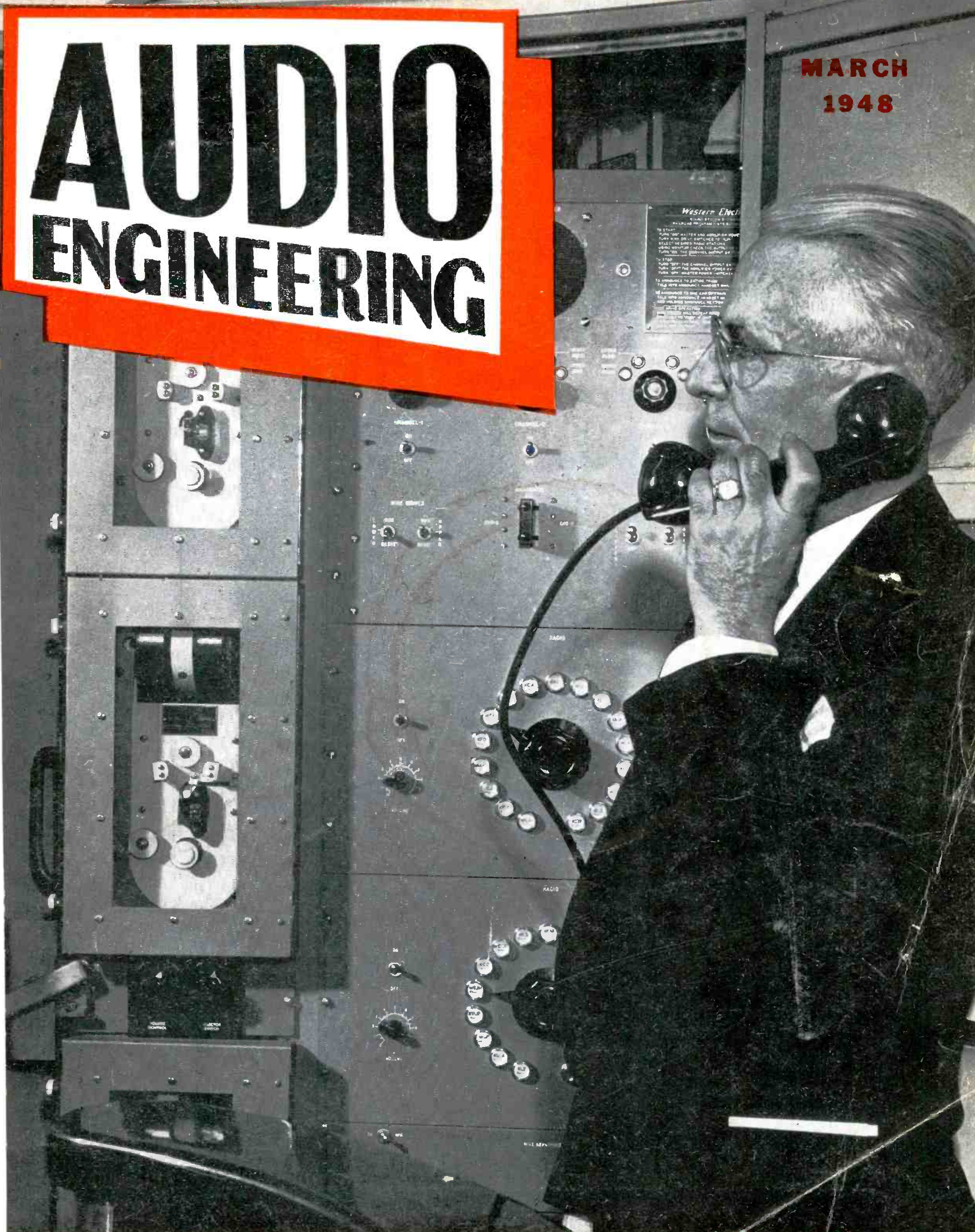
AUDIO ENGINEERING

MARCH 1948



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***Steel Transcription Needle* #151.** The ideal all-purpose transcription needle for original recordings, vinyl pressings and phonograph records. Quality performance is assured since each point undergoes a shadowgraph test. List price **20** for **25¢.**

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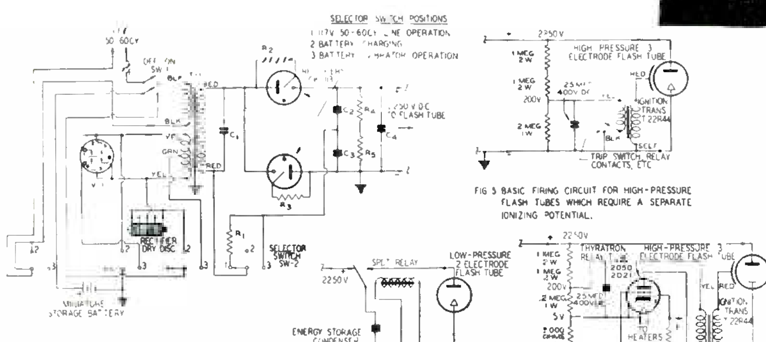

SCHEMATIC DIAGRAM OF UNIVERSAL POWER PACK FOR HIGH SPEED PHOTO-FLASH TUBES

FIG 4 FIRING CIRCUIT FOR LOW-PRESSURE FLASH TUBES

FIG 5 BASIC FIRING CIRCUIT FOR HIGH-PRESSURE FLASH TUBES WHICH REQUIRE A SEPARATE IONIZING POTENTIAL.

FIG. 6 IMPROVED FIRING CIRCUIT USING THYRATRON RELAY TUBE TO CONTROL IONIZING POTENTIAL

PHOTO FLASH POWER SUPPLY

Here is another Thordarson FIRST . . . a typical example of Thordarson engineering skill that has helped established leadership in the field. This circuit features:

- **A.C. Line or Portable Battery Operation**
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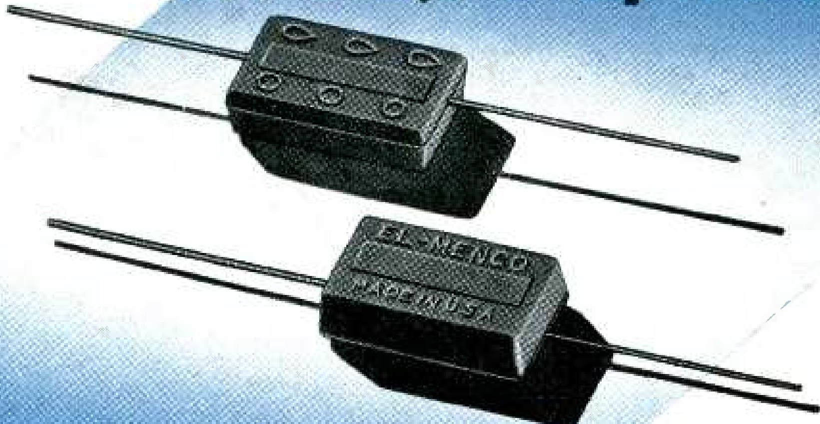

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CONTENTS

COVER ILLUSTRATION

The new Western Electric program distribution system aboard the Burlington's Vista Dome Zephyrs. The program distribution system makes available a choice of two recorded and two radio programs at all times.

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EDITOR'S REPORT

HIGH QUALITY AMPLIFIER

• ALL of us in the audio field have one interest in common—better sound reproduction. For this reason, we call special attention to the article in this issue by our Managing Editor, C. G. McProud, describing an exceptionally fine audio amplifier which he designed around the new 6AS7G dual triode. Several months ago a reader suggested that we investigate the possibilities of this new tube for output service in a high-grade amplifier. Its characteristics are better than the 6B4G, and it did look rather exciting. Many of us had felt, though, that a beam power tube, properly handled, could do as good a job as anyone could want, and preliminary reports from others who had experimented with the 6AS7G were not too encouraging. But we weren't going to risk missing a good bet, so Mac drew up a schematic, gathered together the necessary components and started construction of the amplifier.

Two days later he phoned me from his home. The wiring would be completed in an hour, and would I bring down a 6AS7G tube from the office. When I arrived, the final connections were being made. As soon as these were completed and a cursory check of connections made, the tubes were rather gingerly inserted and the power switch snapped on. After balancing the cathode voltages of the two sections of the 6AS7G, the amplifier was hooked up to his two-way speaker system and phono equipment. It worked beautifully right off the bat. When a high quality sound system is performing as it should, it is never necessary for listeners to go into a huddle to decide whether or not there is anything wrong with it. Its performance was extraordinary and both of us were instantly delighted.

Enough. Try it for yourself, and with our blessing!

AUDIO ENGINEERING SOCIETY

• THE interest created by letters from Frank E. Sherry, in Texas, and C. J. LeBel, in New York City, which were published in recent issues of this magazine, has resulted in the organization of a new engineering society called the Audio Engineering Society. The decision to form a separate organization, rather than to affiliate at this time with some larger group, was reached at the first meeting in New York City, February 17th, at which time the name was adopted. Committees have been formed to prepare by-laws, file formal organization papers, etc. A full story of the aims of the new organization appears elsewhere.

There are many who believe that the best interests of these in the audio field could have been attained by affiliation with one of the older, well established engineering societies, such as the Institute of Radio Engineers or the Acoustical Society of America. Letters from Howard Chinn and Vincent Salmon supporting this contention are published in this issue. But even though the majority of those attending the first meeting belonged to one or both of these societies, and motions for affiliation with the older societies were presented, these motions were badly defeated.

Announcement that Dr. Harry F. Olson will present the first technical paper before the members of the new society indicate that the organization is receiving strong support in high engineering circles. For this, we understand, RCA's extraordinarily brilliant E. W. Engstrom, Vice President in charge of RCA Research Labs, is responsible.

Word from California indicates that a chapter in that section will shortly be formed. The temporary officers tell us that other cities and states are also being heard from.

Our personal conversations with those active in the new organization reveal a great deal of enthusiasm and an absence of self-seeking effort which portend a successful future for the enterprise. We extend our congratulations and best wishes.

WITH OUR AUTHORS

• A NEW series on telephone recording by E. W. Savage starts next month. C. G. McProud is coming out with a new tuner employing a unique band-pass filter and detector, for use with high grade audio equipment. And there are several others, from here and abroad, which we can't announce at the moment.

—J. H. P.

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Letters

Comments on the AES

Sir:

In a recent letter to the Editor, Mr. Frank E. Sherry has suggested the formation of some sort of an Audio Engineering Society. I wish to enter a strong dissent to this proposal, as I believe it will not further the advancement of this field.

The principal reason for this view may be seen from a consideration of the large number of technical groups now extant, each for a narrow field. Nevertheless, this has resulted in duplication of effort, competition for speakers and papers, and a multiplicity of meetings which put a considerable drain on the time of the practicing engineer who must overlook no new developments. A partial solution has been the formation of Technical Societies Councils, as in Chicago and other cities, with a monthly list of meetings made available. I feel that our efforts must be directed toward consolidation and centralization rather than division of energies. A unified group can easily foster sub-groups for specific purposes, and yet retain the advantages of a parent-body which is able, by virtue of its prestige and size, to present with great effectiveness the viewpoint of its members to other groups, be they engineering, civic, or legislative.

Since audio engineering has become a large enough field to merit representation, I wish to propose that those interested consider the Acoustical Society of America. This group is not purely scientific and academic, but has a diversified membership which includes audio engineers, musicians, broadcast engineers, and sound technicians as well as professors (who are in the minority). The Society has recently broadened its membership requirements to include all those interested in acoustics, with more classes of membership; moreover, it has provided for the establishment of regional sections whose primary interest is simply to be the advancement of acoustics. I wish to urge that those interested in audio engineering consider affiliation with the national Society as a valuable means of avoiding adding to the present profusion of specialized groups and at the same time retaining the advantages of national representation. Of course, the particular program undertaken by any such regional group will depend on the desires of its members, the national Society merely offering direction and advice with rather loose control.

In closing, it may be mentioned that a Chicago Section of the Acoustical Society of America is in the process of formation.

Vincent Salmon, Physicist
6220 So. Moody Ave.
Chicago, Ill.

Sir:

I want to thank you for aiding in the formation of an Audio Engineering Society.

Because of a letter which was written by Frank E Sherry, Jr of Victoria, Texas, and appearing in your December issue, I was put in touch with C. J. LeBel and Norman Pickering, both of New York City, and formers of the Society. It is with a deep satisfaction to learn that at last something will be done about nationally recognizing the Audio Engineer in his own right. I still have on hand Issue No. 1 of the original *Sound* magazine issued prior to the war—July, 1941, to be exact.

[*Continued on page 8*]

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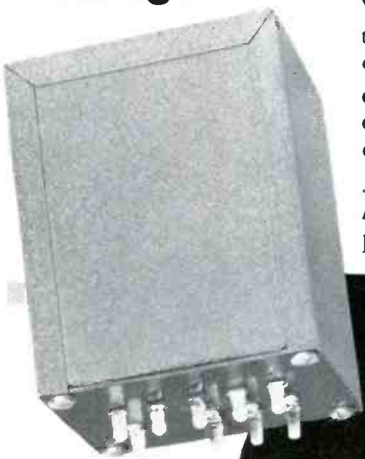
ADC TRANSFORMERS

Fill Super Specifications From Subsonic to Ultrasonic

For Ultrasonic Ranges



This **ADC** Transformer is custom-built to couple the output of an amplifier (30 watts) to a transducer. Impedance Ratio is 2500 ohms (4-2A3) to 500/700/1000/1500/2000 ohms. Transformers have been designed at **ADC** to operate up to 3 mc with useful band width in excess of 1:1000.

Whenever your equipment requires the unusual in transformers, **ADC** has the ingenuity, skill and capacity to produce them. If your problem requires . . .

- reliable performance
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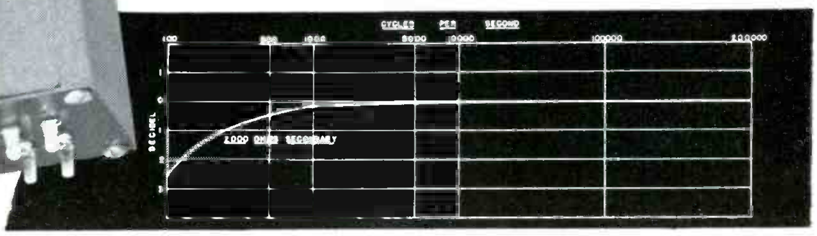
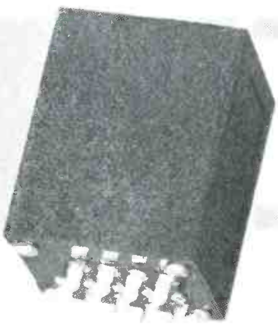
. . . it will pay you to submit your specifications to **ADC** for reasonable prices, quality products and prompt delivery.



For Audible Ranges

This transformer has no unusual electrical properties, but it was designed for extreme dependability. It is an output from pp 6V6 to line, for voice range only (1 db—150 to 4000 cps). It was ordered from ADC simply because the equipment manufacturer required *unfailing* performance.



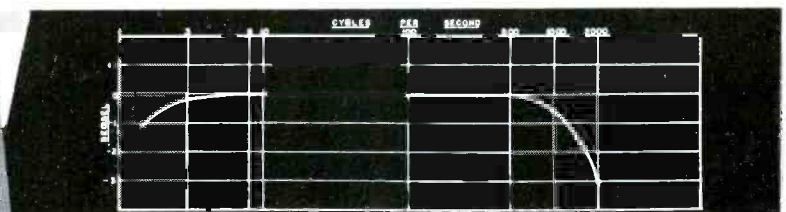
All **ADC** transformers have built-in reliability . . . a feature especially necessary for radio broadcasting, communications, wire recording, telemetering equipment, etc. A slightly higher original cost is more than offset by the dependability and quality of **ADC** design and manufacture.

For Subsonic Ranges

(such as geo-physical work)

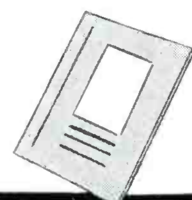
This transformer operates from pp plates (20,000 ohms) to pp grids (320,000 ohms) down to 2 cps. Secondary inductance is over 60,000 henries. It also has tertiary low impedance winding. Hermetically sealed—10 cubic inches.

ADC has designed and made many low frequency transformers—some to operate from frequencies as low as 0.1 cps.



HERE are several charts showing characteristics of unusual transformers developed by ADC engineers. Many transformers have a wide range of requirements shown in the ADC Transformer Catalog. If you do not have your copy—*WRITE TODAY FOR CATALOG NUMBER 46-R.*

Send us your special specifications for prompt and able transformer service.



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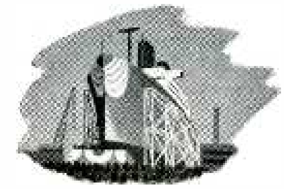

Whenever you need long-period, high fidelity recording, look to the MAGNETONE*—the latest news in wire recording!

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

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

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

Write today for detailed specifications of the

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I am looking forward to the first meeting of the Society with as much hope and anticipation as a kid does the night before Christmas. Thank you again for any aid you might give the group in its initial phases. Thank you also, tho in advance, for the next 12 issues, which I know will be just as jam-packed with information as the last issues.

Jack Hartley
88 Diamond Bridge Ave.,
Hawthorne, N. J.

Dear Editor:

In the December 1947 issue, Mr. F. E. Sherry, Jr., raises the question as to whether the time has come for the audio engineer to form an association of his own. I think not.

It is true that the existing national organizations have not, to date, recognized the existence of audio engineers nor have they given them a voice, as a group, in the affairs of their societies. However, insofar as the Institute of Radio Engineers is concerned, considerable progress has been made towards correcting this situation. For example, as announced in some detail in the January 1948 issue of the *Proc. I. R. E.*, a Committee on Professional Groups has been formed (pg. 105) with the view towards the establishment of groups "within the Institute membership to promote meetings in specialized fields" (pg. 106). In addition other group activities, such as promoting papers in their field, are contemplated. One of the groups specifically mentioned is "audio."

Of equal importance is the establishment by the I. R. E. of an Audio and Video Technical Committee. Thus, for the first time in the history of the Institute, these fields are being recognized in their own right and not as an adjunct of another branch of the science

From an industry viewpoint, audio engineering is also beginning to receive the recognition that is its due. For example, the Radio Manufacturers Association has several active committees on audio facilities covering broadcasting, sound reinforcement and home receiver applications. Also, the American Standards Association has committees concerned with various phases of standardization work in the audio field

It seems to me that the audio and video engineer can best further progress in his chosen field by taking an active and constructive part in the affairs of existing organizations. I cannot see the need, at this time, of an association of audio engineers, any more than I believe there should be an Institute of Sonar Engineers, or of Radar Engineers, or Frequency Allocation Engineers, to name but a few.

Howard A. Chinn
Chief Audio Engineer
Columbia Broadcasting System
New York City

Sir:

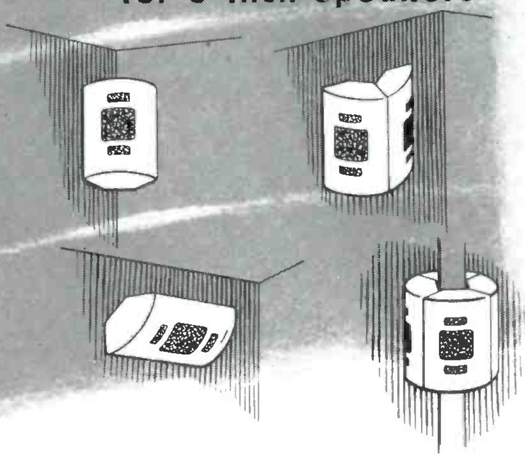
Through AUDIO ENGINEERING I have learned of activities in New York to bring together those who are interested mainly in the audio field. Mr. C. J. LeBel has suggested that it might be possible to determine the extent of interest along these lines in the Philadelphia area, if a letter similar to his were published in AUDIO ENGINEERING.

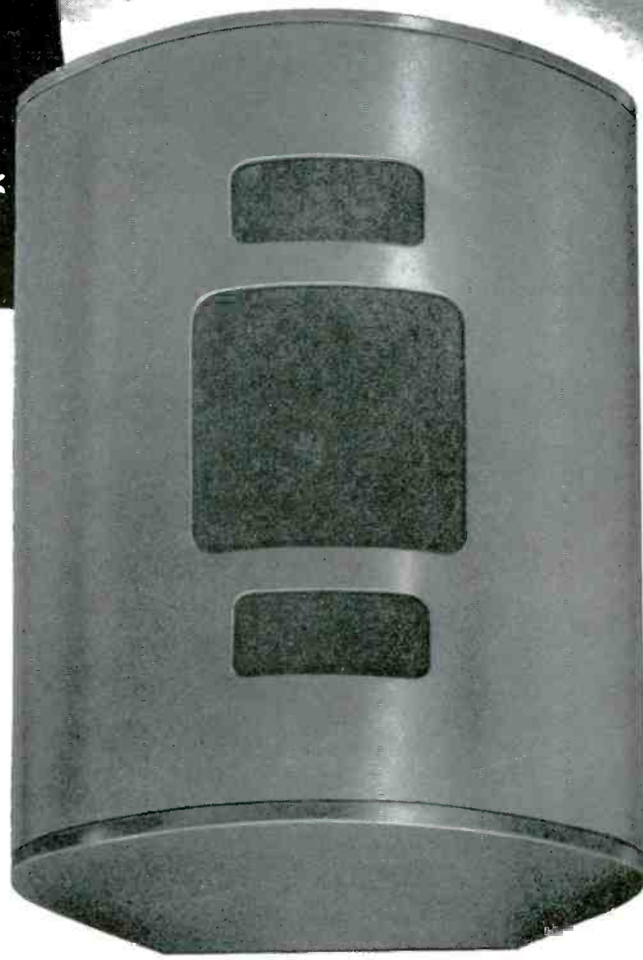
I will be glad to act as a clearing house to receive the names of those in the Philadelphia Area who would care to look into the matter if they will send a post

[*Continued on page 46*]

Jensen "SECTOR" CABINET WITH *Bass Reflex**

for 8-inch Speakers





Model H-81 Sector Cabinet (ST-141) List Price $22.50

They fit anywhere—in 90-degree corners—flat on walls—or in clusters to give wide-angle distribution. Perfectly adapted for nearly all interior sound installations, because of their economy, small size and, above all, the high quality performance of JENSEN speakers in Bass Reflex enclosures. Use with any JENSEN 8-inch speaker. Model P8-SH is recommended for high fidelity as required by many wired music installations.

Type H Sector Cabinets are built around a frame of solid wood with wood composition replacing the conventional plywood panels.

*Trade Mark Registered

Finish is brown opaque lacquer although covering colors may be applied on the job if desirable to match environment. Size: Height 22½", width 17¾", depth 8½" Furnished with mounting brackets and screws.

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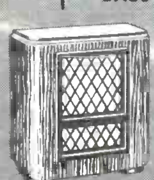
OTHER Jensen CABINETS

BASS REFLEX — PERI-DYNAMIC



IMPERIAL TYPE D
D-151 (15-inch)
D-121 (12-inch)

UTILITY TYPE B
B-151 (15-inch)
B-121 (12-inch)
B-81 (8-inch)

WALL TYPE J
J-61 (6-inch)

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Jensen SPEAKERS WITH ALNICO 5

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BROOK

Brook Amplifier Model 10C2-A. Medium-gain input for tuners, and high-gain input with internal equalization for high-quality pick-ups such as Pickering, G-E, Audak etc.

An Amplifier Which Gives New Meaning To High Quality Audio Reproduction

So outstanding is the Brook All-Triode Amplifier that new engineering and listening standards must be applied to evaluate its remarkable performance.

From an *engineering* standpoint, it is notable in the fact that distortion has been reduced to the vanishing point . . . far lower than in any amplifier using pentodes or beam-power tubes. From a *listening* standpoint, it is notable because of its ability to reproduce fine music with a degree of fidelity never before achieved outside the laboratory.

No matter what the basis for comparison, the performance of the Brook Amplifier is unparalleled. Hear one at your earliest opportunity.

Full technical description will be mailed without obligation. *Write today for Bulletin AC-8!*

SPECIFICATIONS

★ Frequency response flat within two-tenths DB from 20 to 20,000 cycles.

★ Both intermodulation and harmonic distortion reduced to negligibility (Exact figures shown in technical sheet).

★ Rated output 30 watts.

★ Bass and treble compensation—two-stage R-C network. Bass boost as much as 18 DB without boominess.

★ Gain—55 to 120 DB in various models.

★ Impedances — Input, 0.5 megohm standard, others available. Output, 1.5 to 30 ohms, with separate 500-ohm winding.

EXCLUSIVE BROOK FEATURES

TRIODES THROUGHOUT! It is a well known fact among experienced audio engineers that triodes of low amplification factor are essential if minimum distortion is to be obtained. Although their use is costly compared with pentodes, triodes are used *in all stages* of the Brook Amplifier.

SPECIAL TRANSFORMERS. Transformers used in all Brook models are completely free from saturation or leakage reactance effects from 25 to 20,000 cycles at any power up to maximum. They are manufactured to our specifications, and are available in no other amplifier.

AUTOMATIC BIAS CONTROL. ABC is a Brook-patented circuit feature which more than doubles the power output and efficiency of the output system, and at the same time reduces harmonic distortion. It is a principle factor in achieving the remarkably low distortion which is characteristic of the Brook Amplifier.

ENGINEERS—DEALERS—CUSTOM BUILDERS

See the entire line of Brook All-Triode Amplifiers in Booth 288 at the I.R.E. Show in New York, March 22-25. Normal trade discounts apply. Inquire.

The BROOK HIGH QUALITY AUDIO AMPLIFIER

BROOK

Designed by LINCOLN WALSH

BROOK ELECTRONICS, Inc., 34 DeHart Place, Elizabeth 2, N. J.

Hollywood Sapphire Group Meeting

THE MONTHLY meeting of the Sapphire Group met December 10th at Brittinghams Restaurant, Hollywood, Calif., and the Chairman of the meeting was Mr. Bert Gottschalk of Electro-Vox. Among the guests present were Mr. J. P. Maxfield, Consulting Engineer at Altec Lansing Corporation, Mr. Clyde Keith of Western Electric, New York, and Mr. Lloyd Sigmon, Chief Engineer of Radio Station KMPC.

The dinner was hastily concluded in order to attend a subjective listening test at the Altec Lansing Corporation Review Room to select records for the standards program. The following home phonograph instruments, in the $500.00 or better class, were made available by members of the Group for the listening test:

Magnavox.
Zenith.
R. C. A.-Victor.
Connoisseur by Conrac (Altec Lansing Corp.).

A composite two-way loudspeaker using a Webster 70 Record Changer adapted so as to interchange Pickering, G. E., or Clarkston Pickups was also available. All of the home instruments were compared in quality with that of the Altec Lansing A-4 Theatre System.

Before the listening tests began, John K. Hilliard read a memorandum of notes compiled by Mr. J. P. Maxfield and Mr. Hilliard on general factors involved in pre-equalization for phonograph records. This report will be published in the April issue of AUDIO ENGINEERING.

Several members of the Group brought representative recordings, and these were listened to on the theatre system. By a process of elimination, the Khachaturian (HMV) Ballet "Sabre Dance" was selected as a preliminary test record. This record was then played on all of the home instruments submitted. There was a wide variation in quality of reproduction from these various instruments which definitely indicates the lack of a standards program among the manufacturers.

The following comments were noted at the conclusion of the demonstration:

Walter Carruthers of KHJ restated the problem and questioned the use of an average commercial record for the demonstration, and Jim Bayless of RCA suggested that we pick several good commercial records which could be used by RMA for similar demonstration. Mr. Winters of Radio Recorders suggested that we pick our records from the best sellers. Mr. Lloyd Sigmon raised the question of making available a standard record. He had not attended previous meetings and the whole problem of the method of standardization

[*Continued on page 48*]

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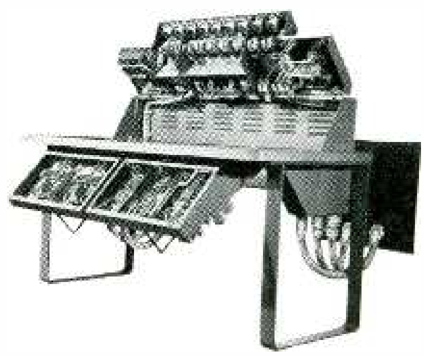

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Balanced Clipper Noise Suppressor

S. LESLIE PRICE*

A simplified noise suppressor with many features. Group listening tests results indicate its superiority over conventional filtering methods.

IMPROVED PERFORMANCE of pickups and of recording techniques has made it possible to realize a higher frequency response from disc recordings than has been practical in the past. For some years now, increasing numbers of records with the higher frequencies recorded on them have been appearing on the market. In those instances where poor material has been used in making the pressings it has been necessary to tolerate the surface noise or to compromise between frequency response and surface noise. High-frequency pre-emphasis recording lessens the compromise, but this technique seems to be used only in the recording of the leading manufacturers. Also, it must not be forgotten that there are already many recordings in use today which do not embody the pre-emphasis feature. We are, therefore, still faced with the surface noise problem.

The various approaches made in the past to solve this surface noise problem have been watched with much interest and anticipation. Pickups with good response vs. frequency characteristics, low distortion, low transient effects, and low response to displacement of the stylus in other than the desired plane, are now available at a reasonable cost. Amplifiers are not a problem and loudspeakers are continually being improved. However, surface noise remains the stumbling block to the greater enjoyment of much recorded material. The proper place to attack this problem is at its source, i.e., in the manufacture of recordings. However, as already mentioned, existing recordings must also be accommodated.

Pre-emphasis, volume expansion, dynamic noise suppression, and fixed filters all contribute towards a reduction of surface noise and all leave something to be desired. The author, therefore, set out to see if he could develop something that would be a worthwhile contribution to the solution of the noise-suppression problem.

Engineer-in-Charge, KSL-FM, Salt Lake City, Utah.

Basic Circuit

The noise suppressor circuit which is described in this article has proven to be effective in reducing the surface noise in record and transcription reproduction, without sacrificing the high-frequency register of the recordings. Observations in the form of listening tests to check the effectiveness of the suppressor were made by small groups of engineers, musicians and laymen. A unanimous preference was shown for reproduction with the suppressor to reproduction using conventional filtering methods.

The basic ideas incorporated in this noise suppressor are similar to those described elsewhere.[1, 2] However, this suppressor differs from Olson's in several respects and is capable of covering a wider frequency band while using fewer filter components.

[1] H. F. Olson, "Audio Noise Reduction Circuits," *Electronics*, Dec., 1947.

[2] Charles D. Cole, "Experimental Noise Suppressor," AUDIO ENGINEERING, Jan, 1948.

The cleverly designed polyacoustic studios of KSL, Salt Lake City, are equally well suited for melodious, majestic organ music or for musical ensembles and vocalists. The axis of the curved surfaces and both the walls and ceiling are mutually perpendicular, thus assuring adequate diffusion of the sound waves.

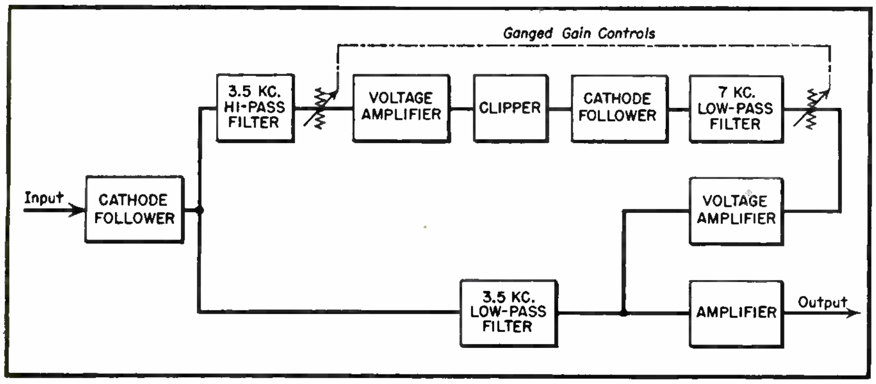

Fig. 1. Block diagram of the first noise suppressor setup, tried experimentally.

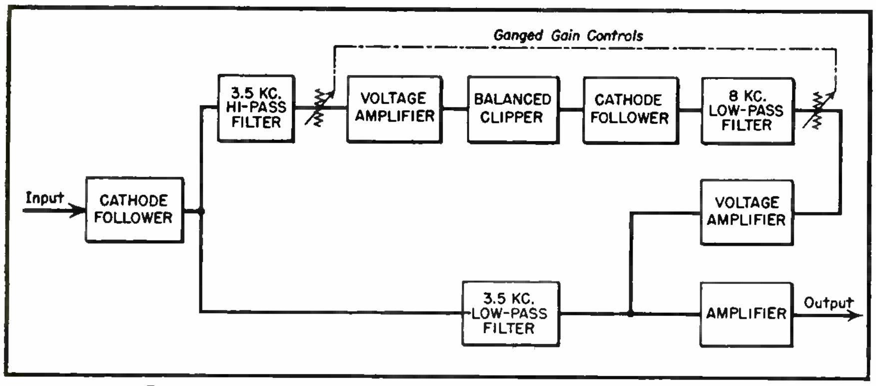

Fig. 2. Second experimental circuit, incorporating fewer filters.

Operation of the suppressor is simplicity in itself. One control adjusts the degree of suppression. Surface noise is reduced while preserving many delicate tones of high frequency such as tinkling bells, triangles, etc., as well as the higher overtones most of which would otherwise be lost.

Fundamental Requirements

Before experiments were started, careful consideration was given to the factors which would detract from the faithful reproduction of phono recordings and transcriptions. A noise-reducing system for high-quality reproduction of phono recordings and transcriptions should:

1—Be capable of faithfully reproducing, in their proper perspective, all useful signals which are impressed on the recording and should provide wide range reproduction when wide range recordings are available.

2—Have various degrees of noise suppression which would introduce a minimum of amplitude, intermodulation and harmonic distortion.

3—Have means of controlling the response vs. frequency characteristic of the system when recordings with objectional distortion are being played through the system.

4—Have automatic control systems or circuits which do not vary the frequency response of the system or the reproduced noise level in such a way that the listener would be conscious of the change.

5—Under average listening conditions, be capable of reducing the noise level of a reasonably good shellac pressing to an unobjectionable level without sacrificing the high frequencies and overtones of the recorded material when used in conjunction with good reproduction equipment.

6—Provide noise suppression during high-level passages as well as low-level passages.

7—Not materially alter the dynamic range of the recording.

8—Not audibly exhibit any delayed action or time constant phenomenon.

First Experimental Circuit

Incorporation of the above requirements in a noise suppressor become the problem and many of them do not lend themselves to an easy solution. *Fig. 1* shows a block diagram of the first experimental suppressor which performed sufficiently well to encourage further investigation with this approach.

The audio spectrum is divided into consecutive bands, the first point of separation being at the highest frequency consistent with reproduced noise that is not of objectionable intensity. Since each frequency band above this point contains an objectionable amount of surface noise, it is passed through a non-linear element which will offer a high impedance to the passage of low intensity signals and a low impedance to the passage of high intensity signals.

The signal level is adjusted so that the larger portion of surface noise will fall below the transition point of the non-linear circuit and will be effectively rejected. Any useful signals having an intensity above the noise level will rise above the transition point and be passed on to the following circuits. Biased rectifiers such as small copper oxide selenium or germanium rectifiers, biased diodes and biased amplifiers will all function as this type of non-linear element.

An amplifier biased beyond cutoff was used for these first experiments. Tubes were used to provide a sharp cutoff characteristic and the gain of the preceding amplifier adjusted to place the peak noise signals just below cutoff. With this adjustment, all noise signals which did not exceed the cutoff value were not admitted by the tube and all signals which exceeded this value were amplified by the tube.

The distortion resulting from this treatment must be reduced to a low value in order that the final results will be

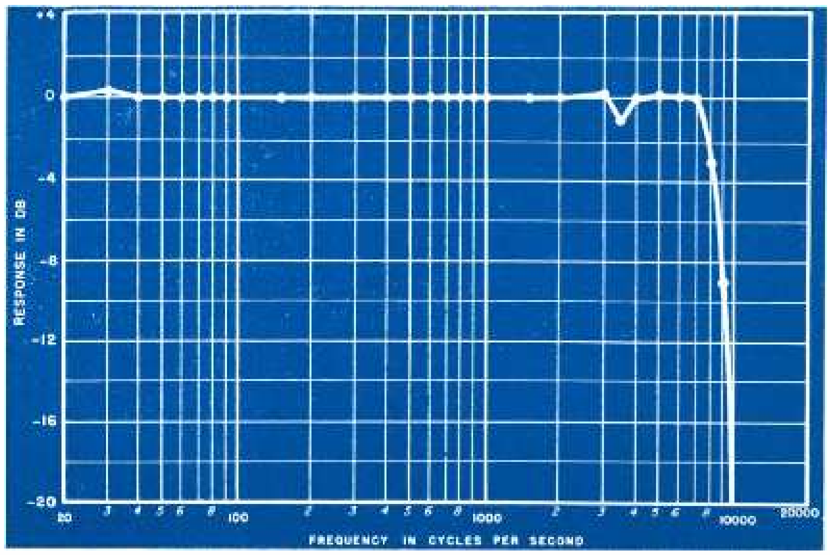

Fig. 4. Frequency response curve of noise suppressor for normal suppression at maximum output.

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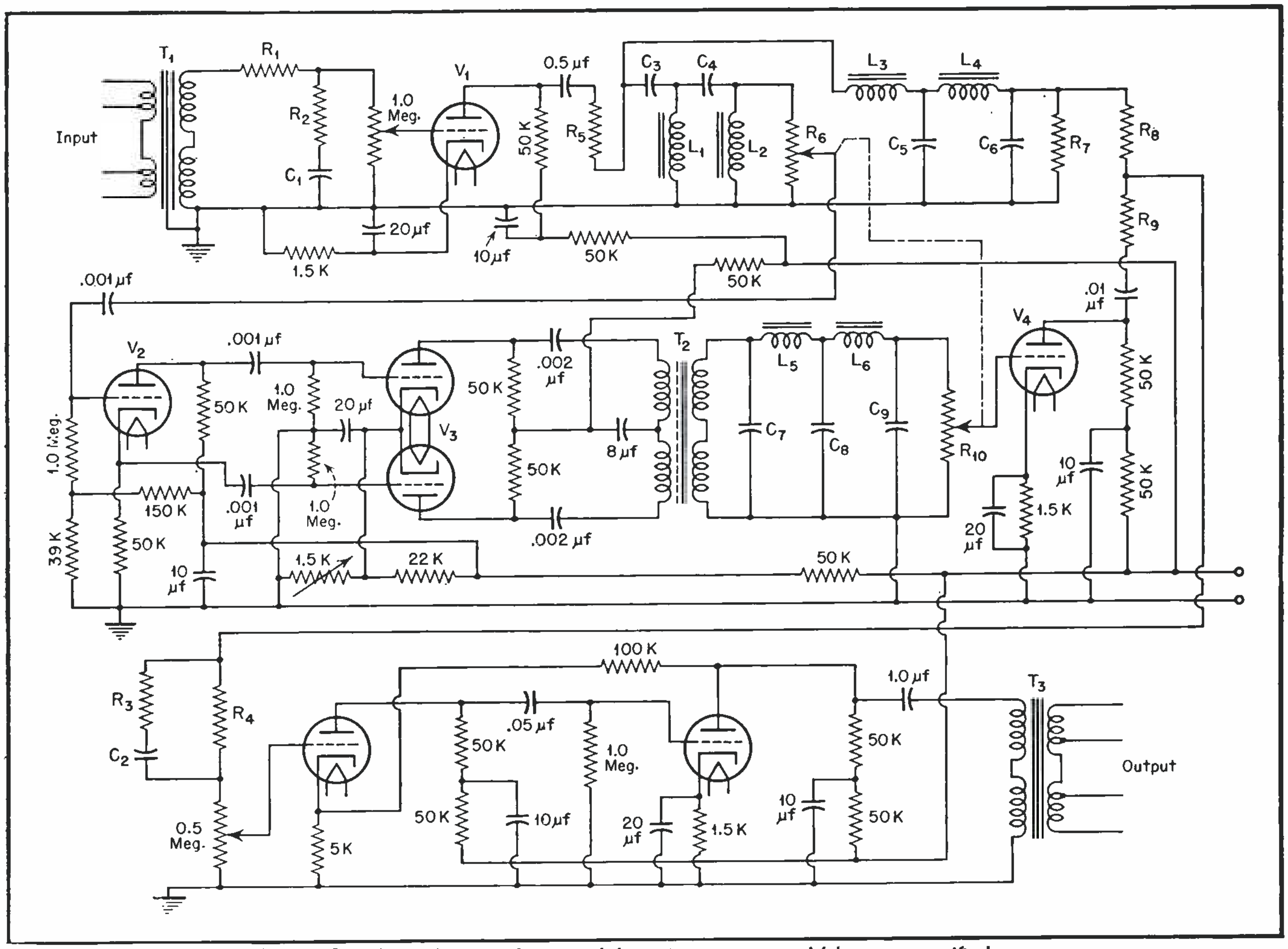


Fig. 3. Complete schematic diagram of the noise suppressor. Values not specified are:

C1—150 μμf (shunt with 250, 000 ohms).
C2—80 μμf.
C3, C4—.0019 μf.
C5—.0076 μf.
C6—.0038 μf.
C7, C9—.0015 μf.
C8—.003 μf.
R1, R2—250,000 ohms.
R3, R4—500,000 ohms.
R5—3800 ohms.
R6, R7, R10—12,000 ohms.
R8, R9—50,000 ohms.
L1—.227 henry.
L2—.1135 henry.
L3, L4—.398 henry.
L5, L6—.398 henry.

Proper performance of filters is important. Adjust loads individually for best results after setting input levels. Resistor adjustment of suppressor can be made by varying clipper bias.

satisfactory. This can be accomplished by limiting the frequencies passing through the non-linear or clipper circuit to slightly less than one octave. Then the second harmonic of the lowest frequency admitted to the clipper will fall outside its pass band. The outputs of the various channels may then be combined in their proper relationship so that the resultant signal is essentially the same as the input signal except that the noise and the low intensity signals are considerably reduced. With this system, several filters of one octave width are needed in order to include all of the high frequencies needed for high quality reproduction.

An Improved Circuit

The same over-all bandwidth may be

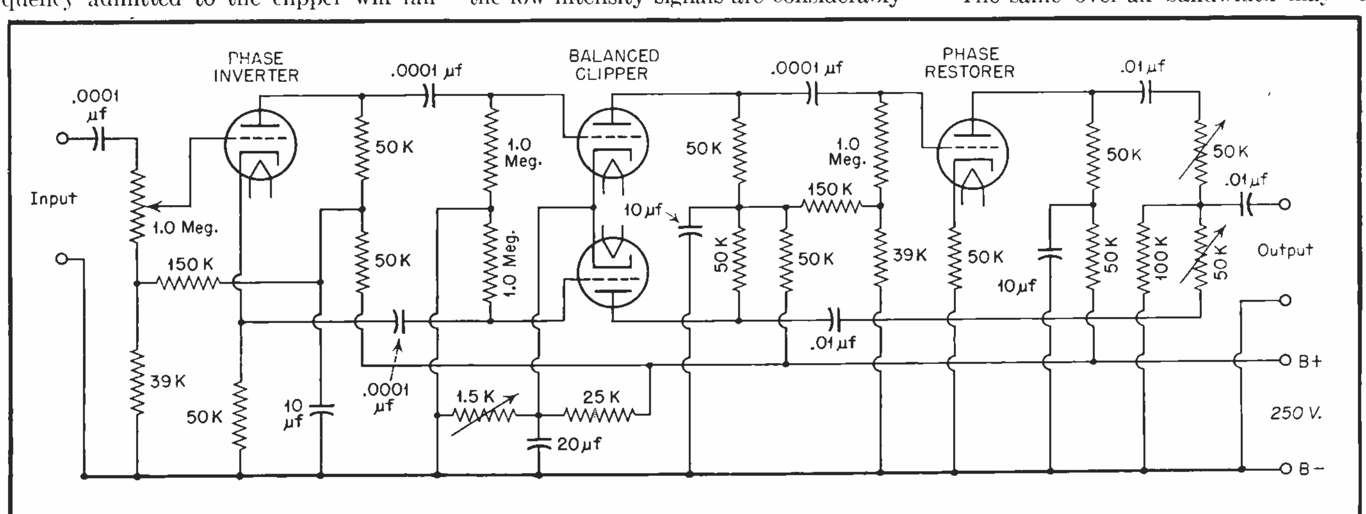


Fig. 5. This circuit may be employed to replace the transformer-terminated design shown in Fig. 3.

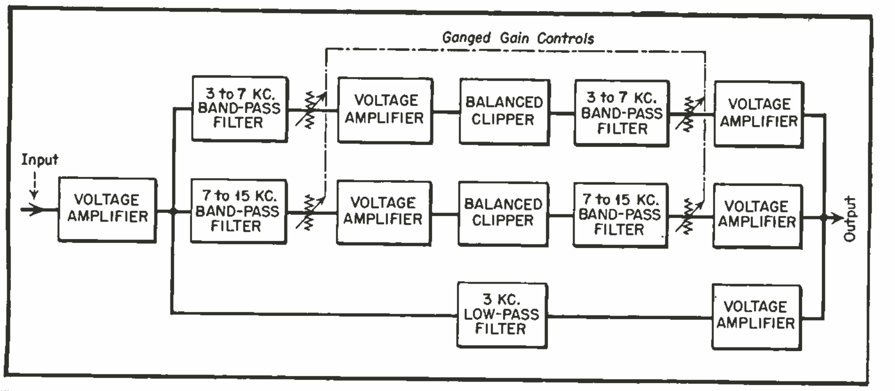


Fig. 6. Block diagram of a circuit with crossover frequencies of 3000 and 7000 cycles.

covered, however, with fewer filters by using a push-pull clipper circuit. The second harmonic distortion generated by each clipper will be greatly reduced when the output signals are combined in the proper phase. With the second harmonic reduced to an acceptable level, the next order of distortion will be the third harmonic. The pass bands can then be designed to include slightly less than one and one-half octaves while still providing proper attenuation of the third and high harmonics.

The block diagram, *Fig. 2*, shows how the second experimental model was arranged to take advantage of this feature. *Fig. 3* is a circuit diagram of a suppressor which incorporates these ideas. R_1, R_2, and C_1 adjust the frequency response of the system to give an approximate flat amplitude to the surface noise of shellac records in accordance with Olson's data.[1] V_1 builds the signal up to a level which places the surface noise signals just below the cutoff value of V_3; V_2 is a phase inverter; V_4 restores the energy lost in the preceding circuits. The output of V_4 is combined with the output of the low-pass filter in the correct relationship. R_3, R_4, and C_2 restore the frequency response of the system. V_3 in conjunction with T_2 is the balanced push-pull circuit described above.

The frequency response curve of this system when adjusted for a normal amount of suppression and at maximum output level appears in *Fig. 4*. A circuit which will replace the transformer terminated clipper is shown in *Fig. 5*.

Cathode followers were used in the experimental models because they conveniently matched the filters which were on hand. Better results will be had when band-pass filters are used preceding and following the clipper circuits. The use of band-pass filters when used in place of the filters shown will reduce intermodulation and will increase the effectiveness of the suppressor.

The block diagram in *Fig. 6* outlines a circuit which takes full advantage of the ideas brought out above. Note that the first crossover frequency in this arrangement appears at three thousand cycles per second, the second crossover appears at seven thousand cycles per second, and that the third harmonic of seven thousand cycles per second falls beyond the response of many amplifiers of most speakers and beyond the normal hearing range. It then only becomes necessary to provide sufficient attenuation of the frequencies at the high frequency limit of the higher frequency channel to guard against intermodulation in this stage.

At the present time, little if any useful

[*Continued on page 37*]

The Audio Engineering Society is Formed

L. GOODFRIEND*

NEW PROFESSIONAL societies are formed so rarely that when one is started everyone wants to know the how and why of its formation.

The Audio Engineering Society was organized at a meeting held in the RCA Victor recording studios in New York the evening of February 17. This meeting was the outcome of considerable discussion amongst leading men in the field, who had often asserted the need for a society devoted exclusively to this neglected profession, but had never followed through. C. J. LeBel began discussing the matter in the summer of 1947 and immediately found strong interest. In a short time a considerable number were interested enough to begin personal contacting. We can thank this group of busy men who somehow found time to help their profession, for the success of the operation.

The meeting, (scheduled at 8:00 P. M.), opened with a brief talk by the acting chairman, Mr. LeBel, audio consultant. He told of the inception of the idea for an audio engineers' organization and emphasized that it was not being sponsored by any commercial group or other engineering society, but rather by men well-known in the field. Norman C. Pickering then discussed the need for a professional organization to foster the growth of audio engineering. He cited the lack of exchange of knowledge caused by absence of a common meeting ground and of a medium for interchange of ideas in the audio field. The group immediately agreed that such an organization should be formed. A motion was carried to form the *Audio Engineering Society*.

The committee which has worked to organize the new society had anticipated an affirmative response in the formation of such a society, and it was announced that the first technical meeting will be held Thursday, March 11, at 7:30 P. M. Dr. Harry F. Olson of RCA Laboratories, will speak on *Problems of High-Fidelity Reproduction*.

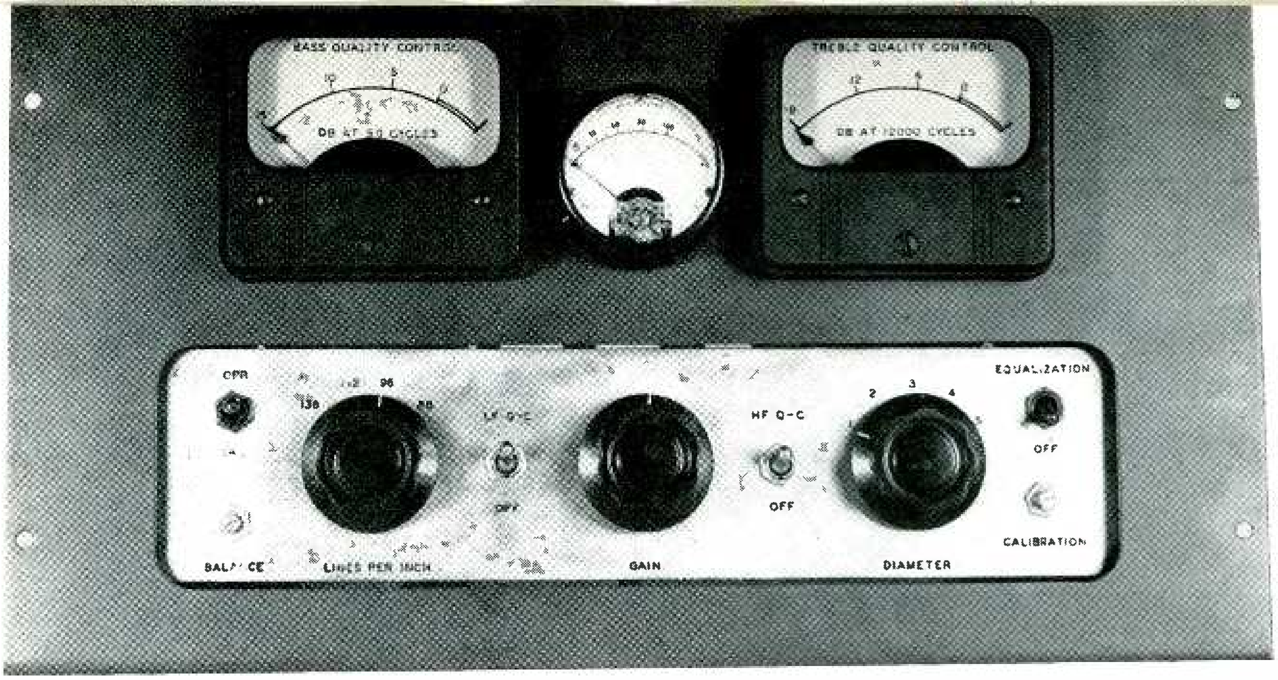
The second Tuesday of each month was selected as the meeting date, registration cards were filled out, and other matters were discussed.

To continue operating, pending completion of a constitution, the members asked the original executive committee, Messrs. J. D. Colvin, C. J. LeBel, C. G. McProud, N. C. Pickering, and C. A. Rackey, and the larger general committee to carry on the Society's business until elections are held. R. H. Schlegel was appointed acting treasurer.

Interest was aroused originally by personal contacts; a letter was published in one magazine and notices were sent to disc recordists, broadcast audio engineers, and others in audio fields, in the vicinity of New York. Response was immediate and widespread, letters were received from coast to coast. The reason for this is discussed at length in an accompanying article, but it can be briefly summarized by saying that audio engineering has been on the fringes of the fields of three existing societies without actually being the central interest of any one of them.

Those interested in joining the national organization or in forming local sections, should write the acting secretary of the new organization, Norman C. Pickering, Pickering and Company, Inc., Oceanside, N. Y., and give the following information: Name, mailing address, company affiliation, and nature of work.

**Research Engineer, Stevens Institute of Technology, Hoboken, N. J.*



Experimental Q-C computer built on a Langevin Progar panel. All controls for basic calibration are located in the rear.

Increasing Volume Level in Disc Recording

EMORY COOK*

Average volume level and dynamic range are extended 6 to 12 db through an ingenious idea.

IF THAT hardy telephone pioneer who first thought up the idea of applying limiting amplifiers to audio work were ever to learn of his device being used for the purpose of *increasing* the volume range capability of an audio system he would probably be surprised, certainly confused. Yet that is exactly what is being and has been done in the case of disc recording. The limiting amplifier is actually being used to defeat its own original purpose. Through the use of two limiting amplifiers operating on different portions of the audio spectrum the recorded peak level obtainable in the groove can be greatly increased. The quality-control, or "Q-C" system, by modifying the response-frequency characteristic of the recording channel, during high level bursts, results in a marked improvement in apparent dynamic range and an increase in average recorded level of from 6-12 db, depending upon the character of program material.

In operation, the action seems to associate itself with frequency response alone, until it is realized that time constants are instead the major factor. A direct parallel exists in the case of motion pictures, where the interruption caused by changing the frame is invisible, just as the rapid control action of this method is inaudible.

*Cook Labs, 139 Gordon Place, Floral Park, L. I., N. Y.

Precepts of System

There are two fundamental reasons why the energy level of a recorded signal must be held within certain limits:

1. The amplitude of the recorded groove must not be so large as to enter into or become tangent to the sidewall of the adjacent groove. (see *Fig. 1A.*)

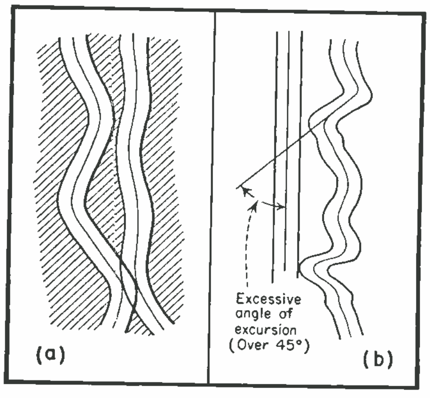


Fig. 1. The two basic limits on recording volume level. (A) Amplitude of excursion and (B) angle of excursion. Excessive angles cause improper tracking, poor record life.

2. The angle of excursion from side to side of the modulated groove must be held within limits determined by the geometry of the system, including playback stylus tip radius and ability of the record material to withstand buffeting by this stylus. (see *Fig. 1B.*)

Disc recording systems usually employ constant amplitude recording below some medium frequency, such as 500 cycles, and constant velocity recording, with or without pre-emphasis, above this frequency. This means that one volt of program input to the system will produce a given amplitude of recording-stylus motion, regardless of frequency, up to approximately 500 cycles. Thereafter, as frequency increases, assuming no pre-emphasis is used, the same volt will produce less and less amplitude the higher the frequency becomes. As a result, virtually all the large lateral amplitude excursions of the stylus are caused by low-frequency components of the program circuit, if no pre-emphasis is used. In other words, if we are able during momentary periods of loud volume to reduce the low-frequency content of the incoming signal, we should be

> The equipment described does not necessarily have to be used to increase recorded volume levels. Instead it may be employed to utilize to greater effectiveness the dimensions of a fine-line groove, so that a 10" record having 4½ min/side plays back at standard level. This possesses certain implications for the renegotiation of musicians' union contracts, where in the past the time per side has been limited by agreeent.—Ed.

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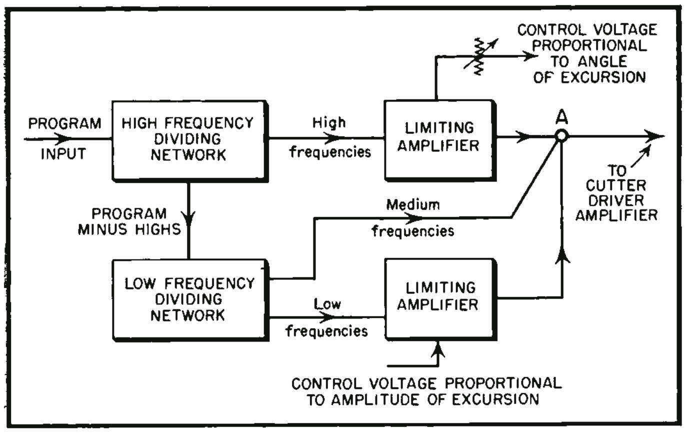


Fig. 2. Block diagram of essential Q-C circuit.

able more nearly to fill the groove with program frequency components above the cross-over point, components which as it happens are squarely in the midst of the most sensitive portion of human hearing, and enable a much higher energy level to be recorded in the groove.

Contrasted to the low-frequency amplitude situation, the sharpest angles of excursion (*Fig. 1B*) occur principally at the high-frequency end of the spectrum, that is at frequencies of 1500 cycles and above. This will, of course, depend to some extent upon the diameter and rotational speed. Therefore, if the peak angles in the groove are prevented from exceeding an acceptable maximum of, perhaps, 35 or 40 degrees, the additional energy level attained by the low frequency modification would not be accompanied by a track made unplayable by sharp radii of curvature of the treble components.

Design Objectives

The problem becomes one of dividing the audio spectrum into three parts: a) The low-frequency portion which causes the largest amplitude excursions, b) the mid-frequency portion which has the greatest effect upon the human ear, and c) the high-frequency portion which is chiefly responsible for playback tracking troubles, needle fit, pinch effect, etc. Referring to *Fig. 2*, this is exactly what has been done. The incoming program if first delivered to the high-frequency dividing network which separates, at the rate of 6 db per octave (See *Fig. 3*), those frequencies above 1500 cycles from those below 1500 cycles. The high-frequency channel thus obtained is passed through a limiting amplifier before it is again combined with the rest of the frequency spectrum. This limiting amplifier must be actuated by an electrical voltage which is proportional to the geometric angle of stylus excursion. It must have a "delay" which permits the attainment of the maximum permissible angle without limiting effect but which reduces the higher audio frequencies after the critical angle has been exceeded. A method of obtaining such a control voltage is described below.

The audio spectrum below 1500 cycles is divided by a second network into two parts, one consisting of those frequencies below 350 cycles and the other containing what remains between 350 cycles and 1500 cycles. (see *Fig. 3.*) This latter mid-frequency channel is not operated upon in any way by a limiter, but the low-frequency channel runs the gauntlet of a forward-acting limiter whose control voltage is a direct function of stylus amplitude. Delay is used in this low-frequency limiting amplifier to prevent limiting from taking place until the stylus has attained some predetermined maximum amplitude. After this point has been passed, however, the low-frequency limiting amplifier will start to operate. It must be borne in mind that with the use of 6 db per octave dividing networks, the worst that can be obtained under condition of severest limiting is a frequency-response curve as shown in *Fig. 4*, where both low and high frequency limiters have operated to cutoff. Moreover, this response persists only momentarily, during loud passages and not necessarily in its entirety even then. Thus, if the incoming signal does not require the action of the high-frequency limiter, due perhaps to very small high-frequency content of the program, then only the low-frequency limiter will take effect. The limiters in the two channels are, of course, not necessarily operated at the same time but only as required and then independently of each other. Still referring to *Fig. 2*, the three portions of the spectrum are again united at point *A* where they may be transmitted to the cutter-driver-amplifier and thence to the cutter itself.

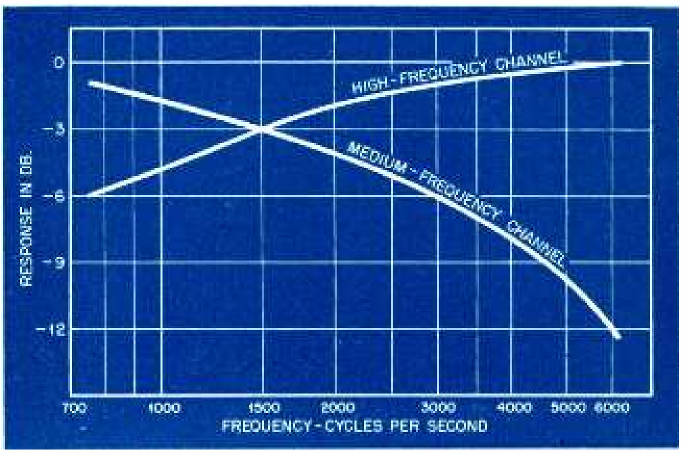


Fig. 3A. High frequency dividing network curves. Split second reduction and restoration of high frequency response avoids widening and sharp angles of groove excursion, insures faithful tracking, and vastly improves record wear.

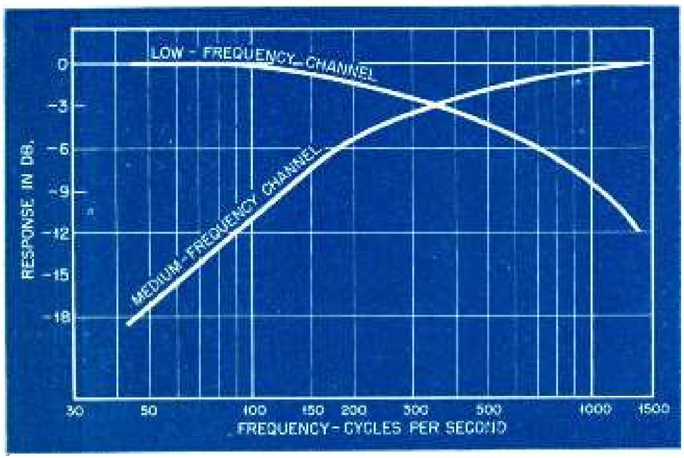
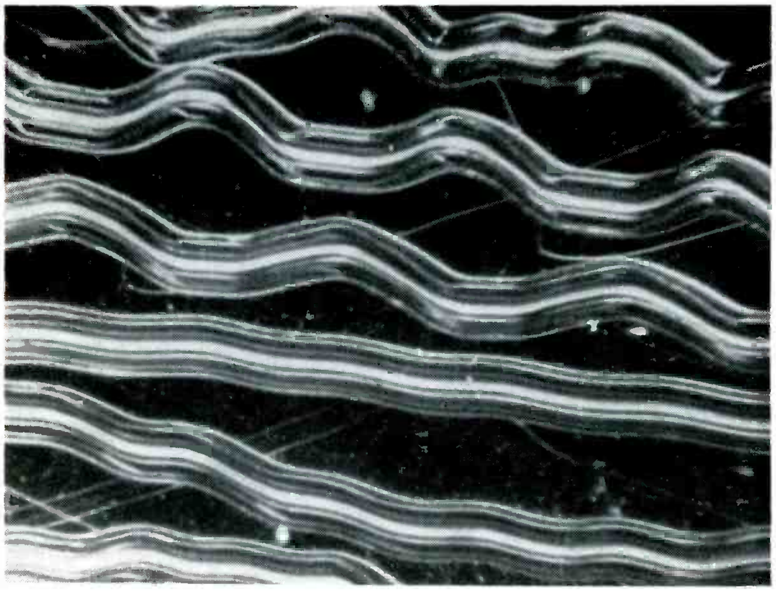
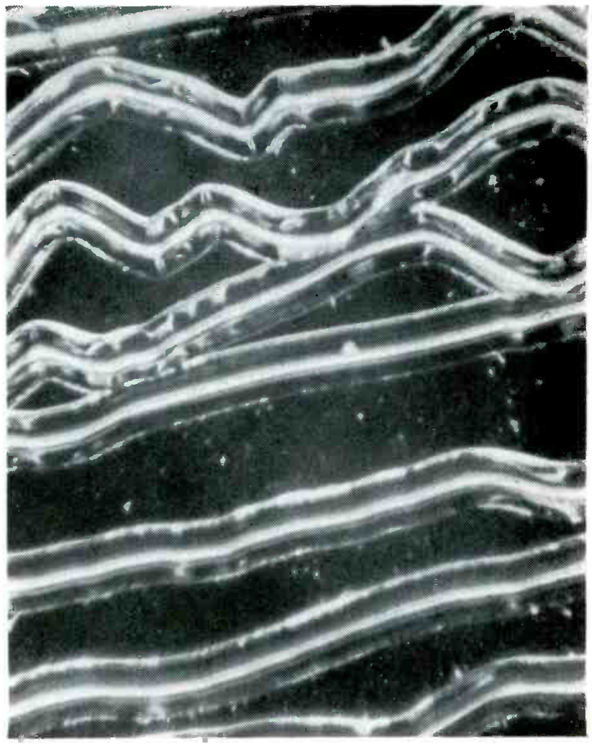


Fig. 3B. Low frequency dividing network curves. Momentary reduction of low frequencies during high level bursts reduces playback equipment distortion.

The High-Frequency Limiting Amplifier

Obtaining an electrical voltage which is proportional to angle of excursion is not a difficult operation, since most cutters are approximately constant velocity devices where the mechanical velocity of the stylus is proportional to the voltage across the driving coil.





(Left): Photomicrograph of Q-C controlled grooves. In this high-level section note utilization of available swing by mid frequencies. This sort of track would not turn out well, however, without use of the ANM stylus.*

(Right): What happens in the groove when signal as at left is turned loose on the cutter undoctored. With good reproducing equipment this sort of thing is playable at outside diameters and sounds fine, but is not susceptible to processing because of the violent cut-overs. *See AUDIO ENGINEERING December 1947, January 1948. (*Photographs courtesy Frank L. Capps & Co. Inc.*)

If we start with a voltage proportional to stylus velocity it is only necessary to know the linear velocity of the track (i. e., r. p. m. and diameter) in order to compute by means of a series of attenuators the angle which will result. A switching device or potentiometer which is varied according to the momentary diameter is then required. In this case a 2db per step attenuator which operates every time the diameter changes to 80 per cent of its former value has been found practicable. This attenuator may take the form of a manually operated control or a series of miniature switches connected to the overhead mechanism of the recording lathe operating automatically as the diameter changes.

Depending on the lacquer formula, and to some extent on the temperature, the angles allowable for instantaneous playback are about 3 db below those which may be tolerated on pressings. Therefore, a MASTER-INSTANTANEOUS switch may be provided which combines this function with an automatic reduction of overall level from the quality control of about 10 db when thrown to the instantaneous position. The diameter position switch is also combined in function with a diameter equalization circuit.

Volume Indicator

The volume indicator used in the quality-control system is not of the ordinary type but selects its reading from the control voltages which operate the two limiting amplifiers. In this way the reading of the volume indicator meter is proportional either to stylus amplitude or to excursion angle. The meter is calibrated by setting the zero point to correspond to the maximum permissible amplitude as determined by low-frequency test tone, and then performing a second calibration to produce the same reading for the maximum permissible angle with a high-frequency test tone. Thus, unless cutter distortion is a factor in limiting the recorded level, it is plain that we do not care about indicating accurately the mid-frequency signal, and the meter reading will represent either velocity angle or stylus amplitude, whichever voltage happens at the moment to be greater. Of course it would be possible to use two separate meters for this purpose, but this would cause operating difficulties.

Dividing Network

Although it would be possible to employ 12 db per octave half sections, as dividing networks the result when used in Quality Control is not pleasing to the ear. The reduction of the high-frequencies at the 6 db/octave rate during high level bursts is difficult even for a practiced listener to detect, for response is immediately restored to normal, thereafter, through use of a short time constant.

Therefore, the basic circuit shown in *Fig. 6* has been devised. It is a constant current divider consisting of a sharp cut-off pentode whose a-c plate resistance of about 1.0 megohm is further increased by leaving the cathode bias resistor unby-passed. The plate load consists essentially of a resistor R_l and condenser C in parallel, with values chosen so that $X_c = R_l$ at the crossover frequency. The percentage change of total impedance in the plate circuit (including the tube plate resistance) due to C is so slight with frequency that the tube acts as a constant current generator. Thus the audio current will divide between the $C-R_h$ leg or the

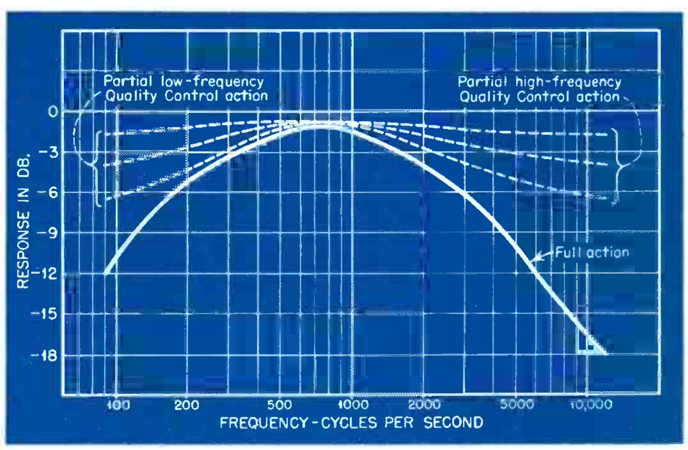


Fig. 4. Worst possible instantaneous frequency condition happens and is gone so fast that the ear never recognizes it.

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R_1–R_l leg depending upon frequency, and at the crossover point equal current will flow in both legs. R_l and R_h are small compared with R_1 and X_c, and the voltage appearing across them is proportional to the current flowing in the respective legs.

Of course, the operating level must be held at a low value to avoid any non-linearity in the tube itself. The end result is a division which must necessarily be perfectly complementary—so that when the signals are later re-combined, no difficulty can be experienced in obtaining a smooth response at the crossover point.

Wear

Studies in shellac pressing wear have indicated that excessive angles of excursion are causes of most of the chipping "gray streaks" which take place at high level points. Even at levels representative of current practice, fortissimo velocity angles are often too sharp, resulting in high unit stresses in the record material from playback stylus impact. When this happens at a crescendo level typical of current practice, it is usually due to either:

1. Microphone placement technique

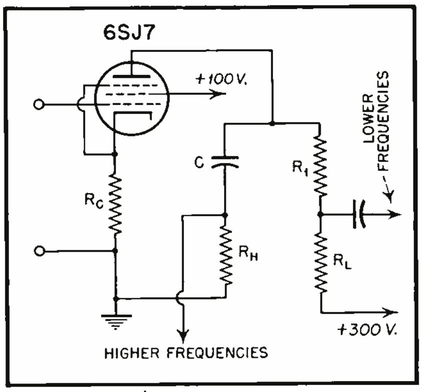


Fig. 6. This constant current divider is a simple and expedient way of getting a perfectly complementary 6db/octave crossover without the necessity of using precision parts. Twelve db/octave may be obtained by substituting an L for R1.

which gives rise to a predominant treble.

2. Excessive high frequency pre-emphasis, or
3. Final crescendo peaks at inner diameters.*

*Unfortunately, somewhere along the line disc recorders became saddled with the outside-in cut—which of course would be all right were it not that most composers and arrangers have the understandable habit of finishing off the job with a heavy punch.

Tracking

The Quality-Control principle of holding to a predetermined maximum the angles of excursion, regardless of diameter, results in consistently good pressing wear even at much higher average VI levels than those which presently characterize phonograph records. The maximum permissible angles may be reached and utilized during a much higher percentage of time than would otherwise be possible. At the same time, the playback needle is enabled to follow the recorded signal with consistent facility.

Intermodulation

Many of the playback systems in use today permit only a modest dynamic volume range before either the second audio tube, the final amplifier tubes, output transformer, loudspeaker —or indeed all four —overload and distort. As a result, many so-called crescendos are wetted down and disappear into a welter of odds, evens, submultiples, and modulated pulses of long duration.

Quality Control attenuates low frequencies as well as the treble if either becomes too loud, thus hampering the

[*Continued on page 38*]

Need for The Audio Engineering Society

By the Organization Committee*

ENGINEERS engaged in the field of audio are generally agreed that there is a definite advantage to a professional society as a means of disseminating information and promoting intelligent study of the problems pertaining to their interests, but there has been considerable doubt that their field has been covered adequately. Audio engineering has been on the fringes of three existing societies without actually being the central interest of any one of them. Because of this, there has been sporadic discussion concerning the formation of a new professional society specifically devoted to audio engineering.

The most recent activity in this connection has been carried on simultaneously in New York and Hollywood. In the East, the interest is high among many of the engineers in the audio profession, but no embryo organization with a technical background has existed as a central meeting ground. The Sapphire Group in Hollywood has attracted audio engineers in that locality, and is a nucleus of activity in the West.

**J. D. Colvin, C. J. LeBel, C. G. McProud, N. C. Pickering, C. A. Rackey.*

The creation of a new professional society is consistent with the example set by other specialized scientific and technical groups, where such course has been found necessary as a result of the inevitable broadening of scope of predecessor organizations.

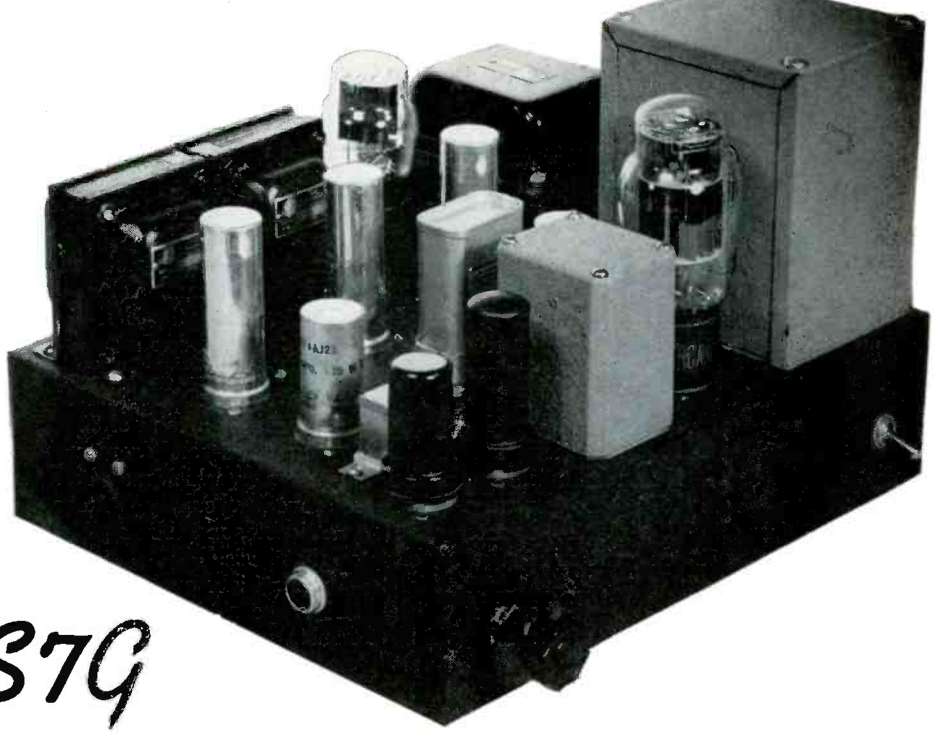
Audio engineering has broadened to the point where a number of separate branches of the field deserve recognition, yet, due to the lack of a specialized organization of engineers and researchers, the advances in the art have not become as widely known as they should be.

For example:

1. *Speech input system design:* Little of a detailed nature has thus far been published and practically no standardization has been achieved.
2. *Studio design and use:* Papers heretofore published have covered fundamental studio acoustics and fundamental methods of utilizing those acoustical conditions. The problems of application and operation from the practical viewpoint have largely been left unreported.
3. *Disc recording:* The gap between the published material and actual practice is so great as to be incredible to one not actually in this field.
4. *Tape and wire recording:* The research aspect has been covered in the literature, but here again there is a big difference between the published information and actual engineering practice.
5. *Hearing aids:* Published information has not kept pace with engineering design practice. It is possible that this is due to the secrecy of a new art, but it may also be due to lack of encouragement of engineering papers.
6. *Public address systems:* The design of large, high-quality systems requires as much skill as that required to lay out a broadcast station, yet virtually nothing has been published on the subject. There are 1500 men in the high-quality field, and with encouragement many papers could be made available.
7. *High quality home reproduction:* The divergence between the ideal as discussed by Fletcher and associates years ago, and current practice is too great. It merits discussion.
8. *Wired music systems:* There are

[*Continued on page 44*]

The high quality audio amplifier



High Quality Amplifier *with the 6AS7G*

C. G. McPROUD*

Outstanding performance from an ultra-modern amplifier

ALTHOUGH not particularly new, the 6AS7G twin triode recently publicized by RCA as an audio output tube is an interesting device, and natural curiosity prompts the experimenter to use the tube in an amplifier to determine its capabilities. The 6AS7G, briefly, was originally designed with two principal uses in view—one being a high-current substitute for the usual 2A3 in tube-controlled voltage regulator circuits, and the other as a driver for the horizontal sweep circuits in television receivers where greater power is required than was previously obtainable with existing tubes. In this particular application, the requirement is for a short duty cycle, but one in which the current is relatively high. Recently, however, it has been given considerable attention as an audio amplifier.

Physically, the 6AS7G is a fascinating tube. In cross section, the elements resemble the sketch in *Fig. 1*, with each plate being composed of two separate and very deep channels, with the short dimension serving as the plate proper, the longer sides being used for heat dissipation. Above and below the element structure are the two radiators for the grids, also used to dissipate the heat. Compared with the 2A3, the 6AS7G is almost the equal of two of the former tubes. Plate dissipation for the 2A3 is 15 watts, whereas that for the 6AS7G is 13 watts *per section*, making a total of 26 watts for the tube. Thus it is seen

Advantages

There are a number of advantages to the 6AS7G which are not obtainable in any other output triode. In the first place, it uses a heater-cathode construction, eliminating the problem of reducing hum from this course. The two sections of the tube are completely separate, permitting the use of separate cathode resistors to obtain grid bias, and making it a simple matter to balance plate currents in the two sections. The plate

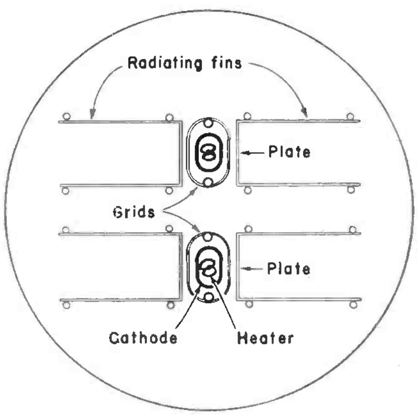


Fig. 1. Cross-section of element structure of the new 6AS7G, showing the unique plate construction with adequate area for heat radiation. Grid radiators are alternately above and below the element structure.

resistance is relatively low, being of the order of 670 ohms at the operating point selected. With this value of plate resistance and the high-current capability of the tube, the plate efficiency is seen to be high. The amplification factor of the tube is 2.1. When working into a 3000-ohm plate load, the effective output impedance of the amplifier—at a 16-ohm winding, for example—is 7.2 ohms, which provides a good damping factor for an amplifier used to drive a loudspeaker.

Design of the Amplifier

Proponents of high-quality reproduction are divided over the relative merits of triodes versus pentodes-with-feedback, but the current trend seems to be back (?) toward the use of triodes for the output tubes in the better apparatus. With this in mind, the 6AS7G was investigated, and since it appeared to have certain advantages over the other tubes of similar power output capabilities, an amplifier was designed

TABLE 1

AUDIO AMPLIFIER SERVICE
Values are for each unit

Maximum Ratings, Design Center Values:

PLATE VOLTAGE	250 max.	volts
PLATE CURRENT	125 max.	ma
PLATE DISSIPATION	13 max.	watts
PEAK HEATER-CATHODE VOLTAGE		
Heater negative with respect to cathode	300 max.	volts
Heater positive with respect to cathode	300 max.	volts

Typical operation, Class A_1 push-pull amplifier. Unless otherwise specified, values are for both units.

Plate	200	250	volts
Grid	−90	−125	volts
Cathode Resistor (per unit)	1500	2500	ohms
Peak AF grid to grid voltage	180	250	volts
Zero signal plate current	120	100	ma
Max. signal plate current	128	106	ma
Effective load resistance (plate to plate)	4000	6000	ohms
Total harmonic distortion (less than)	4	4	per cent
Max. signal power output	11	13	watts
Amplification Factor (per unit)	2.0	2.0	

*It is essential that precaution be taken in equipment design to prevent subjecting the tube to full load current of 250 ma before its cathodes have reached normal operating temperature. The cathodes require approximately 15 seconds to attain normal operating temperature. Unless this precaution is observed, the cathodes will be seriously damaged, if not completely ruined. In speech amplifier service, as indicated under typical operating conditions, the plate voltage may be applied simultaneously with the filament voltage.

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around it. This amplifier was designed on the basis of the highest fidelity of reproduction, and used broadcast quality transformers. It was not intended that any short cuts would be employed, but simply that a good, stable, reliable amplifier should result. The finished amplifier reasonably well justifies the time spent, since the performance comes up to the expectations.

The values published by RCA for typical operating conditions are shown in *Table 1*. This table indicates that the tube draws a high plate current, requires a high grid bias, and is operated with separate cathode resisters to develop this bias. The high bias also indicates a high signal voltage applied to the grids, which poses somewhat of a problem, as will be discussed later. Under the 200-volt condition, the plate dissipation is 12 watts per unit, which appears to be too close to the maximum to provide a factor of safety. Therefore, a slightly higher bias voltage was chosen, in order to reduce the plate dissipation to 10 watts, as well as to reduce the plate current through the primary of the transformer to a more reasonable value.

Commencing the design, the output stage is considered first. A study of the typical operating conditions indicates a plate voltage of 200 and a bias of –95 volts, making a total of 300 volts, allowing for a 5-volt drop in the output transformer, which may be a trifle high. However, a supply voltage of 300 is practicable, and the amplifier is designed on that basis.

Using high quality transformers restricts the choice considerably, but two transformers of Audio Development Company manufacture appear to be suitable for this application. The Type 314C output transformer is equipped with a primary for 3,000 or 5,000 ohms, and with secondary impedances of 600, 150, 16, 8, 4 and 2 ohms, which provides sufficient versatility for most uses. Since the 6AS7G should be operated with a relatively low resistance in the grid circuit for optimum performance, the coupling to the preceding stage should preferably be a transformer. Another reason for the use of a transformer is that it is difficult to obtain sufficient voltage swing from any existing tube in a resistance-coupled circuit unless the grid resistor is made large. Reference to tables in the tube handbook indicate that a 6AU6 would provide adequate grid swing as a resistance-coupled driver, but it seems rather ludicrous to employ two miniature tubes to drive a combined output tube. Furthermore, the added complication of a phase inverter is avoided by using a transformer.

Since some voltage step-up is desired from the interstage transformer, the

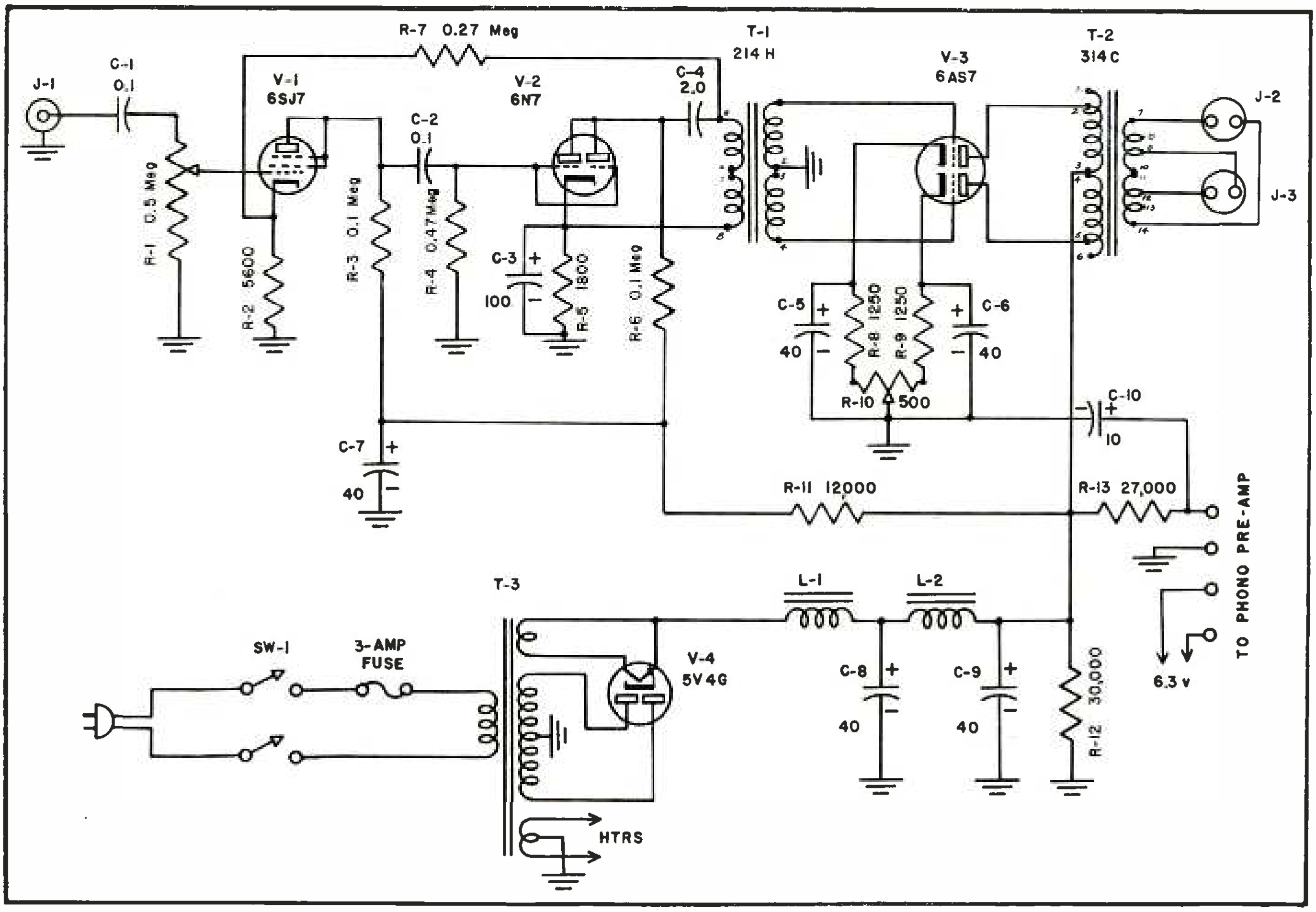

Fig. 2. Schematic of 6AS7G amplifier, showing provision for furnishing plate and filament power to external pre-amplifier.

C_1—0.1 μf, 600-volt, tubular
C_2—0.1 μf, 600-volt, Aerovox 618B
C_3—100 μf, 25-volt, CD UP4AJ23
C_4—2.0 μf, 600-volt, CD TJU-6010
C_5, C_6—40-40 μf, 150-volt, CD UP4415
C_7, C_8, C_9—40 μf, 450 volt, CD UP4045
C_{10}—10 μf, 450 volt, CD BR1045

J_1—input jack, Amphenol 80C
J_2—600-ohm output jack, Amphenol 80PC 2F
J_3—8-ohm output jack, Amphenol 80PC2F

L_1, L_2—7.0 H, 140 ma choke, Stancor C-1421

R_1—0.5 meg. volume control, IRC D13-133
R_2—5,600 ohms, 1 watt
R_3, R_6—0.1 meg, 1 watt
R_4—0.47 meg, 1 watt
R_5—1,800 ohms, 1 watt
R_7—0.27 meg 1 watt
R_8, R_9—1,250 ohms, Ohmite 10 W. Brown Devil
R_{10}—500-ohm wirewound potentiometer
R_{11}—12,000 ohms, 2 watts
R_{12}—30,000 ohms, Ohmite 10 W, Brown Devil
R_{13}—27,000 ohms, 1 watt

T_1—Audio Development Co. 214H, 10,000/80,000 interstage
T_2—Audio Development Co. 314C, 3,000-5,000/600-16-4, output
T_3—400/0/400 at 200 ma; 5 v at 4 amps; 6.3 v at 5.5 amps, Stancor P-6165

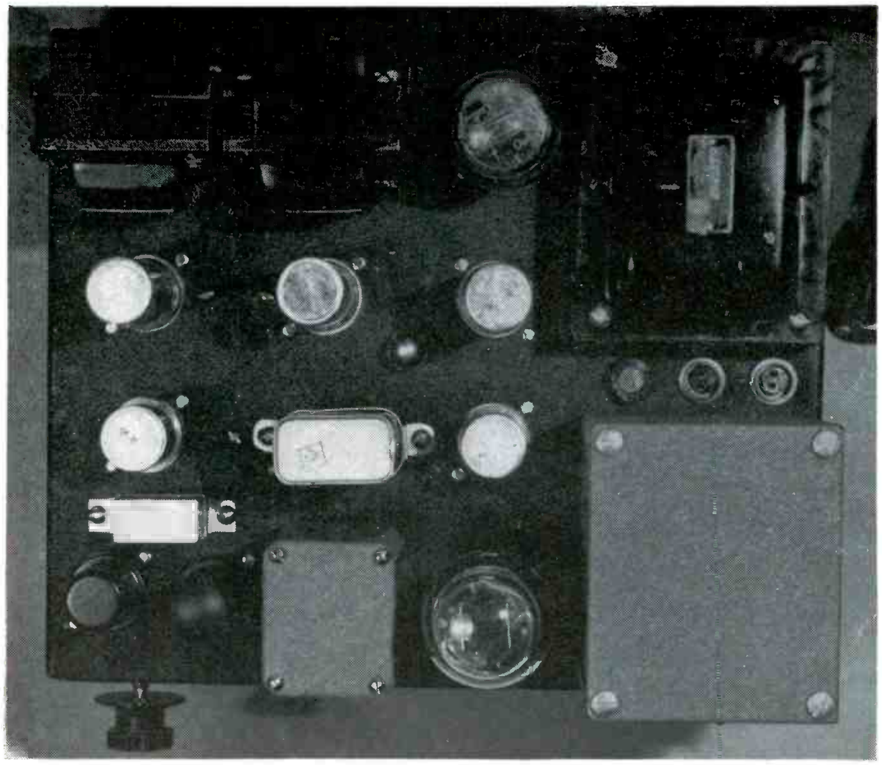

Fig. 3. Top view of amplifier, showing placement of parts. Note simplicity of arrangement. Capacitor above interstage transformer is C_4, used in shunt feed circuit. Note use of inverted can capacitor for coupling between 6SJ7 and 6N7, shown directly above the two tubes.

214H was selected. This transformer has an impedance ratio of 10,000 to 80,000, resulting in a voltage gain of 2.83. The peak grid-to-grid swing is—with the bias chosen—190 volts, or an rms swing of 138 volts. This requires a signal at the plate of the driver tube of 138/2.83, or 49 volts, a value which is readily obtainable from triodes of the 6J5 type. However, an equal amount is obtainable from the 6N7 with ease, and with approximately twice the voltage gain in the tube. The 6N7, with the two sections in parallel, is often used as a driver tube since it is capable of furnishing rather a large amount of power. Although the 6AS7G is operating strictly Class A, some power is to be dissipated in the feedback circuit, used to improve the characteristics of the driver, which is the hardest-worked tube in this combination.

Relatively little total gain was required from the amplifier, so it was considered suitable to use a triode as the first stage. In order that the gain could be increased readily by the simple change to a pentode connection, the 6SJ7 was selected. With this tube line-up, the total gain of the amplifier, without any feedback, was calculated at 68 db. Planning on 20 db of feedback, a net gain of 48 would result, which is still more than sufficient for a "main" amplifier.

Power Supply

The power supply is conventional, using a choke input and two sections for adequate hum filtering. One of the requirements of the 6AS7G is that the plate voltage should not be applied until the cathodes have attained normal operating temperature. This requirement is waived in speech amplifier service where the bias is obtained from cathode resistors, but since it is of some importance in certain applications, it is considered desirable to limit the application of the plate voltage to some extent by using a 5V4G as the rectifier tube. This tube may be operated with up to 500 volts on each plate for choke-input filters, and is eminently suitable for this purpose.

Desiring an amplifier suitable for continuous operation with adequate reserve to keep heating to a minimum, the power transformer selected is designed to furnish 200 ma at 400 volts each side of center tap, 5 volts at 4 amps for the rectifier heater, and 6.3 volts at 5.5 amps for the amplifier heaters. The 5V4G requires but 2 amps, and the tube complement of the amplifier draws 3.6 amps, which means that the entire power supply is "coasting."

Balancing Plate Currents

Returning to the output stage, some provision is desired for balancing the plate currents of the two sections of the 6AS7G, so instead of using separate resistors of equal value, each being 1500 ohms, it was decided to employ two 1250-ohm resistors, connecting to the ends of a 500-ohm potentiometer with the arm grounded. This arrangement provides sufficient control to balance the plate currents. Each cathode is by-passed with a 40-μf, 150-volt electrolytic capacitor, a dual unit being used to conserve space.

The plate load resistor for the 6N7 is 0.1 meg, being coupled to the primary of the interstage transformer by a 2.0-μf 600-volt oil-filled capacitor. At this same point the feedback resistor is connected, providing the isolation for both circuits with the same capacitor. The

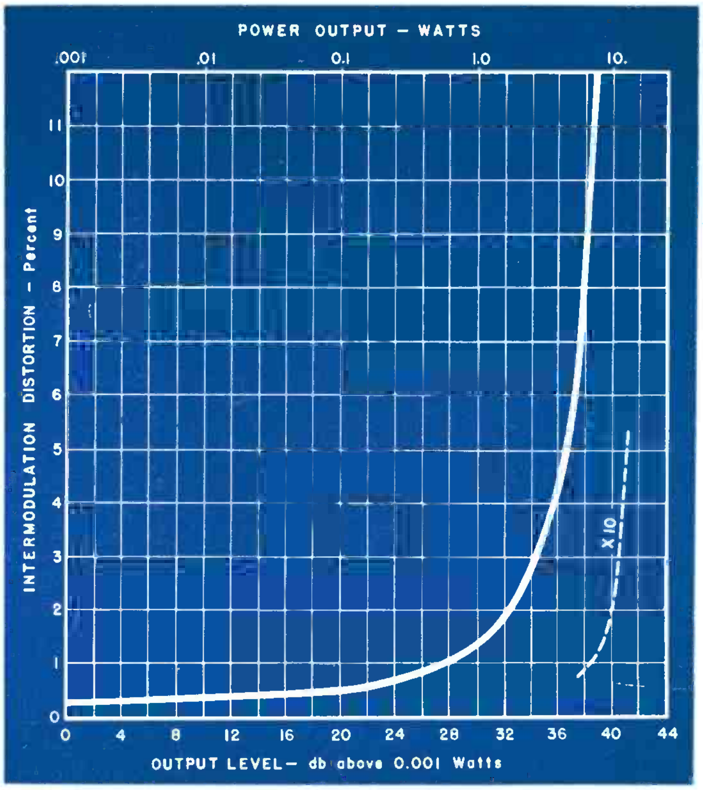

Fig. 6. Intermodulation distortion curves at various output levels.

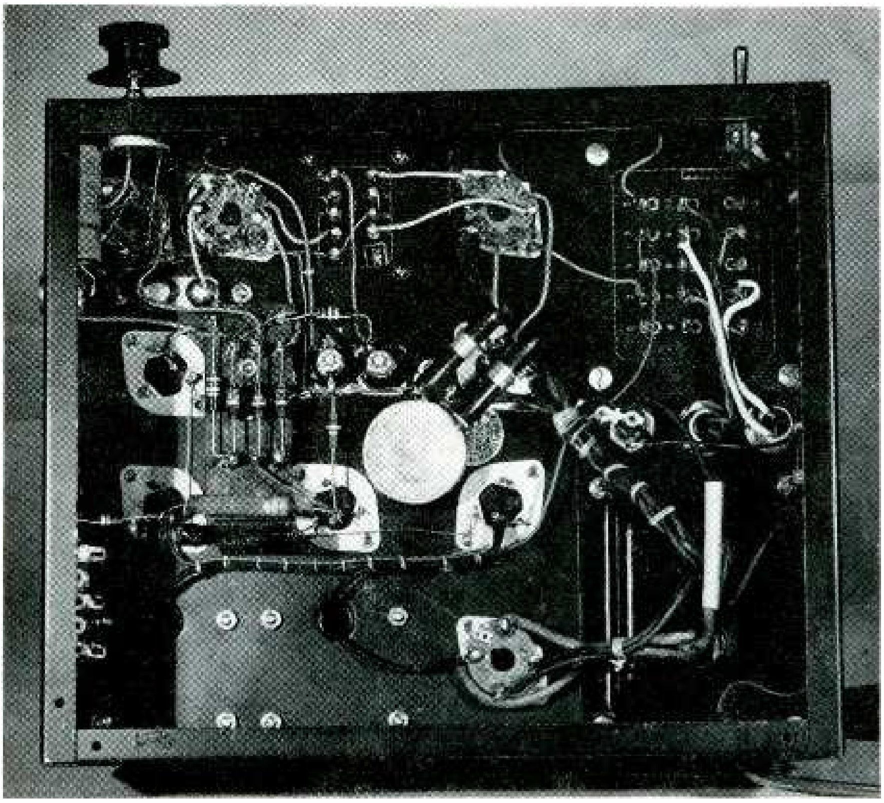

Fig. 4. Under-chassis view of amplifier.

cathode of the 6N7 is by-passed with a 100-μf, 25-volt capacitor. The feedback resistor connects to the unbypassed cathode of the 6SJ7. The complete schematic is shown in *Fig. 2*, with the arrangement of parts both above and below the chassis shown in *Figs. 3* and *4*.

As constructed, the gain of the amplifier without feedback is 67 db, measured from an unterminated 500-ohm gainset, or an actual gain of 61 db. With 26.7 db of feedback, the gain reduces to 34.3 db, without a transformer at the input.

Increasing Gain

If more gain is desired, the first stage may be changed to the pentode connection, with an increase in gain of approximately 20 db, and a 600/50,000 input transformer will give nearly 20 db more. Referring to the schematic of *Fig. 5*, it will be noted that the changes necessary to convert the first stage to a pentode are relatively simple—only one resistor is changed, and one resistor and one capacitor are added. Changing the value of the cathode resistor from 5,600 ohms to 680 ohms automatically compensates for the difference in gain for the two tubes with respect to the feedback connection, and provides approximately the same amount of feedback—in db of gain reduction—when using the same resistor for *R7*.

Performance

With the design considerations outlined, the amplifier was constructed as shown, and then tested to determine how well the 6AS7G tube performed. The principal information required of an output stage is the maximum power output, and the output at a stated percentage of harmonic distortion, usually 5 per cent. Modern engineering and testing standards require information as to the intermodulation distortion in addition to the above. It is generally accepted that an amplifier designed for high-quality reproduction must be capable of

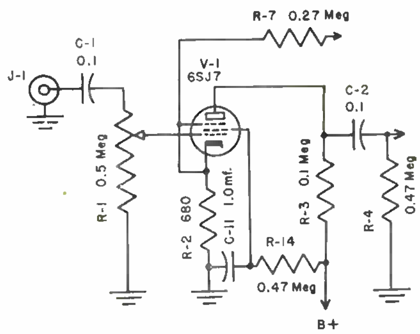

Fig. 5. Schematic of changes to circuit of V_1 when used as a pentode for increase of approximately 20 db in gain. Only required changes are in cathode resistor R_2 from 5,600 ohms to 680 ohms, and addition of R_{14} and C_{11}. No change is necessary in feedback resistor, R_7.

furnishing sufficient output power at a harmonic distortion of less than 1 per cent to be completely satisfactory, and that the intermodulation distortion should be under 2.5 per cent for optimum performance.

This amplifier underwent the necessary tests, and the results are gratifying. The power output at 20 per cent intermodulation distortion, equivalent to 5 per cent harmonic distortion, was measured at 9.5 watts, and at 4 per cent intermodulation distortion (1% harmonic distortion approximately) 3 watts. The intermodulation distortion at 5 watts output is 6.3 per cent, and at 1 watt, 1.3 per cent. This indicates that the performance of the amplifier is satisfactory for the highest quality requirements for home or monitoring applications, using efficient speaker systems where the power requirements are not as severe as in public address systems.

One of the principal advantages of the 6AS7G shows up in the measurement of hum, this value being —45 dbm. When compared to the conventional 2A3 amplifier, this is somewhat better, and it should be noted that no special precautions were taken to minimize hum, nor were any of the "tricks" used. The measured gain is 34.3 db with feedback, and since the frequency response is flat within 0.5 db from 20 to 15,000 cps, it is not considered necessary to reproduce the curve. Intermodulation distortion curves are shown in *Fig. 6*. At 1 watt output, the output impedance at the 600-ohm winding is 258 ohms; at the 16-ohm winding, it is proportionately less than 8 ohms which provides excellent damping for a loudspeaker.

Conclusions

Tests of this amplifier indicate that the 6AS7G is an ideal substitute for a pair of 2A3s or 6B4Gs in the output stage of a quality amplifier. The low voltage and high current requirements of the tube reduce possibility of failure in filter capacitors, especially when electrolytic units are used, and the simplicity of the amplifier makes it ideal for applications where continuous service is required. Although phase inverter circuits are considerably less expensive than high-quality transformers, there is one thing to be said in favor of the transformer—once installed, it may be depended upon for years of service, and its characteristics are not dependent upon the gain of a tube or the constancy of a resistor. When shunt-fed circuits are used, there is little chance of burning out the primary (unless the coupling capacitor fails) and no trouble need ever be anticipated with a good transformer. The characteristics of a transformer-coupled amplifier may be counted on to be constant as long as the unit is in use.

The use of the 6AS7G in quality amplifier service definitely indicates a trend toward simple, reliable design, and if operated at reasonable plate dissipation, the tube should give continued satisfaction.

[See editorial comments (p. 4) on the performance of this instrument.—Ed.]

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Facts About Loudspeakers

O. L. ANGEVINE, JR.,* and R. S. ANDERSON*

PART II A series of articles for beginners in sound engineering.

IN A SPEAKER system, the baffle or housing plays a part as important as the speaker itself. In order to understand the function of a baffle, first assume a speaker operating without a baffle. At low frequencies as the cone moves back and forth, there is ample time for the air to move around the edge of the speaker to equalize the pressure without radiating sound. To avoid this effect, the speaker may be mounted on a baffle (*Fig. 7a*), which in its simplest form is a plane flat surface increasing the length of the acoustic path from the front to the back of the cone. This path should be not less than ½ wavelength of the lowest frequency it is desired to radiate. In some applications a speaker may be set into a wall, thus making a whole wall a baffle but, in this case, the back of the speaker must open into a large volume of air or the enclosure becomes a closed-back housing. (For a more complete explanation of the various types of baffles and housings, see Olson.[4])

A flat baffle may be folded into an open-back housing (*Fig. 7b*) effecting a considerable reduction in space at small sacrifice in the length of the acoustic path from the front to the back of the cone. Here reflections between parallel interior surfaces may cause resonances in the low-frequency region that seem at first to enhance the bass in music. After a while, the listener becomes conscious that only a narrow band of frequencies are thus enhanced and every bass note seems to "touch off" the resonant frequency. Such resonance in the speech band makes speech "boomy." Resonance may be avoided by using non-parallel surfaces or by placing sound-absorbent material on at least one of each pair of parallel surfaces.

The closed-back housing (*Fig. 7c*) is different from both the flat baffle and the open-back housing in that there is no acoustic path from the front to the back of the cone. In this case, low-frequency cut-off is determined by the volume of the housing taken together with the mass of the cone assembly and the compliance of the cone suspension for the speaker used. Considerable economy of space over the open-back housing may be effected. But, here again, parallel surfaces may require treatment to prevent resonance.

The acoustic phase inverter or "bass reflex" housing (*Fig. 7d*) is a variation of the closed-back housing, employing a pipe or hole coupling the enclosed cavity to the exterior. The sound issuing from the "port" will be in phase with the sound radiating from the front of the cone at some low-frequency, thus producing a peak in the response. With a given speaker and volume of housing, the frequency and magnitude of this resonance increases as the size of the port is increased. It is, therefore, possible to adjust the resonance frequency to compensate for speaker deficiencies occurring above the fundamental resonance of the speaker. In this case, as in other types of speaker housings, parallel surfaces may require treatment to prevent resonance.

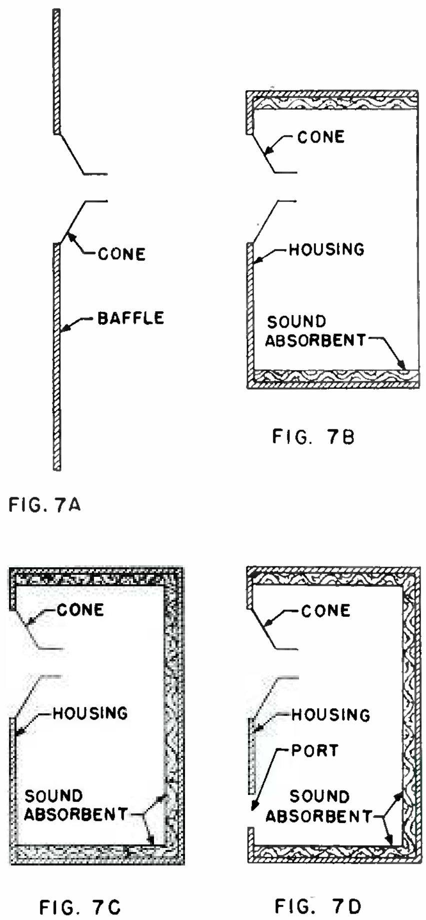

Fig. 7. Speaker baffles and housings: A.—Plane flat baffle. B.—Open-back housing. C.—Closed-back housing. D.—Acoustic phase inverter.

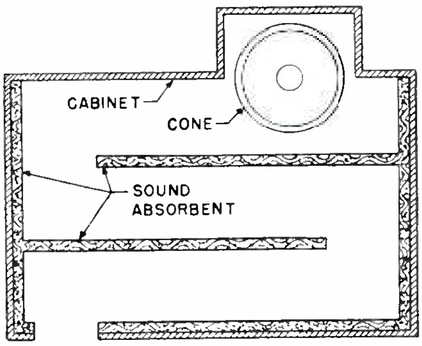

Fig. 8. Acoustical labyrinth.

The acoustical labyrinth (*Fig. 8*) is an absorbent-walled, open-ended tube, one end of which is coupled tightly to the back of the speaker, folded to fit into the cabinet. The mass of the air in the tube acts as though attached to the back of the cone at low frequencies, thereby lowering the fundamental resonance of the speaker system, and thus extending its response to lower frequencies. At a frequency for which the tube is a half-wavelength long, the sound issuing from the open end of the tube is in phase with, and adds to, the sound radiating from the front of the cone. Adjustment of these values permits compensation for deficiencies in the low-frequency response. Note that this is the only system of those described that lowers the fundamental resonance of the speaker.

The housings described above may be modified by the use of distorted shapes or the addition of elements to produce special effects. Many of these effects depend upon the use of resonance to make up for deficiencies in bass response and, in the hands of skilled designers, this attack may result in improved performance for a given space.

Choice of Baffle or Housing

Any of the above types of housings or baffles will produce a satisfactory result when properly designed. The choice of the type of baffle depends upon the size and type of housing which can be accommodated and upon the cost which can be

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Fig. 9. Coaxial speaker system for wide-range reproduction.

allowed. For voice reproduction, or for music where some quality can be sacrificed, a small housing or baffle is satisfactory. For good low-frequency response, any of these solutions run into fairly large dimensions.

In connection with the size of the housing, it is well to remember that the larger the cone, the larger the housing needs to be. For example, if a cabinet of moderate size is used, an 8″ speaker may sound better than a 12″ speaker in the same cabinet. As another example, a Stromberg-Carlson closed-back housing for an 8″ speaker has a volume of 2900 cu. in., whereas the housing, to obtain the equivalent low-frequency response with a 12″ speaker, requires a volume of 6750 cu. in. For a closed-back housing, the volume should be roughly proportional to the area of the speaker cone for equal low-frequency performance. This proportionality involves assumptions concerning the mass and compliance of the cone assembly which hold quite well for the majority of speakers.

Transient Response

Transient response is a measure of the speaker's ability to give faithful reproduction of short, sudden impulses, such as drum beats. Poor transient response is usually characterized by "hangover"—the cone overshoots and continues to vibrate after the pulse ceases. The effect is to prolong short bass notes, making them sound "muddy," and sometimes to invest them with a characteristic tonality corresponding to the pitch of the fundamental resonance of the speaker system.

There are three elements in the system that contribute to hangover—the speaker itself, the housing in which it is used, and the amplifier from which it is driven. For best results, the speaker should be chosen with a low natural resonance, and a high electro-mechanical efficiency—that

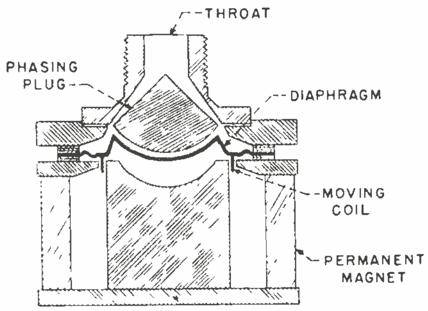

Fig. 10. Horn speaker driver unit.

is, a large voice coil and a high flux density in the gap. The baffle or housing should be large enough to permit the reproduction of the full low-frequency range of the speaker. The amplifier should be chosen with a low output-voltage regulation. Note that all of these factors improve the low-frequency response.

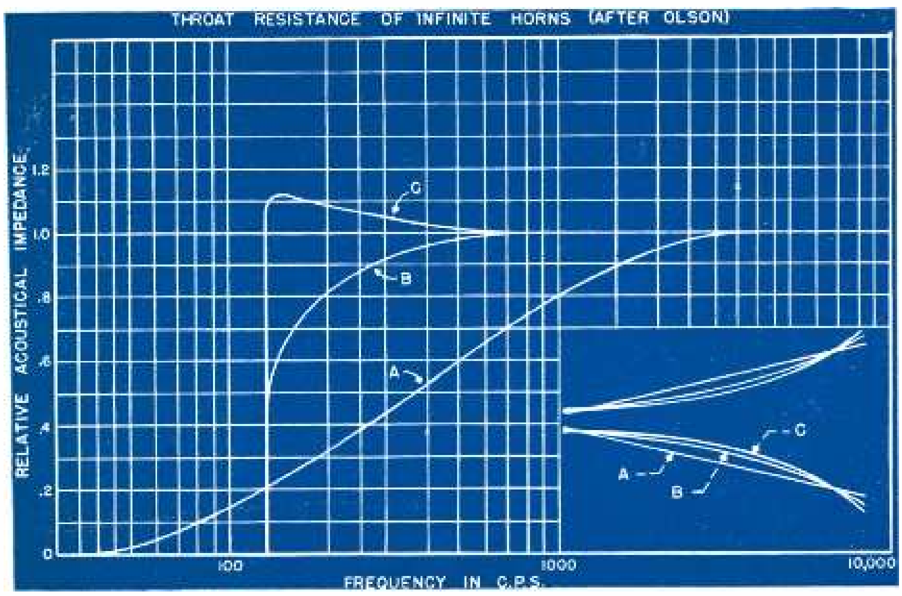

Fig. 11. Throat resistance of infinite horns (after Olson).

Multiple Speaker Systems

There are a number of speaker systems in which more than one speaker is used in order to cover a wide frequency range. While a single speaker may cover a range adequate for many purposes, certain compromises must be made which limits the performance—especially frequency response and intermodulation distortion. These limitations may be largely overcome by using a system comprising a number of speakers (usually two), each of which is designed expressly for a particular frequency band. The electrical input to each speaker may be confined to the frequency band for which it is designed by the use of dividing networks. In its simplest form, a network may be only a condenser in series with the high-frequency speaker. One form of the dual speaker system has a high-frequency "tweeter" mounted above a low-frequency "woofer." In the coaxial system (*Fig. 9*), the tweeter is mounted inside of the coaxial with the woofer, so that in small rooms, where the listener must be near the speaker, the sound will appear to come from a single source. The tweeter may be either a horn-type or a cone speaker, while the woofer is generally a cone speaker as it requires less space for a given low-frequency response than does a horn-type speaker.

Horn-type Speakers

Horns have been used as megaphones since pre-historic times to allow the human voice to be heard at a greater distance. Likewise, horn-type speakers offer greatly improved efficiency and directivity over cone speakers. One of the problems in obtaining high efficiency in a speaker system is to match the acoustical impedance of the mechanical system of the speaker to the relatively low acoustical impedance of free air. In the case of direct-radiator (cone-type) speakers, this is not accomplished too well—note the comparative efficiencies of cone and horn-type speakers given in the previous article. A horn may be considered as an acoustical transformer matching a comparatively high acoustical-impedance driver unit to free air. The availability of such an acoustical transformer allows the design of a driver unit whose acoustical impedance can be matched by a suitable horn.

In current practice the driver unit of a horn speaker (*Fig. 10*), like a cone speaker, uses a "dynamic" magnetic system. The major difference is the small size and stiffness of the metal or cloth-filled-phenolic diaphragm. The same general problems of design occur in the driver unit for the horn speaker as in the cone speaker, except that, since horn speakers are frequently used outdoors, they are usually weather-proofed to some degree.

The horn, to be an ideal acoustical matching transformer, must have a constantly and smoothly increasing cross-section from its throat at the driver unit to its mouth. Modern horns have a cross-section which increases exponentially or hyperbolically, which forms have a constantly increasing rate of flare. These horns have a constant acoustic resistance at the throat down to a sharp cut-off at a low frequency which, in the case of the infinitely long horn, would be proportional to the rate of flare (*Fig. 11*). With a finite horn, low-frequency cut-off is also controlled by the diameter of the mouth which must be about one-third wavelength of the lowest frequency to be reproduced. For good low-frequency response, the horn must be exceedingly large—as an example, 100 cycle cut-off with a one-inch diameter throat requires a horn nearly 8 ft. long and a mouth diameter of more than 3-½ ft.

In an electrical circuit, power can be absorbed only by a resistance; likewise in the acoustical analogy, power can be absorbed only by an acoustical resistance. Therefore, when the acoustical resistance at the throat falls to a low value below cut-off, very little power can be radiated through the horn; thus the frequency response of the horn will exhibit cut-off at the same point as the acoustical resistance.

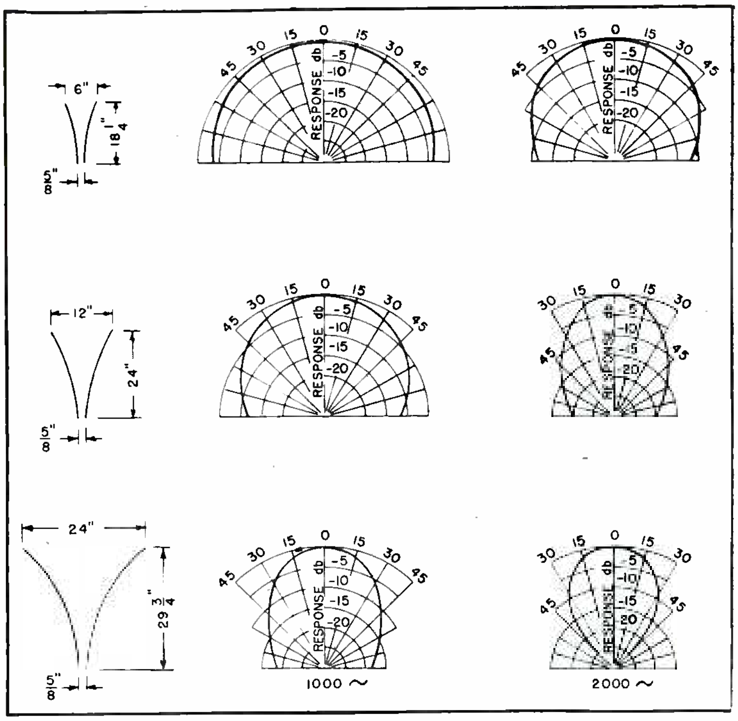

Fig. 12. Horn directional characteristics (after Olson), showing the change in directional characteristic with varying mouth size and constant taper.

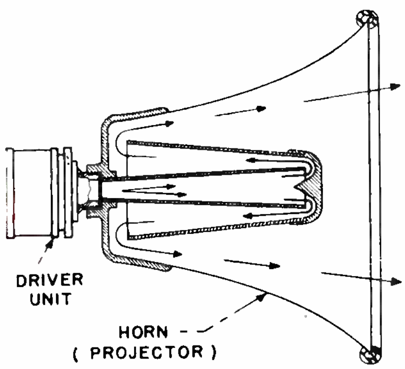

Fig. 13. Re-entrant horn.

A horn speaker should be protected from electrical input below the cut-off frequency. Not only does the acoustical resistance at the throat drop sharply at cut-off, but the acoustical reactance after a sharp rise, also drops steeply. Thus below cut-off there is practically no load on the diaphragm and serious mechanical damage may occur if the input signal is not attenuated at low frequencies.

Directivity

The directional characteristic (*Fig. 12*) of a horn speaker is dependent primarily on the diameter of the bell (mouth) and generally, as in the case of cone speakers, the larger this diameter the more directional is this response. At high frequencies, the flare also plays a part and the speaker becomes somewhat more directional as the flare is reduced.

Horn Construction

Since a straight horn is of unwieldy proportions, the usual practice is to fold it back on itself as shown in Figure 13. This introduces small discontinuities in the rate of flare which result in slightly impaired performance, as compared to the straight horn, negligible in respect to the saving in space.

Horns are usually made of metal because wood or fibre require surface treatment to reduce attenuation by absorption. Vibration of the walls may produce hangover and irregularities in the frequency response. Considering present day construction and material, this problem is usually over-emphasized.

Multi-Horn Speakers

Multi-horn speakers may be used to increase or decrease directional characteristics, as compared with an equivalent single horn. A single horn with a large mouth may not give the expected directional characteristic at high frequencies because sound pressure and phase do not remain uniform over the mouth area if the mouth is large compared to the wavelength. If the large horn is divided into a group of small horns of equivalent total mouth area, the directional characteristic, while remaining the same in the mid-range, is sharper at high frequencies.

The foregoing illustrates that a cluster of small horns is nearly equivalent to one large horn in directivity. This suggests that clusters can be arranged to produce almost any desired directional characteristic. For example, at an airfield it may be desirable to cover a broad area with a minimum dissipation of sound up into the air. This may be accomplished by stacking a number of small horns on top of one another in a vertical column. The resultant directional characteristic with a tight vertical beam and a broad horizontal beam may seem to contradict common sense. The right explanation becomes evident when it is recalled that the larger the horn mouth the more directional it is; therefore, the vertical cluster will be sharply directional vertically where it has its greatest dimension. Its horizontal directivity will be as broad as one of the individual horns making up the cluster.

If diffusion rather than directivity is desired, the horns should be aimed slightly outward. In the case above where directivity was the goal, the mouths of the horns made a flat plane.

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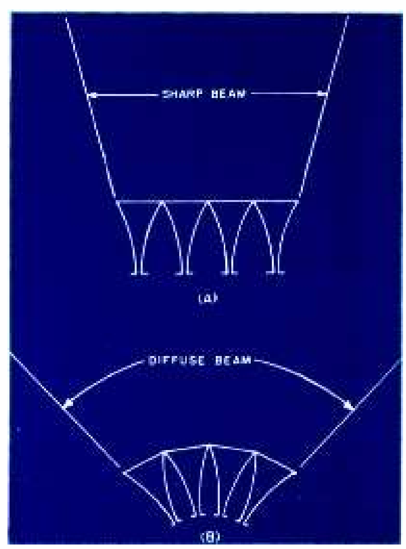
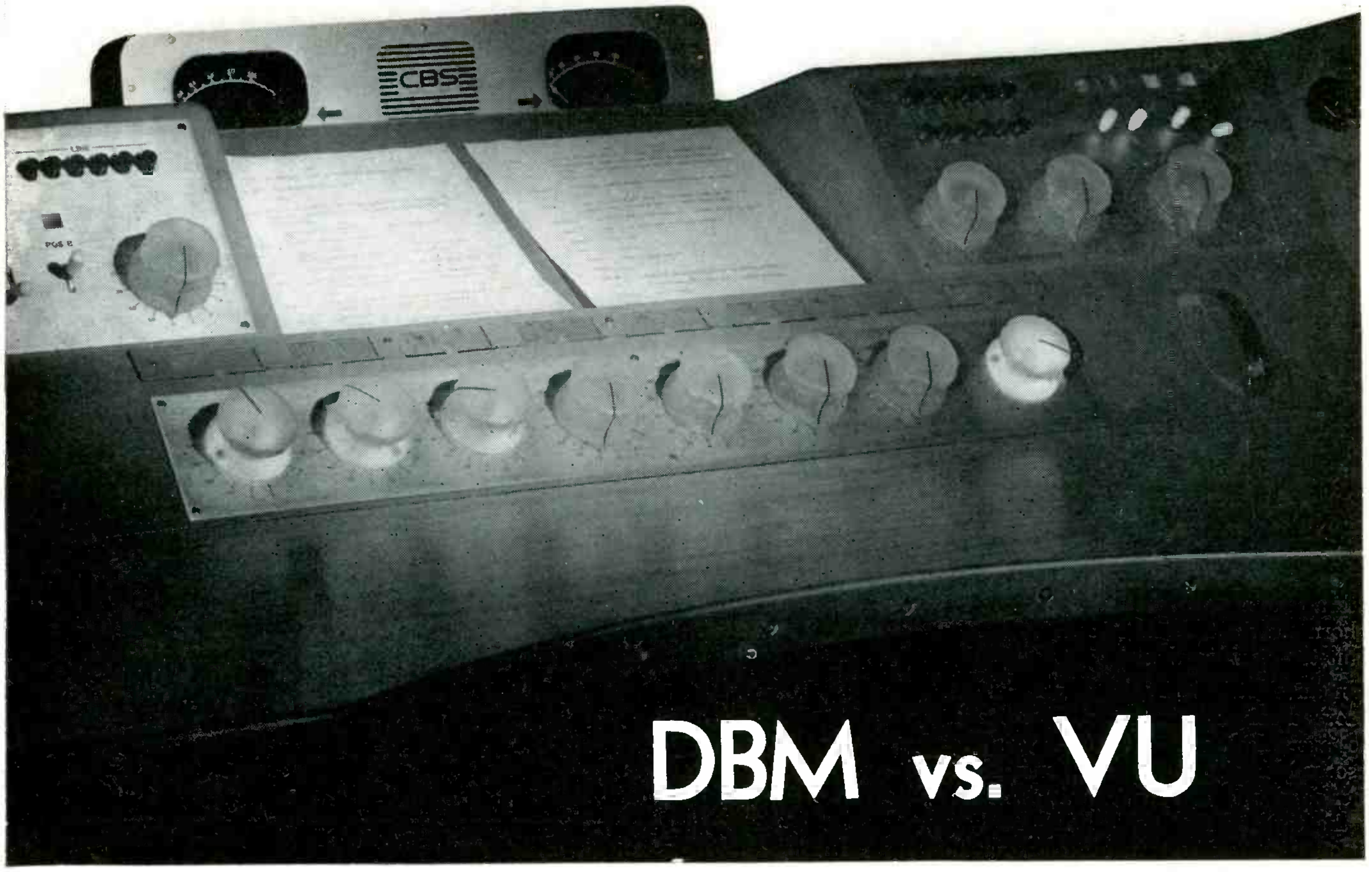


Fig. 14. Horn clusters: A.—For directivity. B.—For diffusion.



A close-up of the center section of the CBS 3B Studio Audio Control Console. One of the many features of this new console is the experimental black scale volume indicators. The divisions and lettering on these black scales (which are contrary to ASA standards) are made with fluorescent material which is excited by ultra-violet light. Markings up to the reference point are in green, those above in red. The pointer, of course, is also coated with fluorescent material. These non-standard, experimental volume indicators were installed in order to explore the desirability of employing a scale of this type in television studio applications where the usual type of scale illumination may be objectionable.

HOWARD A. CHINN*

The author clears up the existing confusion concerning the proper application of these terms.

THE TERM "vu," adopted with the new standard volume indicator and reference level in 1939, has been generally used by the broadcasting industry for expressing both program volume levels and test-tone levels. However, other organizations concerned primarily with performance measurements with test-tone began using a second term, "dbm," shortly after "vu" was introduced. The practice of expressing measurement-signal levels in "dbm," and of limiting "vu" to expression of dynamic volume levels has certain advantages and warrants discussion.

The absolute calibration of the standard volume indicator is stated in terms of its response to a steady single-frequency signal. Thus, by definition, "The reading of the volume indicator shall be O vu when it is connected to a 600-ohm resistance in which is flowing 1 milliwatt of sine-wave power at 1000 cycles per second, or *n* vu when the calibrating power is *n* decibels above 1 milliwatt."[1] To enable the instrument to indicate program volume levels, this calibration specification is augmented by rigid requirements for dynamic, electrical, and other performance characteristics. This is necessary because of the impossibility of exactly relating dynamic meter indications to peak, average, or effective power of transient program signals. When the standard instrument is used and read in the manner prescribed it gives a reliable indication of volume level as so many "vu" above (or below) a reference volume defined as "—that level of *program* which causes a standard volume indicator, when calibrated and used in the accepted way, to read O vu.[2]"

Steady-State Measurements

For steady-state measurements a reading in "vu" denotes a specific single-frequency audio power; for dynamic program indications "vu" denotes only a "volume" level. This dual meaning of "vu" is avoided by use of the term "dbm" for all steady-state measurements. As defined, a reading expressed in "dbm" at once indicates the *power level* of a steady *single-frequency* signal where the number of "dbm" is equal to the number of decibels above (or below) a reference power of 1 milliwatt. On the other hand, a reading in "vu" denotes a "volume" level indication from a program signal. It should be noted that a "vu" reading can be made only on a standard VI whereas sine-wave power level measured with the standard VI or with any other suitable a-c instrument can be expressed in "dbm."

Thus, "dbm" is a unit of finite audio power—identical with the older steady-state application of "vu"—while "vu" may be considered only as a unit of volume level and, as discussed above, has *no connotation of finite power level*. Thus, no direct relation between "dbm" and "vu," as now used, can be established.

However, it is necessary to establish a relation between the "vu" level to be used for program "peaking" and the "dbm" level to be used for system measurements. It has been found that on typical program material of a given crest amplitude the standard VI reaches an indication 8 to 14 db below that reached with a steady tone of the same crest amplitude. Nominally to take into account this 8 to 14 db difference in response, the present practice, originally proposed by CBS,[3] is to require that performance requirements be met at a single-frequency test-tone level that is 10 db higher than the normal program peaking level. This will reasonably insure that system performance is within standards under normal conditions. For example, in a system that is to transmit program

[*Continued on page 37*]

**Chief Audio Engineer, Columbia Broadcasting System, Inc.*

[1]H. A. Chinn, D. K. Gannett and R. B. Morris, "The New Standard Volume Indicator and Reference Level," *Proc. I. R. E.*, Vol. 28, No. 1 (January 1940).

[2]Loc. cit.

[3]H. A. Chinn, "Broadcast Studio Audio Frequency System Design," *Proc. I. R. E.* Vol. 27, No. 2 (February 1939).

AmericanRadioHistory.Com

Coupling Ultrasonic Energy to a Load

S. YOUNG WHITE*

Problems involved in the practical application of Ultrasonics.

IT IS FAIRLY certain that we shall be forced to develop quite a few types of high-power ultrasonic generators to meet satisfactorily all power and frequency ranges in all loads, so we can assume that this problem will never be fully solved. It will probably be a few years before we can generate a thousand kw at 100 megacycles; but there are very bright prospects of having designs in the immediate future that will allow exploitation of an enormous number of fields of usefulness. This means we shall be forced to neglect those fields for which there is no immediate generator readily available.

The next problem is a very difficult one—how to put the energy into a load? What link shall we use to couple the output of the generator to the actual product as it will exist in the factory with minimum disturbance of current practice in manufacture?

This question again will never be fully answered in our lifetime. The writer has contacted about 200 industries, surveying the possible loads. Many plants have half a dozen places where ultrasonics might possibly be fitted into their processing lines, and most of them require a skill and experience that does not exist at the moment. There are two reasons for this condition.

The first reason is rather peculiar. This problem has been gone into with unlimited funds by some very high grade personnel over a term of years by the sub-surface warfare groups. In locating submarines, the problems are mainly concerned with handling a pulse of a few watts, and controlling the transmitted and received pattern in sea water. Incidental problems include protection against shock from depth charges, control of Doppler effect. and so on. Some very elaborate and worthwhile equipment has resulted, but it has almost no application to commercial use of ultrasonic energy.

The second reason is that most audio and ultrasonic work on boundary layers and so on has been done at low power density. For instance, it is a good rule of thumb to limit power in a diaphragm in contact with sea water to about five watts per square inch to minimize cavitation problems. It is common sense to assume that if we go to a kilowatt per square inch we shall have all the normal troubles, and also a whole series of new kinds. This will include very much increased losses, disintegration of many materials and so on.

An investigation of commercial loads emphasizes the fact that matter comes in an infinite variety of forms. We not only have the three classic forms of gas, liquid and solid, but all intermediate shadings, mostly in the enormous field of colloids. Let us review a few.

A simple load is a monatomic gas, which may range in density from hydrogen to xenon. Many loads, however, will be mixtures, such as air, where we have two gases of different densities. The French tell us that such mixtures tend to separate out in a sonic wave and then recombine. This gives an additional loss factor, even if not a different impedance, so we have a complex load. Another gas type consists of more or less long chain molecules, which can be readily broken up by supersonic energy; these, of course, will not recombine. Again we have a complex load.

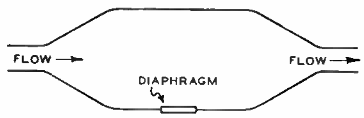


FIG. 1
FLOW CHAMBER FOR EXCITING A LIQUID FOR SHORT PERIODS

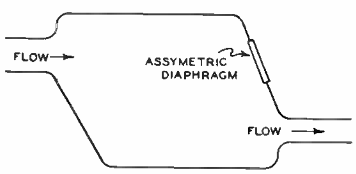


FIG. 2
FLOW CHAMBER FOR LONG PERIOD TREATMENT OF LIQUIDS

Types of chambers used for long and short period treatment of liquids.

Continuing with gas, the next and very common case is a gas of simple or complex type containing an aerosol—some colloid-sized particles which do not settle out by gravity. The complexity of load here is of little importance in practice, however, as it is the nature of aerosols that they are of very small mass per cubic yard of gas, and I do not believe that anyone has been able to measure any difference in the characteristics of such a combination which distinguished it from the gas alone from the standpoint of a load for ultrasonics.

A common type is a mixture of some liquid and some gas in the form of bubbles. This can range from almost pure liquid to almost pure gas, and can probably vary in impedance over a range of over a thousand to one. It is particularly likely to have very large values of absorption of energy, due to the passing of the wave through so many boundaries of such high reflecting value. We have all noticed this bubble mixture in the wake of a surface vessel, and sometimes it extends back to the horizon. This can reflect ultrasonic energy for half an hour after the ship has passed. This type of load must be approached with caution unless it is almost completely one or the other.

Changing Characteristics

This list could go on for a very long article by itself, but the general idea is that dispersoids, emulsions and so on can change the characteristics of liquids through large values, and even solids can have inclusions of sufficient size and number to give very complex combined characteristics. For instance, the characteristics of wood along the fibre are quite different from those across it. We might start treating metal in liquid form, and have the melt solidify.

Another practical point is the corrosive nature of some loads. For instance, titanium dioxide is made to appear in a mixture of sulphuric and hydrochloric acid at 200° F. We know from experience that in general all chemical activity is increased by ultrasonic energy, so we backed away from the design of a diaphragm to work into this load.

Still another problem is offered by temperature. The writer's experience has been that cold causes little trouble, but when handling gas or liquid metals at several thousand degrees, considerable thought must go into the design.

Sometimes the load will be under rather high pressure. The writer has had little experience with this case. Normal pressure fluctuations from a pump usually give no trouble.

In many loads a combination of several such problems will occur. As a

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matter of common sense, anyone going into general applications of ultrasonic energy will avoid such loads unless he is offered some large inducement, and concentrate his efforts on the type of load that shows much greater promise of immediate solution. Fortunately, there are very many such applications, and the following discussion will attempt to point out a few.

Simple Loads

Let us concentrate on gas loads for a while. The turbojet unit* described developes very high instantaneous pressures and accelerations in the gas passing through it. If we extend the impedance matching network so that it is many feet long, we obviously are maximizing the work done on the gas. Here we make the gas itself the load by pumping it through the generator. The useful work would appear by breaking complex gas up into smaller molecules.

If the gas contained a true aerosol, we should tend to first break up the aerosol by extreme acceleration values. If we stopped doing work there, we may have smaller particles than can be otherwise produced, which may be the useful work performed. If the aerosol is a virus or bacterium, we may break it up or render it inactive, or produce a mutation, all of which may be desirable.

These applications would require a closed system complete with the compressor, so we could recover the product. This is quite easy to design. The breaking up of the aerosols also requires that the length of time that they are subjected to the concentrated field be less than that required for subsequent coagulation, otherwise they would be delivered in bunches, each tightly agglomerated. This is also easy.

If we wish to coagulate aerosols, we extend the system physically so that the gas has the field applied to it for about a tenth second and the agglomeration will take place, giving us about 250 units tightly bound together, and with very large electrical charges built up on them. This of course assumes we have chosen the proper frequency.

What are the temperature and pressure limitations on the gas we would handle? The temperature that our present nitralloy rotor can stand is about 800 degrees F. The internal pressure to which the whole system is held can be several thousand pounds, as the system will work well with dense gas. The local pressure drop across the turbojet unit might go as high as several hundred pounds for extreme values suitable for gas break-up but for coagulation we need only about ten pounds across the unit itself.

The writer is uncertain as to the largest sized gas-borne solid or liquid particles that can be safely put through the turbojet unit itself. Notice we do not use the term aerosol, as we suspect that they can be considerably larger. The erosive action of wet steam is well known, as the particles of water hit with sufficient velocity on a wire-drawing valve or turbine blade to produce a local hammer action of about 80,000 pounds/inch in some common cases. This spalls away the surface of quite resistant metals in a short time. Some experience with the unit indicates that if the rotor is properly designed, it carries a "bow wave" of gas in advance of each blade, so the water droplet is deflected, and does not hit the rotor at all.

Removing Blast

There is one annoying feature about sirens and turbojet units that sometimes offer a real difficulty. If we want to put the energy in free space, so to speak, we are bothered by the fact that all the compressed air or steam that operates the unit appears as a blast at the output.

If we wish to insert the unit at the base of an ordinary smokestack to remove the smoke by coagulation of the particles, we usually have a source of steam to supply the initial energy. So we discharge the steam into the base of the chimney, the smoke is moistened by the steam but it works just as well. But if we are using the energy to treat some other gas that would be contaminated by the steam, trouble would result.

It is very difficult to place a separating diaphragm in the path of ultrasonic energy in gas. By definition, the diaphragm must be a solid, and reflection from it may be as much as 99.8 per cent or more. Besides, if we did mechanically oscillate the diaphragm through the large excursions necessary for efficient transfer of energy in gas, a very large amount of work would be done in the diaphragm. We calculated the work done in a four-inch diameter cellophane diaphragm carrying 20 hp of ultrasonic energy from gas to gas, and minimizing mass by assuming the cellophane to be only about two mils thick, it appeared that about ten hp was dissipated as heat in the diaphragm. Thus the order of results showed it was pretty hopeless.

If you wish to coagulate smoke out in open space, the air blast is again a nuisance; it blows the smoke away and spoils the demonstration.

One useful effect can be employed to minimize this. The waves are short enough to be approximately optical, and if reflected from solid metal the efficiency of reflection is quite high, so that multiple reflection can well be used. By experiment, it is found that the air blast expands to a much wider angle than the sonic energy, so after several reflections the blast is undetectable but the energy is well focused, and we have a beam of energy in free space. The small current of air remaining can be neutralized by a very small counter-current, giving perfect freedom from blast.

A Practical Problem in Gas Separation

Let us consider the sort of problem that often arises. A customer comes in and says he has read that the French

*S. Young White, "Too Much Audio," Audio Engineering, May, 1947.

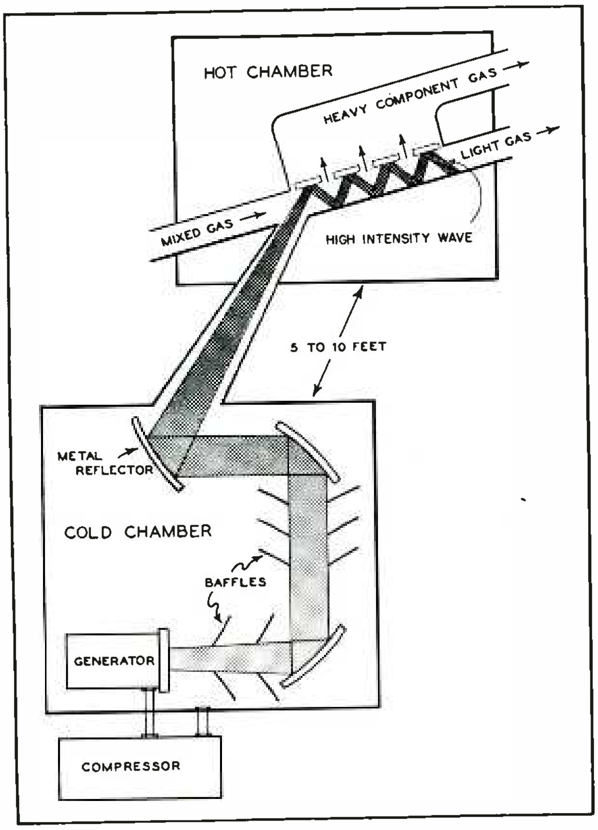


Fig. 3. Gas separation by ultrasonics.

found some gas separation effect in sound waves; that is, light and heavy gases are separated. We point out that the effect is probable, but the degree of separation is not too high—we can probably never reach 99% purity. He agrees that 90% or so would be adequate. We are ready for this, as in combustion with air we tend to ignore the fact that air is 85% nitrogen, and if we could remove 90% of it, many industrial processes would be substantially improved.

In his particular case, however, he wants to separate at a thousand pounds of pressure and above 2,000 degrees F, with maximum separation in one pass, and he must handle a million cubic feet per day, about 500 cfm. The volume does not bother us, as the effect is almost instantaneous and we can have very high velocity through the apparatus.

So we design the set up shown in *Fig. 3*. We cannot visualize a rotor operating at high peripheral velocity at 2,000 degrees, so we arrange to have a hot chamber for the treatment, and a cold chamber for ultrasonic wave generation. (Cold being from zero or so up to 500 degrees.)

In the cold chamber, we have the turbojet unit operating with gas at 1,000 pounds, but the air compressor shown develops only 60 pounds pressure itself, the whole system being sealed off and maintained at 1,000 pounds. The first step in the optical system is to have a widely divergent beam, so as to minimize the energy density in passage, and thus cut the gas losses. Several reflections and a countercurrent remove the blast, and the energy is focused in a long path through the tube, as shown. The length of this path minimizes wave cancellation at the far end.

The gas used in the turbojet is the same gas as we are treating, so we have no contamination.

In the hot chamber, we have the beam in rectangular form hitting the two barriers shown. If we wish, these can be carbon with some heating current through them to maintain gas temperature. These barriers are pierced with numerous small orifices.

The theory is that the sound wave will be set up as a standing wave between the two boundary layers. The gas under treatment will pass rapidly between them, and a traveling wave will be set up. At all times we will have leakage through all the small orifices at once. But the variation in sonic pressure on these orifices will vary from about zero at the negative peaks to some large value on the positive peaks. Consequently, most of the gas that passes through the orifices will be gas at high pressure, or differently expressed, will be gas taken from the high-pressure portion of the wave.

Now the French say that the lighter gas molecules tend to separate out by migrating to the rarefaction portion of the wave; or conversely, there is a concentration of the heavy gas molecules in the pressure portion of the wave. Since we are selectively removing gas from the pressure portion of the wave, the gas that passes through the orifices should be rich in the heavy component, and the gas that goes straight through should be mainly the lighter component of the gas. The process should be extremely rapid, and we really have numerous passes through the apparatus, since the gas passes through many such waves before it is discharged.

Power Into a Liquid Load

Since we often think of processing a liquid flowing through a pipe, the usual way to attempt it is to insert some type diaphragm in the wall of the pipe or a special chamber inserted in the pipeline. Let us consider the limitations of practical design for high power work.

A main point to keep in mind is that all material flowing through must have equal work done on it. Always design the first experimental chamber so that you provide a narrow slot the full length of the top of the chamber, so you can remove a cover plate and insert a probe and examine the entire cubical content of flow chamber for wave intensity. It is not necessary to have pressure on the chamber to simulate working conditions, as the pattern will usually be not affected by absence of pressure.

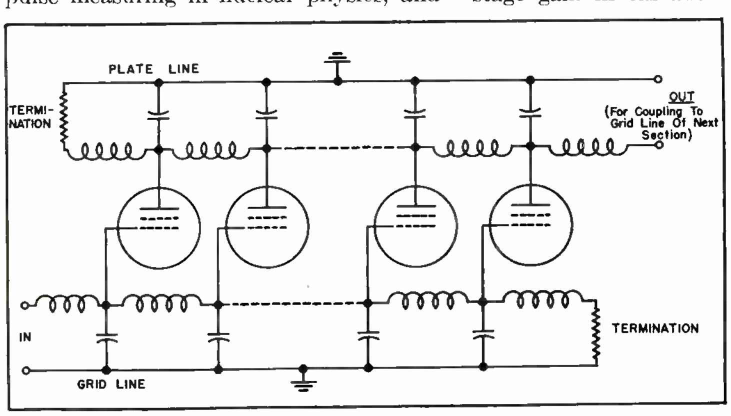
[*Continued on page 41*]

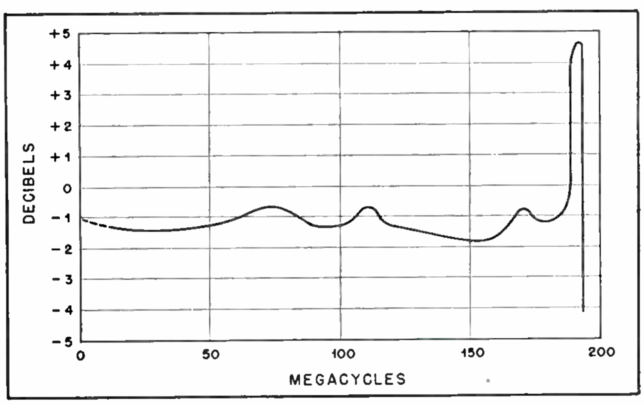
The Distributed Amplifier

VIDEO amplifiers using conventional tubes to provide response flat to 1 db throughout most of the range from zero to 200 mc were described to the San Francisco IRE by Jerre Noe of Hewlett-Packard Co. Work on this project has been done by a co-operating group of engineers from that company and Stanford University. Promising fields of application were listed as video, pulse measuring in nuclear physics, and increasing the sensitivity range of wide-band voltmeters.

Original work on the distributed amplifier was revealed in prewar British publications and this development is an extension thereof. Mr. Noe discussed three types of amplifiers, all variants of the basic circuit illustrated here. Chief advantages are uniform gain and a low noise figure at bandwidths where stage gain in cascade circuits would be at unity or below.

Although the work has not gone beyond the laboratory stage, an amplifier, using two sections of seven 6AK5 tubes each, has been built and studied. Its response curve is illustrated. Over-all gain was 18 db. Mr. Noe pointed out the possibility that certain tube modifications and improved techniques derived from further experience will result in even better characteristics.





Left: Basic scheme of distributed amplifier. Sections like these are coupled together in cascade. Phase relationships are maintained by the same inductance sum in paths through various tubes.
Right: Response curve of 14-tube two-section distributed amplifier using 6AK5 tubes. Designers feel that frequency range can be further extended.

Classical Records

EDWARD TATNALL CANBY*

CONTINUING last month's speculations on the possibility of new types of low-priced sound equipment for the intelligent home listener . . . may I quickly note that the suggested basic price of $75 to $100 would not include cabinet! The cabinet is as basic as is the dish to the salad, no more. (The with-or-without-cabinet principle of selling radio units is well enough established already.) I unintentionally caused confusion by starting my discussion with cabinet possibilities. I suggested that merely for reasons of sales simplicity and appeal, the leading "models" in this line be offered, primarily, in assembled cabinet form up from the separate-unit equipment, though all units, cabinets and the rest, would be available separately, or replaceable (modernizable), to taste. This is a good psychological approach—psychological, because it is important to build prospective confidence in the equipment, counteracting the blind prejudices that keep so many people away from things they could perfectly well cope with, given half a bit of aid and encouragement.

But to continue: I've suggested already a type of basic cabinet unit, perhaps two, adapted as ingeniously as possible to house any and all components, with simple, instant fastenings. (This in itself represents a lot of research and experiment.) Similarly, one might use a basic chassis to fit, onto which various units would be built. Next comes the question of inter-connectibility, vital to the whole scheme. Again, basic units (primarily the phono, amplifier and speaker; secondarily, numerous gadgets) must be instantly and easily separable and removable, and, in the putting-together, wrong connections must be impossible. First, of course, would be the use of various types of plugs, each with its own mate. Second might be—a tentative idea—some sort of simple color code. I have a successful one, made of nothing more than colored cloth sticky tape, on my own outfit. Red plugs into red (input), white to white (speaker output); blue plugs for pre-amps. (No patent—please don't steal!) Before, my friends wouldn't touch my amplifier; now they plug away merrily and no harm done, so far. In any case, there must be no screws, no wiring, soldering. Not even any dangerous-looking (!) exposed electrical elements, even if voltage is .1 volt: this for psychological reasons. *Ad copy: photo of baby with fingers inside cabinet.*) All B voltage untouchable, of course.

But, going further, I am sure that many electrical connections might be made automatically, as so many mechanical actions are now automatic in recent ingenious camera design. An instance might be an amplifier, which, when "plugged" into the cabinet would automatically make its basic connections in the mere sliding in place. More, if the cabinet is to house various types of equipment on a standard chassis (*above*) it might be possible to arrange things so that in each case the right—and different—connections took place automatically. Sounds complex, but the final product might be both simple and inexpensive. Surely there are examples galore of equally ingenious, mistake-proof design in other fields. And look at the record changers that automatically adjust to 10 or 12-inch records, or the Philco stick-it-in-the-slot player, doing

[*Continued on page 38*]

*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.

Popular Records

BERTRAM STANLEIGH**

ON ONE or two occasions in the past, an alert recording engineer has attached the output of an electrically amplified instrument, such as the Novachord or electric guitar, directly to the recording amplifier, thereby avoiding the added distortion and frequency limitation which the instrument's own amplifier and speaker may possibly introduce.

Now Tempo Records has come along with a line of wide-range recordings which utilize this direct recording method whenever possible. The superiority of the method is clearly apparent on their discs, and the quality of their records in general is superlative.

I have no reason to doubt Tempo's claim of a range from 30 to 12,000 cps, although my own speaker will not play below about 60 cps. The other instruments employed on their recordings are very well reproduced, and the balance between instruments is fine. There is a slight lack of room resonance, but the clean, brilliant sound is so refreshing a change that I cannot feel any disappointment. The recordings appear to have a sharply rising characteristic beginning at 1,000 cps. Toward the top of the range some distortion is apparent, but it is not pronounced enough to be a serious annoyance.

The shellac pressings are among the finest being produced in this country today. Their surfaces are as silent as most vinylite and the equal of current British pressings.

The one factor that is likely to hinder the sale of these discs is the music on them. The tunes themselves are hardy old "standards." The performances and

[*Continued on page 45*]

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†Patent No. 2,350,010 *Electro-Voice Patents Pending

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A portion of the Complete E-V Line is shown here

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NEW PRODUCTS

MARION METER

● In answer to industry's demand for a large dial instrument that may be easily read at a distance, affording plenty of space for a multi-range scale, the Marion Electrical Instrument Company has developed a new, rectangular bakelite-cased

Model 56 Meter. This versatile, durable instrument measures 6¼ x 5½". The Model 56 has a 100° arc, 5½ inch scale length and large open face, making it easily adaptable to multi-arc dials

Versatility is augmented through the use of Alnico II magnets in all normal ranges and Alnico V in the more sensitive microammeter ranges.

For further information write to the Marion Electrical Instrument Company, Manchester, N. H.

PICKERING DIAMOND CARTRIDGE

Bringing the advantages of reduced wear on both stylus and records, the new Pickering Diamond Cartridge is now available, using a highly polished diamond for the stylus instead of the sapphire used in the cartridge which has become famous since its introduction less than a year ago. The diamond cartridge is identical with the sapphire model except for the stylus, and mounts in practically any record changer or player without modification.

The long-wearing qualities of the diamond are well known to engineers, but the reduced wear on the records is also an advantage worth considering. Even though the wear of a sapphire stylus is relatively slight, continued use does change the shape of the point to a slight degree, causing increased wear on the record grooves. However, the harder diamond does not wear measurably, but retains its highly polished, accurately shaped point indefinitely—out-wearing at least ten sapphires.

The high quality of reproduction obtainable with the Pickering cartridge is now well known to music lovers and record collectors, and the added cost of the diamond stylus is actually an economy since there should be no need for replacement, even though records may be played ten or twelve hours per day. Under the most rigorous requirements of commercial broadcast use, the diamond styli have shown no appreciable wear. The low stylus pressure—less than half an ounce—contributes further to long record wear.

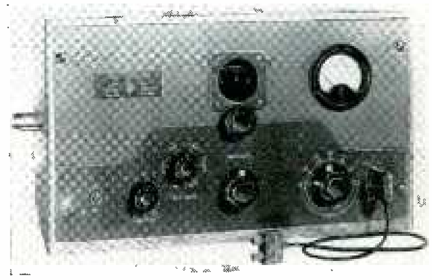
The characteristics of the new cartridge are described completely in the new technical bulletin, now available from Pickering & Co., Inc., 29 West 57th St., New York 19, N. Y.

20-AMPERE VARIAC

The latest item in General Radio's new line of Variacs is the Type V-20, capable of handling 20 amperes in the 115-volt model Like the previously announced V-5 and V-10, the new V-20 delivers considerably more kva per pound than older models. The 115-volt model, Type V-20M, is rated at 3.45 kva, and the 230-volt model, Type V-20HM, at 2.3 kva.

Output voltage is continuously adjustable from zero to 17% above input line voltage. Both models are supplied with case and terminal box cover. Terminal box is designed for use with BX or conduit.

For further data, write General Radio Co., 275 Massachusetts Ave., Cambridge, Mass.



H-P OSCILLATOR

The -hp- 650A covers a frequency range of 10 cycles to 10 megacycles, in decade ranges. No zero setting is required, and minimum adjustments are necessary during operation. The highly stable instrument operates virtually independent of line voltage and tube characteristics changes. Output is flat within 1 decibel from 10 cycles to 10 megacycles Voltage range is 00003 to 3 volts. Output impedance is 600 ohms, but a 6 ohm impedance is also available through an output voltage divider, supplied with the instrument.

Operating entirely from 115 volt a-c power supply, the compact -hp- 650A oscillator is provided either in relay rack or cabinet mounting. Panel size is 19" x 10½" The instrument is 13" deep. Hewlett Packard Company, 395 Page Mill Road, Palo Alto, Calif

MAGNETAPE RECORDER CATALOG

An illustrated 8-page, 8½ x 11 catalog has recently been published by the Magnephone Division of Amplifier Corp., of America, New York City, featuring and describing their new series of high-fidelity magnetic tape recorders and accessory equipment, under the trade-marked name, "Magnetape."

[*Continued on page 47*]

PROFESSIONAL DIRECTORY

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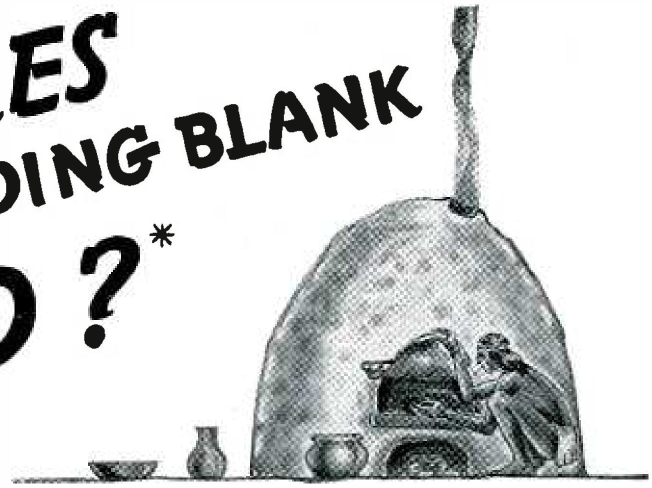
Nº4 of a series

WHAT MAKES A GOOD RECORDING BLANK GOOD ?*

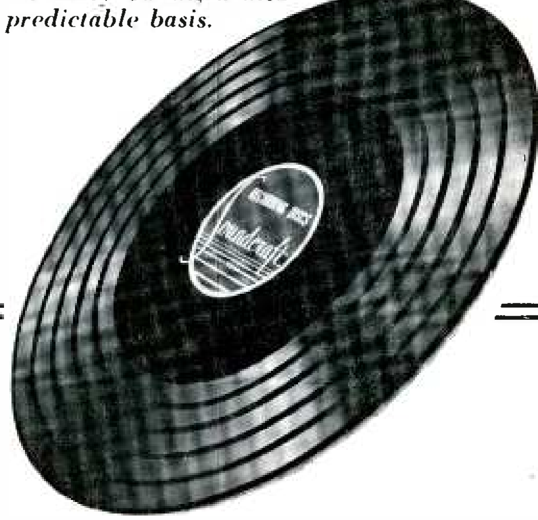


The DRYING PROCESS...

Not one process but two, the Soundcraft disc-drying operation involves both *initial drying* and *curing.*

- *The initial stage immediately after application of lacquer to the aluminum base is most critical. First, Soundcraft minimizes imbedded dust by eliminating handling between the coating machine and drying conveyor. Both coating and drying proceed continuously under air-tight covering in the same huge machine. Forced-draft drying air is both mechanically and electrostatically filtered.*
- Second, *rate* of drying is controlled in steps, initially slow for smoothness and gloss, then accelerated with infra-red to evaporate solvents properly from the bottom up.
- Third, to prevent condensation of noise-producing moisture on the lacquer surface, drying air is de-humidified and rewarmed, a desirable procedure always, a necessity for high-quality summertime production (blush-resistance).
- The *extra* Soundcraft process, curing, uses a low-temperature oven, conditioned air, and infra-red heat to drive out the last vestige of solvents from the coatings leaving the discs at their intended hardness, a permanent consistency that depends only upon inert plasticizers in the lacquer.
- *Though elaborate, the Soundcraft drying process eliminates many shortcomings of conventional methods. It brings the recording engineer a Soundcraft disc free from imbedded dust, moisture-created hiss, and mysterious noisy bands, a disc that establishes recording anew on a standardized, predictable basis.*

**Watch this space for succeeding ads in this informative series on how Soundcraft discs are made.*



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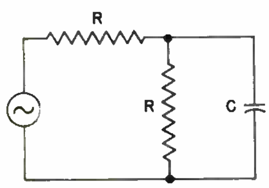
AUDIO DESIGN NOTES

MICROSECONDS-DB. CONVERSION

NUMBERS IN COLUMNS ARE FREQUENCIES IN CYCLE PER SECOND

DB. GAIN OR LOSS	100 μ Sec	75 μ Sec	50 μSec	25 μSec
0	500	670	1,000	2,000
1	850	1,130	1,700	3,400
2	1,200	1,600	2,400	4,800
3	1,600	2,150	3,200	6,400
4	2,000	2,700	4,000	8,000
5	2,400	3,200	4,800	9,600
6	2,800	3,700	5,600	11,200
7	3,250	4,300	6,500	13,000
8	3,800	5,100	7,600	15,200
9	4,400	5,900	8,800	17,600
10	5,000	6,700	10,000	20,000
11	5,600	7,500	11,200	
12	6,300	8,400	12,600	
13	7,100	9,500	14,200	
14	8,000	10,700	16,000	
15	9,000	12,000	18,000	
16	10,000	13,300	20,000	
17	11,200	15,000		
18	12,600	16,800		
19	14,200	18,900		
20	16,000			



WHERE NUMBERS HAVE BEEN ROUNDED OFF, THE FREQUENCY ERRORS DO NOT EXCEED 1 PERCENT.

RC = time constant (μSec)

TO FIND THE FREQUENCY AT A GIVEN LOSS OR GAIN FOR ANY OTHER TIME CONSTANT (t_x), MULTIPLY FIGURES IN COLUMN I (100 μSec)

BY $\frac{100}{t_x}$

AmericanRadioHistory.Com

Noise Suppressor

[*from page 16*]

signal can be found above the surface noise at frequencies beyond twelve thousand cycles per second on available recordings. The high-frequency cutoff should therefore, appear just beyond twelve thousand cycles per second but can be extended to a higher frequency when recordings and pickups have developed to a point that will justify this extended range.

Reproducer Quality

In order that the advantages offered by this type of noise suppressor can be fully realized, high quality performance of reproducers is essential. The units used for the experimental work and listening tests were of the variable reluctance type and were checked for their performance characteristics before they were put into service. Best results were obtained when compensation for recording characteristics was made before the signal entered the suppressor. Therefore it is not necessary to duplicate the correction equalizers in the suppressor.

Equalizers other than those needed for post recording response-frequency correction are not needed for reproduction of good recordings when the above suppressor is being used. Reproduction of recordings in fair condition is noticeably improved while recordings which are worn or gritty have no place in high quality reproduction systems. The problem of turntable rumble and low frequency noise reduction was not considered in this undertaking inasmuch as the problem has been dealt with elsewhere. With increased use of materials which result in lower surface noise and with the marked improvements being made in reproducers, loudspeakers, and methods of noise suppression, the realization of higher quality reproduction from recordings is rapidly approaching.

DBM vs. VU

[*from page 28*]

material at +8 *vu* all single-frequency measurements would be made at a +18 *dbm* test-tone level.

Volume levels, as in the past, should be expressed in "vu" and can be measured only with the standard VI. Statements of single-frequency test-tone levels, however, may be expressed in "dbm." Such test-tone levels can be measured with the standard VI or with any suitable a-c measuring instrument. Performance measurements should be made at a "dbm" level 10 db higher than the normal program peaking "vu" level.

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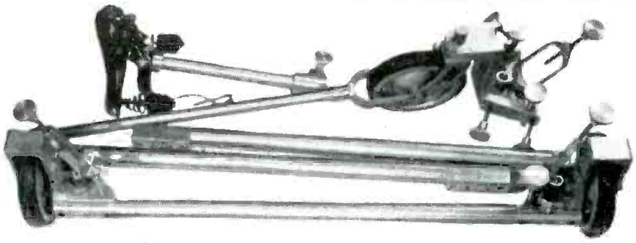

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Increasing Volume

[from page 20]

progress of intermodulation between the two, and making the result easier for a typical playback channel to handle. Perhaps of some importance is the fact that it also does the same for the recording channel. At any rate, an apparent dynamic range at least 10-12 db over present practice is the result.

Summary

The manufacturer of phonograph records—and even transcriptions to some extent—has been fenced in tightly in all directions by strict barriers of *surface noise, amplitudes* caused by instruments in the bass octaves, *angles* caused by high pitched components, *record wear,* and inability of consumer playback equipment to handle extreme lows and highs without *objectionable distortion.* The use of Quality Control pushes back the boundaries by 6–12 db in all directions resulting in cleaner reproduction, longer pressing wear-life, increased trackability, and the virtual transmutation of shellac into vinyl.

Plainly, if it is possible to increase the recorded level 6–12 db at present standards of phonograph record lines per inch without cut-over, it is also possible as a corollary to accept the dividend in a form other than increased volume, i. e., increased *playing time* per side. Assuming for instance a 70-30 cut at 136 lines (.005″ groove width), Q-C makes practical fine-line recordings which are equal in volume level to present standard recordings, and which have no cut-overs. But the playing time is increased by 40 per cent, resulting in an available four and one-half minutes on 10″, and about 6:20 for 12″.

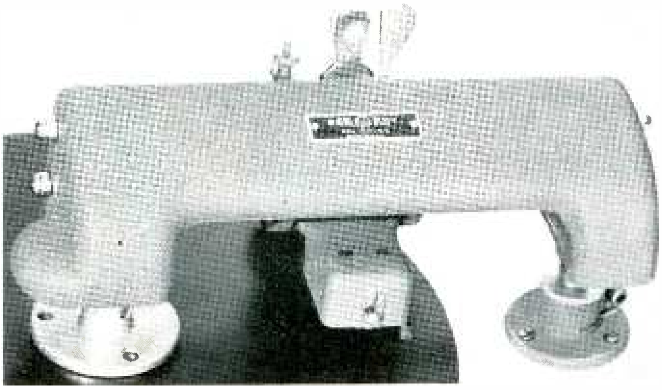
Classical Recordings

[from page 32]

the same. Rightly applied or not, these are samples of the kind of design thinking I conceive as necessary.

In general, I would suggest some extra complexities, to be balanced by some saving simplicities. For example, amplifier power supply would be integral, but B and heater voltage might be available at a built-in socket to take care of outside gadgets such as the inevitable preamp. This would avoid many later conversion headaches, for all concerned. (Our owners, by our own choice, will be the converting kind.) As a fundamental simplicity, I suggest, for one sample, that the basic amplifier, the lowest priced, can be much less powerful than most engineers might envision. I have just experimented directly with a standard 8 watt p-a amplifier. With nylon crystal (not a high-level crystal), played into a fairly big capacity 15-inch speaker, this outfit gives at full volume about all the speaker will take and enough to rouse the neighbors for blocks. With a $15 type 12-inch PM, the same amplifier gives more than the speaker can manage and more volume than 95% of home owners would use in a lifetime. On the basis of this I suggest that a surprisingly low power output—2 to 4 watts, perhaps—would suffice for our basic amplifier unit, making possible higher desirable quality features in the circuit. Fine quality, absence of distortion, would be a vital feature of the outfit. (The London Gramophone engineers have, I understand, built in this manner, with low power, high quality.)

Another minor simplification: a single speaker impedance, with the several available speakers chosen to match it. If more than one output connection should prove necessary, then connections could, again, be automatic, via a multiple-connection plug and socket, and nothing need be said to the purchaser except, "just plug the speaker in." Simple. (But, aside from complete commercial p-a outfits and a few radio chassis outfits, is there any equipment now available where the buyer can "just plug



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MODEL M-12 $89.50

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the speaker in?") To balance this, a necessary complication: there must be, in line with our acceptance of the buyer's intelligent interest, a sensible compensation system—not a mere unthinking tone control. Perhaps the usual tone control for highs, but not so labelled—rather marked for its true function. Unlike most machines the widest range should be fixed as the *normal* position, other positions to be clearly understood as compensation and/or filter for scratch. Your owner, with a reasonable explanation of the facts, will go along with this gladly.

As to the phono end, existing equipment could be used, with adapting plugs, etc. added. The cheap constant-speed rim drive motor is entirely adequate, plus a "wide range" light crystal (*not* the 4000-top variety!), possibly the "QT," for our lowest priced line. Changers inevitably optional, same cartridge; and all of this as a matter of course adaptable to the standard cabinet if desired.

At this point I suggest that a slightly higher priced alternative assembly will also be inevitable, and here the phono might feature the Pickering or GE cartridge. The alternative amplifier for this would be the basic unit plus added pre-amp. Somewhat more versatile controls would be definitely indicated; granting the buyer both intelligence and curiosity as we intend to do, we must provide here a simple choice of bass compensation, as well as treble. I suggest it roughly match turnover points, perhaps 250 and 500, marked "MORE BASS" and "LESS BASS." Plus, definitely, a brief explanation of turnover differences in the accompanying instructions. The buyer is intelligent, remember? (See Canby article in "*Recordings*" magazine, Feb. '48).

Enough. These somewhat inconclusive beginnings may suggest lines of research and experiment to be followed, how the equipment I have in mind would differ from anything now available outside the trade. There remains one vital aspect, a matter of *attitude*—the

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.

Group of unusual Mozart and Schubert items:

Mozart, Adagio and Rondo for Glass Harmonica (arr.). E. Power Biggs, celesta; with flute, oboe, violin, cello...... **Victor 11-9570 (1)**

Mozart, Symphony No. 26, K. 184. Boston Symphony, Koussevitsky...... **Victor 11-9363 (1)**

Mozart, Piano Quartet in E flat, K. 493. George Szell, piano; members of Budapest Quartet............................ **Columbia M 669 (3)**

Mozart, Operatic Arias. Ezio Pinza, Metrop. Opera Orch. Bruno Walter.... **Columbia M 643 (4)**

Mozart, "Salzburg Serenade" (Concertante & Rondo, K. 320; Serenata Notturna, K. 239.) Vox Chanber Orch. Fendler............................ **Vox 161 (4 10")**

Mozart, Horn Concerto No. 4 in E flat, K. 495. Dennis Brain, Halle Orchestra. **Columbia X 285 (2)**

Schubert, Overture in the Italian Style, op. 170. National Symphony Orch. (British), Heinz Unger................ **Decca London K 1357 (1)**

Schubert, Die Schone Mullerin (song cycle). Lotte Lehmann; Paul Ulanowsky, piano.......................... **Columbia M 615 (7)**

Schubert, Symphony No. 6 in C. London Philharmonic, Sir Thomas Beecham. **Victor M 1014 (4)**

Schubert, Quartet in E flat, op. 125, No. 1. Guilet Quartet.................. **Concert Hall AE (3 plastic)**

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ALTEC LANSING News

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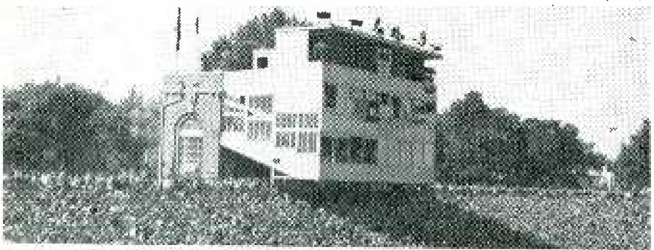
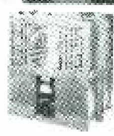


University of Michigan stadium, Ann Arbor, Mich. Altec Lansing large multicell horns driven by Altec Lansing 1/4 KW amplifier, are centralized over press stand, override noise level of 86,000 spectators. Reiss Public Address Systems, Detroit, contractors.

LEADING ATHLETIC STADIUMS NOW CHOOSE ALTEC LANSING PUBLIC ADDRESS SYSTEMS

With million dollar "gates", sports are big business today; leading stadiums throughout the United States, both college and professional, able to afford the best, are installing Altec Lansing public address systems, or are converting previous unsatisfactory systems to Altec Lansing. Altec Lansing produces systems with sufficient power to override high crowd noises with complete intelligibility; high efficiency, directional-character multicell speakers are clustered at one place, thus simplifying installation. Other stadiums using Altec Lansing systems: Griffith, Washington, D. C.; Gardens Arena, Pittsburgh; University of Utah; Briggs, Detroit; etc.

Authorized Altec Lansing stadium specialists will submit estimates and plans on your own stadium public address requirements. Address: Stadium Engineering Department B, 1161 N. Vine St., Hollywood 38, or 250 West 57th St., New York 19.



Above: large multicell Altec Lansing speakers. Below: Altec Lansing 287W 1/4 KW Industrial amplifier.

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important words through which the buyer and owner will actually be approached, in promotion material, in the all-important instruction booklet, and even in the printed labeling of controls. That, plus additional plug-inable units for radio, etc., will come next month.

RECENT RECORDINGS

Beethoven, Wellington's Victory ("Battle Symphony"); King Stephan Overture.
Janssen Symphony of Los Angeles, Werner Janssen.

Artist JS-14 (3 plastic)

A preposterous but interesting work. this Battle Symphony, written originally for a huge mechanical orchestra. Cannon, musket, trumpet flourishes: the French and English represented by two familiar tunes ("Bear Went Over the Mountain" and "America")—it was a huge hit in its day and is highly amusing still. Last part is best musically—variations on "America"—God Save the King. Entertaining notes by Alfred Frankenstein, leading Coast music critic . . . This is remarkably effective wide-range recording on very quiet black plastic. Acoustically what is becoming identifiable as a "West Coast" sound; fairly dead, close-to pickup of instruments, ultra-sharp. King Stephan is a minor work (no battles) but worth a hearing.

Bach, St. Matthew Passion; excerpts.
The Bach Choir and the Jacques Orchestra, Dr. Reginald Jacques. Soloists.

Decca London EDA 43 (7)

One of the finest Decca ffrrs to date. musically and technically. (except for some unfortunate overcutting). A performance in the rather old-fashioned traditional manner. with large chorus—but highly superior musically. English voices, minus super-wobbling tremulo and super-brilliant operatic overtone coloring, bring the actual music through so you can "hear the tune." It helps hugely here. Good harpsichord continuo, benefits from wide range. Very fine acoustics, not too live for this music. Chorus perhaps too far away relative to solos. This is a fine way to have your hi-fi and your Bach too; a minimum of the usual big blur! Alas, the Decca no-monitoring policy tripped them up in several awful spots. Otherwise all is fine.

Mahatma Gandhi, His Spiritual Message.

Columbia 17523-D (1 10")

This talk by Gandhi himself was recorded in the early nineteen thirties. It sums up, in general religious terms, his "reasons" for believing in a universal God. Recording is quite intelligible, though somewhat fuzzy, range restricted to 5000 or less, surface fairly noisy.

Berlioz, Romeo et Juliette, opus 17.
Excerpts. NBC Symphony Orch. Toscanini.
Victor DM 1160 (3) or Victor DV (7) (3) plastic

Welladay! It happens I got both plastic and shellac pressings of this: yep, the shellac has easily a wider tonal range on it than the plastic, to my fallible ear. (Try one inch into side 2, for one good comparison—a soft, high frequency "chink" sound, in the orchestra, easily more audible (my copies) in shellac version. (Other spots comparably.) And this shellac is quiet too, hardly noisier than the plastic. Whole effect (my copies, again) is cleaner on shellac . . . This is absolutely first rate Toscanini, in the kind of tense, explosive music that he is best for. A splendid album, if not exactly restful.

Dvorak, Notturno for Strings, op. 40.
Busch Chamber Players, Adolph Busch.
Columbia 17513-D (1 10")

A beautiful bit of romantic string playing (one ten inch record) smoothly recorded, wide range but velvety. Quite a contrast to the rather rough sound of the Busch group in their monumental albums of Handel Concerti Grossi.

Gould, Minstrel Show.
Minneapolis Symphony Orch. Mitropoulos . . . .
Victor 11-9654 (1)

A raucous, humorous piece for big orchestra, in the new snazzy ballet-musical-comedy style so effective in recent symphonic works. Blats, bloops squawks, sentimental melodies . . Another of those tricky Victor records that give a stunning impression of wide range through liveness and through various rattles, wood blocks et al in the orchestra. You'll find most of this is in medium high range, though, not in high highs.

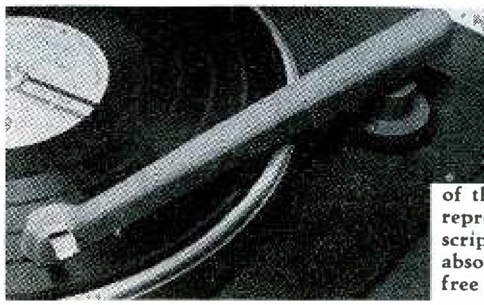
Berlioz, Corsair Overture.
Royal Philharmonic, Sir Thomas Beecham . . . .
Victor 11-9955 (1)

Another kind of Berlioz, with Beecham. Plenty of energy, less tenseness, more lyric. Brilliant show overture, grand for big-speaker outfits. But range is strictly prewar, rolling off I'd guess from around 6000. Lots of brass makes up for it.

Weill, Songs to Poems of Walt Whitman.
William Horn, tenor, Adam Garner, piano . . . .
Concert Hall B 7 (2 plastic)

A set of melodious, skillful but unprofound settings of very great words. Sometimes trite, touched throughout with faint sense of Broadway . . . These Concert Hall records are quiet, unassuming, but highs extend definitely beyond 10,000. Fine piano. Highish turnover.

PICKERING PERFORMANCE



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Write for Technical Bulletin 81

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Ultrasonic Energy

[from page 31]

Two main designs are the "cross shot" of *Fig. 1* and the "long shot" of *Fig. 2*. The choice here depends on how long a time interval the liquid is to be treated, and the rate of flow in the pipe. A usual commercial pipe flow is seven feet a second in many processes.

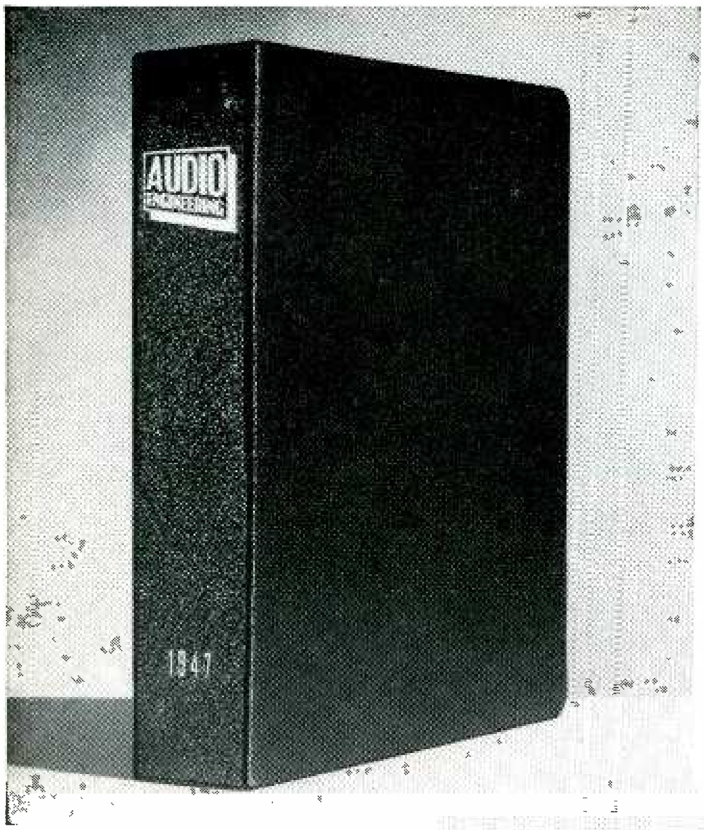
In general, the largest possible diaphragm should be used to obtain minimum energy density. You should also avoid pronounced standing wave pattern, as you will have areas of zero motion where the liquid will have no work done on it. A confused pattern is often desirable, and in some cases we may set the diaphragm off the axis to help produce this type pattern.

Cavitation will be the controlling difficulty. If the liquid is degassed it will help. Anything to lower vapor pressure will help, such as low temperature. If the liquid is a highly compressible one, it is a considerable help.

The diaphragm may be of many materials, from rubber to stellite, and may be a laminated structure. A soft material like monel is nice for general, not very corrosive loads, but is not too resistant to cavitation erosion.

Probably carballoy or norbide would not disintegrate, and would not be attacked chemically. Gold is too soft.

A general answer to cavitation is to put enough pressure on the liquid load so that we bias it to the point where the modulation due to the wave does not have an excursion into the negative pressure region—for one kw to the square inch in water this would be about 300 pounds per square inch. This would probably mean developing a special pump in a local loop that recovers some



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of the energy necessary to pump it up to this pressure in the first place.

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Coated Diaphragm

One experimental observation that seems to be of some promise in the future is in the field of the self-coated diaphragm. Certain types of water-borne particles, such as cellulose in finely divided form, will precipitate on the diaphragm and form a very adhesive coating on it. This coating has the property of acting as an impedance match between the metal diaphragm and the water load impedance, so that for a given excursion of the diaphragm about six times the energy appears in the water. The optimum thickness seems to be a mil or so.

It is easy to try a temporary load of deaerated water with various colloids in it and allow this coating to form to various thicknesses. It is necessary to chose some coating that will not be chemically attacked by the load itself. Then flush out the water and start the load flowing and note the erosion on the coating. In some cases it will be safe to operate for some time.

Loudspeakers

[*from page 27*]

For diffusion, however, they should lie on the surface of a sphere or cylinder depending on whether diffusion is required in two dimensions or one (*Fig. 14*).

Horn Projectors for Cone Speakers

Horn projectors may be used with cone speakers. In this case, the large throat necessitated by the diameter of the cone results in a very large horn indeed. Where these dimensions are unimportant, as in theatres, their use will provide a higher efficiency.

[*The next article in this series will discuss the application in typical installations of speakers described in this and the previous article.*]

REFERENCES

[4] H. F. Olson, "Elements of Acoustical Engineering," (book) 2nd edition, Van Nostrand, New York, 1947, pages 145 through 154.

[5] O. L. Angevine, Jr., "Impedance Matching," AUDIO ENGINEERING, December, 1947.

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Audio Engineering Society

[from page 20]

problems in this field which warrant discussion.

9. *Telephone engineering:* There has been very little material published on the aspects of this art which concern the broadcaster or wired music engineer, and practically nothing in any society journal.

Society Obligations

A professional society has obligations to the art as well as to the members. Among the duties it should assume are the following:

1. Develop technical and public appreciation of the importance of audio engineering as a *separate* profession, with its own distinct background requirements.
2. Foster educational presentation of subjects basic to audio engineering.
3. Foster research on subjects basic to audio engineering.
4. Foster periodic audio engineering meetings. (It is proposed to start with seven to ten meetings per year in each of two or three cities.)
5. Provide a facility for publication of papers on audio engineering.
6. Represent audio interests in the matter of engineering standards before the American Standards Association, the F.C.C., the R.M.A., and others of like nature.
7. Operate an employment register for qualified audio engineers, similar to that operated by the American Institute of Physics for physicists.

Discussion

A number of professional societies (and journals) have been nominally available for papers in the previously listed fields. Unfortunately, what is everybody's responsibility is no one's, and so audio engineering as a profession has had no real sponsorship at all. Likewise there has been no one to encourage interchange of knowledge—presentation of the papers which are the lifeblood of any science.

Encouragement of publication has been badly needed, for the professional society journal situation has not been such as to attract the average audio engineer. One society journal covers the motion picture field, but most motion picture practice (optics, for example) is of little interest to the audio engineer in other fields. Another society journal has an excellent research and acoustical physicist's viewpoint, but one which has not attracted the engineer. The third society journal has attempted the difficult feat of covering the entire electronic

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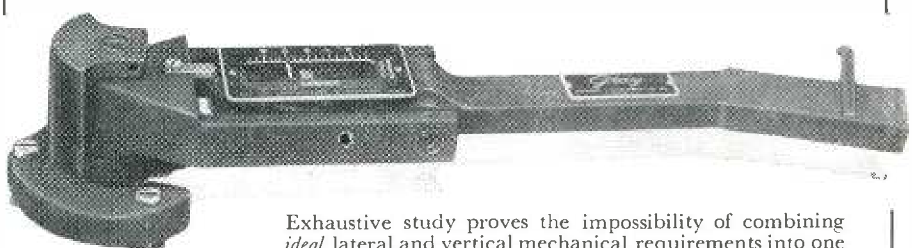

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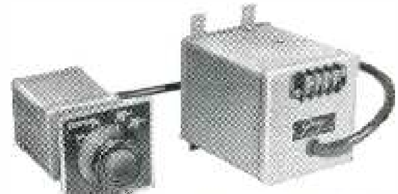

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field, making more than occasional attention to a particular subject impractical. As a result, two recent audio papers showed a lapse of sixteen and seventeen months between the first submission of manuscript and publication, and the fastest action seems about twelve months.

Conclusions

Since the obligations and duties mentioned in the foregoing are not fulfilled by any existing society, it appears that an independent society is now timely—one which is headed by audio engineers of character and run by audio engineers themselves. It has been claimed that there are already too many technical organizations. This argument will not stand close examination, and may be challenged on the basis of what test is used to judge whether there are too many organizations. By the test of operation, there are presently too few, for when too many diverse fields are combined into one group, a society becomes unwieldy. The obligations of encouraging college courses in the fundamentals of audio have not been fulfilled by any organization, and most existing courses in electronics are heavily weighted with radio engineering material.

These objections can be met only by a society and a journal which are 100% audio. Any other procedure diverts most of our resources to the support of activities which only indirectly benefit or interest us. The physicists learned this long ago, and today they have societies for every field of interest.

Popular Recordings

[*from page 32*]

arrangements are the type you might hear over Muzak or at a roller skating rink. Some of these records are described below.

Begin the Beguine, I Got Rhythm, Tempo 564. Ben Light, piano; with Hammond, Novachord, and Vibraphone.

The right hand of the pianist sounds much clearer than his left, but this is probably a defect of the playing rather than the recording. Although neither of these tunes is done full justice by the performers, their performance is lively. The vibraphone is heard only on I GOT RHYTHM.

Deep Purple, Just a Love Nest, Tempo 592. Ben Light, piano; with Hammond and Harp.

The timbre of the harp accompanied by the Hammond is effective in those rare moments when the percussive quality of the piano does not obscure the harp. Both sides are brightly recorded, and the balance is good.

Nola, Twelfth Street Rag, Tempo 978. Herb Klein, Hammond; Lloyd Sloop, Novachord.

Neither of these tunes is suitable for

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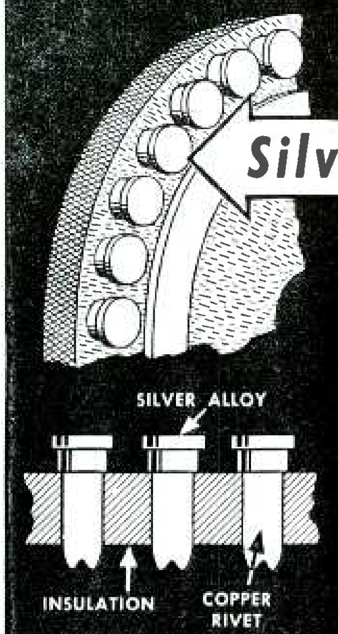

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the instruments here employed. NOLA lacks the crisp, effervescent quality it has when played on a piano, and TWELFTH STREET RAG can only sound well when played by a New Orleans band. The lack of contrast between the instruments is another good excuse to ignore this disc.

Do It Again, Two Loves Have I, Tempo 612. Rite Georg, chanteuse; Hammond and Novachord.

This is one of the funniest records I have ever heard. Although it is supposed to sound sophisticated, the performance is so bad that it sounds like a parody of a continental entertainer. The natural quality of Miss Georg's voicelessness is well recorded.

The Little People, Michael, Tempo 1050. Jimmy Nolan, tenor; with Hammond and Novachord.

Pleasant enough singing of two Irish ballads against a rather weak backing. The singer sometimes gets too close to the mike.

Too Fat Polka, Victor 20-2609. Louis Prima and his Orchestra.

The worst, technically, of the current crop. Prima is too close to the mike on the vocal, and the band is badly monitored throughout. By continuously shifting from section to section, no point is left where the full orchestra can be heard. This sounds like a hurry-up job to catch up with the best-selling Columbia version.

Letters

[*from page 8*]

card to me at the address below. Information of any activities will be sent to all sending in their name, address and field of audio engineering.

William P. West
522 Arbutus St.,
Philadelphia 19, Pa.

From the Audio Engineering Society

We have been flooded with mail from all over the country, and it appears certain that local sections will be formed in a number of cities. In order to help audio engineers get together, we would be happy to act as a clearing house for such operations.

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New Products

[*from page 34*]

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All equipment is presented in organized sections with items indexed for easy reference. A handsome rotogravure section lists public address and intercommunication units for every indoor and outdoor requirement, including ready-to-install systems for a variety of industrial applications. The electronic sound equipemnt section features high-fidelity sound units by Altec-Lansing, Stephens and Clark. This section also includes comprehensive listings of microphones, speakers and other accessories. To meet the needs of radio training programs and experimental work there is a kit builders' section that lists a wide variety of kits, manuals and diagrams. A large technical book section includes leading publications covering the theoretical and practical aspects of radio, electronics and electricty.

Among the featured sections are latest disc, wire and tape recorders by RCA, Webster-Chicago, Presto, Rek-O-Kut, Meissner, Brush and Masco. Other listings include: fluorescent lighting units, lamps and accessories, communications-type radio receivers, photo-electric cell equipemnt, record changers, phonographs and all accessories; Allied's line of Knight radio sets for AM and FM. A new low-cost television receiver by Hallicrafters is ideal for employee lounge or executive offices.

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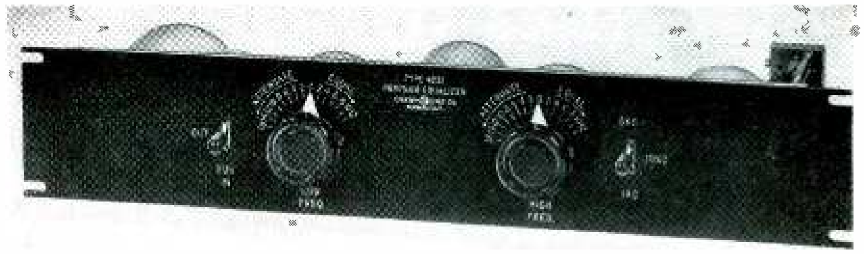

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MAGNETAPE* RECORDER!

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Exclusive Cook Quality Control (Q-C)

- Puts 10-12 db more useful playback level at standard lines per inch.
- With correspondingly low surface noise,
- Makes your record stand out in the juke-box,— or
- Puts 6¼ min. on 12", 4½ min. on 10" (shellac) at standard commercial 96 line level without cutover.

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Write for detailed information

COOK LABORATORIES
139 Gordon Blvd., Floral Park, N. Y.
Telephone: Floral Park 4-7218

Sapphire Group

[from page 10]

was re-outlined for his benefit. Mr. Sigmon then recommended this method.

Mr. Maxfield pointed out that past records had been recorded with a variation in frequency response which could be compensated for by the proper use of bass and treble controls within specified limits so as not to handicap new characteristics which might be desirable. He pointed out also, it would be better if representatives of the various record companies themselves would pick out records which they would like to use for demonstration, and he drew the analogy of motion picture studio test reels, where several motion picture studios submitted sound tracks and from these a standard track was selected for theatre sound reproduction checks.

It was further pointed out in the discussion that we had listened only to the more expensive machines, and the small table model phonographs, which are in the majority, had not been considered. It was agreed that a record which sounded better on the expensive machine as a rule sounded better on the table model.

The advisability of using composite phonographs for the future listening tests was discussed. Jim Bayless explained the problem and said that RCA has already selected a list of records which they thought were suitable for such listening tests. Mr. Birkinhead of Capitol Records promised to supply a list of Capitol releases, Mr. Ken Lambert of MGM Studios will supply a list of MGM records, Mr. Harry Bryant of Radio Recorders will represent the independent recording studios in obtaining a list of their releases, and Mr. Chester Boggs will be asked to represent Columbia.

It was suggested that before we have another listening session, we should make further decisions in committee meetings rather than take the time of the entire group.

As a result of the evenings discussion, the conclusion of the majority present was that the type of listening test, as outlined before, is the best practical method of arriving at the desired standards.

BODGE TO MANAGE WEST COAST OFFICE

● William C. Speed, President of Audio Devices, Inc., New York, the world's largest producer of professional recording discs, recently announced the opening of a new west coast office at 844 Seward Street, Hollywood, California.

Alan H. Bodge, for a year and a half a member of Audio Devices' New York Sales Department, will manage the Hollywood office, according to information released by the President of the recording disc firm. Bodge, a Dartmouth graduate, spent four and a half years in the radar division of the Army Signal Corp. before joining Audio Devices in the spring of 1946.

ADVERTISING INDEX

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A practical 9 months' course in Sound Fundamentals, Recording, and Sound Transmission measurements; in a laboratory containing transmission sets, oscillators, square wave generator and intermodulation analyzer, and other equipment.

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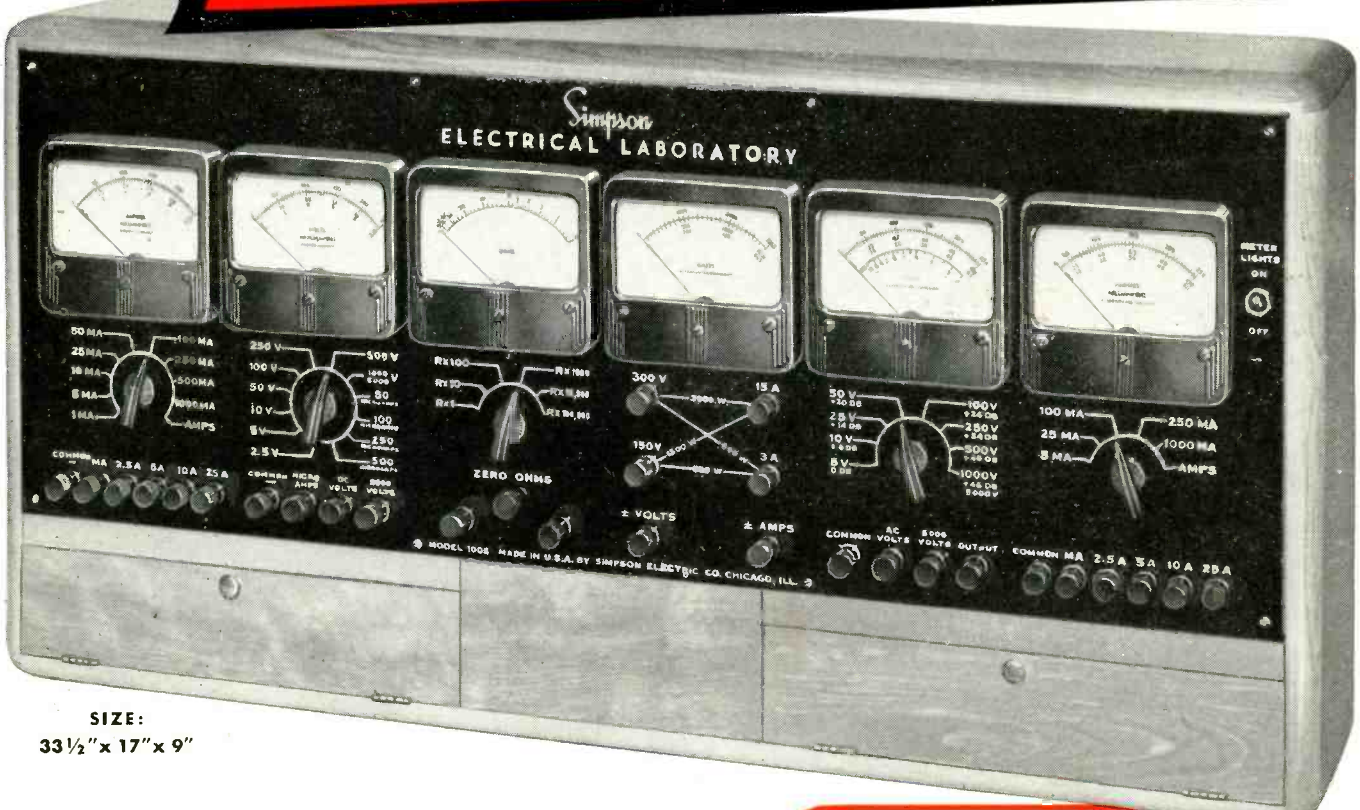
SIMPSON ELECTRICAL LABORATORY
MODEL 1005



SIZE:
33½" x 17" x 9"

All the functions of over 60 separate instruments combined in one unit!

Here is a complete test unit for use by radio, electronic, and electrical technicians in laboratories, shops, or service departments. It is adaptable to the testing of all electrical appliances, small motors, circuits, radio sets, etc. It consists of six individual 4½" rectangular instruments, indirectly illuminated, each with a complete set of ranges.

In addition to the wide variety of A.C. and D.C. voltage and current ranges, a multi-range ohmmeter and a single phase wattmeter have been incorporated. Also, to meet the need for extreme sensitivity required in testing circuits where only a small amount of current is available, an instrument is provided with a sensitivity of 50 microamperes, providing 20,000 ohms per volt on all D.C. voltage ranges. The Electrical Laboratory incorporates a rectifier type instrument for measuring A.C. voltage with a resistance of 1,000 ohms per volt on all ranges. This latter instrument also has in combination a complete coverage of DB ranges, from minus 10 to plus 54 for volume indications.

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***Dealer's Net Price, complete with Leads and Break-in Plug,* $218.00**

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0-1 MA. D.C.
0-5 MA. D.C.
0-10 MA. D.C.
0-25 MA. D.C.
0-50 MA. D.C.
0-100 MA. D.C.
0-250 MA. D.C.
0-500 MA. D.C.
0-1000 MA. D.C.
0-2.5 Amps. D.C.
0-5 Amps. D.C.
0-10 Amps. D.C.
0-25 Amps. D.C.

Meter No. 2
(D.C. Microammeter and Voltmeter)
0-2.5 Volts D.C.
0-5 Volts D.C.
0-10 Volts D.C.
0-50 Volts D.C.
0-100 Volts D.C.
0-250 Volts D.C.
0-500 Volts D.C.
0-1000 Volts D.C.
0-5000 Volts D.C.
20,000 ohms per volt
0-50 Microamps
0-100 Microamps
0-250 Microamps
0-500 Microamps

Meter No. 3
(Ohmmeter)
0-500 Ohms (5 ohms center)
0-5000 Ohms (50 ohms center)
0-50,000 Ohms (500 ohms center)
0-500,000 Ohms (5,000 ohms center)
0-5 Megohms (50,000 ohms center)
0-50 Megohms (500,000 ohms center)

Meter No. 4
(Wattmeter)
0-300 Watts A.C.
0-600 Watts A.C.
0-1500 Watts A.C.
0-3000 Watts A.C.

Meter No. 5
(A.C. Voltmeter, Output and DB meter)
0-5 Volts A.C.
0-10 Volts A.C.
0-25 Volts A.C.
0-50 Volts A.C.
0-100 Volts A.C.
0-250 Volts A.C.
0-500 Volts A.C.
0-1000 Volts A.C.
0-5000 Volts A.C.
Rectifier type 1000 Ohms per volt
DB Ranges —10 to +54
Output Ranges same as volts except 5000 Volt Range

Meter No. 6
(A.C. Milliammeter and Ammeter)
0-5 MA. A.C.
0-25 MA. A.C.
0-100 MA. A.C.
0-250 MA. A.C.
0-1000 MA. A.C.
0-2.5 Amps. A.C.
0-5 Amps. A.C.
0-10 Amps. A.C.
0-25 Amps. A.C.

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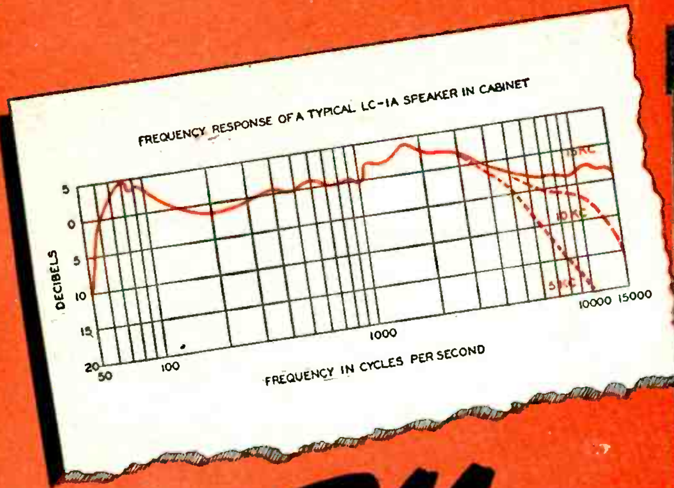


True FM Response

FOR CONTROL ROOMS . . . OFFICES . . . AND HOME MONITORING

. . . with the new RCA LC-1A Duo-Cone Speaker

Prices To Broadcast Stations*

- LC-1A Monitoring Speaker, with Cabinet . . . **$290.00**
- Speaker Mechanism Only (Type MI-11411) . . . **$90.00**

The RCA LC-1A speaker is expressly designed for monitoring FM programs and high-fidelity recordings in broadcast stations. Its response is exceptionally free from distortion—over the full FM range. Read these highlights:

Uniform response, 50 to 15,000 cycles. Audio measurements prove RCA's new speaker free from resonant peaks, harmonic and transient distortion . . . *at all usable volume levels.*

120 degrees radiation at 15,000 cycles! The LC-1A is unique in its ability to project a wide cone of radiation through a constant angle of 120 degrees. And frequency response is uniform throughout! Advantages: It eliminates the familiar sharp peak of high-frequency response usually present in other systems. And exact location of the LC-1A in control or listening rooms *is not critical.*

Remarkably smooth crossover-response. Both cones are mounted on the same axis and have the same flare angle to place their surfaces in line. Thus the possibility of undesirable interference between H-F and L-F units over the crossover range is eliminated.

Controlled "roll-off" at 5 and 10 kc. Because of the LC-1A's exceptional high-frequency response, the surface noise and high-frequency distortion present in many recordings is accentuated. Therefore, a panel-mounted switch is provided to control and restrict the LC-1A's high-frequency range for this type of program material (see response curve).

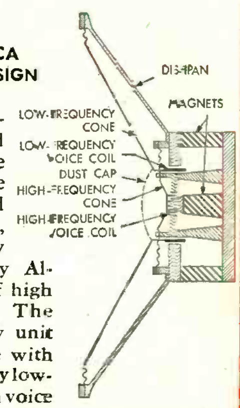
Two fine LC-1A bass-reflex cabinets (optional) are designed to match the Duo-Cone speaker. One is finished in the familiar RCA two-tone gray. The other is finished in dark walnut.

A third model . . . the LC-2A, is now available in light mahogany for executive offices and modern surroundings. Price and delivery information on this speaker is available on request.

For data and further details on Duo-Cone speakers...now in production...write Dept. 7-C

* Effective, Jan. 1, 1948

DETAILS OF RCA DUO-CONE DESIGN



Two individually actuated cones are mounted on the same axis and flare angle, with a specially designed heavy Alnico magnet of high flux density. The high-frequency unit is a 2⅜" cone with an exceptionally low-mass aluminum voice coil. This cone follows out the shallow angle of the larger cone to radiate a pattern at full power over an area of 120 degrees at 15,000 cycles! The low-frequency unit has a massive 15" diaphragm with a high-mass voice coil of large diameter. Its resonant frequency, only 35 cycles . . . with true bass response at all volume levels.

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ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

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