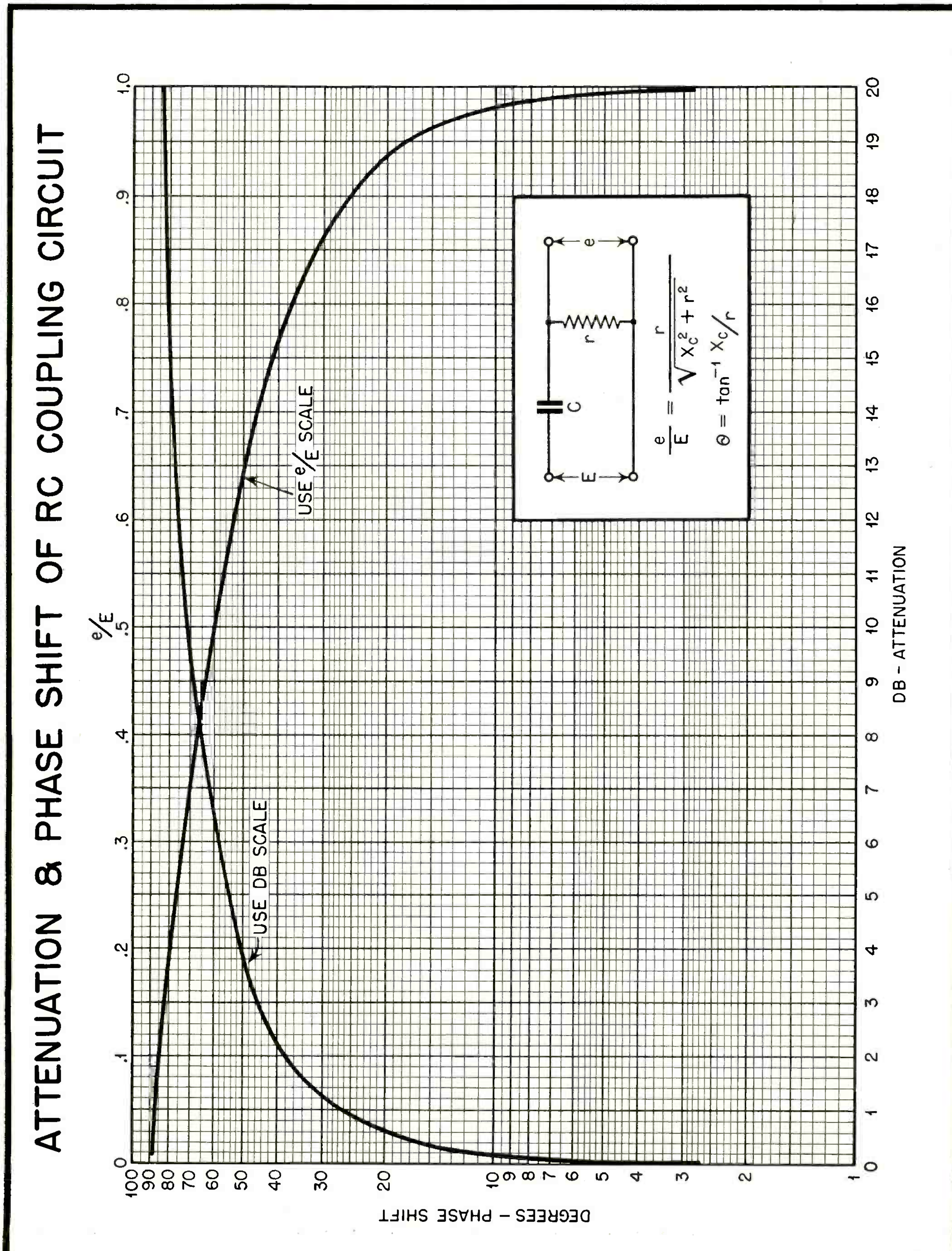


CHART NO. 2


ATTENUATION & PHASE SHIFT OF RC COUPLING CIRCUIT
e/E
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0
DB - ATTENUATION
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
DEGREES – PHASE SHIFT
100 90 80 70 60 50 40 30 20 10 9 8 7 6 5 4 3 2 1
USE e/E SCALE
USE DB SCALE
e
E
C
r
$\frac{e}{E} = \frac{r}{\sqrt{X_c^2 + r^2}}$
$\theta = \tan^{-1} X_c/r$

Classical Records

EDWARD TATNALL CANBY*

THIS is a final installment of the suggestions I've been making towards a new type of inexpensive sound equipment for the intelligent record owner, who wants the flexibility and versatility of the professional separate-unit type of equipment but who has not the technical knowledge to cope with the problems of assembling such an outfit for himself. In previous issues I've suggested a general type of outfit that seems to me highly desirable. I've insisted that considerable daring and ingenuity in the design is what is most needed, that all major components be detachable, available separately, interchangeable (for replacement and modernization) and above all, designed to be assembled without special wiring, clamped, plugged, twisted together in a moment, with absolutely fool-proof connections provided via, shall we say, monogamous connectors; the principle may be even carried farther to provide automatically right connections for differing equipment —varying amplifiers, speakers with different impedances, etc. As to performance, the proposed equipment should, I've maintained, provide *low* power—2 to 4 watts—and the highest possible quality of signal; intelligent and intelligently labelled compensation controls are decidedly to be desired. And all this at a really low price, too.

The more detailed suggestions I've already made, needless to say, merely illustrate lines of thought that might be followed in the detailed working-out of such an outfit. I'm even aware that a few points of mine are mutually contradictory. No matter. I am mainly interested in an *attitude*, and the carrying of that attitude into actual designing.

*279 W. 4th St., New York 14, N. Y.

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 dope 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, if put 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.

[*Continued on page 40*]

Popular Records

BERTRAM STANLEIGH**

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 millenium has not yet been reached, but the situation has improved to so great an extent that it is now possible to hear both soloist and accompaniment above the hissings 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 important 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 Capehart. 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:

Lover—Brazil.
Les Paul, guitar................ **Capitol**
Termed *the new sound*, this record is a

[*Continued on page 39*]

**41 East 59th St., New York 22, N. Y.


ON E-V DESK STAND
Mounts on new E-V Model 415 reclining desk stand


ON FLOOR STAND
Has ⅝"-27 thread adapter for conventional stands


HAND-HELD
Fits hand comfortably


AVAILABLE WITH SWITCH
Optional slide-to-talk shorting switch


MOBILE COMMUNICATIONS
With relay control switch and hang-up hook

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 2³⁄₁₆"x 1". 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.*

Model	Type	Output db	Freq. Resp. cps	Cable	Price
915	Crystal	—50	60-7500	7½ ft.	$10.00
915-S*	Crystal	—50	60-7500	7½ ft.	11.50
615	Dynamic	—57	55-7500	7½ ft.	16.50
615-S*	Dynamic	—57	55-7500	7½ ft.	18.00
615-SR**	Dynamic	—57	55-7500	7½ ft.	20.00
215	Carbon	—26†	200-4000	48 in.	8.25
215-S*	Carbon	—26†	200-4000	48 in.	9.75
215-SR**	Carbon	—26†	200-4000	48 in.	10.00

*with slide-to-talk shorting switch
**with slide-to-talk relay control switch and hang-up hook
†using input transformer

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 . . . . **$ .55**

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NO FINER CHOICE THAN **Electro-Voice**

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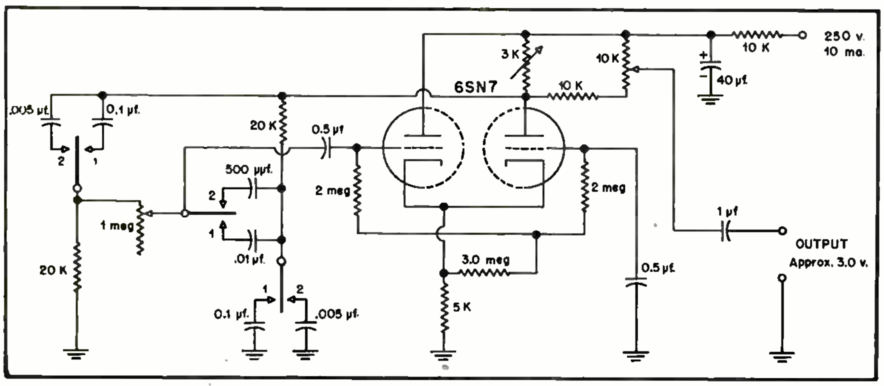
TECHNICANA

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-E_g characteristics of each tube are not linearized and the over-all 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 35 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. Mot. 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 origination, 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

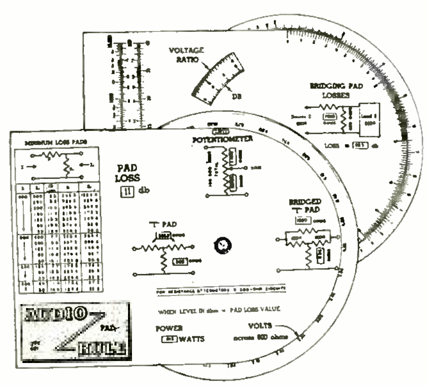
Royal V. Howard, NAB Director of Engineering, addressed the San Francisco Radio Executives Club recently, reviewing the general television scene with particular emphasis on video's commercial applications and future possibilities.

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,

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 much 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 ratios between impedance, voltage, and db are shown. The reverse of the rule consists of a circular slide rule with one scale divided into db, 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 dbm.



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 19, 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 microphone inputs, one phono 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, Port 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.

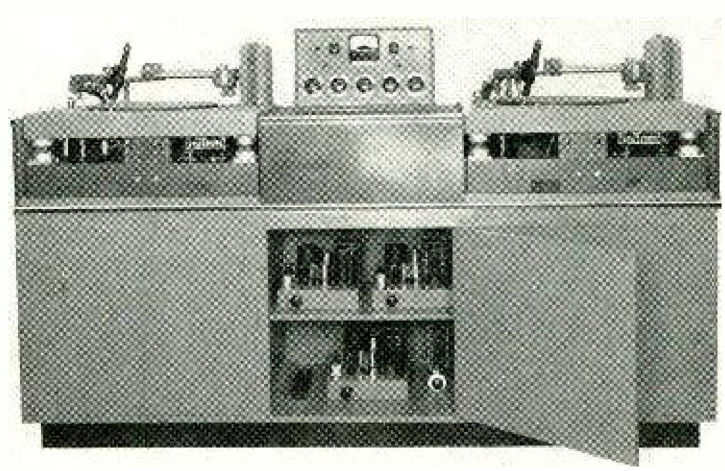
New Bulletin HS-1 available upon request to the manufacturer.

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 enamel 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 73-B) 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.

Telephone Recording

[*from page 23*]

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 5 years, with 260 working days yearly, 6 hours per day. Written off at this rate, one transcribing unit costs 3.8¢ per hour.

Doubling the cost of the transcriber would mean an increased expense to the customer of 3.8¢ an hour.

Labor to operate this transcriber now costs around $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 plus or minus 20%
Pitch of tone	1400 cycles per second with a tolerance of plus or minus 10%

Frequency of occurrence of each signal	not less than 12 seconds and not more than 15 seconds
Level of tone	equal to the average telephone talking signal strength.

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 cuts 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 overmodulation by second and third harmonics of the soprano voice when a rising characteristic between 1,000 and 5,000 c/s had been introduced. The only justification for a rising characteristic, with subsequent correction in the reproducer, was the relative reduction of surface noise; the proper approach would be to reduce noise at its source by research into alternative materials for the record.

Vinyl plastics have been given extensive trials as an alternative to standard shellac mixes and show considerable promise. They were, however, more expensive and preliminary market research in America seemed to indicate that the public did not yet regard the improvement as worth the extra cost. The absence of abrasives means that more care would have to be taken to ensure that a correctly shaped needle point, and specially designed pick-up movements, might be needed, owing to the reduced elasticity of the groove wall. The recording characteristic is intimately bound up with the properties of the record material, and a statement of mechanical impedance limits at the reproducing point should be included in any standardization of frequency characteristic.

Groove Shape

On the questions of change of groove shape in the various stages of manufacture of a stamper, and the possibility of deterioration in use, it was stated that change of shape (of the order of + 5 deg.) between the original wax and the final stamper was compensated by modifications in the shape of the recording cutter (stylus). Routine sampling maintained a check on the quality of the stamper; in general the life was shorter when vinyl plastic was pressed than when shellac-based materials were employed. Groove wear during playing was discussed and it was remarked that sapphire tips did not necessarily damage the groove walls. A record that has been played 1,000 times by a commercial pick-up with 38 gm. vertical weight on the sapphire tip was played by way of proof.

Sapphire Tips

Opinions differed on the life expectation of sapphire tips. Some speakers stated that wear could be detected after 50 playbacks, others that 2,000 playings could be obtained with a 30 gm. pick-up before the width of the flat reached 0.002 in. This amount of wear could be tolerated on standard records, but would be noticeable when the upper frequency limit of recording was 15 kc/s.

In the absence of the grinding-in process, which was completed with steel needles in the silent outer run-in grooves of a record, the shape of the sapphire and diamond styli was of paramount importance in controlling surface noise. The development of lightweight pick-ups and the demand for 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

[from page 30]

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 cleanly separated, and there is no noticeable distortion. The final cutting does up to about 10,000 cps. 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... **Columbia**

Kay Kyser Orch. Gloria Woods and the Campus Kids, vocal........... **Columbia**

The many new waxings of this calypso-type number indicate that the record companies expect it to be a hit. There are certainly enough good recordings here to make it one. With the exception of the Kay Kyser version, they are all appealing. The London disc has the widest range, but the balance between singer and band on the MGM platter sounds just as fine. Betty Garrett sings at one mike while the band sounds as if it were all being picked up from a second mike placed well back. For real calypso, Miss Garrett injects too much individual personality into her version. Janette Davis makes the most of the tune's rhythm, and her disc has the added humor of a heckler named Sy Shaffer.

Sabre Dance Boggie.

Freddy Martin and his Orch....... **Victor**

Sabre Dance,

Woody Herman and his Orch... **Columbia**

Both popular arrangements from Khachaturian's *Gayne Ballet Suite* are vastly unlike the original. Herman's version is more exciting because it *jumps* with the whole orchestra. The Freddy Martin side features the piano on a separate mike. Both recordings are clear but lacking in highs. The piano is particularly well recorded on the Martin platter.

Le Disque Usé.

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

[from page 25]

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]

Early Models

The earliest (Model A) Hammonds 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 background 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, with 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 "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 *wider* 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]

RECORD LIBRARY

In this spot a continuing list of records of interest will be presented. The 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-pops" music, well recorded.

Bizet, Symphony in C Major
N. Y. Philharmonic, Rodzinski.
C MM 597 (4)

Britten, Young Person's Guide to the Orchestra.
Liverpool Philharmonic, Sargent.
C MM 703 (3)

Delibes, Sylvia Ballet music.
BBC Theatre Orch. Robinson.
Decca London EDA 5 (2)

Filtz, Symphony in E Flat.
Boyd Neel Orchestra, Neel.
Decca London K 1680 (1)

Gould, Interplay (ballet music.)
Robin Hood Dell Orch. Gould.
C MX 289 (2)

Handel-Beecham, The Great Elopement.
London Philharmonic, Beecham.
V DM 1093 (3)

Milhaud, Le Bal Martiniquais. (2-piano).
Robert and Gaby Casadesus.
C 11831-D (1)

Offenbach-Rosenthal, Gaite Parisienne.
Boston Pops Orchestra, Fiedler.
V DM 1147 (4)
V DV 9 (4)

Prokofieff, "Classical" Symphony.
Philadelphia Orch. Ormandy.
C MX 287 (2)

Strauss, Johann, Polkas.
Boston Pops Orchestra, Fiedler
V DM 1049 (3 10")

Tchaikowsky, Nutcracker Suite.
Andre Kostelanetz & His Orch.
C DM 714 (3)

Thompson, Virgil, The Plow that Broke the Plains.
Hollywood Bowl Orch. Stokowsky.
V DM 1116 (2)

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 ascribed to 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 (2)

Will there ever be a clean, undistorted, wide-range recording of this music? Not these! The Victor set must be an oldish one; no highs, much distortion of string tone. Some fancy fixings-up by Sir Thomas, with a too-big orchestra relieved by uncalled-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 superficially more brilliant, pleases most listeners—but there is very considerable distortion not present in the more subdued original.

Moussorgsky, Boris Godounov; Nursery Scene.
Derek Barsham, boy soprano. Gladys Palmer, Norman Lumsden. London Symphony, Robinson.
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 tyro 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—

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 (5)

Brahms given 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 Sevitsky.
Victor DM 1189 (5)

This seems to me about the best recording technically to come from Victor since the 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 high highs and so disappointing to some, yet more than making up for that lack in the fine resonance, in the excellent solo instrument pickup and the equally good ensemble sound. The music, early Tchaikowsky, is a highly competent symphony, if a bit repetitive now and then, and will be welcome to many merely because it is not overly familiar, as is so much Tchaikowsky.

Bach, St. Matthew Passion; excerpts.
The Jacques Orchestra, the Bach Choir, Reginald Jacques conducting; Elsie Suddaby, Kathleen Ferrier, Eric Greene, William Parsons.
Decca London EDA 43 (7)

Ffrr is good here, allowing for both interesting perspective and for brilliant tone color and clear enunciation of words. The performance is very British—honest, highly musical, by no means the brilliant 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 grossly overcut, with broken-down grooves. They could have pulled this down just a bit!

Stravinsky, Pastorale for Violin and Woodwind Quartet; Russian Maiden's Song.
Joseph Szigeti, violin; Stravinsky, pianist and conductor; woodwind soloists.
Columbia 72495-D (1)

Pastorale 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 musically but still an extraordinary recording sensation. You can hear Szigeti **breathe** quite audibly—first time I've got that on a record, though it is the plague 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

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-side-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 (+10 dbm, for example) and that the decade attenuator dials on the 6-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 attenuators 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 4*]

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 lusting 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 particular 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, depth perspectives, 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 clean precision of the violins, the agitated flutterings of the woodwinds and a stentorian motif in the brasses. This complex, polyphonic arrangement can be channelized and localized in the listening room, making for a quality of reproduction that is acute with dramatic intensity and effects. In the absence of stereophonic 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 "prestissimo" 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 So. Kensico 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 esthetic lines, so often neglected by engineers.—Ed.]

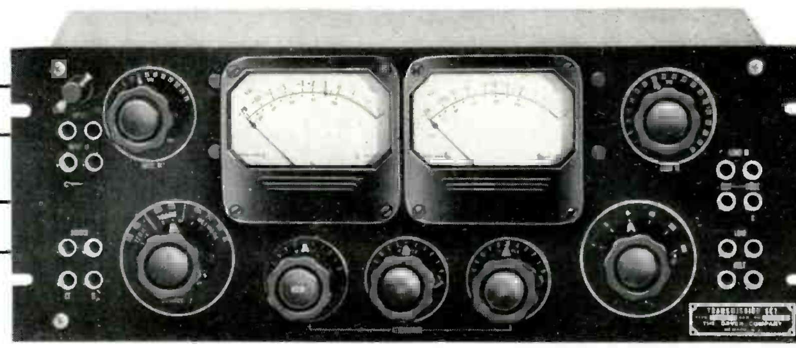
ADVERTISING INDEX

VERSATILE *New* TRANSMISSION MEASURING SET*

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.

AUDIO OSCILLATOR



SPECIAL FEATURES

1. Completely shielded wide range isolation transformers used in the Input, Source and Load networks. Set functions equally well from balanced or unbalanced oscillators and measures balanced or unbalanced systems.
2. Accuracy ±0.1 DB, 50 cycles to 15 KC.
3. Accuracy independent of level over the range +26 to −100 DBM.
4. Source isolation provided for measurement of filter or equalizer networks or unloaded transformer input systems. Loss of isolation network automatically registers on the attenuation dials.
5. Attenuation steps of 111 DB in steps of 0.1 DB.
6. Source and Load impedances within ±2% over range 50 cycles to 15 KC.
7. Input and Load VI meters and attenuators can be used as standard 7500 ohm input VI networks. Calibration can be accurately adjusted without disturbing the calibration of the Transmission Measuring Set.
8. Provision for feeding Distortion-Noise meters.
9. Unit type assembly with individual sections, such as Source, Attenuation and Load can be readily removed from the panel for servicing, if necessary. Each section is a complete assembly with its own jacks and terminal block.

FACILITIES TO BE TESTED

APPLICATIONS

1. Audio Gain Measurements.
2. Audio Loss Measurements.
3. Complex Circuit Measurements.
4. Measurements of matching and bridging devices.
5. Measuring Mismatch Loss.
6. Frequency Response Measurements.
7. May be used as two Volume Level Indicators.
8. Provision for feeding Distortion-Noise meters.

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*Patent Pending

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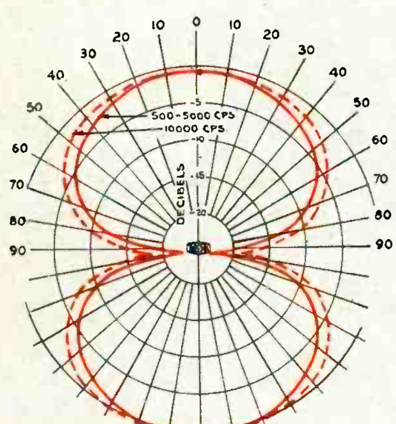
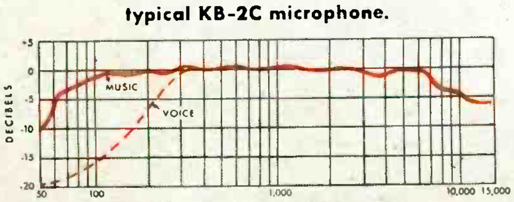
This unit was developed in cooperation with the General Engineering Department of the Columbia Broadcasting System.

The KB-2C shown here is actual size.

New VELOCITY MICROPHONE *Bantam Size!*



Directional characteristics of a typical KB-2C microphone.



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

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

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