AUDIO ENGINEERING

SEPTEMBER
1950
35c

INCLUDING
VIDEO ENGINEERING
SECTION

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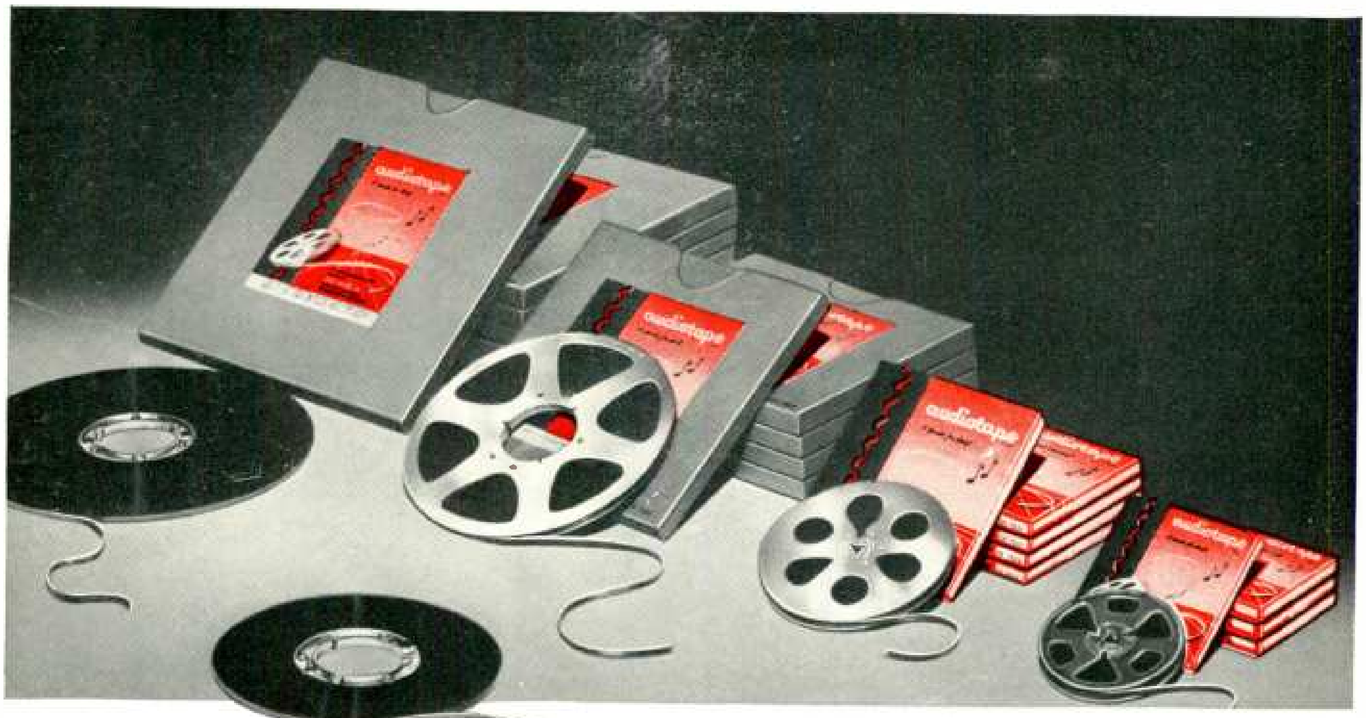

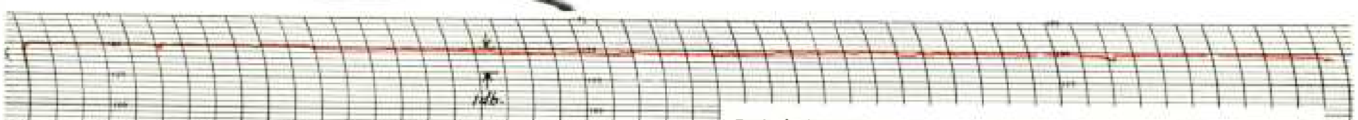

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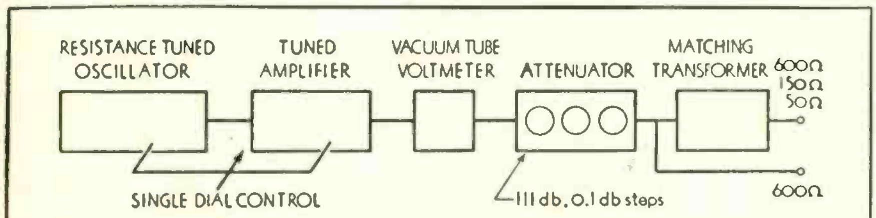

Figure 1 — Circuit Structure of -hp- 206A Generator

Full details available on request

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SPECIFICATIONS

FREQUENCY RANGE: 20 cps to 20 kc, 3 bands.

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LETTERS

Tracking vs. Tracing

Sir:

In the article on pickup tracking in the May issue, I used the word "tracking" to designate the mechanical contact or "fit" between the stylus and the groove. Some consideration was given to the selection of this term as "tracing," as suggested by Mr. E. F. Good (LETTERS, Æ, *July 1950*), is not preferred because of the close association of "tracing" with the term "tracing distortion." As we know, due to the excellent work of Lewis and Hunt as well as others, tracing distortion can occur even though good mechanical contact is maintained between the stylus and the record groove, and my choice of "tracking" was greatly influenced by such considerations. "Tracking error" instead of "tracking" is the term used to designate the angle between the vibration axis of the pickup and a plane containing the tangent to the unmodulated groove. This has been a tentative ASA (American Standards Association) definition for several years and, I believe, is well on its way towards becoming an accepted and generally used standard.

H. E. Roys,
Sound Engineering Section,
RCA Victor Division,
Camden, N. J.

TV Lighting

Sir:

One of the most encouraging things about television is that once in a while we see an adult face on the TV screen which is lighted according to standards which are acceptable either in still photography or in motion pictures. If such a rarity can be achieved once, it can be duplicated and finally become the rule rather than the exception. It is unfortunate that the majority of TV portraits of adults are not lighted satisfactorily but are lighted in the manner commonly used for babies and young children.

I hope Mr. Rackey's article in the July issue is the beginning of better lighting for TV portraits. The key to the present difficulty seems to be Mr. Rackey's Rule III which states "The lighting should not be toppy, i.e. directed from too high an overhead angle." If the TV studios will go easy on this rule for a while and begin to raise their key lights in order to produce at least a small nose shadow, we will begin to receive better TV portraits. Anyone who will take the trouble to watch long enough will eventually find a face on TV which is lighted in this manner and, I am sure, be convinced that TV can begin to approach good portrait photography.

Philip L. Bruce,
4753 Faculty Ave.,
Long Beach 8, Calif.

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COVER

New, compact three-head assembly for Magnecord professional tape recorders. Erase head is at the left, recording head at center, and the playback head—which may be used for simultaneous monitoring of tape output while recording—is at the right. Record and playback heads are triple shielded to eliminate crosstalk and hum, and can be aligned or replaced individually. This new assembly is standard on both PT63 and PT7 equipments, or may be obtained as a conversion kit for PT6 recorders now in the field.

AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at 10 McGovern Ave., Lancaster, Pa., by Radio Magazines, Inc., D. S. Potts, President; Henry A. Schober, Vice-President. Executive and Editorial Offices: 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States, U. S. Possessions and Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U. S. A. Entered as Second Class Matter February 9, 1950 at the Post Office, Lancaster, Pa. under the Act of March 3, 1879.

AUDIO PATENTS

RICHARD H. DORF*

THE PROBLEM of putting out good recordings is still before us in a degree not much diminished during the last few years. The tape industry is fairly new—yet it is generally conceded that the best tape-recorded material can sound better than ditto on a disc. Nevertheless, the disc is still the most convenient way of distributing recorded music, both technically and economically, so the fight for better discs goes on.

* *Audio and Television Consultant, New York.*

One of many approaches to better sound on discs is contributed by W. V. B. Roberts in his Patent No. 2,488,936, assigned to RCA. The scheme is to use FM for both recording and reproducing, not only to contribute all the noise-suppressing advantages of FM, but also to overcome one of the basic hurdles in any device dealing with audio—the tremendous frequency range that must be handled. Tremendous, that is, in terms of the ratio between upper and lower limits, which is what counts.

The central idea of the scheme is quite simple. Under present conditions, an ideal recording device—in this case cutter, stylus, and record lacquer—must respond to frequencies between, say, 30 and 15,000 cps, a range of 500 to 1. If that could be reduced to even 4 to 1, all the equipment concerned could operate at much higher efficiency and retain its characteristics over that band much more uniformly.

Mr. Roberts first proceeds to design a record cutting system for operation at and around 50 kc. Provided the system does not have to cover a very great range, that is entirely feasible using, perhaps, a crystal cutter driving a very light cutting or embossing point. Various physical arrangements are possible—embossing on a pre-grooved disc, or cutting a hill-and-dale groove (which would allow a 12-inch disc to play for 15 minutes at 500 lines in the outer 3-inches of the record), and so on.

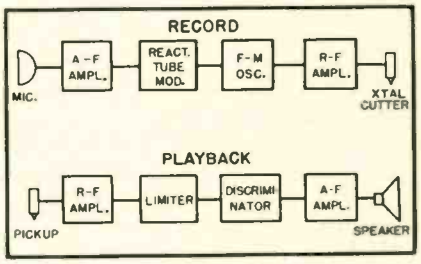

Figure 1

His electrical system blocks out, as shown in the diagram of *Fig.* 1, a setup similar in essence to an FM transmitter. The sound source drives an a.f. amplifier (in which pre-emphasis may be incorporated), a frequency-modulated oscillator, and an r.f. amplifier, whose output drives the cutter. If the mean frequency of the oscillator were 50 kc, amplitude maxima could be set to cause it to swing from, say, 20 to 80 kc, which would give a total frequency range for the system of only 4 to 1—and it could be less. The system would not be frequency-sensitive for a.f. at all, since nothing would affect the rapidity with which the carrier frequency could be varied.

The playback system would consist of suitable 50-kc (or perhaps video-type) amplifiers and an appropriate FM demodulator, plus the usual audio amplifier. Variations in recorded or tracked amplitude could be washed out by conventional limiters, which means that table rumble, surface noise, and those other common bugaboos would disappear.

The application for this patent was filed in 1940, though it was granted only lately. It may be that some technical flaw was found that prohibited commercial development of the system, but it is also likely that other commitments of the assignee may have stood in the way. If the latter is the case, further work along these lines may well be profitable in terms of the better sound for which we are all seeking.


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EDITOR'S REPORT

LOUDSPEAKERS

While looking through a number of catalogs and other literature available from manufacturers and distributors, we were struck by one omission which seems important if the ultimate in sound reproduction is to be attained. Most good quality loudspeakers are shown without any specific cabinet, whereas even the newest beginner in this field knows that the performance of a speaker is critically dependent upon the type of cabinet in which it is enclosed.

In some cases, the speaker manufacturer will suggest that a given model should be mounted in a cabinet of certain specific dimensions, either with or without a port, depending upon the speaker design. But beyond this, few manufacturers specify the exact size and shape of the optimum cabinet, nor do they specify the proper size, shape, and location of the port, nor the proper thickness of the wood to be used in constructing the enclosure.

While it is undoubtedly true that the space available to the user may be limited, nevertheless we feel that a few comparisons can be made. When a person buys an electric refrigerator, he takes it in the sizes that are available and makes room for it in his home. The same conditions obtain with pianos, which are made in several styles, each having the best possible tone for its size. But not so with loudspeakers—the user buys one which is designed for use with an eight-cubic-foot, well-braced, solid cabinet and then mounts it in a two-cubic-foot box made of thin plywood. Then he complains that he does not hear enough bass below 50 cps, or that it is "boomy" on the low notes.

There is no good excuse for a user to complain about the reproduction from a given speaker unless it is housed as the manufacturer intended that it should be. When the user cuts corners to make a small box, or to mount a speaker in an open-backed radio cabinet, or to mount it in shallow bookshelves with less than the required volume behind the baffle, he should expect no more than he gets from the unit. On the other hand, many manufacturers do not specify the correct housing with sufficient accuracy to ensure satisfactory performance for each user. The cure might seem to be the use of an unfinished baffle cabinet which could be placed within a false housing made to match the surroundings in which the unit would be operated.

Another consideration is that practically all reputable speakers are good—some probably better than others —but all are capable of reasonably good reproduction. Let us then buy the best speaker that we can afford, judging by comparative listening in suitable cabinets and surroundings, and house it in some fashion which meets our requirements. Then let us adjust the frequency response of the power amplifier so that the acoustic output from the speaker is satisfactory with a "flat" signal fed to the amplifier. These adjustments should be in the form of some semi-permanent equalization—not by means of the tone controls. This method should ensure the best possible tone quality from a given speaker and enclosure.

PHONOGRAPH SPEEDS

As this issue goes to press, we read an announcement of a new phonograph speed—14 r.p.m. There is little that we can say regarding this new device from a radio set manufacturer. While it is doubtful if the new speed will make any headway—particularly with the quality-conscious listeners, it is just possible that it will, consumers being completely unpredictable. We also hear rumors of a 50-r.p.m. speed, supposed to be in production somewhere. Try to visualize the complications required of an automatic record changer for "all five."

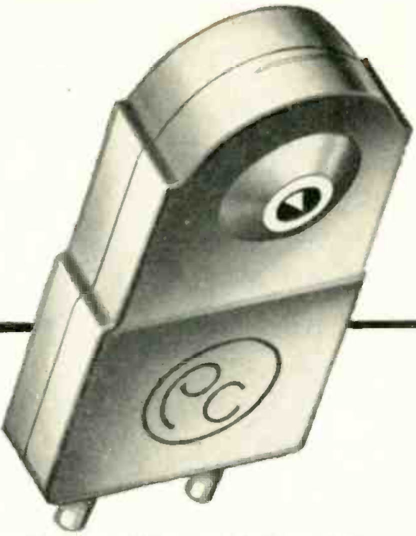
In another magazine we saw an article which we hope was intended as comedy. The writer of this piece indicated that a new all-speed changer is about to make its appearance, following the introduction of an all-groove stylus which plays both microgroove and standard records with satisfactory fidelity and record wear. The new speed was determined by averaging the present three, arriving at 52.1 r.p.m.—not too far from the 45, but changing pitch and tempo of the 78's and LP's considerably. The clue to the comedy approach began to be apparent in the second item mentioned—a sapphire phonograph record played in an oil bath with a graphite stylus.

We wonder how many people read the first item and rushed immediately to their nearest dealer in search of a 52.1-r.p.m. turntable which was claimed to eliminate all their troubles with three speeds.

If there is anything to the addition of more speeds to the already-too-many three, most of us will have to resort to sound-effects turntables—with continuously variable speed control from 10 to 130 r.p.m. We still favor the LP for long numbers, the 45 for short.

APOLOGY

We hate to do this, but "due to circumstances beyond our control" the story about the Jensen G-610 speaker is delayed until the October issue. From this we learn that it is not always desirable to look too far —like a month—into the future.



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Recording and Fine-Groove Technique

H. E. ROYS*

A discussion of the factors involved in fine-groove recording at 45 and 33 1/3 r.p.m. for transcriptions and phonograph record masters.

PROFESSIONAL RECORDING at standard speeds of 33 1/3 and 78 r.p.m. is now a well established business in the broadcast field. Over the past twenty years many advances have been made in equipment design and in recording technique, and recently broadcast stations are finding it desirable to make provisions for fine groove recording setups.

Fine-groove recording offers some advantages that should not be overlooked by the broadcaster. For example, a twelve-inch blank is good for 30 minutes of recording—15 minutes to a side—and the smaller blank means a substantial saving in both first cost and storage space. Moreover, due to the potentialities of the fine-groove system, an improvement in quality, as will be pointed out later in discussing intermodulation and the innermost recording diameter, is also possible. All of this can be accomplished *by using only standard recording equipment as illustrated in Figs. 1 and 2* with very minor alterations. In addition to a description of equipment, it is the purpose of this article to discuss recording techniques. Groove shape, stylus fit, and groove pitch are discussed, as are many of the design features that are essential whenever fine-groove recordings are being made.

Equipment

The simple, yet proved system setups shown in *Figs.* 1 and 2 have been selected as practical "73-B" recording circuits (for 45, 33 1/3 and 78 r.p.m.) which will provide good day-to-day performance. Both are typical broadcast recording layouts—easy to setup—and are made from standard-stock RCA recorder components and accessories. In these diagrams, each recording component is represented by a block which includes the stock identification or ordering number. Most of these items are described and pictured in the RCA Broadcast Equipment Catalog which may be used for further reference. In addition, a complete line of recording equipment accessories is available.

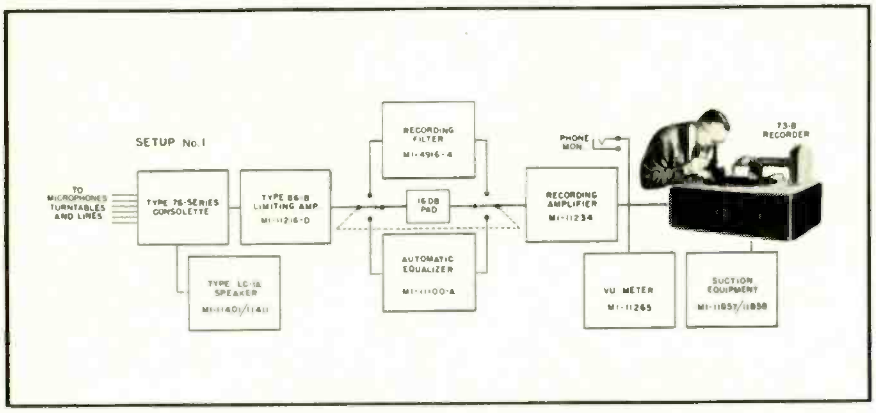


Fig. 1. Basic single-channel setup.

Either recording system fully meets the requirements for high-quality recordings (fine groove or standard) in broadcast and television services, recording studios, advertising agencies, and educational institutions.

For fine-groove recording, no changes are required in the recording layouts illustrated. The addition of fine groove recording kit, MI-11882, to the 73-B recorder and a change in cutting stylus are the only modifications required. Recordings can be made at 45 r.p.m. if new motor drive pulleys MI-11860 for 45 and 33 1/3 r.p.m. or MI-11861 for 45 and 78 r.p.m. are obtained.

Three different types of styli are available:

1. Routine microgroove styli.
2. Master styli, which are made to the customer's specification. The usual specification is: 90 deg. included angle, 0.25 mil radius of the cutting tip, burnishing facet 0.2–0.5 mils.
3. Anti-Noise-Modulation styli with multiple burnishing facets.
   a. V-groove, 111 stylus, included angle 87 deg. and a sharp cutting point, 3 burnishing facets each 0.1 mil.
   b. Similar to (a) except the tip radius is 0.25 mils.

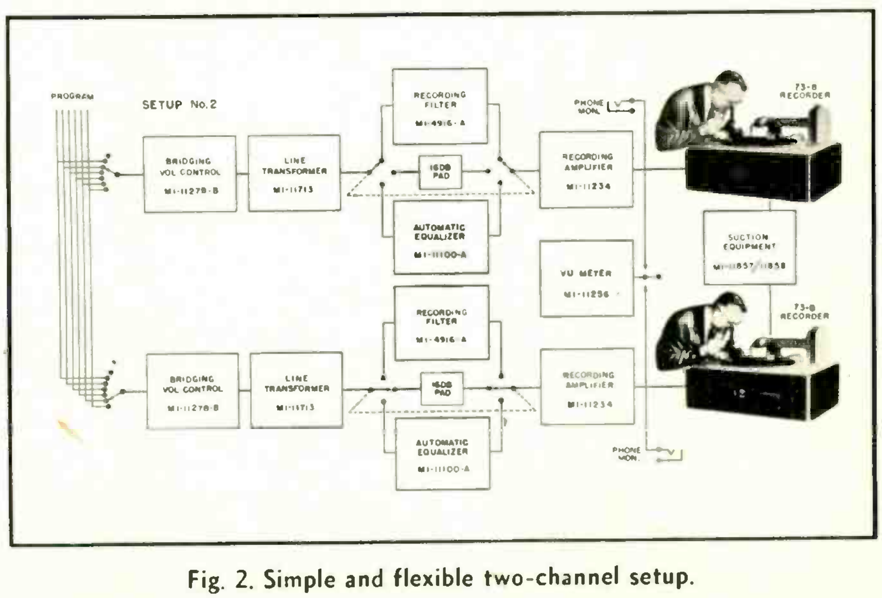


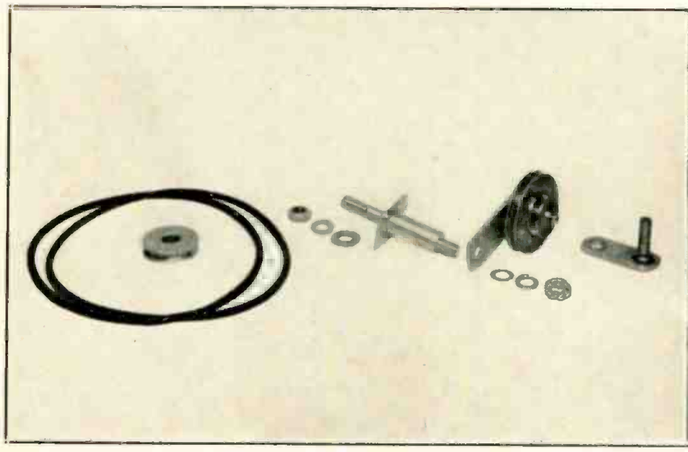
Fig. 2. Simple and flexible two-channel setup.

* *Engineering Products Department, RCA Victor Division, Camden, N. J.*

The kit (*Fig.* 3) is designed to adapt the RCA Type 73-B Professional Recorder for recording more grooves per inch than is normally possible. A speed-reducing pulley and belt system replaces the original belt coupling between the turntable spindle and the cutter-head drive mechanism. The new coupling reduces the speed of the cutting head across the turntable by half without changing the turntable speed, and thus doubles the number of grooves per inch. The design of the kit permits restoring the recorder to its original cutting speed conveniently and quickly.

The kit contains the following parts:

1. One pulley assembly.



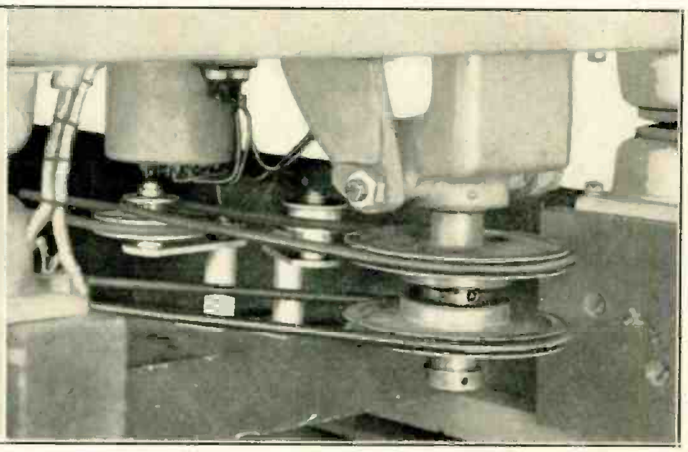


Fig. 3 (left). Parts supplied in Fine-groove kit, MI-11882, and Fig. 4 (right), showing installation of kit on standard recorder chassis.

2. One post assembly for mounting pulley assembly.
3. One double pulley.
4. One arm assembly for remounting the belt-idler pulley originally in recorder.
5. Two rubber-filled cord belts.
6. Mounting hardware for above parts.

Recording Technique

The technique involved in fine-groove recording is essentially the same as that used in making standard NAB transcriptions. In order to minimize playback distortion, commonly known as tracing distortion, it is desirable to establish a limit for the recording level. A peak recording level of about 14 cm/sec has been assumed in this article since the work on 45 r.p.m. records has indicated this to be a reasonable and acceptable level for fine-groove recording. The value is believed to be in fair agreement with the levels normally used for transcription recording. A common means of adjudging the recording level is by comparing the output of the recorded lacquer with that obtained from a fine-groove pressing (either 45 or 33 1/3 r.p.m. phonograph record). Some discrepancy may occur in doing this however, due to the greater yield of the lacquer under the pressure of the stylus tip, since the lacquer is much softer than the vinyl used for pressings. The loss in output would be more noticeable at the higher frequencies where the wavelengths are shorter. Frequency test records that have been calibrated for recorded level are particularly useful for level checks, and RCA has several of these available.[1] Two banded frequency records—12-5-25 for 33 1/3, and 12-5-31 for 45-r.p.m. operations—are obtainable. The 33 1/3 record has a wide deep groove with a bottom groove radius of less than 0.5 mil so that it can be used for response measurements with pickups having tip radii that range from 0.75 to 3.0 mils. Frequencies from 30 to 12,000 cps are covered by this record. Record 12-5-31 is for fine-groove reproduction only, and frequencies from 50 to 10,000 cps are included.

Records 12-5-39 for 78 r.p.m., and 12-5-37 for 45 r.p.m. are particularly useful for level checks since they contain frequency bands recorded at different levels. Both records were made for distortion testing[2] and contain intermodulation frequencies of 400 to 4000 cps. The 78-r.p.m. record has peak levels ranging from about 4.4 to 27 cm/sec, varying in 2-db steps. The 45-r.p.m. record has peak levels ranging from about 3.8 to 18 cm/sec, also varying in 2-db steps.

High frequency tip-up, such as prescribed by NAB for a standard lateral characteristic, can be used in the normal manner when cutting fine-groove lacquers. However, in order to record the high frequencies on the lacquer it is essential that the width of the burnishing facet of the cutting stylus be small (otherwise appreciable loss in recorded level may occur). The loss becomes great whenever the width of the facet becomes appreciable with respect to length of the recorded wave.

RECORD CONSTANTS

Groove Dimensions

In disk recording, the width or depth of the groove should be governed solely by the dimensions of the playback tip and not by modulation or the spacing between the grooves. It is the primary function of the groove to provide a means of establishing good firm mechanical contact with the playback stylus tip. To do this a recording stylus having a suitable tip shape must be selected and the depth of cut properly adjusted when recording. The depth should be such that the contact with the groove sidewalls is well below the top, so that surface scratches and edge irregularities are not reproduced as noise. An ideal groove contour and stylus fit for a 1.0-mil playback tip is illustrated in *Fig.* 5. For lateral recordings, contact along the bottom of the groove is not desirable as pointed out by Andrews in his article on the importance of groove fit;[3] hence it is usual practice to use a cutting stylus with a tip radius much smaller than that used for reproduction. For normal groove recording where a 2.5 or 3.0 mil stylus is used for playback purposes, the groove depth and width should be greater so that the principle of maintaining contact below surfaces of the disk is still retained.

Tracing Distortion and the Innermost Diameter

When the outside diameter is fixed by selection of the disk size, the starting diameter is thus essentially fixed too. The pitch, or number of grooves per inch, for a particular playing time then depends upon the innermost diameter. In

[1] These records can be obtained from Custom Record Sales, 120 E. 23 St., New York.

[2] H. E. Roys, "A method of determining the tracking capabilities of a pickup," AUDIO ENGINEERING, May, 1950.

[3] D. R. Andrews, "Importance of groove fit in lateral recordings," AUDIO ENGINEERING, July, 1949.

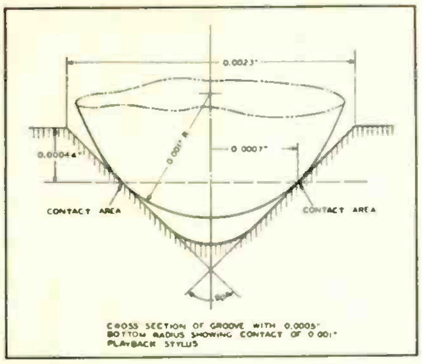


Fig. 5. Groove cross section and ideal stylus fit for fine-groove recording.

determining the innermost diameter, consideration should be given to reproduction. The reproducer or pickup uses a rounded tip of a finite radius, and when the recorded wavelengths became short and comparable to the size of the playback tip, difficulty in tracing the path of the recording stylus occurs. The resulting effect is known as tracing distortion, and it may reach serious proportions near the inside of the disk where the wavelengths are short.

Tracing distortion has been studied theoretically by Hunt and Pierce[4] and also by Hunt and Lewis.[5] RCA has spent considerable time and effort in studying the problem; good results in correlating theory, practice, and measurements have been obtained. Frequencies of 400 and 4000 cps when combined and used as an intermodulation test signal[6, 7] have been found valuable for such studies. Some of the results of the investigation are shown in *Fig.* 6, and these can be used in determining the innermost diameter for the 12-inch fine-groove lacquer. Listening tests over a wide-range system by trained observers have shown that distortions exceeding 10 per cent intermodulation (based upon test frequencies of 400 and 4000 cps) are evident so that the 10-per cent value was selected as a design limit. It can be seen from *Fig.* 6 that 10 per cent modulation is reached at 6.5 inches diameter for 33 1/3 r.p.m. and 4.9 inches diameter for 45 r.p.m. when using a 1.0-mil playback tip and a peak recording level of 5.55 in. per second (approximately 14 cm/sec). This recording level is believed to be representative of the peak levels normally encountered in transcription recording. It can also be observed in *Fig.* 6 that existing standards for 33 1/3 r.p.m. transcriptions and 78 r.p.m. recordings permits distortions far exceeding 10 per cent at the inner diameters. This type of distortion (known as tracing distortion) is particularly noticeable at the inside of some 78 r.p.m. recordings where the recorded level is high. The 45-r.p.m. system was designed so that 10 per cent intermodulation was not exceeded even at the innermost recording diameter, and a diameter of 4.9 inches was selected for the last music groove.

Number of Grooves per Inch

Having thus determined the value of the innermost recording diameter, the number of grooves that does not exceed 10 per cent intermodulation

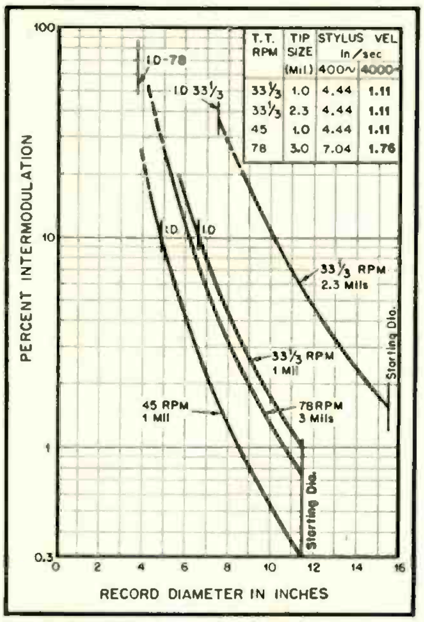


Fig. 6. Per cent intermodulation for different turntable speeds, playback tip sizes, and recording diameters.

per inch can be calculated. These are given for turntable speeds of both 45 and 33 1/3 r.p.m. The total number of grooves, *G*, for 15 minutes will be:

$$(45)\quad G = 15 \times 45 = 765$$

$$(33\,1/3)\quad G = 15 \times 33\,1/3 = 500$$

The usable playing radius, *PR*, available is:

$$(45)\quad PR = \frac{11.5 - 4.0}{2} = 3.3 \text{ inches}$$

$$(33\,1/3)\quad PR = \frac{11.5 - 6.5}{2} = 2.5 \text{ inches}$$

where 11.5 is the starting diameter and 4.5 and 6.5 are the finishing diameters in inches.

The number, *n*, of grooves per inch will therefore be:

$$(45)\quad n = \frac{675}{3.3} = 204$$

$$(33\,1/3)\quad n = \frac{500}{2.5} = 200$$

In order to allow a few blank grooves at the beginning and end of the recording, this number should be increased to 208 for either 45 or 33 1/3 r.p.m.

The pitch, *p* would therefore be:

$$p = \frac{1.00}{208} = .0048 \text{ inches}$$

If we maintain the groove width as shown in *Fig.* 5, the "land" (material between the grooves) will be .0025 inches. For ease of adjustment in recording the depth of cut can then be adjusted so that for a stylus that cuts a groove having a 90 deg. included angle the width of the groove will be equal to that of the land.

A greater number of grooves per inch can be used, and many fine-groove records are cut with as high as 275 to 300 grooves to the inch. When the playing time is such that close spacing is unnecessary, it is advantageous to cut a slightly wider and deeper groove so that better contact is assured between groove and reproducer tip.

RECORDER DESIGN FEATURES

Cutter Bounce

There are several design features that have been incorporated in the 73-B recorder that make it particularly suited for both normal and fine-groove recording. These features are the results of

[*Continued on page 36*]

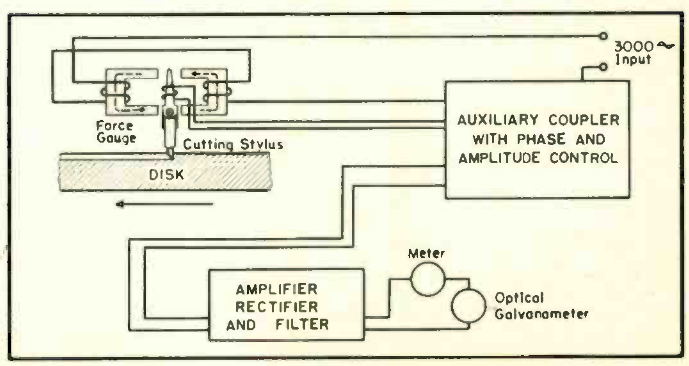


Fig. 7. Force gauge used for cutter bounce measurements.

[4] J. A. Pierce and F. V. Hunt, "On distortion in sound reproduction from phonograph records," *J. Acous. Soc. Am.*, July 1938.

[5] W. D. Lewis and F. V. Hunt, "A Theory of tracing distortion in sound reproduction from phonograph records," *J. Acous. Soc. Am.*, January 1941.

[6] H. E. Roys, "Analysis by the two-frequency intermodulation method of tracing distortion encountered in phonograph reproduction," *RCA Review*, June 1949.

[7] M. S. Corrington, "Tracing distortion in phonograph records," *RCA Review*, June 1949.

Imagery for Describing Reproduced Sound*

VINCENT SALMON**

Concluding the description of the body of terms suggestive of the sensations experienced—classified, defined, and illustrated as much as possible to facilitate oral or written description.

A trained auditor, using as guideposts dominant ranges of music and speech, can pick out and listen to the various frequency regions named in Part I. These ranges may be described by terms indicating their contribution to the overall intensity or loudness, and tone quality.

The presence of *extreme lows* is shown by the sensations experienced in the pit of the stomach, as with strong pedal tones from a pipe organ; hence the term *belly-lows*. These are usually confined to frequencies below 60 cps, and are reproduced *cleanly* only on the best equipment. The ordinary listener rarely hears them, even in a juke box, where the harmonics are likely to be more intense than the fundamental. It may be remarked parenthetically, that all that is required from a juke box is a rhythmic *grunt*.

Lest these terms give the impression that audio engineers are especially odd, consider this quotation from Wedgwood's "Dictionary of Organ Stops," called to the writer's attention by Dr. W. T. Bartholomew. "The process (of softening zinc by subjecting it to heat) takes all the virtue out of the metal, rendering it brittle and productive of a hard, 'hungry' tone."

When the *lows* are slightly in excess of normal the sound is *tubby;* increasing the *lows,* as by resonant-circuit tone controls, may cause transient excitation of a *boom* of frequency near the resonance. An increase over a larger range, centered near 100 cps, adds to the *grunt*. Increase of the *lows* must be used with caution, for it may objectionably raise the level of hum and *rumble* in the system. The latter is especially troublesome in light turntables used for slow-speed records, and its removal is a real challenge to the design engineer.

In the *lower middles* the contribution to the overall energy is rising to a maximum, and it is here that the proper *balance* of spectral energy provides the proper *body*. More low middles increase the *punch* until the program is *solid*, and has *sock*. In the upper portion of this range also occur important fundamentals and harmonics of music, as well as the lower formants of speech. A deficiency in system response in this range permits masking by louder components of frequency above this range, leading to a *tinny* or *thin* sound. A moderate deficiency sounds *lean,* while a moderate excess is *mellow; flat-sounding* is used when slightly more intensity is added. A fairly large excess may cause a system to be condemned as *dead, dull,* or *thick,* while an inordinate excess is *muddy* or *drummy*.

The region of the *upper middles* lies between the two critical frequency ranges of speech and music and is hence frequently used for locating the cross-over in a two-way speaker system. This avoids troubles which would occur if the cross-over effects discussed earlier occurred in a critical region. It has been noted that with cross-over in this range it is difficult to obtain a *masculine baritone* without losing some of the *warmth* which makes sopranos bearable. All this, of course, is phrased in terms of sound reproduced on good quality systems, and does not refer to the original sources.

In the *lower highs,* extending roughly from 1500 to 4000 cps, are the frequencies contributing a great deal to the loudness of a complex tone. This range is usually

[*Continued on page 29*]

TABLE III

Imagery for Loudness of Various Ranges

Top Terms Loudest; Special Terms in Parentheses

Extreme Lows	Lows	Lower Middles	Upper Middles	Lower Highs	Highs	Extreme Highs
		Sock; Drummy		Shrill	Harsh	
Belly-Lows	Grunt	Solid; Dead, dull, thick		Brassy, metallic	Hard	
	Boom	Punch; Flat-sounding	Masculine baritone	Bright, brilliant		
(Excess) ↑	Tubby	Body; Mellow			Crisp	Brittle
↓		Lean	Warm soprano			Soft
(Deficiency)		Thin				
		Tinny				
		(Balance)		(Bite, tinkly)		(Naturalness)

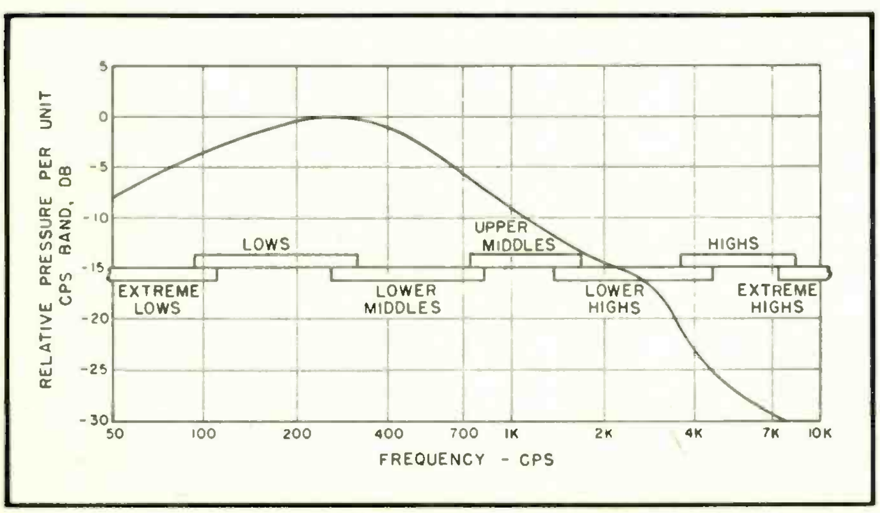


Fig. 4. Compromise most-probable-pressure spectrum of speech and music.

* Presented in part at the Thirty-third Meeting of the Acoustical Society of America, May 8–10, 1947. Many of the data herein reported were obtained while the author was employed by the Jensen Manufacturing Company, Chicago, Illinois, and are published with their permission.

** *Stanford Research Institute, Stanford, California.*


VIDEO
ENGINEERING

VIDEO ENGINEERING

SECTION OF

AUDIO ENGINEERING

CONTENTS SEPTEMBER, 1950

COVER

View of DuMont Telecruiser, showing units on shock-mounted racks and covered ready for transit. Directly opposite the door are the Variacs for controlling the voltage into the camera chain. Mr. McCord's description of the video circuits of the Telecruiser will appear in the next issue of VIDEO ENGINEERING

ADVERTISING INDEX

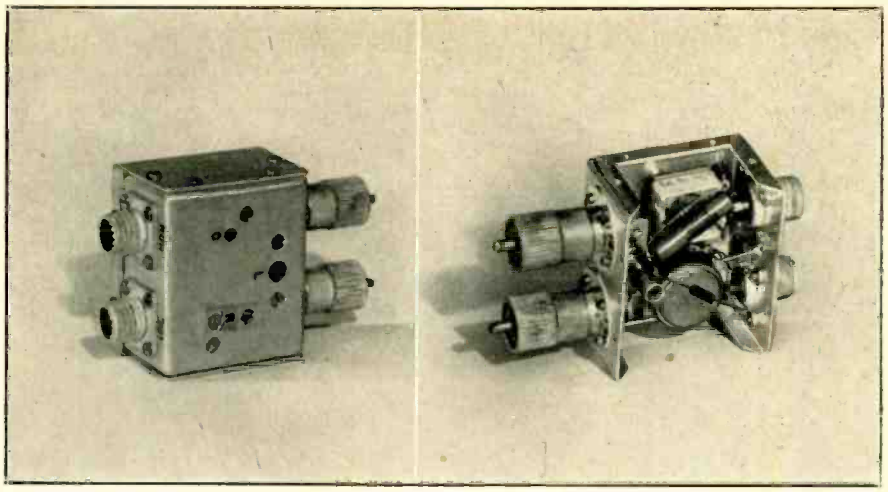


Fig. 1. (A) CBS 1-A Video Line Pad. The unit mounts directly on the output terminals of the associated video line amplifier by means of the male co-axial connectors at the right. Frequency elements L and C are readily accessible for adjustment. Voltage-calibrating element R, which normally requires only initial adjustment in a given installation, can be reached by removing the small cover plate over the access hole. (B) Interior of chassis of pad, showing arrangement of components.

impedance of 2000 ohms or more, which represents the plate circuit impedance of a type 6AG7 power tube. In order to obtain the required 75-ohm output impedance, it has been common practice to parallel-connect two 6AG7 output stages and shunt a 75-ohm resistor across the output terminals of the amplifier. Thus, the source impedance presented to the outgoing video line is 75-ohms, shunted by the relatively high plate-circuit impedance of two parallel 6AG7 stages. Furthermore, because of the high-impedance nature of the 6AG7 circuits, the gain and useful-load-current capability of the video amplifier is essentially the same whether one 6AG7 is used, or whether two are connected in parallel and shunted by a 75-ohm resistor.

CBS 1-A Video Line Pad

All of the problems so far discussed are uniquely solved by the CBS 1-A Video Line Pad. The insertion of this device between the output terminals of an existing video line amplifier and the input to a video line provides the requisite isolation and impedance-matching without degradation of normal performance characteristics.

In a large video installation, a large number of unity-gain distribution amplifiers are required, both for feeding outgoing video lines and for general local distribution of video signals. Currently in greatest usage for these purposes at the CBS New York Studios is a five-channel video distribution amplifier. Therefore, the video line pad was primarily designed for use with this unit. Except for mechanical design considerations, however, it will become evident to the reader that the video line pad is applicable to almost any video output stage which has high-impedance (constant-current) characteristics and the requisite load current capability.

Electrical Features

The CBS 1-A Video Line Pad is a completely passive network (i.e., it contains no tubes or sources of energy) which provides approximately 14 db of isolation between a video line and an associated picture and waveform monitor, yet which causes no appreciable reduction of the gain, load-current capability or bandwidth of the video system in which it is inserted. In one sense, it is a "lossless" device, an interesting example of "something for nothing." Actually, it will shortly be seen that no fundamental principles of network theory have been violated; the pad simply takes expedient advantage of an inherent characteristic of most present-day video line amplifiers. The isolation provided by the pad is sufficient to reduce the usual magnitude of line distortions to negligible or entirely usable values so that direct monitoring of the outgoing signal to the line is possible.

Designed for direct connection to a distribution amplifier of the type described above, the pad provides two co-axial output terminals, a "LINE" feed, and a "MONITOR" feed, respectively. The LINE feed is designed to feed a video line of 75 ohms nominal impedance, while presenting a 75-ohm source impedance to the outgoing video line. The MONITOR feed is designed to feed a picture and waveform monitor on a high-impedance basis. An externally-adjustable control is provided to compensate for the shunt capacitance of the monitor input cabling and circuits. Controls are also provided for bandwidth adjustment and amplitude calibration.

Mechanical Design

The CBS 1-A Video Line Pad is assembled in an aluminum chassis which mounts on the associated distribution amplifier, self-supported by a pair of male co-axial video connectors. The latter are so spaced that they "straddle" two adjacent output channels of the amplifier. A pair of female video connectors on the pad chassis provides convenient connection to the outgoing video line and the monitor input circuits, respectively. Two frequency-compensation controls are externally accessible on one side of the chassis. A third control, which provides amplitude calibration, is accessible by removal of a small cover plate. Two views of the pad are shown in *Fig.* 1.

Theory of Operation

A schematic diagram of the CBS 1-A Video Line Pad is given in *Fig.* 2. The block diagram of *Fig.* 3 shows the connection of the pad to a distribution amplifier.

In *Fig.* 3, P_1 and P_2 of the pad mate with J_4 and J_7, respectively, of the amplifier, thus paralleling these channels. At the lower range of video frequencies the effects of L_1, C_1, C_2 and C_3 of *Fig.* 2 upon operation are negligible and the circuit reduces to the simple resistance combination of R_1, R_2, R_3, R_4 and R_5.

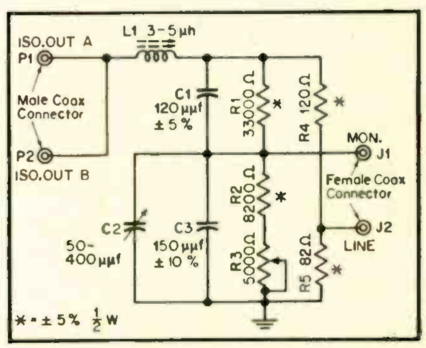


Fig. 2. Schematic diagram of video line pad. P_1 and P_2 connect to the line amplifier output. J_1 supplies signal voltage to a high-impedance picture and waveform monitor, while J_2 feeds signals at standard level to the outgoing video line. A source impedance of 75 ohms is presented to the outgoing line with an effective isolation of approximately 14 db between J_1 and J_2.

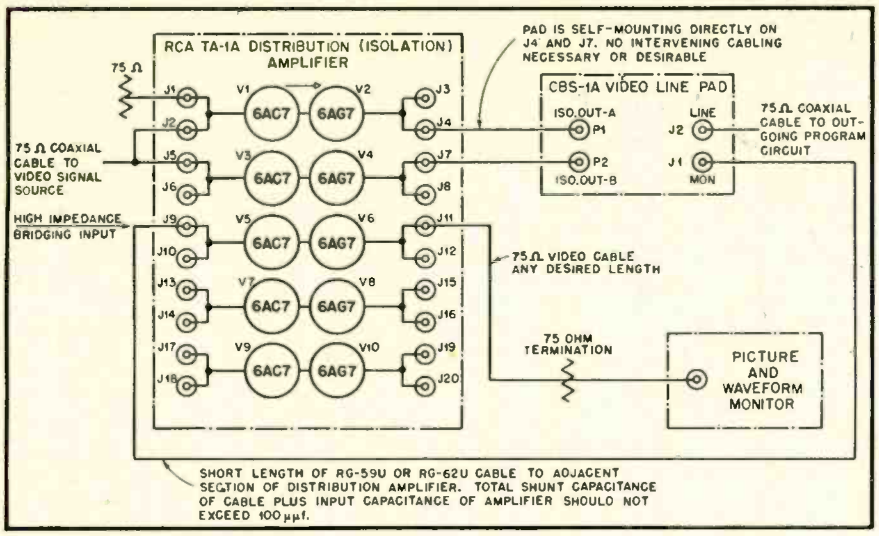


Fig. 3. Installation details for video line pad when employed in conjunction with a widely used type of distribution amplifier.

R_5, in conjunction with the shunting effect of R_4 and the plate-circuit impedance of the paralleled 6AG7 triode stages, V_2 and V_4 of *Fig.* 3, provides the desired net resistance of approximately 75 ohms as seen looking into the pad from the line feed-point J_2.

The series resistance of the voltage-divider network R_1, R_2, and R_3, is so high with respect to that of the load circuit that less than 1 per cent of the 6AG7 output signal current flows through this branch. Furthermore, the current flowing in an external 75-ohm load connected to J_2 is only slightly reduced by the presence of the series resistor R_4, due to the relatively-high source impedance (1000 ohms, approximately) of the 6AG7 plate circuits. On the other hand, the signal voltage appearing at the junction of R_1 and R_4 is higher than that across the line at J_2 by a ratio of greater than 4 to 1, assuming the external load impedance at J_1 is 75 ohms.

The voltage-divider network made up of R_1, R_2, and R_3 is so proportioned that the signal voltage appearing at the monitor jack J_1 is exactly equal to that at J_2, when J_2 is terminated in a pure 75-ohm resistance. Since the monitor-circuit input resistance is usually on the order of 0.5 megohm or more, the signal level at the monitor jacks is almost entirely a function of the ratio established by R_1, R_2, and R_3.

Any signals appearing at the monitor jack J_1 are isolated from whatever spurious effects may occur at J_2 by a factor of approximately 5:1. For example, a hum voltage of 0.1 volts, peak-to-peak across R_5 (an actual condition met in a typical instance) is reduced to a value of approximately 0.02 volts at the monitor jack J_1, while the desired signal at both J_1 and J_2 is maintained at a 2-volt value. In a similar manner, the signal at the monitor jack J_1 is isolated from the effects of impedance-variations in the external load connected to J_2.

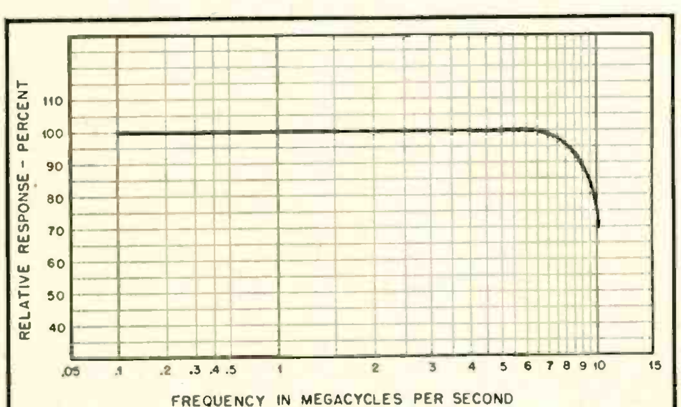
At the middle and high ends of the video-frequency range, the shunt capacitance of the 6AG7 output stages, if uncompensated for, would degrade the frequency response characteristic. Therefore, there is employed a series-peaking circuit made up of the 6AG7 output circuit capacitance, in combination with L_1 and the C_1-C_2-C_3 network. The values of L and C are so chosen that a flat response characteristic up to 7 mc is maintained at the line output jack J_2. In addition, the capacitors C_1, C_2 and C_3, plus the input capacitance of the external monitor circuits, form a capacitance voltage-divider which complements the resistance branch R_1, R_2, and R_3, in such a way that the frequency-response characteristic at J_1 is exactly the same as that at J_2 (assuming a 75-ohm resistance termination at J_2). To insure exact frequency compensation at J_1, C_2 is made adjustable, and of a range sufficient to correct for the input capacitance of the monitor circuits connected at J_1.

Installation

The installation of the video line pad in a location where two distribution amplifier sections have previously been paralleled to provide a 75-ohm nominal source impedance is very simple. *Figure* 3 shows a typical arrangement in which the pad may be used to feed any 75-ohm outgoing line simultaneously with a remotely-located picture and waveform monitor.

In cases where the picture and waveform monitor is located within a few feet of the pad, the installation will be even simpler, in that the monitor may be bridged directly across the output of the pad, without the necessity for the intervening distribution amplifier section shown in *Fig.* 3.

While the mechanical design of the line pad is such that it mounts most conveniently when used with a particular distribution amplifier, it may also be used at the output of other video amplifiers which have two 6AG7 or equivalent high-impedance plate feeds available. For instance, the input to the pad may



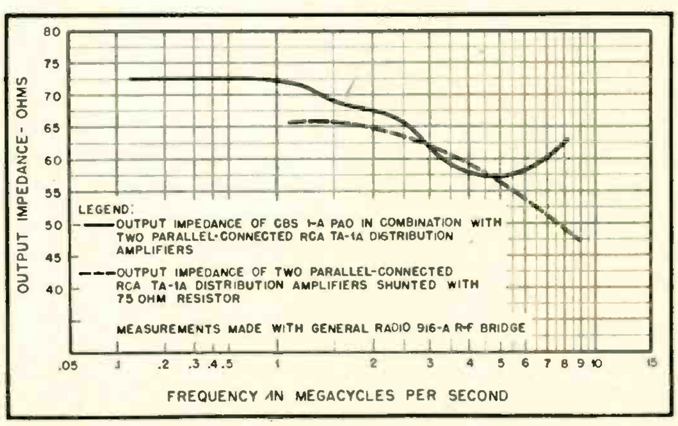


Fig. 4 (left). Combined response-frequency characteristics of video line pad and distribution amplifier, when used in the arrangement shown in Fig. 3. Combined bandwidth is nearly as great as that of the distribution amplifier alone. Fig. 5 (right). Output-impedance versus frequency characteristics of video line pad when used in the arrangement of Fig. 3. For comparative purposes, there is also shown the output impedance of a commonly used arrangement of two parallel-connected distribution amplifiers shunted by a 75-ohm resistor. The output impedance of the line-pad arrangement is seen to be closer to the desired value of 75 ohms at nearly all frequencies.

be driven by parallel-connecting the line and monitor outputs of a stabilizing amplifier. In such instances, very short, low-capacitance, flexible cables may be required between the amplifier output terminals and the input to the pad. It is exceedingly important that the extra capacitance added by the above interconnecting cables be kept at an absolute minimum, or the video bandwidth may be substantially reduced.

Operation and Adjustment

In normal usage it should not be necessary to change any of the controls on the video line pad after initial alignment in a given installation. The following detailed alignment procedure is based upon the installation shown in *Fig.* 3, but is equally applicable to other arrangements.

1. Terminate the pad in a pure-resistance of 75-ohms at J_2 (or at any subsequent point along the outgoing line circuit where it is desired to maintain reference signal level; for instance at a video jack field). Bridge an amplitude-calibrated, high-impedance oscilloscope input across the terminating resistor.
2. Leaving the outputs paralleled through the line pad, but temporarily removing the jumper which normally parallels the two inputs, feed a 60-cps square-wave signal into one of the two paralleled distribution-amplifier sections (for example, feed the signal into J_1 of *Fig.* 3 with J_4 temporarily disconnected). Adjust the input square-wave amplitude at J_1 of the distribution amplifier to 2-volts, peak-to-peak. Adjust the gain and low-frequency-phasing controls of the active amplifier section until a 1-volt, tilt-free, signal is observed at the line output (J_2 of CBS 1-A pad).
3. Remove the signal input from first amplifier section. Feed the 60-cps square-wave signal to the second distibution amplifier section, and repeat all adjustments called for in 2., above.
4. Restore the parallel-connection of the inputs of both distribution amplifiers, keeping the 60-cps square-wave input signal at 2-volt level. The output signal at J_2 of the pad should now be very close to 2-volts, and free of tilt. If any further adjustment is required to make gain of parallel combination exactly unity, readjust the gain controls of both sections in equal increments. Similarly, re-adjust both l.f. phase controls, if required.

   Note: The procedure so far is no more than the normal process of establishing unity gain and equal distribution of load between the two amplifier sections.
5. Remove the cover plate on the line pad to permit access to the screw-driver-operated control R_3. Bridge a high-impedance amplitude-calibrated oscilloscope across the MONITOR output of J_3 of the pad and adjust R_3 for a 2-volt signal level at J_3. Or, in other words, adjust R_3 until the signal voltage at the MONITOR output of the pad is exactly the same as that at the LINE output. Replace the cover plate over R_3. This adjustment is not likely ever to require retouching in any given installation.
6. Adjust the gain and low-frequency-phasing controls of the third distribution amplifier section which is bridged across the MONITOR output of J_3 of the pad for a 2-volt, tilt-free signal across the 75-ohm terminating resistor at the input to the picture and waveform monitor; i.e., adjust the third amplifier section for a unity-gain condition.
7. Change the frequency of the input square-wave signal to 10 kc. Adjust C_2 on the pad (screw-driver adjustment, externally accessible) until the signal obseved on the waveform monitor is square—having neither overshoot nor undershoot on its leading and trailing edges. Alternatively, a composite television signal may be used in place of the 10-kc square-wave signal, in which event the criterion for proper adjustment of C_2 is that the horizontal blanking and sync pulses have zero slope on top.
8. Connect a video sweep generator to the input of the paralleled distribution-amplifier sections. Connect a high-impedance video detector and oscilloscope across the LINE output terminating resistor at J_2. Adjust L_1 for most the uniform response. Usually it will be desirable to also adjust the interstage series and shunting peaking of the parallel-connected distribution amplifiers. Care should be taken to make the peaking-coil adjustments in pairs so that the compensation will be shared approximately alike by the two parallel channels. It will be found possible to obtain an over-all frequency characteristic which is entirely flat to 7 mc and not more than 1 db down at 8 mc.

Once the above procedure has been completed in a given installation, very few readjustments of the pad should be required for the life of the installation.

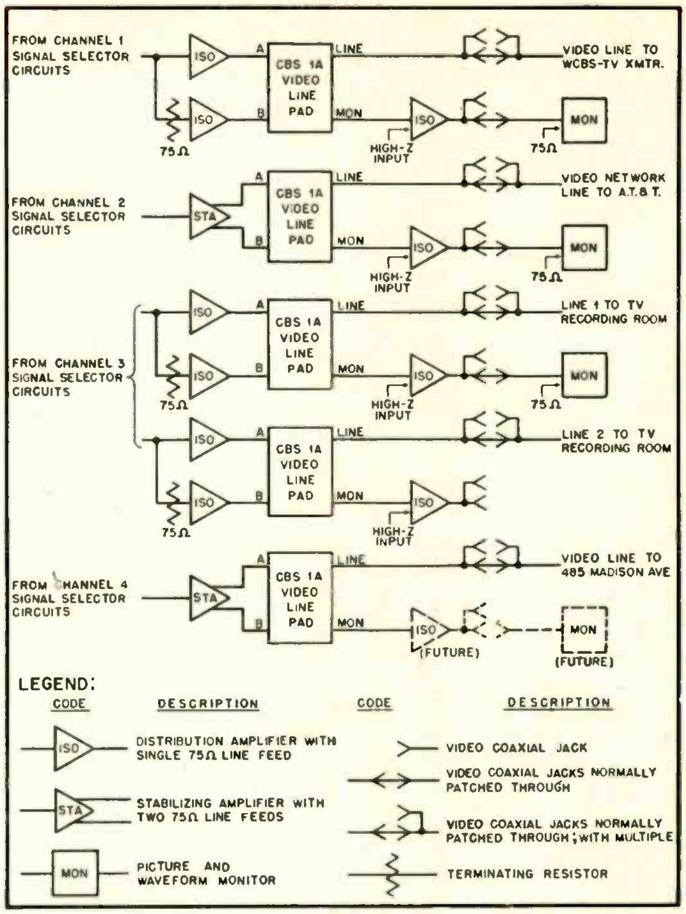


Fig. 6. Line diagram of a portion of the WCBS-TV master control room video facilities showing application of the video line pad. Note that the picture and waveform monitors give positive indication of continuity of signal through all video amplifiers.

Electrical Performance Characteristics

Measurements upon a typical video line pad installation such as shown in *Fig.* 3 have shown that the frequency response to both line and monitor circuits can be made completely uniform up to 7 mc with a drooping characteristic above that frequency. *Figure* 4 shows a typical frequency response curve of the CBS 1-A pad in combination with an RCA type TA-1A Distribution Amplifier. Amplitude linearity characteristics of the distribution-amplifier-pad combination are essentially the same as those of of the distribution amplifier alone.

The output - impedance - versus - frequency characteristic of the pad and distribution amplifier combination is somewhat closer to the nominal 75-ohm value than that of parallel-connected and 75-ohm terminated distribution amplifiers alone. The impedance-frequency characteristics of both combinations are shown in *Fig.* 5.

Application to Video Distribution System Design

The video line pad will prove generally useful as an isolating element wherever it is necessary to provide reliable monitoring of the input signal to any video line. As an example of how it

[*Continued on page V15*]

Practical Television Lighting

C. A. RACKEY

Part II. Concluding the discussion of the fundamental problems which must be considered in the planning of television studios.

In a studio, the most useful light unit supporting structure is a grid of steel pipe, suitably dimensioned and suspended at a height of approximately twelve feet from the floor. This will clear the usual ten-foot flats and will also permit proper vertical travel of extensible fixtures. Other suspension heights may be dictated by lower ceiling heights, with ten feet as a practical minimum. Where studio heights permit, a portion of the grid may be suspended at eighteen to twenty feet to provide for two-story or balcony scenes and the like. Where six feet or more clearance with the ceiling is available, a cat walk above the grid will prove useful in hanging and mechanical and electrical control of fixtures; otherwise all manipulations must be by means of ladders or movable platforms.

A grid forming rectangles four by eight feet is good; four by four feet would be somewhat better and would provide more coverage.

Light bridges, which are made up of two tower or pillar structures connected overhead by a bridging member have been both used and contemplated but have not proven too practical. An adaptation of this idea is the use of two tall pipe standards bridged by a pipe or a light truss member, with light units mounted on the latter. This has proven useful as a relatively portable and demountable affair, where such features have been required.

Chester A. Rackey, Manager of Audio and Video Engineering, National Broadcasting Company.

Mr. Rackey is responsible for design, standardization, construction, and installation of audio and TV equipment, systems, and related physical properties at NBC. He is a senior Member of I.R.E., Governor of A.E.S., Chairman of R.M.A. Committee on Broadcasting Practices, member of R.M.A. Audio Facilities Committee, etc., and is on the Editorial Advisory Board for Video Engineering.

In an actual theatre stage set-up, there is little choice but to use normal staging practice, with lighting hung from battens overhead and from "trees" in the wings. Adequate front lighting should be provided by installing batteries of fixtures around the facia of the first balcony, facing toward the stage.

Electrical Distribution and Control

Proper flexibility of electrical control requires that the circuit from each fixture be available for plug connection (patching) at some central control point. This—assuming that a sufficient number of pre-hung fixtures are available—will reduce operating costs by reducing manpower and time required for set-up and subsequent operating control. Should this expenditure not be feasible at the outset, the facilities should be so planned that future additions toward this end can be accommodated.

The light-control point should be so located within the studio that it will provide reasonably good visibility of the individual sets and, at the same time, some means of communication with the technical and program production staff. At this point a plug board should be installed to make it possible to connect individual or limited groups of fixtures either to dimmers or to switches, or to both.

Modern television lighting practice, especially if dramatic productions are contemplated, requires dimming facilities and several types of dimmers are available for this purpose. The older, resistance plate dimmers, are widely used, but are limited in that the amount of dimming available depends upon their loading. Artificial loading is necessary where the lamps to be dimmed constitute a load which is substantially below the optimum load of a particular plate. So called "electronic" dimmers are much more useful because the load can vary over wide limits within their maximum thermal dissipation capacity. These dimmers are actually not electronic, being tapped or slider-type auto transformers. True electronic dimmers, using thyratrons or other vacuum tube means for load-current control, are available but to the writer's knowledge have not been used in television, being thus far confined to theatrical staging. They show considerable promise for the future, though presently somewhat expensive in first cost.

Some Quantitative Data

A modern television lighting system should be designed to provide a maximum light intensity of 200 foot candles in a horizontal plane, at waist height, over the entire set. In terms of incandescent lighting, this requires, under practical conditions, 40 watts per square foot of horizontal area. The total demand, however, can be reduced by a use factor of 50 per cent since it can be assumed that not more than half the studio area will be in use at any one time. With fluorescent lighting fixtures, the above total can be reduced by a further 50 per cent.

In terms of heat removal, each kilowatt of light in use will require 0.285 tons of refrigeration capacity in an air conditioning system.

Concerning the number of lighting units required, one method of approximation is to divide the total wattage on the set by the average unit rating and add 50 per cent. Another method is to assume that, with controlled-type units, one should be hung at each intersection of a grid of four foot squares over the entire set area. Twenty per cent should be added to this number for other types of units required in addition to the basic overhead lighting. Following the acquisition of an initial supply of units, actual experience thereafter will indicate further quantities and types of fixtures required. As the television business is in

[Continued on page V14]

A Laboratory Television System

RALPH L. HUCABY

The description of an experimental installation which essentially duplicates TV studio and control room facilities for advanced development work.

A TELEVISION SYSTEM for a development laboratory is unique in that it must provide a degree of flexibility not ordinarily needed in a broadcast station installation. We were recently confronted with the problem of designing such a system in the Television Terminal Equipment Laboratories of RCA-Victor. The installation was required to perform three primary functions. First, it was to provide a dependable source of synchronizing and driving puses, video signals—both with and without sync—and other necessary signals, and was to distribute these signals to the various laboratory locations for use in the design and development of television broadcast equipment. Secand, the system was, as far as possible, to take the form of a typical television studio that could be used in demonstrations to prospective customers. As such, it was to include at least one sample of every item of equipment designed in these laboratories, all co-ordinated into an operating system similar to that found in any medium-sized television station. This demonstration function was to be independent and self-contained so as to provide a minimum of interference with the laboratory distribution function. Third, but by no means the least important, the facilities were to provide a means of life testing the equipment since it would be in practically constant use during a forty-hour week. *Figure* 1 shows a simplified block diagram of the system that was developed to fulfill these three requirements. This has now been in use for a year with very good results. Various sections of this functional diagram will be referred to and discussed in the following sections.

Signal Sources

Any laboratory television system must have several dependable picture sources of high quality. The four primary video signal sources may be found at the extreme left of the block diagram in *Fig.* 1. These consist of a studio camera, a film camera, a monoscope camera, and a modified television receiver that produces an "off-the-air" signal. They will be discussed in the order mentioned.

The image orthicon studio camera is located in a small studio (shown in *Fig.* 2), complete with lighting equipment and the other facilities necessary for the production of small television shows. The camera is mounted on a movable dolly which allows the cameraman to adjust the elevation of the camera or to move it about the studio floor to obtain views from different angles and distances. An electronic viewfinder is incorporated in the camera, permitting the cameraman to view the picture being televised. The camera control and monitor are located in the control room in the extreme right console section as shown in *Fig.* 3. The signal source has been very useful—particularly for the presentation of demonstration programs to customers, and for the investigation of new camera circuits and studio lighting techniques.

In order to provide facilities for the investigation of film pickup, a small room is equipped for a film studio. The film camera, employing an iconoscope pickup tube, is located in this studio with the projectors (see *Fig.* 4). A mirror arrangement called a "multiplexer" makes it possible to feed one film camera with any one, or with any combination of three optical images without changing the physical location of either the projectors or the camera. The three picture sources consist of a 35-mm film projector, a 16-mm film projector, and a 2″ × 2″ slide projector for transparencies. The control rack shown in the background of *Fig.* 4 contains a video monitor, a projector control panel, and a power supply for the pulsed light source on the 35-mm projector. The video monitor may be switched by the projectionist from the film-camera output to any one of three predetermined signals for video cueing purposes. The projector control panel provides facilities for remote starting or stopping of either film projector or for effecting an optical changeover between projectors. The slide projector lamp may be turned on or off or its brightness controlled from this panel also. The film-camera control and monitor are in the second console section from the right in *Fig.* 3. These film facilities permit the testing of new ideas and improvements on equipment identical with that in general use. They also make possible experimentation with new film-camera tubes, and provide film pictures for use in demonstration programs for customers.

The third signal source is a monoscope camera which is rack-mounted in the control room. It employs a tube containing a fixed test pattern and provides a signal which may be used to check other equipment for scanning linearity, resolution in both horizontal and vertical directions, and low-frequency phase shift. The fact that this camera delivers a constant signal of fixed amplitude and quality makes it the most-used test signal by the laboratory engineers.

The rack-mounted television receiver shown in *Fig.* 5 forms the final signal source of this television system. It is a standard home receiver that has been modified to provide both video and audio outputs for connection to the picture and sound switching systems. This picture source has been indispensible for demonstrating the capability of the switching facilities to handle programs originating from a remote point as well as those of local origination. It has also been useful to those engineers engaged

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in the design of equipment to handle remote signals that have been subjected to disturbances such as those often encountered in coaxial network or microwave relay transmission.

Switching Systems

To realize maximum flexibility, provisions must be made for quick selection of any signal source for distribution to any given point in the laboratories. For this purpose, three different types of video switching equipment have been incorporated into the design of this layout. *Figure* 1 designates these three as "Studio A" Switching, "Studio B" Switching, and Master Control Switching, all using the various video sources described above. "Studio A" Switching will be discussed first. This is composed of RCA's standard Type TS-20A relay equipment. The switching is done by means of remotely-controlled, rack-mounted relays, and the fades and lap dissolves are effected electronically through the use of a mixing amplifier which is mounted together with the relays and which is also remotely controlled. A Program Director's Console (extreme left of *Fig.* 6) is a part of these facilities and contains three video monitors to assist the technical and program directors in conducting the program. The Technical Director, seated at the left, has at his fingertips all the remote controls for operating the relays and fading amplifier, while the Program Director, seated on the right, has ample desk room for scripts, etc. Both have adequate intercom facilities for talking with all pertinent points in the laboratories.

The rack-mounted relay chassis contains special video relays accommodating six inputs and three outputs. One output is used to feed a preview monitor in the console with which the Directors may preview any of the six inputs prior to using them "on-the-air." Mixing Amplifier 1 (see *Fig.* 1) serves as a sync interlock amplifier by adding local synchronizing pulses to all local video signals but passing any composite remote signals to the monitor without sync addition. The other two outputs are connected to the inputs of Mixing Amplifier 2 which serves as the electronic fade and lap-dissolve amplifier. Its output is in turn fed to Stabilizing Amplifier 1 where any switching transients and low-frequency disturbances are removed, and synchronizing pulses are added to all local video signals before they are routed to Master Control Switching. A monitor output from this amplifier feeds a line monitor in the console so that the directors may observe the outgoing picture at all times. The third console monitor is a spare to be used as the occasion demands.

"Studio B" Switching is less elaborate, but performs the same basic functions as that of "Studio A." Here a Type TS-10A switching equipment (fourth console section from the right in *Fig.* 3) is used and is denoted on the block diagram of *Fig.* 1 as a *manual* switching system. This means that all video signals are brought directly to the switch-

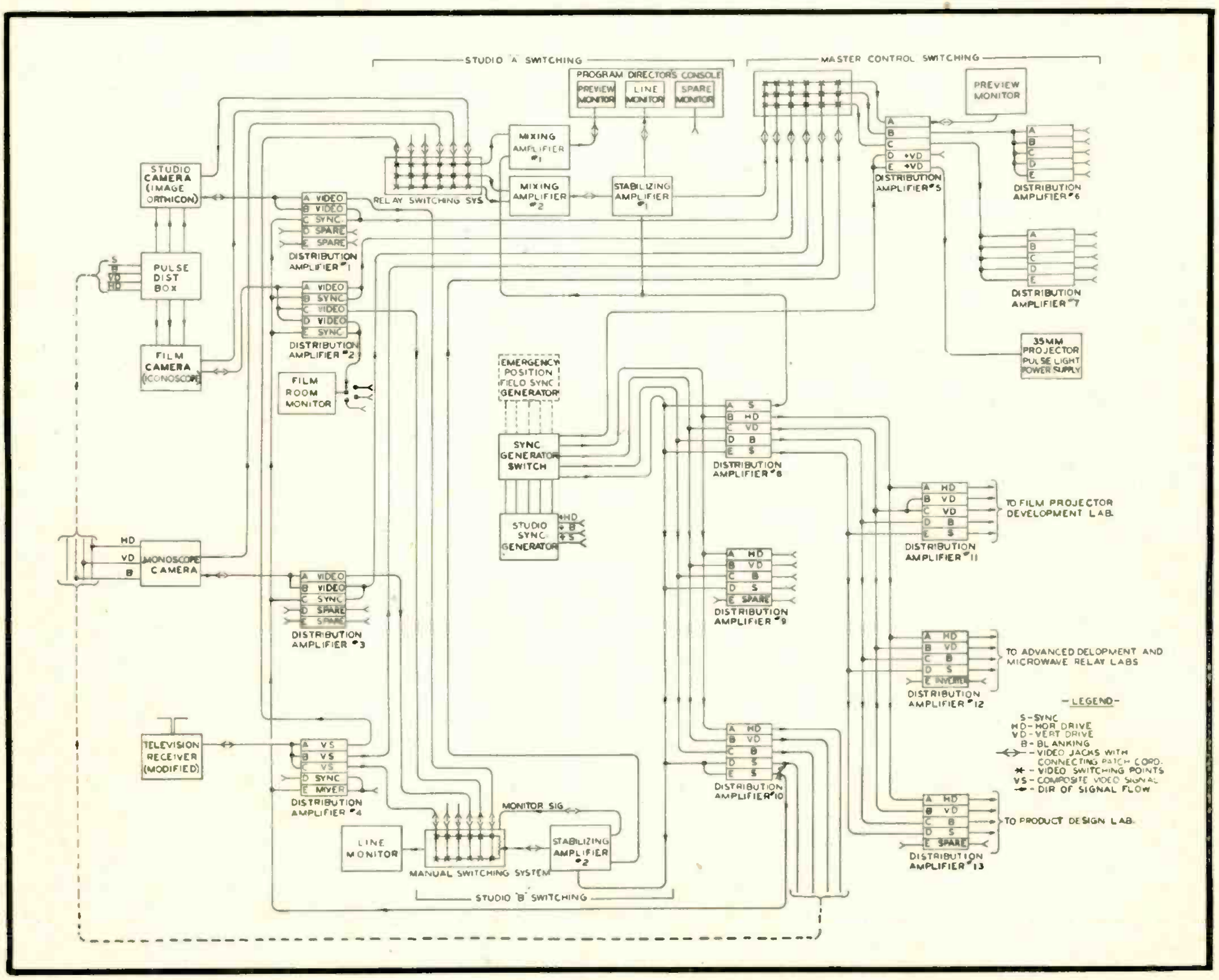

Fig. 1. Functional diagram of video facilities.

Fig. 2 (right). Small studio containing lights, microphone boom, and Image Orthicon camera. Fig. 3 (above). Video console with camera controls, "Studio B" switching, and master switching preview monitor.

ing unit instead of being routed to rack-mounted relays as in the "Studio A" system, and that fades and lap-dissolves are done by means of potentiometers in the video circuits rather than electronically in a mixing amplifier. The TS-10A output is fed to Stabilizing Amplifier 2 which functions in this arrangement as Stabilizing Amplifier 1 does in the "Studio A" system. A monitor output drives a line monitor so that the program director, who also serves as technical director, may have constant check on the outgoing picture. Preview provisions are limited to remote signal inputs only, of which there are two in the TS-10A. Since this switching unit is located where the director may view all local signals on the camera control monitors, it is not necessary to provide preview facilities for them. Intercom circuits are built into this switching equipment enabling the director to talk to all necessary points.

Fig. 4. The author adjusting a slide projector in the projection room. The film camera is at the left, 16-mm projector at the right, and the upper magazine of the 35-mm projector is visible above the film camera.

The Master Control Switching System (Type TS-1A) is a rack-mounted panel with provisions for six inputs and three outputs. Push buttons on the panel permit the manual connection of any input to any or all outputs. This unit is shown directly below the video jack panels in *Fig. 7*. The six inputs consist of the four previously described signal sources plus the outputs of "Studio A" and "Studio B". Of the outputs, one feeds a master-control preview monitor, and the other two feed Distribution Amplifiers 6 and 7 thus providing a total of ten signal outputs that may be routed via the jack panel to the various laboratories through permanent trunk lines. Sections A, B, and C of Distribution Amplifier 5 serve as "buffers" between the TS-1A and its distribution system. Although extremely simple, this master switching system is quite adequate and dependable.

Interconnections Between Signal Sources and Switching Systems

Planning the distribution of the four signal sources to each of the three switching systems presented no special problems, but a discussion is given here to provide a clear understanding of the installation. For an example of the necessary interconnections, refer to the studio camera chain in *Fig.* 1. The studio, film and monoscope cameras have two outputs each; one of these connects directly to the "Studio A" switching equipment. The other terminates at the inputs of sections A and B of Distribution Amplifier 1. The output of section A then goes to the "Studio B" switching facilities. Since only composite signals are fed to Master Control Switching, synchronizing pulses must be added to the camera signal before it is sent to the TS-1A. This is done in sections B and C of Distribution Amplifier 1. Section B carries the video, section C supplies the sync, and the two are mixed to form a composite signal by simply tying these amplifier outputs together. This same interconnection procedure is used with the film camera and monoscope with the exception that an extra sync mixer is used with the film camera to supply a composite signal to the film room monitor switch.

The interconnections used with the "off-the-air" receiver are somewhat simpler. Since this signal is already composite when received, no sync mixing sections are necessary.

The flexibility of this television system has been kept to a maximum by the extensive use of coaxial video jack boards. Equipment failures may be quickly patched out, additional signal sources may be patched in, signals may be re-routed through the system, and

Fig. 5. Operator adjusting rack-mounted television receiver.

Fig. 5. Program director's console at left, with audio consolette and turntables in foreground.

many other unusual situations and requirements are easily met through the medium of the patch panel shown in *Fig. 7*.

Pulse Distribution System

The heart of any television installation is the synchronizing generator and the pulse distribution amplifier. In this layout it was not only necessary to supply pulses to the camera chains, but also to supply them to all laboratories for use in equipment design. The pulses distributed include sync, horizontal drive, vertical drive, blanking, and positive vertical drive—the latter being used to key the power supply for the 35-mm projector pulsed light source. (An improved design of this power supply using negative vertical drive is now available but has not yet been installed in this system.)

The source of these basic pulses is a Type TG-1A Sync Generator which occupies one of the racks shown in *Fig. 5*. A sync generator switch makes it possible to switch instantaneously to another generator which can be connected and operated as a standby. By referring once more to *Fig. 1*, it is fairly easy to trace the pulse routes after they leave the sync generator switch. Due to the rapid accumulation of input capacitance, only a limited number of distribution amplifier sections may be bridged across a given coaxial line without disturbing rise-time or wave-form. For this reason, Distribution Amplifier 8 was included as a "buffer" to isolate from the coaxial lines the input capacitances of Amplifiers 11, 12, and 13 which supply the laboratories with the basic pulses.

Distribution Amplifier 9 supplies the pulse signals to the jack panels so that they may be patched to the various labs to take care of unusual requirements that arise from time to time in development programs. Amplifier 10 provides the pulses that are used by the monoscope, film and studio cameras. Since Section E of this Amplifier performs a special function, it is worth mentioning here. The normal amplitude of the sync signal from the generator is approximately four volts, peak-to-peak. The sync-mixing amplifiers, such as Section C of Amplifier 1, require only 0.5 volts to add to the normal 1.5 volts of video in order to produce the standard 2.0 volts of composite signal fed to Master Switching. Therefore, some means must be utilized to reduce the 4.0 volt signal to 0.5 volt. This was accomplished by placing a variable attenuator at the output of the above mentioned Section E.

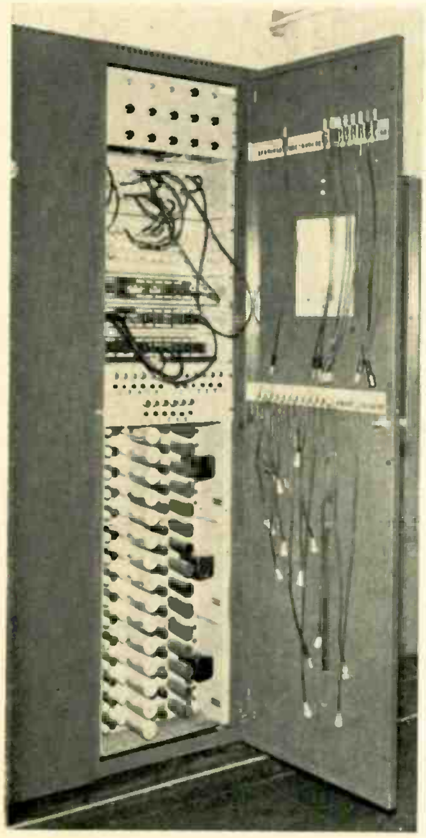

Fig. 7. Video equipment rack with door opened to show jack panels, master control switching, and distribution amplifiers.

Special Considerations

It might be of interest here to explain why so many distribution amplifiers have been used in this system design by giving a brief description of the amplifier and its uses. Each amplifier chassis contains five individual amplifier sections, each of which has unity gain (a small amount of gain variation is possible), high input impedance and an output designed to work into a 75-ohm load. Their characteristics make them especially useful for isolation between a signal source and its load, for bridging a 75-ohm line without upsetting its termination, for providing multiple outputs from a single input, for mixing video and sync to obtain a composite signal, and for increasing a signal amplitude by paralleling two or more amplifier sections. Three of these chassis may be seen at the bottom of the rack shown in *Fig. 7*.

Fig. 8. Audio equipment racks and portable oscilloscope.

In this television system, spare distribution amplifier sections have been brought out to the jack panel for use in meeting special requirements. One section (section E of Amplifier 12) has been modified to serve as a signal inverter for changing the polarity of a video signal from negative to positive, or vice versa—a situation that occasionally arises.

Power Supplies

The five racks of regulated d.c. power supplies necessary to operate this system have been located in a separate room primarily to isolate the heat from the working area of the control room. The d.c. load has been distributed among the power supplies with an eye to maximum efficiency and the ability to shut down certain parts of the system independently without disturbing other parts.

Nine RCA Type WP-33B supplies (600 ma at 280 volts), fourteen Type 580C (400 ma at 280 volts), and three Type TY-25A (300 ma at 280 volts) were used in this installation.

Audio Facilities

The primary objective of this discussion is that of describing the video system, but brief mention should be made of its companion audio system. It was designed by Mr. R. E. Bailey of RCA and embodies most of the latest equipment types and techniques. The facilities are built around a Type 76B Consolette which provides for auditioning, monitoring, switching, and mixing the audio signals associated with this television system. The input signals to the consolette are derived from two turntables, four microphones, two film projectors, a communications receiver, and a television receiver. *Figure* 6 shows the consolette and turntables located between the "Studio A" and "Studio B" video switching consoles to promote close coordination with the program director at either console. The rack-mounted audio equipment may be seen in *Fig.* 8.

The audio system design is quite conventional with one possible exception. Arrangements were made to permit feeding a turntable output into the studio loudspeaker even though a studio microphone is in use. This is useful for providing a low level of music in the studio to aid a vocalist who wishes to sing with the transcription on the turntable. This technique is used occasionally in certain types of programming. No attempt has been made to allow simultaneous switching of both audio and video signals since this presents specialized problems which vary with each installation. The audio facilities are entirely independent of the video and have given excellent results to date.

Conclusion

The system described here has worked very well and has shown itself flexible enough to meet 95 per cent of all the conventional and unconventional situations that can and do arise in a television engineering laboratory. However, some additions and modifications could be made to increase the flexibility, and they are listed here to guide anyone who might have to plan a similar layout.

Experience has indicated that, in addition to feeding the video from each camera chain to each of three switching systems, a fourth output, without sync, appearing at the jack panel would be very useful. A stabilizing amplifier, placed between the "off-the-air" television receiver and distribution amplifier 4, would allow gain, sync stretching,

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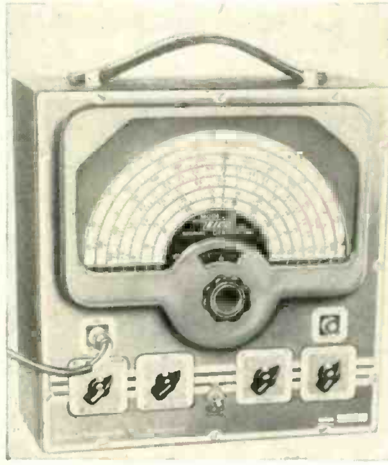
and other adjustments to be made prior to using the signal with any of the switching systems. Another output channel could be added to the relay switching system of "Studio A" and used to make the spare monitor in the Program Director's Console function as a second preview monitor. More spare distribution amplifier sections could be provided as well as more coaxial lines between the control room and the laboratories. Six lines to each lab might be considered as a workable minimum.

Many of these features can, of course, be added in the form of future expansion, but a much neater installation is realized when they are included in the original design.

The writer wishes to express his appreciation to Messrs. W. J. Poch, John H. Roe, H. N. Kozanowski, and Eric Lind of the Radio Corporation of America for their assistance in the preparation of this article.

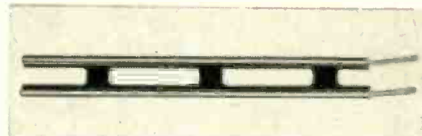
NEW PRODUCTS

● **Signal Generator Kit.** Servicemen and engineers who prefer to build their own test equipment will find interest in the decision of Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y. to release the well-known **EICO** Model 315



r.f. signal generator in kit form. Designated Model 315-K, the unit affords one per cent accuracy on seven ranges covering 75 kc to 150 mc. Internal audio generator provides 400-cps tone for modulation and for external audio testing.

● **Low-Loss Twin-Lead.** Excessive lead-in losses are avoided with Goodline Air-lead, now being manufactured by Don Good, Inc., 1014 Fair Oaks Ave., South



Pasadena, Calif. Loss reduction is the result of using 80 per cent less dielectric than is found in most conventional twin-lead. Samples as well as descriptive material will be supplied by the manufacturer.

● **Television Booster.** Many unique qualities are stressed by the manufacturer in announcing the Tune-O-Matic, a high-gain, self-tuning TV booster with all-channel circuit and four stages of amplification, recently placed on the market by Electro-Voice, Inc., Buchanan,

Mich. In operation the Tune-O-Matic is entirely automatic, requiring no adjustment after installation. All tuning is done by receiver controls. Regulation of gain is by means of receiver **CONTRAST** control. Automatically tuned for all channels the booster supplies extra signal strength uniformly throughout the TV spectrum. Full information will be supplied by the manufacturer.

TV LIGHTING

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a state of expansion it is, generally speaking, practically impossible to have too many light units!

As for dimmers, these usually come in groups of five, arranged for mechanical ganging. Two assemblies (of five each) will be sufficient for the average medium sized studio.

Code Authorities and Safety

Due caution should be used in designing the initial installation, and in the subsequent operation of television lighting systems. The primary hazard is fire from hot lamps or from overloaded circuits. A second important hazard is mechanical—that of having fixtures fall down or of having operational personnel fall off ladders, platforms, and cat walks. A third hazard is the possibility of electrical shock due to improperly insulated or grounded electrical details.

Fire underwriters and local electrical building code authorities should be consulted and followed faithfully, bearing in mind that, in event of accident, violations may endanger the purse or personal liberty of both design and management personnel—in terms of fines or jail sentences—in case they should be found responsible by a court of law.

Economics

The major cost factors of television operation seems to be the salaries paid to technical operations, program production, and talent personnel. Therefore, any means of saving set-up and operating man-hours is a means of increasing efficiency and reducing expenses. This means, in general, that maximum advantage should be taken of any mechanical methods of saving time, specifically such things as ample facilities, and centralization and concentration of controls. It means, further, that every dollar spent on proper and competent initial design and an adequate original installation of facilities, no matter how high the original cost may appear, will save several dollars later on. Make-do is always possible, but must be paid for with time!

ISOLATION NETWORK

[from page V7]

may be applied advantageously to the outgoing video lines of a sizable network originating station, there is shown in *Fig.* 6 a block diagram of a portion of the WCBS-TV master control room facilities. Note that in this arrangement a failure in any program circuit, including the final video line amplifiers themselves, will be indicated positively at the monitor feed point of the pad. This was not true of earlier arrangements where it was necessary to bridge the monitors across the inputs to the video line amplifiers in order to be free of the spurious indications which appear when monitoring across the lines directly.

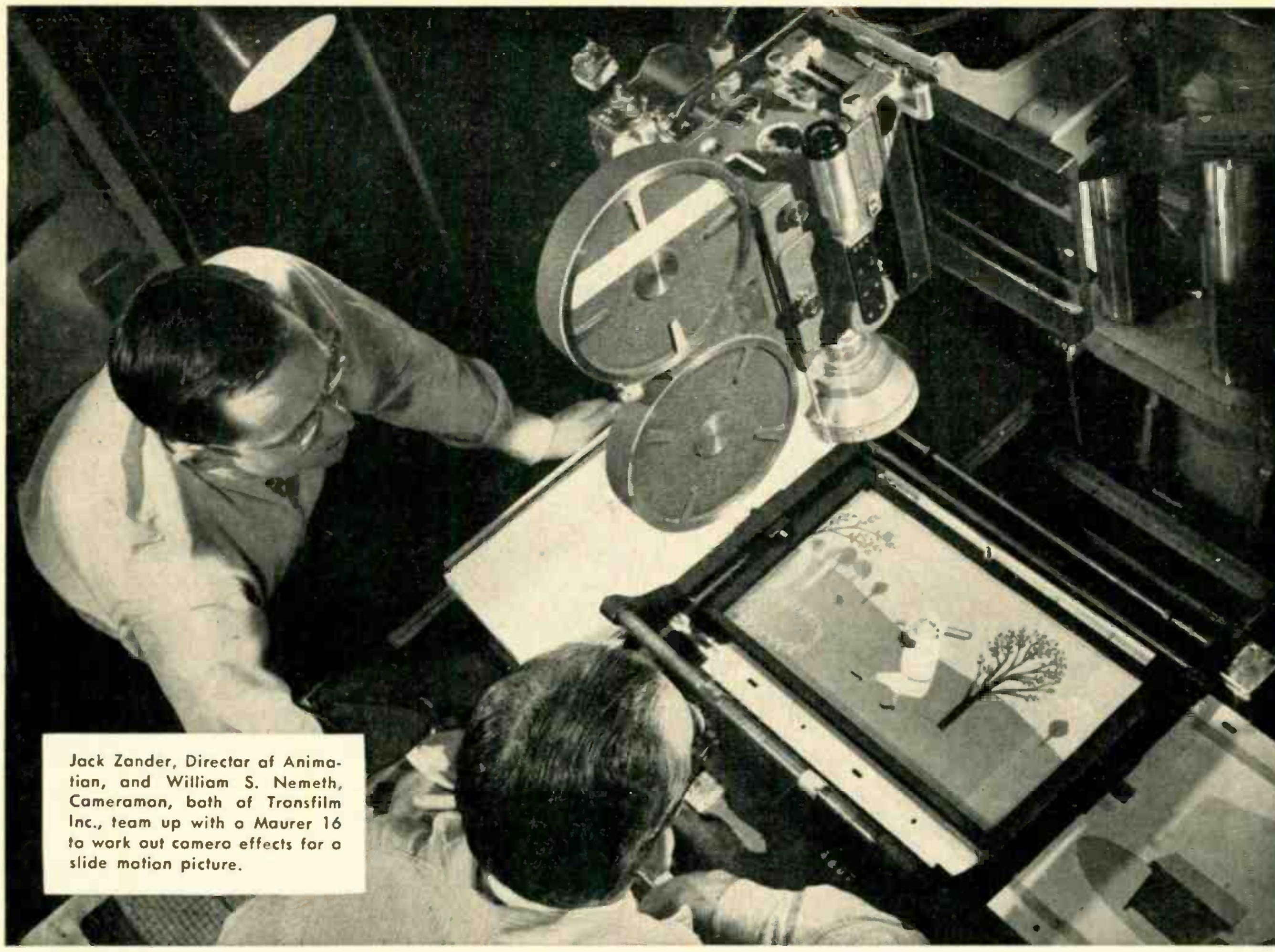
Conclusions

The CBS 1-A Video Line Pad serves as a satisfactory isolating element between a picture and waveform monitor and the video line across which the monitor is bridged. The 14 db of isolation it affords is adequate to permit direct monitoring of the video signal fed to lines which have moderate amounts of hum or other disturbances on them, or which terminate in an impedance which varies greatly with frequency, such as many leased lines. The use of the pad therefore greatly increases the operating reliability of the video distribution system in which it is employed, since it permits monitoring at a point beyond all vacuum tube circuits.

The insertion of the pad between the output of a distribution amplifier and the video line it feeds does not appreciably degrade either the frequency-response, gain or amplitude-linearity characteristics of the distribution amplifier.

The use of the pad and distribution amplifier combination provides an appreciably better-matched source impedance than the previously-used parallel-connected and 75-ohm-terminated distribution amplifiers alone. While *Fig.* 5 indicates that the pad does not simulate an absolutely constant-impedance video signal source at frequencies above 1 megacycle, it is as good or better than that provided by the widely-employed expedient of two parallel-connected distribution amplifier channels shunted with a 75-ohm resistance. Neither arrangement provides a reactance-less, constant-impedance video signal source, but either is apparenty acceptable at the present state of the art. Should a better impedance-frequency characteristic eventually be required, it is possible to improve the performance of the CBS 1-A by the addition of one or more reactive elements to the network.

The development of the CBS 1-A Video Line Pad was carried out under the general direction of Howard A. Chinn, Chief Audio-Video Engineer of the Columbia Broadcasting System.



Jack Zander, Director of Animation, and William S. Nemeth, Cameraman, both of Transfilm Inc., team up with a Maurer 16 to work out camera effects for a slide motion picture.

The Maurer 16 mm., designed specifically for professional use, is equipped with precision high-power focusing and the finest view-finder made. Standard equipment includes: 235° dissolving shutter, automatic fade control, viewfinder, sunshade and filter holder, one 400 foot gear-driven film magazine, a 60-cycle 115-volt synchronous motor, one 8-frame handcrank, power cable and a lightweight carrying case.

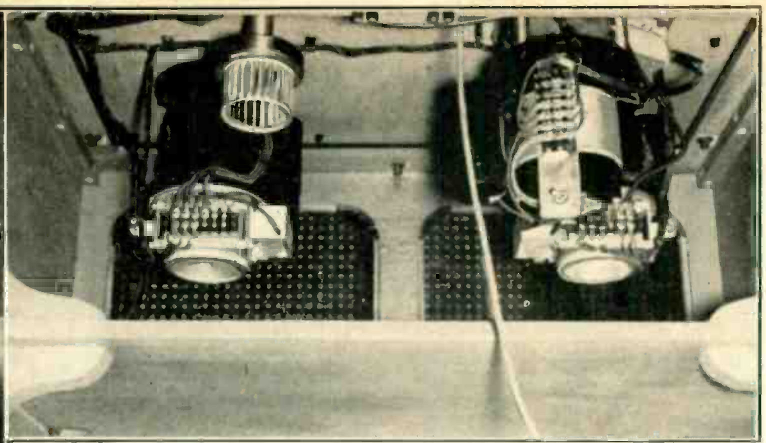


Fig. 1 (left). Top view of professional-type recorder (Ampex). The tape feeds from the loaded supply reel at the left past a tape guide which automatically actuates a motor switch. The control panel is shown below the supply reel, with the magnetic head assembly to its right. The drive capstan and pressure roller are at the right of the head assembly, with the take-up reel above. Fig. 2 (right). Motors and brake-drum assembly of the same machine.

The Art of Tape Recording—V

JOEL TALL*

The author describes methods of maintaining tape-recording equipment so as to produce consistently good recordings both in the studio and in the field.

Broadcast engineers will concede that the proper maintenance of standard broadcast equipment is a chore requiring extensive experience and systematic logical reasoning. When one adds the maintenance of mechanical components, such as are found in tape machines, to that of electronic equipment, the job of the maintenance engineer becomes highly specialized in character. It is the writer's earnest hope that this article will serve, in a necessarily general manner, as a primer in the work of tape machine maintenance.

Whether tape recorders are in continuous service or not, a periodic check should be made of the complete machine at least every 100 hours of use. The operation of the mechanical portions should be tested before and after any necessary greasing and oiling and a speed check made with stroboscopically-marked tape or with a measured length of tape. The brakes should be adjusted, if necessary, relays and switches cleaned as indicated by inspection, and tubes should be tested. After the first rough inspection, the erase and bias currents should be checked against specifications and a noise and distortion test made. If noise tests indicate magnetized heads, they should be demagnetized and the noise and distortion test should be repeated. When this distortion and noise prove satisfactory at 400 cps, a frequency check at the upper limit of the recorder's spectrum should be made in order to check head alignment. Another test, using normal input and output loads, should provide the finishing touch.

* *Columbia Broadcasting System, New York.*

The Tape Drive System

Shown in *Fig.* 1 is a typical drive system. The function of this mechanism is to move the tape at a constant speed past the magnetic heads. Anything that causes any aberration from a constant speed will cause audible "flutter" and "wow," defects which, at the present high stage of tape recorder development, should not be tolerated. Typical "flutter" or "wow" specifications run less than 0.1 percent which cannot be heard by even the most discerning listener.

The basic parts of the modern tape drive system are

1. The capstan
2. The capstan pressure-idler
3. The drive motor

In most modern machines the drive capstan is positioned directly after the head assembly so that the tape is pulled through the assembly at a constant speed. In at least one very well designed machine the tape drive is located between the supply reel and the head assembly, and its action serves to feed the tape at constant speed *into* the head assembly. Then the tape is kept taut by the pull of the take-up motor. Whatever system of drive is used, the maintenance engineer should check for any trouble that would make for any variation from *constant longitudinal travel* on the part of the tape. Any "binding" of the tape will result in vibration-modulated sounds being recorded on the tape, plus the accompanying distortion. A slow variation in speed will cause wow, a fairly rapid variation will cause flutter. Any part of the tape-travel path that introduces vibration *in any plane* should be repaired.

The Drive Motor

Modern professional tape recorders utilize hysteresis motors for the drive system. A properly-designed motor of this type, provided that it has sufficient torque for the job, will maintain constant speed within certain limits. The frequency of the a.c. supply should not vary more than one cycle for best results, and the voltage should be above the minimum specified by the manufacturer. Drive motor speed may vary slightly according to temperature, since the grease in the bearings exerts more friction when cold than when warm. It is, therefore, recommended that speed checks be made at normal operating temperatures.

The drive capstan and pressure idler assembly should be checked to make sure it is perpendicular to the tape. If it is out of order in this respect, the tape will try to travel up or down on the capstan, a condition which will be immediately apparent to the operator. The pressure-idler should be checked for proper pressure against the capstan when in operating position. The pressure

[*Continued on page 42*]

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Automatic Audio Gain Controls

J. L. HATHAWAY*

A discussion of the development and application of program-controlled circuits in broadcasting, with a description of a general-purpose AAGC amplifier in regular use.

The purpose of this paper is to cover briefly the history of Automatic Audio Gain Controls at the National Broadcasting Company. With this equipment line levels may be held more constant, the average level increased many fold, and the listening public—both radio and television—subjected less to sudden drastic changes of sound volume. The new automatic control incorporates a number of improved features as compared to those which are currently employed for adjusting gain as a function of program level, thereby eliminating undue volume fluctuations. Such control equipments are not only called Automatic Audio Gain Controls, or AAGC's but compressors, limiters, program regulators, and a number of other descriptive names, some complimentary and some uncomplimentary. Improper maintenance or operation, as well as unsuitable design, accounts for most of those in the latter category, but judging from the fact that there are in the United States thousands of units giving satisfactory daily service, it is obvious that results are generally well worth while. Even in the field of television, sound transmission is greatly improved through the use of a good AAGC, such as the new Type ND-333.

Early Experiments

Laboratory development of Automatic Audio Gain Control systems has been underway off and on for twenty years, sometimes directed toward solving particular operating problems and other times emphasizing control system improvements. Some of the units developed are relatively complex, while others are extremely simple, such as that shown on *Fig.* 1. Here a small tungsten filament lamp was connected in a low-impedance circuit so that its resistance variation caused over-all changes of attenuation. Such a tungsten bulb changes resistance by more than 10 to 1, hot to cold, implying a possible attenuation change as great as 20 db. This arrangement *should* be highly effective when preceded by an amplifier of sufficient gain and power handling capacity to heat the filament on program peaks to at least a dull glow. However, its usefulness is restricted by poor timing characteristics. An ordinary small filament has similar heating and cooling thermal lags, and timing determined by these lags has been found completely unsatisfactory for good control. Because heating is *too slow*, around 125 milliseconds, high-level spurts of program are allowed to pass unattenuated and are readily heard. Because cooling is *too fast*, certain desirable program level fluctuations, such as those occurring in speech, are reduced or removed almost completely.

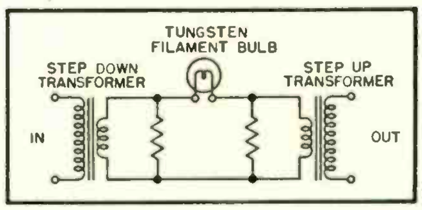


Fig. 1. Earliest form of simple AAGC used in 1929.

During early experimental work, without known prior art, the importance of utilizing extremely dissimilar gain reduction and gain recovery times was not appreciated. Then in 1934 a circuit was tried having a gain reduction or "attack" time of around 10 milliseconds, together with a recovery time of slightly over one second. After only a short period of careful listening, it was obvious that this combination was superior to anything previously tested, and in fact that first breadbroad setup did a worth while job of controlling gain. Various attack and recovery times were then tried with engineers acting as guinea pigs. When the attack time was greater than about 30 milliseconds, short bursts of high-level peaks were audible, and the over-all effect was not as pleasing as with attack times below 10 milliseconds. In going below 10 milliseconds, there was no appreciable change in over-all effect until the attack time was made less than 200 microseconds. With such a short attack time, the sound quality was the same as that for a time of around 1 millisecond, but on programs of local origin the level was appreciably lower due to extreme crests of high-frequency peaks causing greater gain reduction. The *recovery* time most desirable seemed a matter of properly fitting the particular application. Where greatest possible average level was desirable, rapid recovery—around 1/3 second—seemed best. Where least noticeable effect by the automatic action was called for, a recovery time somewhat greater than 1 second seemed preferable.

Early Application

Shortly after the initial experimentation on time constants, a number of rack mounted units were constructed and placed in service in New York, Cleveland, and Chicago. Some of these served to regulate levels in automatic announce booths whereby news flashes could be placed on the air without waiting for control engineers to reach the studios. Others were for use on regular studio or field pickup progams to aid and supplement the control engineer's efforts in feeding proper level onto the telephone lines. Also a portable unit was used with great effectiveness in the gondola of the stratosphere balloon during its record-breaking flight in 1935, and by the following year we were getting

* *National Broadcasting Company, New York.*

Automatic Audio Gain Control systems into our special events beermug and pack transmitter designs. Since then, more or less hand-tailored controls have been employed in a wide variety of applications, including television sound and broadcast transmitters, disc recorders, tape recorders, film recorders, and field and studio amplifiers. Many of these units have different charactetristics, sometimes because of the nature of the application, and sometimes because of the difficulties involved in building circuits with optimum characteristics in portable equipment.

Characteristics and Measurements

Many characteristics of Automatic Audio Gain Control—such as frequency response, input and output impedance, signal-to-noise ratio, and harmonic distortion—are similar to those of ordinary amplifiers. It is essential in the measurement of some of these either to block out the control circuit or else to employ a signal level which is safely below the threshold of control. Measurements of recovery and attack times require radically different technique. Recovery time may be determined by watching a VU meter connected to the output of the unit under test and measuring time for it to reach steady state reading after suddenly reducing to normal a tone signal which has been 10 to 20 db above normal. Attack time is readily determined by means of an oscilloscope, preferably one equipped with a P7 screen and a triggered single-sweep circuit. Here, the scope is connected to the output of the Automatic Audio Gain Control and tone applied to the input at just under threshold level. This level is suddenly increased (usually by 6 to 20 db), and the scope displays the over-all effect. *Figure* 2 is a drawing made from typical oscilloscope patterns, (A) showing a good AAGC in proper adjustment, and (B) showing either a good one far out of adjustment or a poor one even at its best adjustment. The drawings show tone applied at just under threshold control level, followed at time 0 milliseconds by a 12 db increase. At (A), perfect balance results in complete cancellation of all "thump" or "plop" component, the signal being symmetrical about the axis. After about 1 millisecond, complete stability is reached at a level some 2 db above that at the start. (B) illustrates a condition of misbalance, the dotted line average representing a severe plop component above the axis and lasting for many milliseconds. A plop of this magnitude is readily audible and has a secondary effect—also audible—of depressing the gain to a subnormal level because of the excessive control potential caused by the misbalance. Thus, for a large fraction of a second, depending upon the recovery time, the *high*-level input peak has actually caused a *low*-level output. Complete stability should be reached within the recovery time, although this is not shown in the figure.

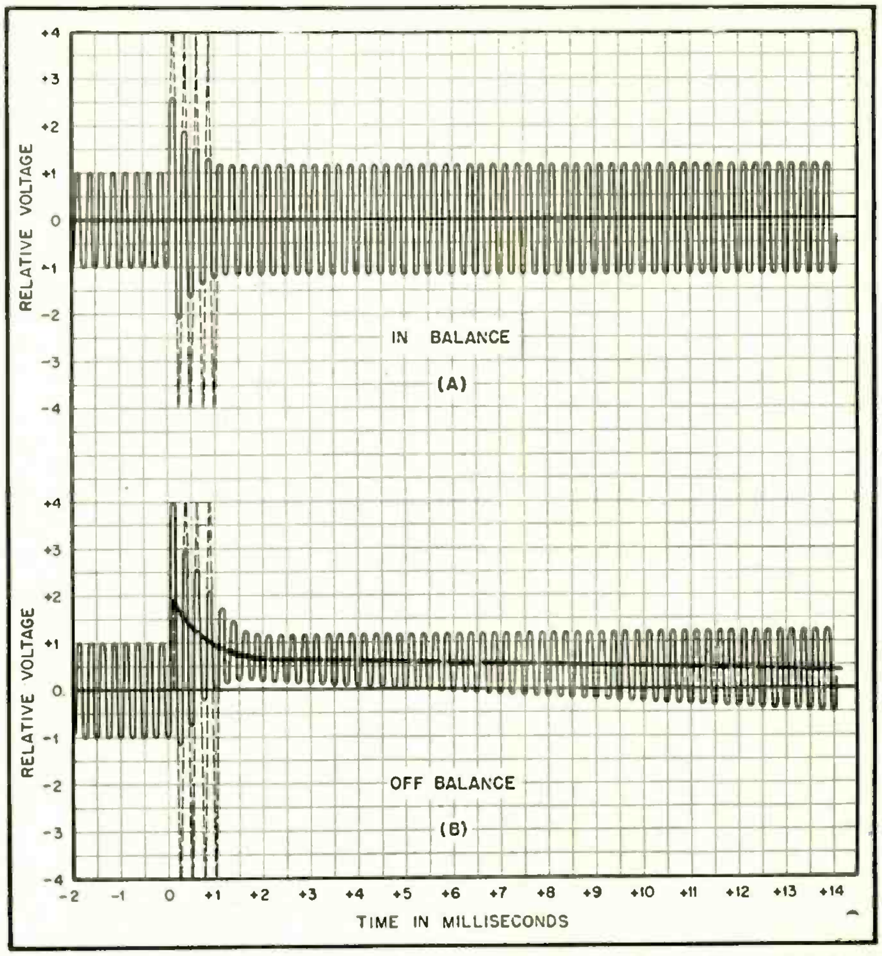


Fig. 2. Drawing made from typical 'scope patterns to show effect of "plop" generation. (A) shows signal passing through well-balanced amplifier as a result of an increase in level of 12 lb. (B) shows same signal passing through a poorly balanced amplifier, resulting in an average value differing from the axis, or zero.

Unbalances of push-pull tubes or circuit components are responsible for plop generation. Its seriousness in relation to program is obviously a function of program level at the controlling tubes. Thus a given misbalance with low program level might be quite objectionable, whereas it would be completely insignificant if the tubes were operated at higher program level. Therefore, in good AAGC design, with given tube parameters, the program level at the threshold of control must be as high as possible in order to minimize plop. At the same time, it cannot be excessive, since harmonic distortion becomes equally objectionable.

Control Characteristic

"Control Characteristic" refers to the effectiveness of an Automatic Audio Gain Control in reducing excessive level variations assuming no undue wave form distortion or plop generation. *Figure* 3 illustrates three different types of control characteristics. Where complete high-level limitation is called for, as at a broadcast transmitter, it is desirable to utilize a so-called "limiter" characteristic, curve 3. Something less drastic, such as the modified limiter of curve 1, should be employed as a supplementary aid to a control operator, and the unit should, in this application, be located in the circuit following the manual controls, but preceding the volume indicator and loudspeaker so that the operator sees and hears the combination of both manual and automatic control. For operatic and symphonic programs intended for music lovers, the control effect should be much less, as in the so-called "Compressor" characteristic of curve 2.

Amount of Gain Reduction

A common question related to Automatic Audio Gain Control application is "How much gain reduction?" This is

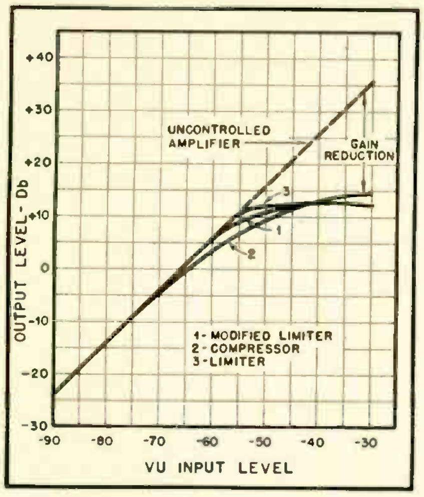


Fig. 3. Typical control characteristics obtained in various forms of automatic amplifier circuits.

not a simple question and a simple reply is too incomplete, some applications calling for greater gain reduction than others. For example, where no manual control is exerted, the extreme input variations can at times account for as much as 20 db of gain reduction. Controls at broadcasting transmitters are not normally subjected to such extreme variations, since manual control has been previously exerted, but even so, surprisingly large variations do exist, as a result of different control operators, different types of programs, and different amounts of telephone lines. This was pointed out two years ago in data taken to chart these variations at our N. Y. broadcasting station. With all adjustments fixed, the number of gain reduction peaks and their amplitudes were counted by a two-man team for several ten-minute periods throughout the day and evening and the results tabulated. Three of these periods are charted on *Fig*. 4. Two of them depict extremes and show a surprising difference, the one from Hollywood obviously having passed through a long-peak-ironer before arriving in N. Y. This ironer was more effective some days than others, but generally functioned in dual manner. First it slightly compressed all extremely high levels at each of many repeaters. Second, it eliminated all frequencies above 5 kc, thus accounting for much of the difference between average and peak potentials.

Use With Pre-emphasis

The use of Automatic Audio Gain Control in disc recording circuits has been found highly advantageous because it permits increased level with corresponding improvement in signal-to-noise ratio and at the same time provides for greater reliability. Where the NAB recording characteristic is utilized, a rather special condition results, calling for a special control. In recording with this characteristic, high frequencies are electrically pre-emphasized by a circuit of 100 microseconds time constant, meaning about a 10-db rise at 5 kc and a 16-db rise at 10 kc. If the automatic control is located in the circuit after pre-emphasis, all peaks, including those occasionally caused by extreme high frequencies, are eliminated, which might seem desirable. However, listening tests indicate that this is far from desirable because the program gain control becomes highly unsatisfactory whenever extreme highs exist. This is caused by the level ducking unpredictably during some of the highest passages at the very time the ear expects greatest level. That is, the medium-frequency components which largely determine loudness are suddenly depressed just when they should be the strongest. This condition does not prevail if the Automatic Control is operated prior to pre-emphasis in the circuit. In *this* situation a different degradaton occurs in the form of occasional high-frequency cross modulation due to overloading by the pre-emphasized components, especially so because of the usual high-frequency recording and reproducing troubles. There is no general rule as to which is the lesser of these two evils, since each leads to degraded sound reproduction. However, tests and usage over many years have shown that a midway condition is entirely satisfactory. For such an arrangement the Automatic Audio Gain Control may be located either ahead of or following the pre-emphasis, whichever is the more convenient. If *ahead*, the amplifier within the AAGC unit feeding potential to the rectifier should be "half way" pre-emphasized. If *following*, the rectifier-amplifier should be de-emphasized "half-way," or about 8 db at 10 kc. This latter arrangement works out very easily in most cases through the use of a single small capacitor shunting the side amplifier or rectifier feed circuit.

To be concluded next month

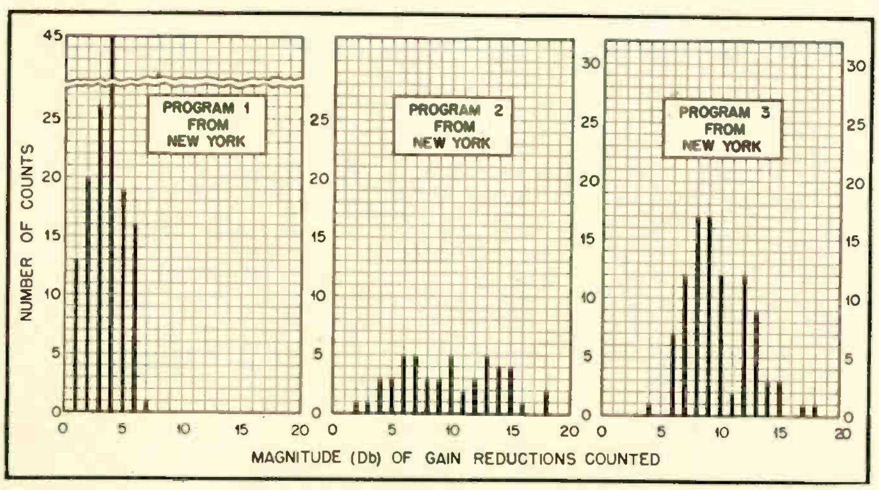


Fig. 4. Actual counts of gain reduction peaks occurring in programs from different sources.

BALTIMORE GROUP TO MEET SEPT. 6

The Baltimore Audio Engineering Association will meet on September 6 at 8:00 p.m. in the Academy Room of the Emerson Hotel. The main feature of the evening will be a lecture and demonstration by Melvin C. Sprinkle, sponsored jointly by the Peerless Electrical Products division of Altec Lansing Corporation and the Wholesale Radio Parts Co., Baltimore jobbers.

Employment Register

POSITIONS OPEN and AVAILABLE PERSONNEL may be listed here at no charge to industry or to members of the Society. For insertion in this column, brief announcements should be in the hands of the Secretary, Audio Engineering Society, Box F, Oceanside, N. Y., before the fifth of the month preceding the date of issue.

- **Audio Technician.** Employed in audio field at present; experienced in development and construction. Enthusiastic, good troubleshooter and maintenance man; wide knowledge of serious music. Desire position in studio, lab, or custom installation firm. Box 801.
- **Audio, TV Field Engineer.** 10 yrs practical experience in maintenance of professional audio, TV, and radar equipment; design and maintenance custom home music systems. Member AES; Assoc AIEE. Good tech. educ. bkgnd; exc. references; exp. customer relations; extremely conscientious. Presently mgr. TV service lab and field service technician, electronic organs: Desire field work hi-fi audio or TV. Prefer Washington, D. C. area; consider other. Box 701.

Harvey Radio Company's Audio-Torium establishes new approach in demonstration and sale of audio equipment.

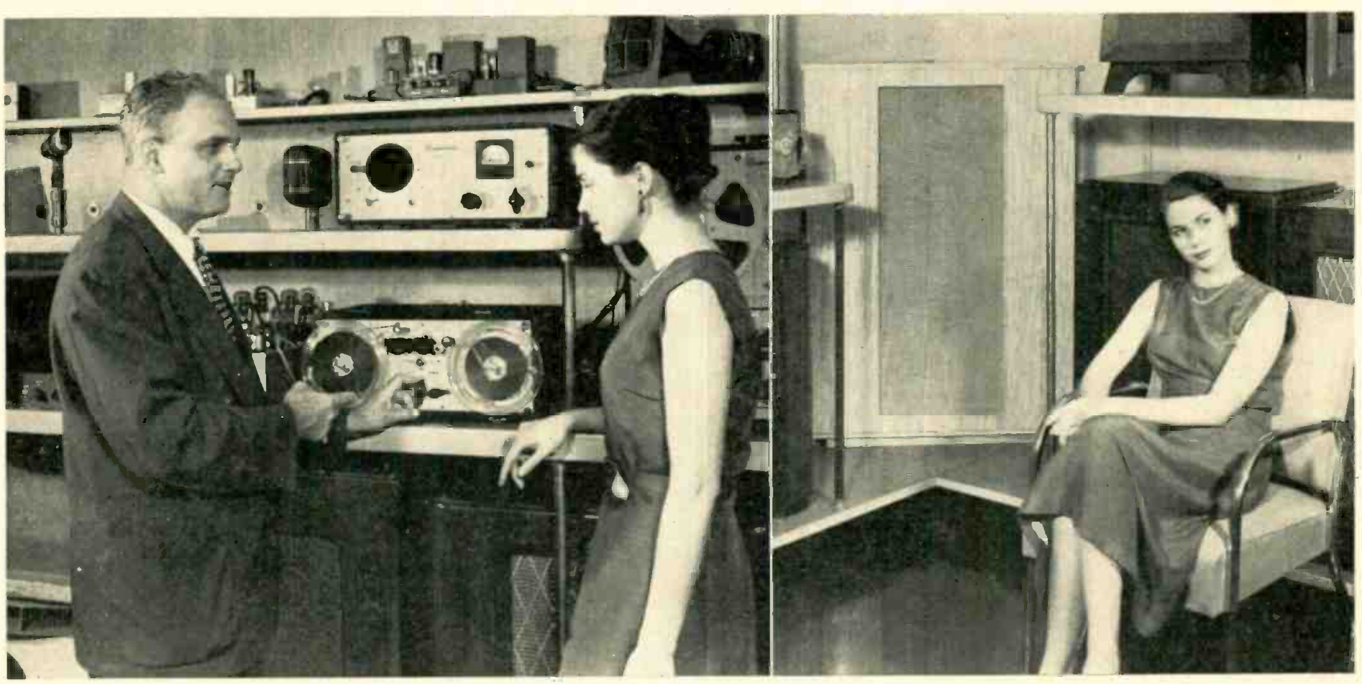
New, Advanced Sound Department

GREATLY EXPANDED INTEREST on the part of the general public in the field of audio equipment has established it as the country's fastest growing hobby. No longer are high-quality amplifiers, pickups, tuners, recorders, and speakers limited in their appeal to professional engineers. Persons in all stations of life have come to realize that a fine audio system is well within the realm of both their abilities and their pocketbooks, and that only through possession of such a system can they indulge in one of life's more rewarding experiences—fine music reproduced in their own homes with the verve of the original live performance.

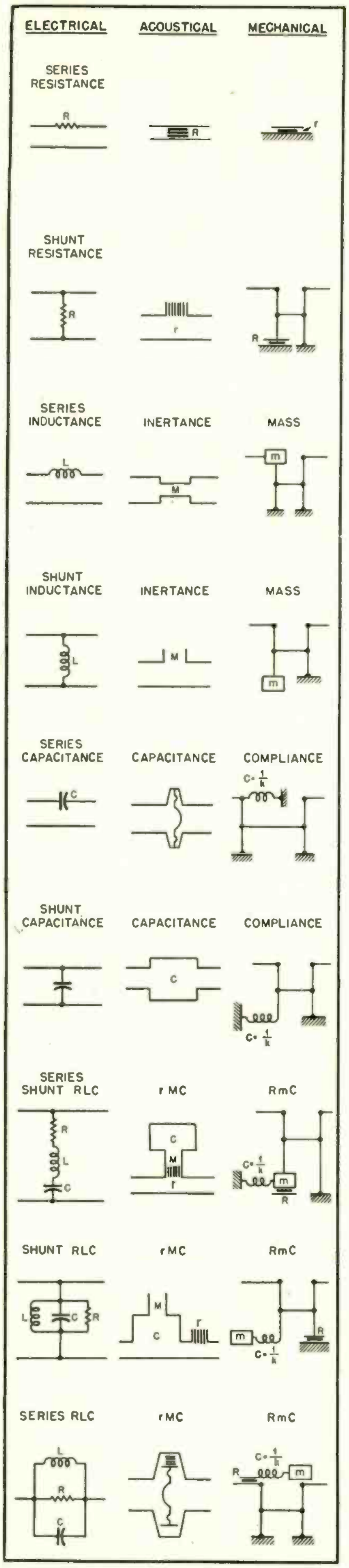
Yes, audio and the public have arrived, but this is more than can be said about many jobbers and dealers in sound equipment. True, there is a small number of far-sighted dealers who recognize today's growing demand for audio components as but the forerunner of a business whose volume will be limited only by the effort expanded in its development, but it must be painfully admitted that this group represents a small minority. Most equipment dealers are still operating in the horse-and buggy days—those days when a customer who expressed interest in any item other than a stock-model radio receiver was immediately classed as a ham or an engineer and given the full treatment that frequently goes with such distinction—demonstration of audio equipment bailing-wired together in a room with good solid-plaster walls and concrete floor, the dealer basking all the while in the knowledge that the poor bewildered soul was perfectly capable of allowing for all these shortcomings in his efforts to evaluate the equipment's performance.

Fortunately, this description of demonstration procedure is more poetry than truth, but the fact remains that relatively few dealers are equipped to demonstrate and merchandise audio equipment as it should be done. Such a situation reaches the height of paradox when plotted against the realization that, television excepted, audio components represent the most rapidly ex-

[*Continued on page 28*]



Harvey Sampson, president of Harvey Radio Company, Inc. explains features of Magnecord tape recorder to Miss Luci Turner, Production Manager of Æ. Right, Miss Turner evaluates sound reproduction from Lansing corner speaker.



AUDIANA

Dynamical Analogies

LEWIS S. GOODFRIEND

In designing and studying electromechanical and electro-acoustical equipment, the ability to reduce the entire system to a common basis facilitates mathematical analysis. The common basis lies in the use of dynamical analogies, in which the equations for each system may be shown to be mathematically identical. This enables engineers to draw an electrical schematic for any mechanical or acoustical system and solve the equations for the electrical system which will give the answers for the original system. These methods often speed analysis far faster than cut-and-try or physical measurement methods. It is also possible to build all-electronic models based on the analogies and apply input voltages to the system. The voltages at other points will then give all the unknown values. This is equivalent to measuring the pressure in an acoustical system or the force in a mechanical system to determine the unknowns.

In the early days of radio it was common to draw analogies between electronic systems and water pressure systems. The radio art soon outgrew this method, and today there are few engineers working with audio or radio who cannot handle electronic circuits with greater ease than mechanical or acoustical circuits. Therefore it is convenient to use a method whereby we may determine from the physical system its electrical equivalent.

To this end, Hanle, Firestone, and Olson have developed different but equally effective analogies between the three systems. Without any reflection on the merits of the other methods, the analogies derived by Olson will be used here. The Firestone analogies are discussed in an article on horn loudspeakers in the January, 1950, issue of Audio Engineering.

Comparisons

To establish the validity of the analogies, it is only necessary to compare a few equations from electronics and mechanics. The simplest are for the dis-

[*Continued on page 46*]

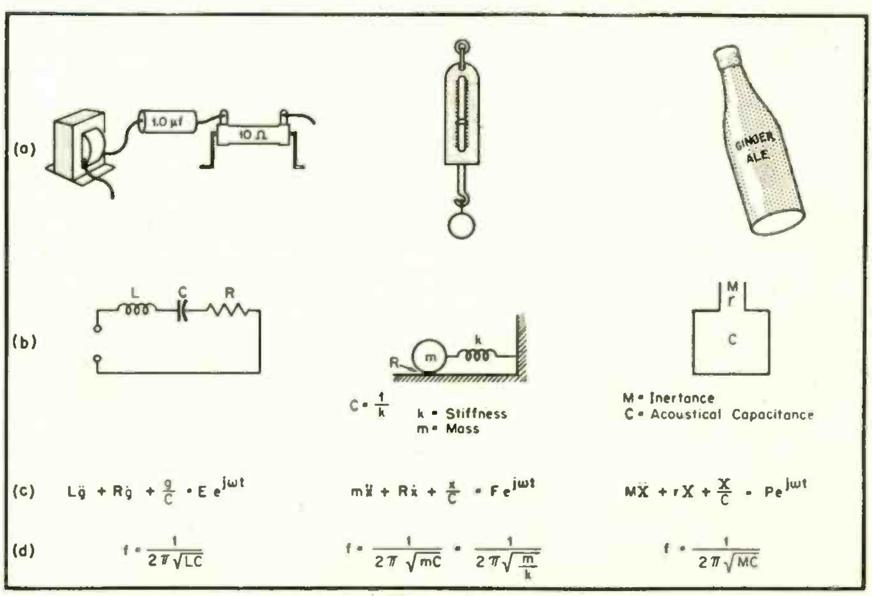


Figure 1.

Jensen presents... G-610 TRIAXIAL

a NEW loudspeaker which for the *first time* spans the full frequency range of the ear!

A new, skillfully integrated combination of three independently-driven units . . . two compression driver and horn combinations, plus heavy-duty direct radiator . . . with 3-channel electrical crossover and control network . . . achieving the widest frequency range and finest reproduction ever attained!

Write for Data Sheets 160 and 152 which describe the G-610 and other Genuine Jensen Wide Range Speakers.

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EDWARD TATNALL CANBY*

Professional Recording

CONTINUING THE DISCUSSION of tape recording which ended quite abruptly in last month's column, the statement was made that there are two major fields in which tape machines incorporating improved efficiency of reproduction (at the lower-than-normal speed [for highest quality] of 7½ inches per second which is claimed by at least one manufacturer—Ampex) may be expected to operate.

The first of these fields is the professional, and in this field the new development poses some extremely interesting questions. Professional recording is now set up on what appears to be a fairly rigid basis as to speeds: the 15-in. speed is standard, the 7½ and 30 are secondary standards. Though equalizations are yet to be made uniform, and other specifications are only roughly uniform as to tolerance, the 15-in. speed has made such enormous progress that nothing less than a major change in the tape process could now change it. Suppose, then, it proves indeed true that Ampex and/or others can produce 15 quality at 7½? Or even approximate it? Is this a major change, and will the standard 15 speed be affected in the professional industry? Your guess is equal to mine; but note some very pertinent factors.

There is without any doubt much professional recording that could be done, at a saving of vast amounts of tape, with standards perhaps somewhat lower than the present 15 quality—recording that falls in-between the 15 and 7½ present categories. The present 7½ response, is generally limited to around 8000 cps, is simply not good enough; whereas the full, wide-range response of the faster may well give an "excess" of quality, in relation to tape costs.

If, then, at the slower speed a quality *almost* equal to present fast-speed work is available, the savings in tape might be worth it in a decidedly large number of cases. Needless to say, the extent of such a changeover to the slower speed would depend upon rather complex relations between tape costs and other costs, since in many cases the tape footage is actually a rather minor item of expense in a large operation. It would be rash to attempt to prophesy one way or the other. Very possibly the greater tape efficiency may not appeal at all to most tape users—but then, there is always that persistent feeling, to be heavily reckoned with, that if there is a more efficient machine, then a less efficient one will not do!

There is one more factor, however—the increased difficulty of editing tape at the slower speeds. Edited tape today accounts for a huge footage, in almost every area of professional tape use, radio, records, and all the rest. Editing at 15 is not too easy, but at 7½ it is decidedly more difficult. Depends, of course, on the kind of editing you do, and on the required accuracy. But to remove a single syllable or an *s* at the slow speed is bound to be more tricky than at the fast. In big business—radio especially—the ease of editing is of utmost importance, and it can hardly be imagined that a mere saving of millions of feet of tape would be an incentive to louse up the vital chopping and patching function!

Unless Ampex has patents that would prevent it (and here I have no information whatsoever), there can be no doubt that other manufacturers will be forced to make at least some modification in their present machines to bring them into line—if only because of the unpleasant look on paper of a set of specs that seems to offer only half of another company's offer. I would guess that in the next few years the narrower gap width will be made use of to varying degrees in order to improve performance at 7½ in., even in those machines which continue to use the 15–7½ combination. (The improvement at 15 would, of course, be less important or not important at all, since standards are already high, and other factors—such as wow and flutter—would be just as vital.) Barring unforeseen developments, the narrow gap might seem impractical in cheap home-style machines because of cost of manufacture; its main importance should be in the higher quality professional and semi-professional offerings.

"Hi-fi" Home Recording

How about non-professional tape recording? Here, it would seem, the new development may be of very great importance, and principally because the presently announced recorder aims fairly close to a large potential home market for tape re-

[*Continued on page 24*]

* *279 West 4th Street, New York 14, N. Y.*

Pops

RUDO S. GLOBUS*

I HAVE RECENTLY RECEIVED a number of letters requesting, in one way or another, that I dwell on the relationship between jazz and serious music. One in particular pointed up my "chamber music" analogy and called for an extension of the same. Fortunately, all this coincided with a reading of a new biography of Jelly Roll Morton by Alan Lomax (Mister Jelly Roll; Duell, Sloan & Pearce, $3.50). Jelly Roll, pianist composer of such things as the King Porter Stomp, Jelly Roll Blues, Alabama Bound, has been revered as a jazz great by a small, select elite. The biography will enlarge the group and will supply one of the most accurate treatments of the jazz myth. What is important to us is not so much the social character of one major jazz musician, but the specific factors which led to the emergence of jazz in this country as a legitimate art form. For supplementary reading in connection with the ideas of this column and as a magnificent entré into the world of jazz, Mister Jelly Roll is highly recommended.

Some ten years ago, a more or less important jazz critic rendered the opinion that an analogy might be made between jazz and the so-called early history of classical music. He went so far as to maintain that jazz was an infant art form which might be compared to the so-called infancy of classical music as manifested by Bach, Mozart, and Haydn. This precarious and highly imaginative conception leaks at the seams. To begin with, it is the height of audacity to refer to Bach, Mozart, and Haydn as primitives. They appear at one of the most highly sophisticated moments of musical history and are basically the culmination of the slow, laborious development throughout the middle ages. It is also ridiculous to refer to jazz, especially in terms of its development in the 20's and 30's as primitive. It, too, represents an equally sophisticated emergence out of the

[*Continued on page 40*]

* *960 Park Ave., New York 28, N. Y.*

RECORD REVUE

[*from page 22*]

corders—machines that will give, as the small home machines do not, a quality equivalent to that obtainable in the separate-unit phonograph systems now so widely available.

The new unit is perhaps too expensive for all but the fanciest "hi-fi" home installations. And yet it is attractive as no other machine has been. In home tape recording (and in many types of semi-professional and educational recording too) the cost of tape is a major factor. On the other hand, the problem of tape editing, so vital in professional work, is often non-existent in home recording and is seldom of great importance. Thus a machine—Ampex or any other make—which can offer, in the economical, non-editable, twin-track form real "high-fidelity" recording at slow speed is obviously of great significance. A 1200-foot reel of tape on this type of machine will play for a solid hour at 7½—in contrast to the fifteen minutes of hi-fi tape now available on the semi-professional machines. And, for reasonable quality—plenty good enough for all but the super-duper hi-fi fan—the performance at 3¾, giving *two* solid hours of music per 1200-foot reel, with tonal range to 9000 cps, is fabulous!

It is perhaps no accident, then, that the new type of recorder is designed on the double-track basis. The reasoning must be, we can gather, that the professional field is not expected to be the direct concern of the first models, at least, in this new line. Double track recording emphasizes extreme economy of tape, but precludes editing. If the narrow gap construction can be adapted to a simpler, cheaper machine to sell, perhaps, in the $500 range or lower, the entire quality home recording field will be revolutionized—or, shall we say, opened up; for at present a few Magnecorders, Prestos, and Concertones in the hands of relatively few private individuals constitute the extent of "high fidelity" home tape recording.

Tape Records?

One more speculation. Might not this development in economy change the picture as to the possibility of commercial pre-recorded tape? Yes—without any doubt at all, if other factors are favorable.

Rumors of pre-recorded tape "records" have been floating about now for a long time, and so far all to no avail. As LP recording has mushroomed, it has been fairly clear that tape records were becoming for the moment less and less likely. Too many unfavorable factors, among them the high cost of tape itself. Tape records could not easily compete in any mass market with discs for other even better reasons however. Mass tape would have to be in some cartridge or self-threading form, ultra-foolproof, and this in itself is a major obstacle. Tape is clumsy to use at best, must be rewound somehow, or if twin-track, played all the way through. Spotting of particular places, or even of movements or numbers, is difficult. It would require some very special argument right now to persuade anyone to buy a tape player and a library of pre-recorded tape, except perhaps in a limited, hi-fi area.

But again, don't underestimate the weight of the new development right here. If we can have 9000 cps out of tape at 3¾ in. per sec., we have an extraordinarily cheap medium and, moreover, a medium highly economical of space. Similarly for the wide-range 7½ in. speed. It is for industry to figure out the right combination—but, if not in mass-production "pops" records, then pre-

SOUND RECORDING

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STOCK NUMBER	DESCRIPTION	600 ft. REEL	1200 ft. REEL	2400 ft. NAB 10½"
211RPA	GREEN-BAND (plastic base) Sensitive LONG LIFE. "SOFTERIZED"	3.50	5.50	11.00
211BPA	GREEN-BAND (plastic base) BLACK OXIDE	3.50	5.50	11.00
205RPA	YELLOW-BAND (plastic base) UTILITY-STANDARD for general purpose, professional use	2.75	4.50	9.00
205RKA	YELLOW-BAND (Kraft base) same as 205RPA	2.25	3.50	7.00
200BKA	ORANGE-BAND (Kraft base) BLACK OXIDE	2.25	3.50	7.00
195RPA	BROWN-BAND Domestic (plastic base) RED OXIDE	2.25	3.50	7.00
195RKA	BROWN-BAND Domestic (Kraft base) RED OXIDE	1.75	2.50	5.00
195BPA	BLACK-BAND Domestic (plastic base) BLACK OXIDE	2.25	3.50	7.00
195BKA	BLACK-BAND Domestic (Kraft base) BLACK OXIDE	1.75	2.50	5.00

NOTE: 4,800 ft. lengths of ALL above types may be supplied upon request.

EXPLANATION OF NOMENCLATURE—STOCK ITEMS

RPA: Red oxide, plastic base, coating wound inside
BPA: Black oxide, plastic base, coating wound inside
BKA: Black oxide, Kraft base, coating wound inside
RKA: Red oxide, Kraft base, coating wound inside

When it is required that active side of tape be wound outside, specify "B" in place of "A" as suffix, example: BKB would indicate Black Oxide, Kraft base, wound with active material outside.

MADE IN U. S. A. BY ORRADIO INDUSTRIES, INC., OPELIKA, ALABAMA

recorded tape is made very greatly more practicable in some other field, whether it be the "hi-fi" market, the educational (audio-visual) field, or what. Keep your eyes open here.

A final word, more directly upon this department's concern, records of classical music. Space doesn't allow for details now of the very significant boom in tape and LP instantaneous copies—of both records and broadcasts. Suffice it to say that, mostly on a "free" basis, many people are copying their old records, their new records, their friends' records onto tape; many others are doing so for a consideration (laws or no laws), and there are commercial outfits galore who will copy any old thing for you any way you want, as well as all sorts of tape and LP exchange arrangements springing up. Tapes made from broadcasts are now sold openly and even advertised, though this would seem to raise some highly flammable issues.

At present, as with tape itself, this multiple radio-record tape copying activity divides neatly in two parts: First, the "home recording" quality material—slow tape speed, cheap machines, usually played on the same or, if on LP, on inferior commercial home machines; and second, genuine high fidelity tape work, done usually at 15, often copied onto high-quality LP records.

As outlined above, the new development will jump right into the middle of every phase of this activity, both in the home and in the production end. Tape savings at 3¾ in. will be fabulous and libraries of copies well worth while. At the wide-range 7½ in., the hi-fi enthusiast can copy all he wants, from the air or from records, without burying the house in floods of expensive tape at 15 in.

Does more need to be said? Only that all of us should keep our eyes on the models-to-come next year: We'll see what's what.

Record Releases

Mozart, Piano Sonata for Four Hands in F, K. 497; Rondo, K. 511, Minuet in D, K. 355, Gigue in C, K. 574.
Lukas Foss and Walter Hendl, pianists.
Period LP SPLP 508

The sonata for four hands, one piano, is the kind of music that is not often heard in concert, because there is hardly a pianist in the business who will submit himself or herself to the indignity of two-on-a-bench required in such cases! (Of course one could use two pianos, but the audience would titter even more.) The music was written for home use, or private use in any case, and on records it finds its own perfectly. This is no small Mozart, but rather a fairly imposing work and well worth the listening. The several two-hand pieces on the reverse (played by Lukas Foss) are important small Mozart items, very beautifully played, for my money—better, indeed, than the four-hand sonata itself. Recording of the piano is realistic, though the piano itself isn't too hot an instrument, evidently. So what—it's a good sound.

Satie, "Parade" ballet music (1917); Auric, "Les Matelots" ballet music (1925)
Houston Symphony, Efrem Kurtz.
Columbia LP: ML 4305 (10")

Dukas, The Sorcerer's Apprentice; Chabrier, Danse Slave from "Le Roi Malgré Lui;" Glinka, Russlan & Ludmilla Overture.
Paris Conservatory Orch. Enrique Jorda.
London LP: LSP 193 (10")

On two ten-inch LP's here are five enjoyably skillful semi-light works, with excellent recording for hi-fi use. The Satie "Parade" is the fanciest, with lots of assorted blurps and blats in 1918 style; the Auric "Sailors" is a smoothly modern ballet score—sounds like today's. The old familiar "Sorcerer" takes on new excitement both musically and technically—ffrr wide range recording is fabulously successful in this piece, and the young Spanish conductor, Jorda, makes it sound fresh and tense. So also with the other Jorda performances; the Danse Slave will remind you of the familiar "España" Rhapsody, same composer; it's full of fancy percussion effects, wonderfully recorded.

D'Indy, Symphony on a French Mountain Air; Franck, Symphonic Variations.
Robert Casadesus, piano; (a) N. Y. Philharmonic, Munch; (b) Philharmonia Orchestra, Weldon.
Columbia LP: ML 4298

My personal tastes are agin the kind of music that D'Indy writes here—same period as the now familiar St. Saens Symphony #3 with Organ, but this is more turgid, thick, complicated, less straightforward. However, lots of listeners love the piece, and you'll find it well recorded here. Piano good but (as usual) a bit percussive, twangy, in the U. S. style. The reverse, made in England, has the same pianist—but a far softer, more natural piano sound! Difference between U. S. and European piano recording nicely summed up for the ear, in spite of accompanying orchestra. The Franck Variations, an old war horse of the concert hall, is still a lovely piece and worth ten "Mt. Airs" to my ear. M. Casadesus isn't the warm player that this music needs, though.

Bach, Sonatas for Flute and Harpsichord.
Fernand Caratge, flute; Marcelle Charbonnier, harps. **Polydor-Vox LP: PL 6160 (2)**

For those who like real close-up music of this sort, here's a monumental recording (seven sonatas, one arranged from a Bach violin Sonata) that combines hi-fi, excellent acoustics and presence, with top performance. So realistic is the recording that a slight hiss or edge to the flute, which at first seems to be distortion, turns out to be breath noises! (Some will say, "too close" —I find it good in these works which are, after all, works to be heard at close range.) Beautiful balance between the instruments and, for once, a natural, non-tinny harpsichord sound. This is the way the music sounded when written. Tape originals.

Schubert, "Unfinished" Symphony (#8 in B minor).
London Symphony Orchestra, Josef Krips.
London LP: LPS 209 (10")

The "Unfinished" joins the hi-fi parade for good. This is the third LP of it so far—I haven't heard the other two, but I'm willing to bet that this has the best sound by far. The ffrr sharp-edged recording with its clear separation of orchestral details is marvelous for this symphony—the music is full of breathtaking little inner melodies, usually lost in the shuffle both on older records and—alas—in concert too. Here they come out shimmering. A really fascinating record for the score studier, not to mention anyone who has missed this music hi-fi style so far. A good performance, the slow movement very good; Bruno Walter's on Columbia is probably better and more subtle by a slight degree, but an older recording.

AUDIO-TORIUM

[*from page 19*]

panding phase of the entire electronic equipment industry.

Foremost among prominent dealers to recognize the importance audio equipment has achieved as a market factor is New York's Harvey Radio Company. Emphatic evidence of this recognition will come this month with the formal dedication of the "Audio-Torium"—Harvey's new Sound department which represents complete departure from the concepts of merchandising and demonstration which have prevailed in the industry in the past.

Centrally located in the heart of the famous Times Square district, the Audio-Torium typifies the sound department of the future—smart and inviting in appearance, acoustically treated, and thoroughly stocked with equipment of leading manufacturers.

Design of the new sound room takes into full consideration the increase in knowledge of audio equipment by the general public, music lovers in particular. As a result, no effort has been spared in avoiding the bread-board technique for interconnecting tuners, amplifiers, pickups, speakers, etc., which, though it makes perfectly good sense to those of us in the know, is frightening to the layman-music lover who is thinking in terms of transferring the equipment on demonstration to a well-appointed living room. All equipment on display is permanently connected to a large central control board which affords fingertip selection of any among thousands of possible audio component combinations, and A-B tests of everything from pickups to speakers.

Some idea of the stress placed on idealism in demonstration facilities may be gained from a brief description of the type of wiring used for connecting various components to the central control panel. Freedom from high-frequency attenuation is assured by feeding signal from low-level pickups and tuners through cathode followers prior to introduction into amplifier inputs and by using low-capacitance coax-type cable for both input and output circuits, using Cannon Type XL connectors throughout.

Equal emphasis on correctness is evident in the appearance of the Audio-Torium. Blonde oak-panelled walls, a decorative, acoustically-treated ceiling, and indirect fluorescent lighting are unique, to say the least, in the field of audio equipment merchandising.

It can be seen from this description how thoroughly the Harvey organization believes in the future of audio. Although the Audio-Torium represents an investment of thousands of dollars, and for this reason could hardly be duplicated *per se* by smaller companies, it can and should be duplicated in varying degrees of size by dealers throughout the country. Only by according the audio market the attention it warrants can equipment dealers adequately serve their growing lists of customers for amplifiers, speakers, pickups, tuners, and all the other items that go to make up a fine music system.

—*H. K. R.*

IMAGERY

[from page 14]

emphasized in sound systems intended to produce the loudest sound regardless of quality. It also is the range which makes a large contribution to the intelligibility of speech in the presence of noise, and hence is considerably emphasized in military communications systems. In terms of high-quality sound systems, a deficiency in the *lower highs* resembles an excess in the *lower middles*. An excess in the former is first *crisp*, becoming *bright* and *brilliant* as more *bite* is added. A large excess is *brassy, metallic*, and *shrill*, while if the excess is confined to the upper portion of this range the result is *tinkly*.

Many of these terms have arisen from listening done principally with direct-radiator speakers whose cones vibrate in parts in this region. This type of vibration results in a lowering of the effective moving mass at the voice coil, and an increase in the coil velocity, leading to axial sound pressure levels sometimes as much as 8 db above these from the *lower middles*. This rise depends on the angular position of the auditor, and hence the aural judgment of a sound system must include a complete statement of listening conditions, especially for the *lower highs* and *highs*.

In the *highs*, extending from 4000 to 8000 cps, we find that a smooth and not too steep *roll-off* sounds *soft*, and makes *surface noise* somewhat less objectionable. A slight excess will be *brittle*, becoming *hard* and finally *harsh* as the excess is increased. Toward the upper end of this range normal amounts of signal, *cleanly* reproduced, add a pleasing *naturalness*.

In the *extreme highs* no terms are accepted which describe the signal, because the loudness contribution from the intended signal is here so often masked by noise and distortion. Few persons have been privileged to hear a system completely *clean* from original source to the ear of the auditor. For example, tracing distortion in phonograph records played with other than a new and perfect stylus makes the *extreme highs* practically useless commercially. This is not to decry attempts to extend the frequency range; but, as has been emphasized by many others in the field, reduction of distortion and noise must come first.

This description of the various ranges may be summarized in Table III, in which the upper terms refer to an excess of loudness in the region involved. Special terms are in parentheses.

Comparison of Frequency Ranges

The critical auditor will often compare two sound systems that are alike except for one component, which is switched for so-called A-B tests. When the proper control is exercised so it is certain that only one variable is altered, this is a very effective means of making a choice based on characteristics which a trained auditor may select at will. One of these characteristics is known as *balance*.

Balance refers to the relative loudness of two or more frequency ranges, due principally to response-curve shape. It is recognized by its effects on timbre, on audibility in the presence of noise, and on response roughness.

Consider first the primary effects of response-curve shape. By using known instrumental and speech sounds as guides, an experienced auditor can pick out and compare regions of excess or deficiency quite accurately. He can detect slight *unbalance* as a *bump* with a complementary *scoop*, while greater *unbalance* appears as a *bulge* in one range compared to another which is *light*. A region may contain still more loudness and be *full* compared to a *very light* one. The *full* region becomes *very heavy* when extremely *unbalanced*.

By concentration on extreme frequencies, the auditor may detect a slow *roll-off*, or a *sharp, peaked*, cut-off. If the *lows* and *lower highs* are both present to excess, the system is *sway-backed*. An abrupt change in the sound-pressure level from one frequency range to an adjacent one is detected as *shelving*. This often occurs in the *upper middle* range of direct-radiator speakers, or with phonograph records made with one transition frequency and played back on a system designed for another.

Unbalance in the response curve may alter program material considerably if it occurs between the two critical frequency regions, the *lower middles* and the *lower highs*. Here most of the terms refer to an excess in the *lower highs*, and since this is a failing common to many inexpensive microphones, pickups, amplifiers, and loudspeakers. For example, musical instruments may become *woody, reedy, brassy*, or *metallic*. Upsetting the *unbalance* of speech formants may cause *rasp, snarl, whang*, and *yap*. In vocal music, especially baritone selections, another effect known as *caw* or *crow* enters. This appears to be due to difficulties at the lower edge of the *lower highs*, or even in *upper middles*. It is not as *edgy* as *rasp*, but adds an unpleasant effect of which the word *caw* is onomatopoetically suggestive (note also *rasp, snarl, whang* and *yap*, all with the vowel *a*). With some instrumental music, *caw* is not objectionable, but its removal is necessary for general listening.

It has been mentioned that the intelligibility of speech in the presence of noise is usually improved by an excess of *upper middles* and *lower highs*. This permits the desired signal to have greater *carry* by *cutting-through* and *over-riding* the background noise. Used in moderation, this adds *incisiveness* to speech; ordinarily it is sufficient to *roll-off* the *lows* at a 6 db-per-octave rate, if the background noise is low. This is done in motion picture work by use of a smaller-than-usual interstage coupling capacitor or by a specially designed "dialogue filter."

If there are large and rapid variations in response in a relatively narrow frequency interval, the response is *rough*. This factor is one which contributes to listener *fatigue*, in which a system that sounds good initially finally grates on the nerves so that eventually the urge to turn it off becomes overwhelming. An excess of the *lower highs* also has a similar effect, and many sound-system components labelled as "high fidelity" have become unpopular because of this. Some auditors state that they prefer a

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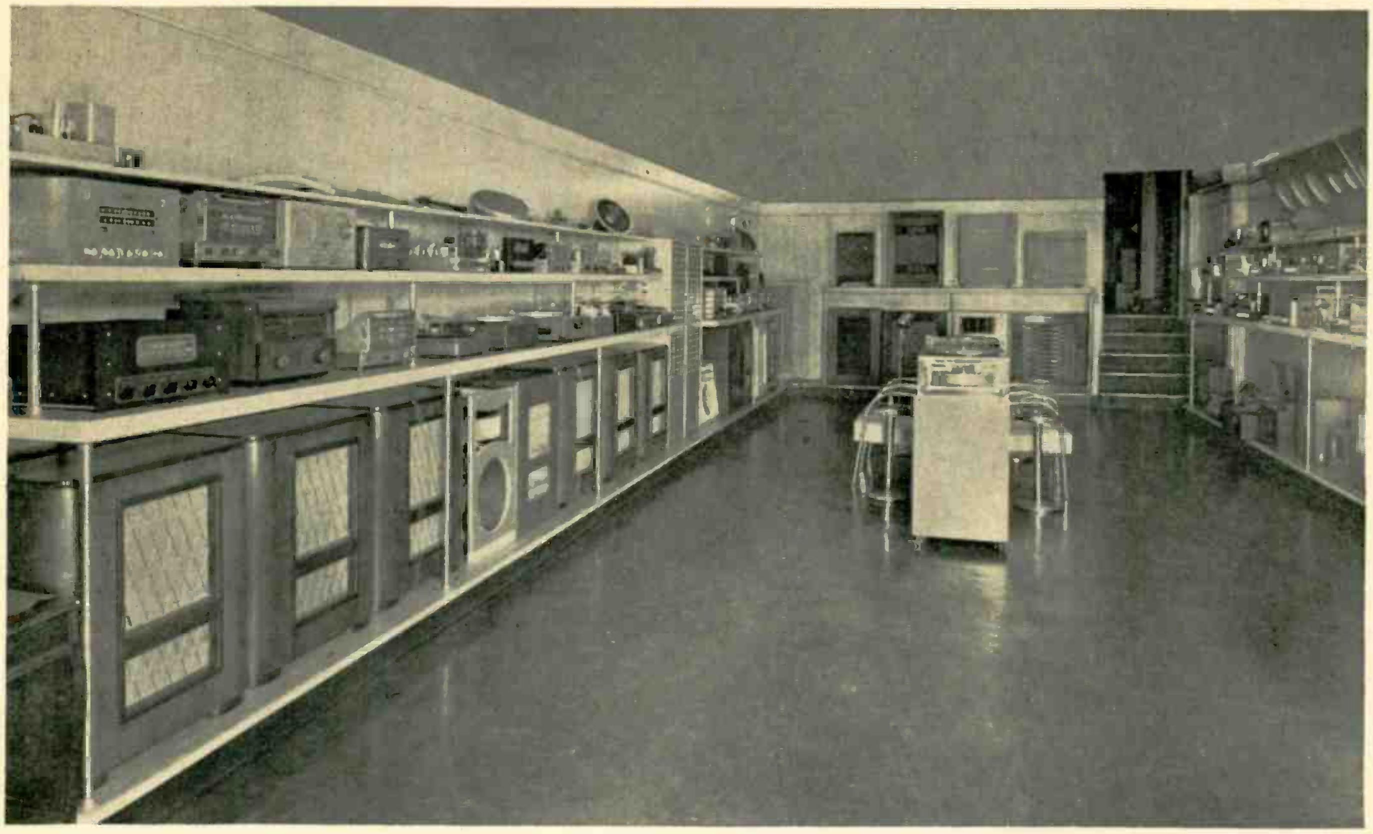

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smooth, clean system of moderate frequency range to a *rough, clean* system in which wide range is obtained at the expense of *roughness;* the evidence seems to favor this view.

It is known that a sharp cut-off or positive slope before cut-off at high frequencies will lead to a poor transient response in the region of the resulting peak. This phenomenon is sometimes used in restricted range sound systems to convey the impression of a greater range, since the ear hears the shock-excited transient more often than the normal signal, which usually has weak components in the *highs.* In moderation this practice is not too objectionable in restricted-range systems, but if the response is also rather erratic at cut-off the results are definitely undesirable. The program material sounds *ragged* and *spitty,* and the *whisker* at the main peak can sometimes be detected. Often a response curve is specified as required to lie between two limits; its *smoothness* within those limits and its behavior at the extremes is likewise as important, and should also be specified.

The terms of this section are summarized in Table IV.

Over-all Characteristics

As may have been noticed, the terms just discussed are becoming more difficult to tie down to specific objective counterparts than were those of the first groups. In this final group of terms only vague relations exist between them and the measurable characteristics. However, since overall effects are very important to the listener,

TABLE IV

Frequency Range Comparison

Class	
Balance	Unbalance, balance; bump, scoop; bulge, full, light; swaybacked; shelving.
Extremes	Roll-off; sharp, peaked.
Effects on Program	Rasp, snarl, whang, yap; caw, crow. Woody, reedy, brassy, metallic.
Intelligibility	Carry, cuts through, incisive.
Roughness	Smooth, rough, listener fatigue; ragged, spitty, whiskery.

and these terms are quite useful in describing the performance of a sound system, an attempt will be made to indicate the sensations and the probable causes involved.

Most of the terms are concerned with *presence,* which turns out to be used with at least three different connotations. First, it is used to indicate position. In motion picture work *presence* refers to the lack of *localization* of the reproduced sound, so that the ear is beguiled into believing that the sound issues from the location the eye follows. In general this requires the proper recording techniques as well as non-directional and properly placed loudspeakers. *Position presence* also appears in the *mass* of reproduced sound as evinced by the ability of a trained listener to sense the spatial position of the choirs of instruments or voices. For example, by the use of a general pick-up microphone placed for proper program liveness[4] plus close-up soloist's or "spot" microphones, the microphone outputs may be so combined that on reproduction the soloist appears to *advance* or *come forward* out of the orchestra, and *stands out* above the accompaniment. The fine line that separates the desired effect from that of a *dead* solo with *distant* orchestra is all too easily overstepped, however, and requires careful control at the point of program origin. On the other hand, with too much liveness the soloist is *lost* in the orchestra, or even appears to *recede* back into it during some passages. Undoubtedly masking and the ratio of direct and reverberant sound are among the main factors in this type of *position presence.*

A second use of the term *presence* indicates the degree of *intimacy* achieved. We are all familiar with the extreme methods used by crooners, some of whom crowd a ribbon microphone so much that the *intimacy* becomes a rather undesirable familiarity. Restriction of reverberant sound and emphasizing lower frequencies are seen to be controlling factors here. Beyond this, however, it is still possible to increase the *intimacy* by subtle changes in the response and directionality characteristics, producing the effect of the soloist performing personally for the auditor, establishing a feeling of *rapport.* Some of this is due to the audibility of fortuitous noises associated with the soloist such as those of taking a breath, violin bow scrape at the initiation of a tone, or key clicks in wind instruments. As these noises have considerable high-frequency components, they are especially noticeable in a low-distortion, low-noise system which is thus so *clean* that the frequency range may be safely extended.

A third type of *presence* is *detail presence,* in which an auditor is able to pick out an individual instrument or soloist, and more or less easily follow its melodic line throughout the changing *mass* of sound. The sound is then said to be *transparent* or *translucent:* no *acoustic fog veils* the ensemble, and each instrument stands out with *clarity.* If the sound system unduly emphasizes the *lower middles,* it will usually not have *detail presence,* and will sound *opaque* or *muddy.* It is not always desirable to have *transparent* sound: it enables an auditor to count the instruments in an orchestra, and some radio show sponsors have been known to prefer *muddy* sound for this reason. Also,

[4] J. P. Maxfield and W. J. Albersheim, *J. Acous. Soc. Am.,* 19, pp. 71–79 (1947).

if a program is too *transparent*, the *lower highs* may appear too *bright* on some program material, and the ensemble effect may be lost.

Besides presence, another over-all characteristic is the *size* and other attributes of the apparent source. This is influenced by the *liveness*[4] of the program material, which, when properly adjusted, results in a *broad, non-localizable* source from which the sound *floods out*. With too much liveness the sound appears to come from an adjacent live room, while too little liveness results in *dead, flat* reproduction, the sound seeming to be *compressed* and to issue from a *hole in the wall*. If the response is *peaked* at the upper portion of the *lower middles*, the sound may also have a *megaphonic, hollow* quality, appearing to come *out of a barrel*. Increased liveness can ameliorate, but not remove this quality entirely. With the proper combination of *liveness*, apparent *source size* and lack of directionality, some critics have referred to *big* and *well-focussed* tones of great *volume* (not loudness).

Realistically reproduced sound is *natural, life-like*, and *pleasing*. That is, one cannot detect a *canned music* sound, nor does it *fatigue* the listener. By the proper choice and sequence of preparatory program material, it is possible to aid the ear in the illusion of *realism*. We may define *realistically* reproduced sound[5] as that which produces in the listener the same sequence of psychological states that he would have experienced in the presence of the original program, if listening under conditions normal for that program. On the other hand, with *perfectly* reproduced (engineer's) sound there is reproduced at the ears of the auditor the same spatial and temporal variation of sound pressure as would exist were the auditor normally in the presence of the original sound. Thus *perfect* reproduction does not necessarily imply *realistic* reproduction, because the psychological set of the auditor when listening to reproduced sound is usually quite different from that when listening directly. Thus careful control must be exercised over physical factors affecting distortion, *unbalance*, response *roughness, presence*, directionality and *apparent source size*. It is a function of the imagery described in this paper to form a bridge between the subjective and objective factors, and thus aid in achieving the desired type of reproduced sound. Note, however, that if a sound jury is used, and is making conscious judgments and choices, the altered psychological set thus introduced makes them non-typical listeners, and hence the results of all listening tests are suspect and must be scrutinized from this point of view.

Most of our radio and motion picture listening is for amusement, information, or background sound (as to relieve loneliness). This type of sound requires only *adequate* reproduction, in which the sound is tailored to be suitable for the intended use. There may be extreme *unbalance* between the loudness of music and speech, but if the sponsor's message gets across this is desirable from his point of view. Special

[5] V. Salmon, *J. Acous. Soc. Am.*, 21, 55 (1949).

effects (echo chambers, narrow-band filters, sound effects) may be employed to direct the listener's emotional pattern along desired channels. Incidental music is especially useful in this regard, for it can change moods, and is most successful when the auditor does not notice it. In *adequate* reproduction the response of the listener, as revealed by the imagery, is practically the only means of determining the value of the expedients employed.

A summary of the general terms just discussed appears in Table V.

TABLE V

Over-all Characteristics

Class	Terms
Position Presence	Localization, mass of sound; advance, come forward, stand out; distant, dead, recede, lost.
Intimacy Presence	Intimate, rapport.
Detail Presence	Transparent, translucent, clarity; opaque, acoustic fog, veiling, muddy.
Source Size	Liveness; broad, volume, floods out, big tones, well-focused tones; dead and flat, compressed, from a hole in the wall, out of a barrel.
Realism	Presence, natural, life-like, pleasing; canned music.
Reproduction	Realistic, perfect, adequate.

Conclusion

The ear may act as a sound level meter, wave analyzer, integrator, response-curve indicator, distortion meter, and frequency meter. Its scale readings are expressed by a body of imagery which identifies and suggests, more or less successfully, the type and intensity of the sensations involved. It is by means of this imagery that a trained auditor may assess the extent to which the desired type of reproduction (*realistic, perfect, adequate*) of sound has been achieved. The judgments may then often be translated back into engineering language for alteration of the tangible physical variables. Many of the terms are tactile and optical in nature, which may be of interest to embryologists. Others are frankly onomatopoetic.

In compiling these lists, generous use has been made of expressions employed by music critics, engineers, and lay listeners. The discussion has been couched in as positive and definite language as possible so that disagreements may be equally definite. Such adverse reactions, as well as suggestions for more correct or more precise definitions and for additional terms, will be welcomed by the author.

FINE-GROOVE

[*from page 13*]

studies[8] made years ago to improve the operational characteristics of the recorder. The recording head MI-11850-C was changed from the "vertical" to the "flat" type, and the pivots about which it rotates raised. These changes were made in order to minimize "cutter bounce," a form of oscillation that occurs at some low frequency, depending upon the mass of the recording head and the effective stiffness of the system.

The vertical motion due to bounce cuts a groove of varying width and depth, and in extreme cases the cutting tip may leave the disk entirely. Naturally, a grove of varying depth does not promote good pickup tracking, and, of course, no groove at all omits some modulation.

Force Gauge

In order to study cutter bounce, a simple device was constructed to permit measurement of the force at the tip of the stylus while cutting a blank groove. The pole piece and armature of a recording head was rotated 90 deg. from its normal position. This permitted movement of the armature in a direction tangent to the groove, as shown in *Fig.* 7. The stylus, of course, was mounted so that the cutting surface remained in its normal plane. The deflection of the stylus was measured electrically. A 3000-cps field supply was used, and any movement of the stylus induced a 3000-cps voltage in the armature coil which was proportional to the displacement.[8]

For steady forces or forces which vary at a very low rate, a direct-current meter was used to measure the rectified 3000-cps voltage. For variations at a higher rate, a galvanometer was used to indicate the modulation after the 3000-cps carrier had been filtered out.

Bounce Measurements

Vertical oscillation or bounce was readily encountered as evidenced by the results shown in the oscillograms of *Fig.* 8. Means were then studied for minimizing it.

Since the bounce is an oscillating condition, it can be suppressed by introducing resistance into the mechanical system. *Figure* 8 (A) shows a recording of the vertical oscillation at 78 r.p.m., and *Fig.* 8 (B) shows how it was reduced by means of an air dashpot. The dashpot is effective, but suffers a disadvantage when the disk is tilted due to warpage or turntable wobble.

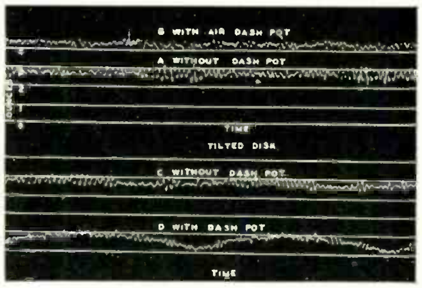

Fig. 8. Oscillograms showing cutter bounce and improvement obtained with an air dashpit.

If enough resistance is used to reduce the oscillation effectively, it may cause the recording head to act sluggishly on warped disks and cut a groove of varying depth. *Figure* 8 (D) shows the force variation with the dashpot on a 16-inch lacquer disk which was tilted 0.025 in. to simulate the motion produced when the blank is warped. The once-around variation in force, due to the tilt, is plainly evident. It is interesting to note that the average force without the dashpot, *Fig.* 8 (C), shows almost no variation, thus illustrating the self-regulating action of the recording head even with the disk tilted.

Since the dashpot had some disadvantages, an advance ball was tried. *Figures* 9 (A) and (B) show the cutting forces measured at 33 1/3 r.p.m. without and with the advance ball, and *Figs.*

[8] H. E. Roys, "Force at the stylus tip while cutting lacquer disc-recording blanks," *Proc. I.R.E.*, November 1947.

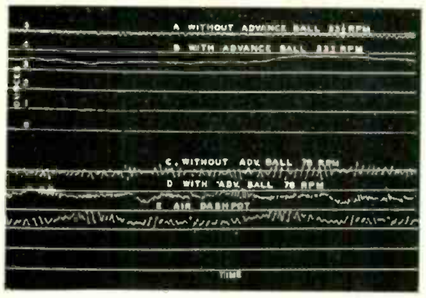

Fig. 9. Using an advance ball reduces the amplitude of oscillation, but introduces some irregular variations.

9 (C) and (D) show the same tests at a turntable speed of 78 r.p.m. The galvanometer beam was shifted for each trace so that its position with respect to the ordinate FORCE scale is only relative. The force scale was included to show the magnitude of the force variations being measured. The frequency of oscillation is raised and the amplitude of oscillation is decreased, but the force now varies considerably due to the fact that the self-regulating action of the head has been sacrificed by using the advance ball, which holds the stylus at some predetermined depth independent of hardness of the lacquer.

Perhaps the best way to use the advance ball is to adjust it so that it barely touches the disk, and so that it clears entirely when the recording head is raised by hard spots but does not dig in too deeply when cutting softer portions. In this way the self-regulating action of the cutter is partially retained, the beneficial action in reducing bounce is partially retained, and the protection of the stylus tip from damage (due to dropping or recutting the same groove) is wholly retained.

Recorder Action

The oscillograms, with the recording head suspended freely, show the average force to be nearly constant;

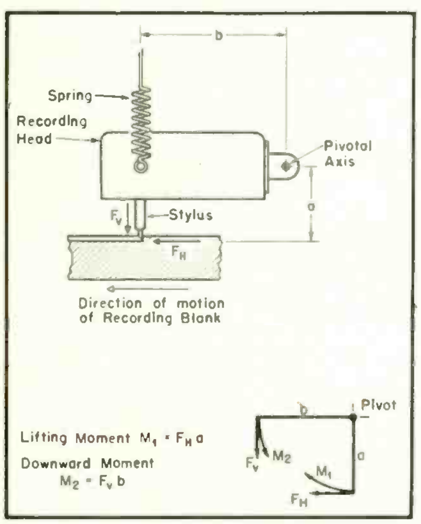

Fig. 10. Forces acting on the recording head.

low-frequency variations due to hard spots or record warpage are not evident. The horizontal force, F_1 of *Fig.* 10, at the stylus tip while cutting, creates a moment M_1 about the pivotal axis which tends to raise the recorder. Opposing this is the downward moment M_2 created by the vertical force F_2 also acting about the same axis. F_2 is measured with the stylus clear of the record but with the stylus at the same height relative to the pivot as when cutting the groove. During cutting, equilibrium is attained when the two moments are equal, and the depth of cut is regulated by adjusting the vertical force by spring or counter-weight adjustment. Data taken with a sharp-edged cutting stylus show these two moments to be equal. The product of the horizontal and vertical forces, F_1 and F_2, by their effective distances from the pivotal axis, a and b, resulted in $M_1 = M_2$, showing that the record material does not exert a vertical force on the stylus.

Pivot Location

Experiments indicate that the height of the pivotal axis above the surface of the disk is important, and if too low, oscillation occurs, which results in variations in depth of cut. *Figure* 11 illustrates the variations (in the width of the groove experienced with a tilted disk) as the pivot height was changed.

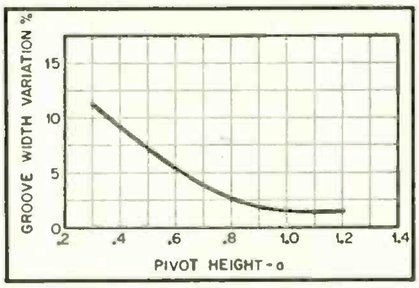

Fig. 11. Groove width variation with pivot height.

The decrease in the width variation with increased pivot height is believed to be due to several practical factors which perhaps may best be illustrated by the following example: If the pivot point is only 0.25 in. above the cutting plane, a cutting force of 2.4 ounces (for a groove about 5 mils wide) results in a lifting moment of of 0.6 inch-ounce. If b, *Fig.* 10, is 2 inches, the vertical force for balanced moments is then only 0.3 ounce. With a recording head having an effective weight of 5 ounces about the pivotal axis, the frictional force at the pivots and between mechanical linkages used for raising and lowering the recorder may be of the same order of magnitude as this balancing force. Likewise, the additional vertical force required for burnishing when a sapphire is used may be greater, and so result in a depth reg-

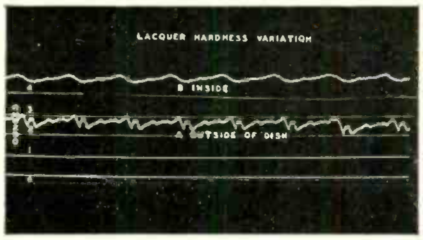

Fig. 12. Lacquer hardness variation of a 16-inch blank.

ulation which is only partially due to the cutting force at the stylus tip. When a spring is used for groove-depth adjustment, the design should be such that small variations in extension of the spring (due to the rise and fall of the recorder because of record warpage or turntable wobble) will not alter the vertical force appreciably or change the depth of cut. In the 73-B design using a suitable spring and raising the pivot height to 1 in. increased the vertical force to 1.2 ounces and greatly improved the controlling action due to the cutting force. Satisfactory results were then obtained without the aid of an advance ball or dashpot.

Lacquer Hardness Variation

Measurements were made of the variation in lacquer hardness by using an advance ball with the gauge. In *Fig.* 12, (A) shows the cutting-force variation on the outside of a 16-inch disk, and (B) shows the results obtained near the center of the same disk. Part of the once-around variation may be due to warped disks, although every effort was made to reduce such an error by using a long arm between the recording head and its pivot bearings. Any unevenness of the surface would also cause some variation, for the advance ball could not be located closer than about 1/8 in. from the cutting tip. This unevenness probably accounts for some of the difference noted between the measurements made on the outside and on the inside of the disk, for the disk surfaces are noticeably more wavy near the edge. These variations are not too serious, however, as good recordings can be made with such disks. As an example of what extreme variations may be encountered in disks of the very inexpensive class, the results obtained with a paper-base disk are shown in *Fig.* 13.

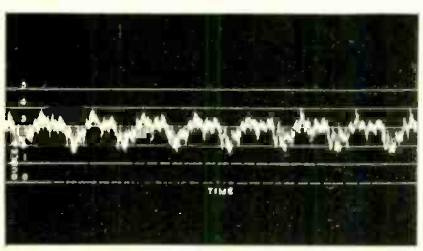

Fig. 13. Lacquer hardness variations obtained with a coated paper-base disc.

POPS

[from page 22]

morass of primitive ancestry. We can therefore junk such romantic pish-posh and try to determine what the relationship really is and whether it is actually worth while to attempt to derive one.

If we begin with the simplest of possible conceptions, we can say with equanimity and a certain amount of righteousness that music is noise . . . pure and simple unadulterated noise, no matter what form is involved. There is an infinite number of ways of making noise . . . helter skelter, deliberate, with good intent, with evil intents, and so on. One particular kind of noise is called music. It is called music because it is called music. The rhythmic regularity of machines in a factory represent noise as formally organized as the rhythmically regular noise made by a jazz combo and a symphony orchestra. The distinction between the noise-making machine and the noise-making orchestra simply involves the fact that the machine was not created to make noise as its primary function . . . an orchestra was. Furthermore, the individual who creates the noise imaginatively gives a symbolic significance to the noise he is creating . . . not so the inventor of the machine.

Therefore, to sum this up so far, music is noise which is distinguished by the fact that the noise is the primary object and that it has been created with a specific purpose or objective which has to do with listening to the noise itself. Generally speaking (although more specific details should be added), any noise which corresponds to the above definition is music. Jazz is music, classical music is music, pops are music, etc. But to be more precise, where is the dividing point between jazz and classical music?

Dividing Point

For the past twenty years, we have been bombarded by exuberant young men and equally exuberant old men who maintain that there is no dividing point. But really . . . what sheer nonsense. The use of certain so-called jazz harmonies and certain so-called jazz tempi by Gershwin in large orchestra works does not constitute the creation of a new form. Syncopation is one of the oldest things in the world and can be found in the most austere of serious composers. Jazz harmonies and harmonic treatments can be found in Debussy, in César Franck and even in Tchaikowsky (although not as crudely and without the innocuous melodic line). Such specific jazz treatments which can be found in Milhaud's Creation du Monde and the Ravel Piano Concerto are novelty treatments which bear no relation whatsoever to jazz other than a purely secondary one.

The relationship between jazz and serious music is purely formal. The use of two and three part song form, even a modified sonata form, exists in jazz. Jazz musicians and serious musicians use the same instruments and the same anatomical parts. As indicated in a previous column, there is a close psychological relationship between jazz and chamber music. But other than the above, the relationship ends. The basic quality of jazz is thoroughly different from and even opposed to that of serious music. An understanding of and an appreciation for jazz is dependent upon the recognition of this one intrinsic point and no amount of bosh with reference to such cliches as "folk music," "primitive music form," etc., will do as a substitute. It is a total impossibility to record jazz, to reproduce it, or simply amplify it without a secure recognition of this point and the necessary intelligence to develop it.

In jazz, the composer, instrumentalist and listener are one. Any specific jazz performance or jazz composition can happen once and only once. As music it is characterized by absolute temporality. It cannot survive in the same form and cannot be repeated. While the same is true of serious music, it is only a superficial feature. While it is unlikely that a pianist can play the same Chopin Prelude the same way twice, his basic conception remains the same and the music as scored remains unchanged. The classical pianist studies the score in terms of an objective attitude and tries to arrive at an interpretation which corresponds both to the intrinsic factors in the music and his conception of them as seen, as it were, from a detached objective point of view. At least, this is what he should do. The jazz musician is, basically, the music that he is playing. The particular way he feels, the particular sounds that appeal at a certain moment, the tempi, etc. The conventionalities of Dixieland being what they are today notwithstanding, this is the case in any true jazz situation. The music is strictly off the cuff and revolves around a consistent and unchanging rhythmic base.

The jazz listener is involved in a diametrically opposed situation. Where the jazz musician is all individual, the jazz listener is not individual at all. He attempts as much as possible to project himself into the situation of the musician. Whereas the serious musician is as thoroughly objective as possible, the serious music listener is all individual, attempting to become subjectively infused with the music he hears. The serious music listener is the musician and composer combined . . . he reads into the music and the performance the requirements of his own personality. The jazz listener is merely the shadow of the jazz instrumentalist, attempting to make the jazz ego his own. He delights in the exquisite variations, cooked up on the spur of the moments by the jazz man, and reacts with apathy to the bad nights . . . as does the musician himself.

Here is the crucial distinction between the two forms . . . a distinction which has nothing whatsoever to do with primitive, sophisticated, formal, informal, and so on. To continue with relationships and differences would be a waste of time. More is unnecessary. The natural extension of this is a consideration of what this means with reference to the audio engineer in all his chameleonesque forms:

1. To allow for jazz participation, recordings have to be infinitely live, wide open, wide range, acoustically correct for the jazz situation, and allowing for a maximum of presence. This is clearly an extension of the ego participation theory.

2. The reproducing equipment should be able to project in a technically adequate manner (no more, because adequacy is infinitely more realistic than the grandiose expressions of 50,000 cps down to .005) with an acoustical arrangement patterned after the requirements of the room and the feasibility of a poly-acoustical projection.

The same requirements are, of course, basic to adequate chamber music recording and reproduction. This does not involve the implication that the music is of the same character. The psychological conditions are similar as detailed earlier . . . no more . . . no less.

Jazz is essentially a participation experience of an emotional nature. It can be a source of satisfactory aesthetic experience. It all depends on you.

I see that I have no more space, so record releases will be continued next month.

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AMPLIFIER, ADC Model 45B, PP2A3's, 10-watt, ±1 db 50 to 10,000 cps, 20-db bass and 17-db treble boost, plus extra ADC line bridging input trans; list $182.50, all for $50, or three transformers and reactor only for $40. Also Meissner Model 9-1091 AM-FM tuner, $100. Details on request. Box CS-2, AUDIO ENGINEERING.

FOR SALE OR SWAP: Newcomb KX-30 p.a. amplifier, three mike inputs, bass boost and attenuation, treble boost and attenuation, 20 to 20,000 cps within 1 db. Interested in Presto or Rek-O-Kut turntable and Gray or similar arm. Box CS-3, AUDIO ENGINEERING.

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FOR SALE: Browning AM-FM tuner; HiFi HF720 20-w ampl; Webster-Chicago changer; Altec Lansing 15" spkr; Electronic Workshop 15-w ampl; Lear wire recorder with 10-w ampl; Magnecord tape recording mechanism. All in excellent condition. suitable for custom installations. For more details, write Henry Marchell, 90 Henshaw Ave., Springfield, N. J.

Records

FOR SALE: Victor albums M-935, Swarthout, $2.50; DM-740 Brahms-Horowitz, $4.50; M-358, Gershwin, $1.50; DM-1224, Handel, $2; AM-509, Rimsky-Korsakov, $4.50; Decca ffrr EDA-16, Dukas, $2.25. All in fine condition, used only with diamond stylus. F.O.B. New York, Box CS-4, AUDIO ENGINEERING.

TAPE RECORDING

[*from page 15*]

should be accurately maintained at the value specified by the manufacturer. Too much pressure may affect speed and cause over-heating of the drive-motor; too little pressure will cause slipping and erratic speed. The rubber-faced pressure idler should be inspected for glazing or any out-of-round condition. Cleaning with alcohol is recommended for the idler facing, as well as for other parts contacted by the tape.

The Magnetic Brake System

In the majority of machines used in broadcasting, the supply reel and the take-up reel are actuated by their own motors. The supply motor field (and in some instances, when in reverse, the take-up motor field), when the machine is recording or reproducing a tape, is hooked up to exert a pressure *opposite* to the direction of tape-travel. The e.m.f. necessary to produce just enough pressure is controllable and should be adjusted so that the tape is held flat against the heads at all times during the normal operations of recording or playing back. Once a machine has been thus adjusted, simple reading of the voltage at the motor terminals should be sufficient as a maintenance check. Note that if this adjustment is not correct the tape will be too taut or too slack. Tautness will cause the tape to curl toward the coated side, thus making for poor recording; obviously, a slack tape will not contact the heads properly, resulting also in poor recording.

Early recording machines designed in Germany coincident with the Magnetophon utilized a mechanical brake on the supply motor both for tape tautness and for rapid braking. The modern tape recorder utilizes a mechanical braking system similar to that on an automobile, except that it is actuated by solenoids. These brakes should be so adjusted that there will be no tendency for tape either to break or to spill.

On forward or rewind high speeds (five to ten times the normal speed) the tape may wind unevenly on its platter or "throw loops." This condition may be due to unevenly cut tape, to eccentricities of tape manufacture, or, most commonly, to a too-high speed. The normal cure is to adjust the rewind and fast-forward speeds downward by reducing voltage at the motor fields. Where it is desirable to keep the fast speed, a cover-plate for one-sided reels should be utilized to insure against spilling the tape.

Present day power supplies for professional and semi-professional tape recorders are well-designed and trouble free. Ordinary care should ensure long life. It would be well to check voltage-regulator tubes and to replace them periodically. They have been known to produce peculiar audio oscillations and flutters. Test all tubes regularly and make sure ventilation is sufficient for the temperature of the room.

The high-frequency oscillator (60–100 kc and over in professional type recorders) is generally a modified Hartley circuit. Its main function is to generate a perfect sine wave. The output of the oscillator may be taken directly to the erase and record heads in the case of semi-professional recorders. However, in most instances the oscillator in broadcast equipment is followed by r.f. amplifiers. It is axiomatic that the more complete the erasure the better the recording will be. There are two points to check periodically in the oscillator system. First, make sure that its output does not contain distortion. Second, see that the output measures up to specifications in wattage delivered. Most machines now incorporate a meter for reading bias and erase current, or if not it can easily be obtained. The manufacturer of the equipment will provide instructions for adding this useful feature.

Note that the bias current mixes with the audio current at the record head or in the transformer feeding the record head. It should not be allowed to get into the audio system at any other point.

Bias Current Adjustment

Bias current should be adjusted only when equipment is available to check its level and the effect on the recorded tape. Generally, in the present day highly-equalized recorder, the bias current setting is a compromise. An increase in bias will improve low-frequency response but cause the high end to drop because of excessive erasure. If, again, the bias is left too low, the low frequencies will distort excessively. (See Part II on "Recording.") When measuring equipment (noise and distortion test set or signal generator and oscilloscope) is not available, the approximate bias level may be found in the following way: Record a low-frequency signal (100–250 cps) at the correct level to the input. Increase the bias until the tape output reads maximum level. Beyond this point there is a choice. If better lows are desired, the bias may be increased still further, but the dynamic range will be compressed by so doing.

The record and playback amplifiers, generally built in separate units, are not extraordinary in design or construction and do not require any extended treatment. The chief troubles to guard against are r.f. interference and tube noise. Radio-frequency noise may be trapped out at the input to the playback amplifier. Tube noise and residual hum should be at least below the level of the tape noise in a well-designed professional machine (at least 55 db below maximum output).

The magnetic heads are the most carefully designed parts of the recorder. They require careful use and maintenance to remain in good working order. Do not run tape at high speed in contact with the heads, because the tape then acts as an abrasive and wears the pole pieces. Heads that are constructed like the one shown in *Fig.* 3 may then

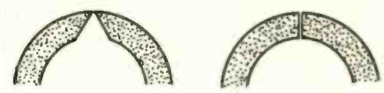


FIG. 3 FIG. 4

Fig. 3 (left). Type of core assembly liable to damage from tape abrasion. Fig. 4 (right). Core design not injured by abrasion.

need to be replaced. Others, like that of *Fig.* 4, will not be damaged appreciably, but may only require re-alignment.

The head gaps should always be kept in alignment, perpendicular to the tape travel. Any mis-alignment between the record and play heads results in losses, especially at the higher frequencies (see *Fig.* 5, showing exaggerated mis-alignment). All professional recorders incorporate some means of alignment in the head mounting, and the machines should be checked periodically to make certain it is correct. In order to make alignment checks, an audio osillator, a test tape with several high-frequency cuts, and an output VU meter are required. The playback head should be aligned for greatest response at the top frequency. Then a new recording on fresh tape should be made at the same frequency from the oscillator output. The playback output level of this new recording should equal that of the test tape. If it is not equal, the record head should be re-aligned. While making these tests, be certain that the same type of tape is used throughout.

The heads should be kept absolutely clean. They should be cleaned with a lint-free cloth moistened in alcohol every half-hour of use. A coating of dust or oil, even the residue that may be left after recording with a "lubricated" tape, may result in a muddy recording, lacking in highs.

A considerable increase in tape noise may occasionally be noticed which cannot be traced to improperly erased tape, uneven bias-current wave-shape, or a noisy record amplifier. The most likely cause of the noise is a magnetized head, which leaves a d.c. noise-signal on the tape. The instruction book will probably designate the correct procedure for demagnetizing the heads. One good method is to record and playback tone at any frequency (the lower the better), increasing slowly to about four times normal level, holding it there a few seconds, then decreasing slowly to zero. When demagnetizing by this method do not exceed the wattage rating of the heads. Another method is to use a 115-volt a.c. demagnetizer, now available, which requires only a few seconds to neutralize the core structures thoroughly. It is wise to disconnect the heads from their respective amplifiers if an external demagnetizer is used.

The ability of magnetic tape to capture and keep a signal depends upon its physical and magnetic properties. Almost any tape manufactured today will deliver good quality reproduction. Research in tape coatings and plastic processing results in better products every year. However, it is important to adjust the bias for the tape used, and to observe care in the handling of the tape. It should be stored in dust-free cabinets where it is not subjected to any stray magnetic fields. A normal room temperature of 70° F. and a low humidity will ensure its long life.

The problems of maintaining tape recording equipment in the field are similar to those found in studio operations in most respects. The outstanding problem of the recording engineer travelling with his equipment is that of obtaining a satisfactory a.c. supply. The most commonly used supply is a motor generator set driven by storage batteries and regulated manually to 60 cps. How to care for such equipment is known by most broadcast engineers and will not be touched upon here. Magnetization of heads by lightning is naturally much more common in the field than in studio operations, and it is good routine to check *before* playing in order not to ruin a valuable recording. (An ordinary compass may be a valuable device in this operation.) Altogether, maintaining equipment away from the studio requires more ingenuity and experience of the engineer. Unique problems arising from unusual conditions may require unorthodox methods of maintenance, but whatever the conditions, the engineer with the "know-how" of tape recording will do a creditable job.

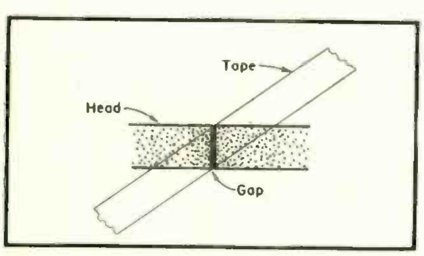


Fig. 5. Exaggerated tape-head misalignment.

AUDIANA

[*from page 20*]

sipation of heat by a resistance. In the electronic case

$$r = \frac{e}{i}$$

and from mechanics we get that for rectilinear motion

$$r = \frac{f_M}{u}$$

for rotational motion we get

$$r = \frac{f_R}{\theta}$$

and finally in the acoustical case we may write

$$r = \frac{p}{U}$$

In the above equations the symbols are defined as follows:

r = resistance, in all systems, in ohms absolute
f_M = mechanical force, dynes
f_R = torque, dyne-centimeters
θ = angular velocity, radians per second
p = pressure, dynes per cm²
U = volume current, cm³ per second
u, v or $\dot{x}$ = velocity, cm per second.

Again it is possible to find comparative equations for moment of inertia, the flywheel effect, and for the energy stored in a capacitance or spring. The analogies between mass, inductance and inertance may be expressed by the following equations:

$$f_R = I\frac{d\theta}{dt};\ e = L\frac{di}{dt};\ f_M = m\frac{du}{dt};\ p = M\frac{dU}{dt}$$

where I is the moment of inertia; $\frac{du}{dt}$ is the acceleration; and M, the inertance, is defined as $M = \frac{m}{S^2}$ in which m is the mass and S is the cross-sectional area over which the driving pressure acts to drive the mass in cm².

The equations for capacitance or compliance in the analogous cases are

$$e = \frac{q}{C};\ f_M = \frac{x}{C_M};\ f_R = \frac{\theta}{C_R};\ p = \frac{X}{C_A}$$

In the last equations $C_A = \frac{V}{\rho c^2}$ and X = volume displacement, cm³.

If the three simple systems shown at (A) in *Fig.* 1 are drawn schematically in their own systems they will be as shown in (B). However, the electrical analogy for each of them is that shown for the R, L, and C. Further proof of this may be obtained from the differential equations for the three cases shown at (C). It may be seen that the form for the three equations is the same. The equations for the resonant frequency for each case is shown at (D).

Electro-acoustical Systems

In using dynamical analogies to study electro-acoustical systems, it is necessary to deal with all three systems—electrical, mechanical and acoustical. However, to handle the mathematics with ease, it is simpler to use only one pair of systems, the electro-mechanical. It is possible to use mass, compliance, and mechanical resistance which may be derived from the acoustical system. Where necessary the motional electrical impedance may be determined from the mechanical equation for the acoustical system, and then the electrical properties of the system determined.

The motional electrical impedance is the impedance of the electrical system due to the motion of the mechanical system. In an electrodynamic system the motional impedance is

$$Z_{EM} = \frac{(Bl)^2}{z_M}$$

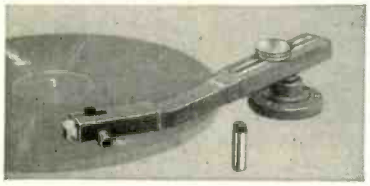
where z_M is the total mechanical impedance of the mechanical circuit.

The example below shows the necessity of analyzing the problem carefully

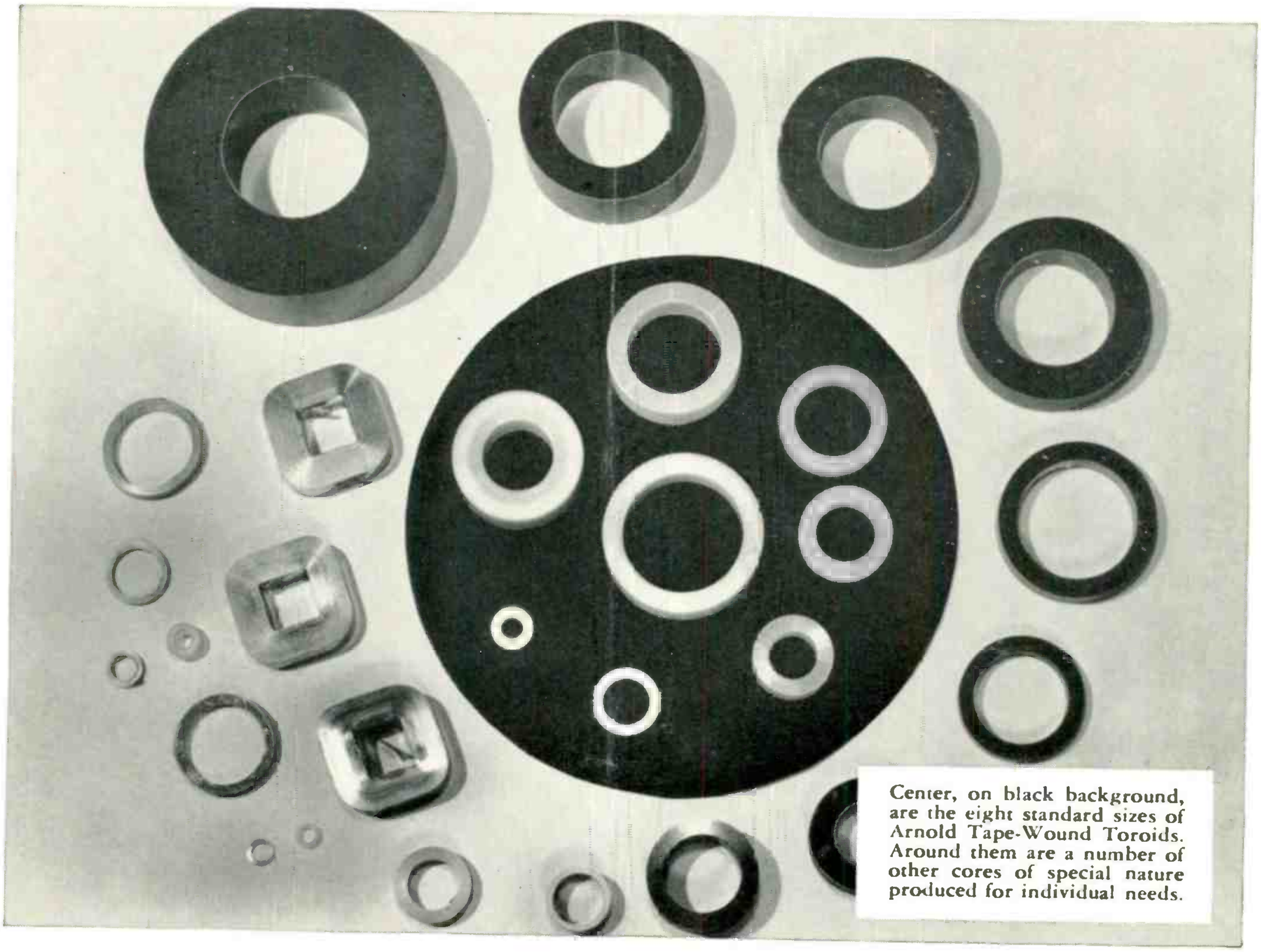
Fig. 2. The holes in this telephone mouthpiece have air resistance and mass which must be included in the design of the handset microphone.

so that no element is neglected. Such things as the inertance and resistance of narrow slits or microphone grilles (see, for example, *Fig.* 2) must always be included until their magnitude has been determined. Other examples of this are the ports in loudspeakers baffles and the pores in sound absorbing materials.

(*To be continued*)



ADVERTISING INDEX



Center, on black background, are the eight standard sizes of Arnold Tape-Wound Toroids. Around them are a number of other cores of special nature produced for individual needs.

ARNOLD TAPE-WOUND TOROIDAL CORES

of DELTAMAX 4-79 MO-PERMALLOY SUPERMALLOY*

APPLICATIONS

- MAGNETIC AMPLIFIERS
- PULSE TRANSFORMERS
- NON-LINEAR RETARD COILS and TRANSFORMERS
- PEAKING STRIPS, and many other specialized applications.

RANGE OF SIZES

Arnold Tape-Wound Toroids are available in eight sizes of standard cores—all furnished encased in molded nylon containers, and ranging in size from ½" to 2½" I.D., ¾" to 3" O.D., and ⅛" to ½" high.

RANGE OF TYPES

These standard core sizes are available in each of the three magnetic materials named, made from either .004", .002" or .001" tape, as required.

In addition to the standard toroids described at left, Arnold Tape-Wound Cores are available in special sizes manufactured to meet your requirements—toroidal, rectangular or square. Toroidal cores are supplied in protective cases.

*Manufactured under licensing arrangements with Western Electric Company.

W&D 3182

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