Typical Esterline-Angus curve showing exceptionally high output uniformity of plastic-base Audiotape. Test made at 1000 cycles, 15" per second, for 2500-foot roll. During the past 60 days Audio Devices has produced and sold over 9,000 miles of plastic-base Audiotape—all with output curves similar to this!

UNIFORMITY PLUS
that's what you get in every reel of
Audiotape*

Unequalled uniformity of output volume is one of the outstanding advantages of Audiotape. This is especially important in professional work where shows are edited and assembled on tape. For even slight variations in output can become very objectionable when splicing brings high and low volume sections together.

Every 2500-foot reel of plastic-base Audiotape is guaranteed to have a volume deviation, at 1000 cps, of not more than ± ¼ db within the entire length—and not more than ± ½ db from reel to reel. And these are outside limits, not averages. What’s more, every 2500-foot reel is guaranteed to be entirely free from splices!

This extremely high uniformity is made possible by Audio’s specially designed coating machines, which permit control of coating thickness to within five millionths of an inch. During the past 60 days, these machines have turned out more than 9,000 miles of plastic-base tape—with a volume deviation of not more than ± ½ db!

Remember—when you use Audiotape, you can be sure of the results every time. For every foot of Audiotape is monitored for output, distortion and uniformity—your assurance of the finest, professional quality recording tape obtainable.

Audio Devices, Inc.
444 Madison Ave., New York 22, N.Y.

*Trade Mark

- STRAIGHT-LINE SLITTING that makes tape track and wind absolutely flat.
- FREEDOM FROM CURL that permits tape to maintain perfect contact with heads.
- SMOOTH UNWINDING with no tendency to stick layer-to-layer.
- NO FRICTION SQUEAL. Smooth surface rides quietly over pressure blocks and tensioning devices.
- LOW COST. 2500-foot roll on NAB hub has list price of $10—subject to Audio’s usual discounts to professional users.
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TEST IT—COMPARE IT
We will be glad to send you a free 200-foot sample reel of either plastic-base or paper-base Audiotape. It will speak for itself.
SETS A NEW PERFORMANCE STANDARD!

Voltage accurate within 0.2 db
Distortion less than 0.1%
Continuously variable a-f voltage
Frequency range 20 cps to 20 kc
High stability of frequency

-hep- 206A Audio Signal Generator

For the first time all the features listed above are combined in one precision instrument, to give you signals of utmost purity and accuracy for high fidelity measuring work. In addition, -hp- Model 206A Generator includes low-temperature coefficient frequency determining elements for high stability and unvarying accuracy over long periods of time. A precision attenuator varies output signal level in 0.1 decibel steps throughout 111 decibels.

Resistance-tuned Oscillator
The resistance-tuned oscillator is followed by an automatically tracked amplifier whose high selectivity reduces oscillator harmonics. Following the 111 db attenuator is a transformer which can be matched to loads of 50, 150 and 600 ohms. A 600 ohm single-ended output is also provided (Fig. 1).

Specially designed for testing high-quality audio circuits, the -hp- 206A is ideal for FM transmitter maintenance, studio amplifier and console testing, a source for bridge measurements, a-f voltage or transmission measurements; and for other applications requiring a very low distortion signal of known amplitude.

Full details available on request
HEWLETT-PACKARD CO.
1640L Page Mill Road, Palo Alto, California
Export Agents: Frazer & Hansen, Ltd.
301 Clay Street • San Francisco, Calif., U. S. A.

SPECIFICATIONS

FREQUENCY RANGE: 20 cps to 20 kc, 3 bands.
CALIBRATION: Direct in cps on lowest band.
STABILITY: Better than 2%. Low temperature coefficient frequency network.
OUTPUT: -15 dbm into 50, 150, 600 ohms. Approx. 10 v into open circuit.
OUTPUT IMPEDANCE: 50, 150, 600 ohms balanced. 600 ohms single ended. Matched internal impedances.
FREQUENCY RESPONSE: Within 0.2 db, 30 cps to 15 kc, beyond meter, at all levels.
DISTORTION: Less than 0.1% above 50 cps.
Less than 0.25% below 50 cps.
HUM LEVEL: 70 db below output signal, or 100 db below zero level.
OUTPUT METER: Reads in dbm or volts.
ATTENUATORS: 111 db in 0.1 db steps. Accuracy approximately 0.1 db.

Power Supplies   Frequency Standards   Amplifiers   Electronic Tachometers   Frequency Meters
UHF Signal Generators   Square Wave Generators   Audio Frequency Oscillators   Attenuators
Audio Signal Generators   Noise and Distortion Analyzers   Wave Analyzers   Vacuum Tube Voltmeters

HEWLETT-PACKARD CO.
1640L Page Mill Road, Palo Alto, California
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Figure 1 – Circuit Structure of -hp- 206A Generator

Audio Engineering • September, 1950

AmericanRadioHistory.Com
Radio Engineers Use More Magnecorders Than All Other Professional Tape Recorders Combined

GREATEST FLEXIBILITY
For delayed studio or network broadcasts, you can mount a Magnecorder in a rack or console cabinet. For remote, slip it into its really portable case. You can add to your Magnecord equipment as you need it—combine and carry Magnecorders to suit every purpose.

HIGH FIDELITY, LOW COST
No other recorder offers you such high fidelity at such a low price. Users are enthusiastic about the amazing tone quality and low distortion of Magnecordings. Magnecord frequency response: 50-15 kc, 2 db. Harmonic distortion less than 2% Meets N.A.B. standards.

MORE FEATURES
Magnecord leads the field! Your Magnecorder now can have 3 heads (separate erase, record, and playback) to permit monitoring from tape. Three speeds 115′, 71⁄2′ and 31⁄2′ up to an hour on a 7′ reel available on both PT6 and PT63 equipment. Dual track heads also available if desired.

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360 N. Michigan Ave., Chicago 1, Ill.
Send me latest catalog of Magnecord equipment.

Name:
Company:
Address:
City, Zone, State:

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, E., 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, Calif.
CONTENTS SEPTEMBER, 1950 VOL. 34, NO. 9

Letters .................................................. 2
Audio Patents ............................................ 4
Editor's Report .......................................... 8
Recording and Fine-Groove Technique—H. E. Roys .... 11
Imagery for Describing Reproduced Sound—2—Vincent Salmon .. 14
The Art of Tape Recording—V—Joel Tall ......... 15

AUDIO engineering society SECTION

Automatic Audio Gain Controls—J. L. Hathaway .. 16
Employment Register .................................. 18
New, Advanced Sound Department ................. 19
Audiana—Dynamical Analogies—Lewis S. Goodfriend .. 20
Record Revue—Edward Tatnall Canby ............. 22
Pops—Rudo S. Globus .................................. 22
Advertising Index ....................................... 48

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 equipment, or may be obtained as a conversion kit for PT6 recorders now in the field.

WHAT IT IS:
A kit of special styli with miniature heating elements, a cutterhead adaptor and a heat control with calibrated meter.

WHAT IT DOES:
Applies thermoplastic principles to disk recording; eliminates mechanical loading of the cutter by the disk material.

RESULTS:
• Reduces basic surface noise at least 20 db.
• Minimizes frequency discrimination at innermost diameters
• Eliminates most difficulties due to production differences in blank disks.

Recordings made with the Fairchild Thermo-Stylus Kit retain the esthetic listening appeal of original sound.

WRITE FOR ILLUSTRATED DETAILS
SPECIFY YOUR CUTTERHEAD

FAIRCHILD
RECORDING EQUIPMENT
CORPORATION
154TH STREET AND 7TH AVENUE
WHITESTONE, N. Y.
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.

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 modulator.

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- 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.
MULTIPLE CONDUCTOR CABLES

Every Type for Every Service

Sold Exclusively Through Recognized Wholesale Distributors.
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.
LOUDSPEAKER
MODEL 180L
Designed to satisfy the musical ear. A low-cost high quality loudspeaker with smooth wide-range response (within 5 db. 45 to 12000 cycles) and low distortion... the only loudspeaker with acoustically adjustable bass response... occupies less floor space than any other high quality loudspeaker — less than one square foot.

PICKERING PICKUP CARTRIDGES
FOR THE FINEST AUDIO QUALITY

No other Pickup will reproduce LP records with the fidelity of Pickering Cartridges... they are the most widely used by record manufacturers, recording studios, broadcasters and music enthusiasts who demand the effect of a live performance from their records.

The nearest approach to a live performance is a recording played by a system equipped with Pickering High Fidelity Audio Components... Speaker, Cartridge, Arm, Preamplifier, Record Compensator, etc.

Pickering Cartridges Series 120 and 150 are for standard records... Series 140 are for micro-groove records... They track with phenomenally low record wear and virtually eliminate harmonic and intermodulation distortion as well as frequency discrimination... all Pickering Cartridges available with either sapphire or diamond styli.

RECORD COMPENSATOR
MODEL 132E
This compensator, with 6 positions of equalization, provides the flexibility required to properly equalize for the different recording characteristics used by various record manufacturers... it is a most important addition to record playing systems using magnetic pickups.

PREAMPLIFIER
MODEL 130H
This preamplifier represents the most advanced design ever achieved in phonograph preamplifiers... it equalizes the bass response of records and transcriptions and provides the necessary gain for high quality magnetic pickups... its intermodulation and harmonic distortion is exceptionally low — better than most professional equipment.

PICKUP ARM — MODEL 190
The only arm specifically designed for optimum performance on both microgroove and standard records.
- Statically balanced to eliminate tendency to skip when jarrsed.
- Minimum vertical mass to track any record without imposing extra vertical load on grooves.
- Sensitive tracking force adjustment.
- Magnetic arm rest.
- Rugged frictionless bearings.
- Plug-in cartridge holder.
- One-hole mounting — self-contained levelling screws.
Cartridges used with this arm require 50% less vertical tracking force than when used in conventional arms.

Pickering & Company, Inc.
Oceanside, N. Y.

For the finest audio quality specify Pickering Components

Pickering High Fidelity Components are available through leading jobbers and distributors everywhere... detailed literature will be sent upon request.
A focus on better, low-cost telephone service

In the new microwave radio relay system between New York and Chicago, giant lenses shape and aim the wave energy as a searchlight aims a light beam.

Reasoning from the action of molecules in a glass lens which focuses light waves, Bell Laboratories scientists focus a broad band of microwaves by means of an array of metal strips. To support the strips these scientists embedded them in foam plastic which is virtually transparent to microwaves. Rigid and light in weight, the plastic is easily mounted on relay towers.

This unique lens receives waves from a wave guide at the back of the horn. As they pass across the strips, the waves are bent inward, or focused to form a beam like a spotlight. A similar antenna at the next relay station receives the waves and directs them into a wave guide for transmission to amplifiers.

This new lens will help to carry still more television and telephone service over longer distances by microwaves. It's another example of the Bell Telephone Laboratories research which makes your telephone service grow bigger in value while the cost stays low.

BELL TELEPHONE LABORATORIES

Working continually to keep your telephone service big in value and low in cost.

AUDIO ENGINEERING • SEPTEMBER, 1950
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.

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.
   a. V-groove, 111 styles, 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.

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

Fig. 1. Basic single-channel setup.

Fig. 2. Simple and flexible two-channel setup.
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.
2. One post assembly for mounting pulley assembly.
3. One double pulley.
4. One arm assembly for renumbering 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 adjusting 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.

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 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; hence it is usual practice to use a cutting styli 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

---

**Fig. 3 (left). Parts supplied in Fine-groove kit, MI-11882, and Fig. 4 (right), showing installation of kit on standard recorder chassis.**
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 and also by Hunt and Lewis. 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 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. transcription 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 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:

\[
(45) \quad G = 15 \times 45 = 765
\]

\[
(33 \frac{1}{3}) \quad G = 15 \times 33 \frac{1}{3} = 500
\]

The usable playing radius, \( PR \), available is:

\[
(45) \quad PR = \frac{11.5 + 4.0}{2} = 3.3 \text{ inches}
\]

\[
(33 \frac{1}{3}) \quad PR = \frac{11.5 + 6.5}{2} = 2.5 \text{ inches}
\]

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:

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

\[
(33 \frac{1}{3}) \quad n = \frac{500}{2.5} = 200
\]

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:

\[
(45) \quad p = \frac{100}{208} = 0.49 \text{ inches}
\]

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.

**RECORDE 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

---


*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 the stomach, as with by 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

* 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.

TABLE III

Imagery for Loudness of Various Ranges

<table>
<thead>
<tr>
<th>Extreme</th>
<th>Low Terms Loudest; Special Terms in Parentheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lows</td>
<td>Low Term</td>
</tr>
<tr>
<td>Belly-Lows</td>
<td>Sock, Drummy, Solid, Dead, dull, thick</td>
</tr>
<tr>
<td>Grunt</td>
<td>Brassy, Hard</td>
</tr>
<tr>
<td>Boom</td>
<td>Punch, Flat-sounding Body; Melody</td>
</tr>
<tr>
<td>(Excess)</td>
<td></td>
</tr>
<tr>
<td>Tubby</td>
<td>Lean, Warm soprano</td>
</tr>
<tr>
<td>(Deficiency)</td>
<td>Thin, Tinny (Balance)</td>
</tr>
</tbody>
</table>

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]
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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 coaxial 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, P1 and P2 of the pad mate with J1 and J2, respectively, of the amplifier, thus paralleling these channels. At the lower range of video frequencies the effects of L1, C1, C2 and C3 of Fig. 2 upon operation are negligible and the circuit reduces to the simple resistance combination of R1, R2, R3, and R4.

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 (6) in interior of chassis of pad, showing arrangement of components.

Fig. 2. Schematic diagram of video line pad. P1 and P2, connect to the line amplifier output. J1 supplies signal voltage to a high-impedance picture and waveform monitor, while J2 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 J1 and J2.
\( R_L \) in conjunction with the shunting effect of \( R_S \) and the plate-circuit impedance of the paralleled 6A97 triode stages, \( V_4 \) and \( V_6 \) of Fig. 3, provides the desired net resistance of approximately 75 ohms as seen looking into the pad from the line feed-point \( J_L \).

The series resistance of the voltage-divider network \( R_T, R_L, \) and \( R_R \) is so high with respect to that of the load circuit that less than 1 per cent of the 6A97 output signal current flows through this branch. Furthermore, the current flowing in an external 75-ohm load connected to \( J_L \) is only slightly reduced by the presence of the series resistor \( R_L \) due to the relatively-high source impedance (1000 ohms, approximately) of the 6A97 plate circuits. On the other hand, the signal voltage appearing at the junction of \( R_T \) and \( R_L \) is higher than that across the line at \( J_L \) by a ratio of greater than 4 to 1, assuming the external load impedance at \( J_L \) is 75 ohms.

The voltage-divider network made up of \( R_T, R_L, \) and \( R_R \) is so proportioned that the signal voltage appearing at the monitor jack \( J_M \) is exactly equal to that at \( J_L \), when \( J_M \) 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 \( R_T, R_L, \) and \( R_R \).

Any signals appearing at the monitor jack \( J_M \) are isolated from whatever spurious effects may occur at \( J_L \) by a factor of approximately 5.1. For example, a hum voltage of 0.1 volts, peak-to-peak across \( R_L \) (an actual condition met in a typical instance) is reduced to a value of approximately 0.02 volts at the monitor jack \( J_M \), while the desired signal at both \( J_L \) and \( J_M \) is maintained at a 2-volt value.

In a similar manner, the signal at the monitor jack \( J_M \) is isolated from the effects of impedance-variations in the external load connected to \( J_M \).

At the middle and high ends of the video-frequency range, the shunt capacitance of the 6A97 output stages, if uncompensated for, would degrade the frequency response characteristic.

Therefore, there is employed a series-peaking circuit made up of the 6A97 output circuit capacitance, in combination with \( L_P \) and the \( C_L, C_M, C_{D} \) network. The values of \( L \) and \( C \) are so chosen that a flat response characteristic up to 7 megacycles is maintained at the line output jack \( J_L \).

In addition, the capacitors \( C_L, C_M, \) and \( C_{D} \), plus the input capacitance of the external monitor circuits, form a capacitance voltage-divider which complements the resistance branch \( R_T, R_L, \) and \( R_R \) in such a way that the frequency-responsiveness characteristic at \( J_M \) is exactly the same as that at \( J_M \) (assuming a 75-ohm resistance termination at \( J_M \)). To insure exact frequency compensation at \( J_M \), \( C_{D} \) is made adjustable, and of a range sufficient to correct for the input capacitance of the monitor circuits connected at \( J_M \).

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 6A97 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.

V6  VIDEO ENGINEERING  SEPTEMBER, 1950

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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-ohm at \( J \), or 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 \( J \). of Fig. 3 with \( J \) temporarily disconnected). Adjust the input square-wave amplitude at \( J \) 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 (\( J \) of CBS 1-A pad).

3. Remove the signal input from first amplifier section. Feed the 60-cps square wave signal to the second distribution-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 level at 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 I.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 \( R \). Bridge a high-impedance amplitude-calibrated oscilloscope across the monitor output of \( J \), of the pad and adjust \( R \) for a 2-volt signal level at \( J \). Or, in other words, adjust \( R \) until the signal observed on the waveform monitor at the moitor output of the pad is exactly the same as that at the line output, replace the cover plate over \( R \). This adjustment is not likely even 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 \( J \) 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 \( C \) on the pad (screw-driver adjustment, externally accessible) until the signal observed on the waveform monitor is square-wave, without 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 \( C \) 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 \( J \). Adjust \( L \) 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.

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 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]
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 de-mountable affair, where such features have been required.

In an actual theatre stage set-up, there is little choice but to use normal staging practice, with lighting hung from battlement and from "trees" in the rear 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 thyatrons 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 pulses, 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. Second, 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" x 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 indispensable 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...
A Laboratory Television System

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.
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.

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 car-

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.

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.

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

VIDEO ENGINEERING • SEPTEMBER, 1950

V11
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.

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.

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 Console which provides for auditioning, monitoring, switching, and mixing the audio signals associated with this television system. The input signals to the console are derived from two turntables, four microphones, two film projectors, a communications receiver, and a television receiver. Figure 6 shows the console 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, would allow gain, sync stretching,

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LABORATORY TELEVISION SYSTEM
[from page 13]
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 space 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., 376 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 155 mc. Internal audio generator provides 600-cps tone for modulation and for external audio testing.

• 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.

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TV LIGHTING
[from page 19]
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 per-
sonal 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 77

may be applied advantageously to the outgoing video lines of a sizable network originating at a large master control room of the WCBST-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 apparently 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.

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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.

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]
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.

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 work 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 programs 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

Automatic Audio Gain Control systems into our special events beer mug 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 characteristics, 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 sub-normal 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.

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 waveform 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
Three and evening and the results tabulated. ten-minute periods tion peaks and pointed out two surprisingly large variations previously exerted, but variations, not normally subjected to controls much as variations, have 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 discounting 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.

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 discounting 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.

To be concluded next month

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 lecture 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 trouble-shooter and maintenance man; wide knowledge of serious music. Desire position in studio, lab, or custom installation firm. Box 601.

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. B.S.; 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.
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 hailing-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]
In designing and studying electro-mechanical 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 displacement.

(Continued on page 46)
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...achieving the widest frequency range and finest reproduction ever attained!

Write for Data Sheets 160 and 132 which describe the G-610 and other Genuine Jensen Wide Range Speakers.

JENSEN MANUFACTURING COMPANY Division of the Muter Company
6633 So. Laramie Ave., Chicago 38, Portsmouth 7-7600 In Canada: Copper Wire Products, Ltd., 351 Carlaw, Toronto.

AUDIO ENGINEERING • SEPTEMBER, 1950
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 end) and high-fidelity (at the higher end) are already in evidence. The two are the professional and the semi-professional, or home, fields. The major field 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-inch 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-inch 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 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 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 saving 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 pos-sibly 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 lose 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 come 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 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

Pops

RUDO S. GLOBUS

I HAVE RECENTLY RECEIVED a number of letters requesting reviews of some Pops...
A motor car in which the spark plugs are not replaceable???

UNTHINKABLE

... Precisely so in a music reproducer. For years AUDAX has been pointing out that, for a reproducer to be practical, replaceability of the stylus—at home—is highly important.

The now famous AUDAX POLYPHASE, which plays 33 1/3—78—45 rpm records with equal facility and faithfulness, permits instant replacement, by you, of either or both stylis—at will.

FURTHERMORE—It is significant that, thanks to persistent Audax crusading, stylus replaceability has become a MUST with practically every radio manufacturer.

from a letter—

"As an engineer, I admire the highly ingenious and beautifully engineered AUDAX POLYPHASE instrument I purchased a while ago. Your ads have been emphasizing the remarkable EAR QUALITY and FAITHFUL reproduction of POLYPHASE. I find that, if anything, your claims are modest in that respect. But, how about the other highly important features of this remarkable instrument ... ?"

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Never before such EAR QUALITY such FAITHFUL reproduction ... that is POLYPHASE.

but...

ONLY YOU can decide what sounds best and most pleasing to your ears. Therefore . . . . see it, HEAR it and compare it with any reproducer at any price . . . . then, you be the judge.

The new AUDAX tone-arms have no equal. They do far more than just stay in the groove (tracking ability). They are engineered to optimum TRACKING EFFICIENCY. A difference which is highly important to the continued smooth surface and distortionless performance of your records.

There is no such thing as a permanent point—be it diamond, sapphire or metal. They all wear with use and will cause serious damage if continued in use beyond the safety point.

AUDAX COMPANY
500 Fifth Avenue, New York 18, N. Y.

"Creators of Fine Electro-acoustical Apparatus for over 30 years"
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—Amplas or any other make—which can offer, in the economical, non-vital, 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 7/8 in contrast to the fifteen minutes of 33⅓ tape now available, or the semi- professional machines. And, for reasonable quality—plenty good enough for all but the super-duper hi-fi fan—the performance cost of tape is $1, 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 such an extent, in the $50 range or lower, the entire quality home recording field will be revolutionized—or, shall we say, opened up; faced with a few Mass-recorders, 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 Lathco-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-proof, and this in itself is a major obstacle. Tape is clumsy to use at best, might not be wound somehow, or if twin-track, played all the way through. Spouting 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 33 1/3 in, per sec, we have an extraordinarily cheap medium and, moreover, a medium highly economical of space. Similarly for the wide-range 78 in. speed. It is for industry to figure out the right combination—but, if not in mass-production "pops" records, then pre-
LIMP as Boiled Spaghetti
AND IT WON'T STICK

THERE IS A GRADE OF IRISH SOUND RECORDING TAPE FOR EVERY NEED AND PURPOSE.
USE THE BEST GRADE SUITED FOR YOUR REQUIREMENTS!

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

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.

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**FEATURES IDEAL REPRODUCTION**

**TRANSCRIPTION ARMS**

**NEW VISCOS-DAMPED 108-B ARM**

For all records—33 1/3, 45 and 78 r.p.m. Radically new suspension development on the viscous damping principle for perfect tracking of records and elimination of tone arm resonances. Instant cartridge change with automatic correct stylus pressure. Solves all transcription problems. Ideal for LP records. For Pickering, new GE (short), old GE (long) cartridges. Write for bulletin. Price, less cartridges, $56.00 (effective Sept. 1st). Cartridge slides for both GE and Pickering are furnished.

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Designed to meet strictest requirements of modern highly compliant pick-up cartridges. 3 cartridge slides furnished enable GE 1-mil, 2½-mil or 3-mil cartridges or Pickering cartridge to be slipped into position in a jiffy. No tools or solders! Superb reproduction of 33 1/3, 45 or 78 r.p.m. records. Low vertical inertia, precisely adjustable stylus pressure. Write for bulletin. Price, less cartridges, $45.15

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**MODEL 602 EQUALIZER**

Has 4 control positions, highly accurate response curves. Price, $49.50

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**Gray Research and Development Co., Inc.**

Division of The Gray Manufacturing Company

Originators of the Gray Telephone Pay Station and the Gray Audograph

Audio Engineering • September, 1950
joyably skillful remi-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 that sounds like today's. The old familiar "Sorcerer" takes on new excitement both musically and technically—ffr wide range recording is fabulously successful in this piece, and the young Spanish conductor, Jordà, makes it sound fresh and tense. So also with the other Jordà 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 akin to the kind of music that D'Indy writes here—same period as the now familiar St. Saëns 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 passive, 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 Garage, 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 (#5 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 L.P. 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 ffr 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.

Let's not go hog-wild!

Yes—let's not go hog-wild on advertising claims—after all, anyone with a dictionary can put a lot of words together and sound superior.
But—for superior sound—only you—the users of Soundcraft products are in a position to prove, for yourself, the consistent top-quality performance of all Soundcraft recording media—whether tape, discs, or style.

All this advertisement can accomplish is to get you to try Soundcraft products.

Only by actually using Soundcraft constantly can you demonstrate, to your own satisfaction, the consistently better performance Soundcraft has to offer the recording industry.

SOUND CRAFT'S ONLY CLAIM IS ITS PROOF OF PERFORMANCE

Dear Soundcraft:
Please send your recording media catalog.
Our favorite disc distributor is

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A world of up-to-date, highly compressed, essential data for the engineer
in Volume II of the NEW
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Fourth Edition
Editor-in-Chief, HAROLD PENDER,
University of Pennsylvania

Volume II—COMMUNICATION-ELECTRONICS
with KNOX McLWAIN, Hazelton Electronics Corporation

Entirely rewritten, Pender's ELECTRICAL ENGINEERS' HANDBOOK is a compact collection of practical data, charts and tables prepared by 71 specialists in all branches of electrical engineering.

Volume II—COMMUNICATION-ELECTRONICS provides engineers with valuable information for all phases of their work. Because of the extensive advances in the electronics field in recent years, many portions of the book have been expanded to include current developments. Most of the illustrations used are new to the fourth edition.

Standard data, new developments thoroughly covered

Frequency modulation and pulse techniques in both the communication and radar fields appear in this volume for the first time. Radio aids to navigation are also included. There is an expert treatment of non-linear electric circuits. Plentiful information is given on radio antennas, radio wave filters, microwave plumbing, transformers with iron cores, and single-mesh and coupled circuits. A complete section is devoted to electromechanical-acoustic devices, including data on loudspeakers and telephone receivers, microphones, magnetic recording and reproducing of sound, photographic sound recording, and piezoelectric crystals.

Optics, television broadcasting, medical applications included

There are also self-contained sections on optics: physiological, geometric, and electron; sound reproduction systems; a new section on television, including television broadcasting and receivers. A section on medical applications of electricity includes such subjects as diathermy and high-frequency surgery, the medical uses of ultraviolet and infrared radiations, high-voltage shock, and x-ray burn.

October 1950
1164 pages plus index
$8.50

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If I decide to keep the book(s) I will remit price plus postage; otherwise I will return the book(s) postpaid.

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Address

City

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Employed by

(Offer not valid outside U. S.)

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.

Centralized 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 achieving 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 a 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 tingly.

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 recog-

HE CHOSE

MAGNECORDER
Professional Tape Recorders Fit every purpose — every purse!

PT6 SERIES
— world's most widely used professional tape recorder.

PT63 SERIES
— 3 heads to erase, record, and monitor from the tape.

PT7 SERIES
— A complete console for only $950.00. Models for portable or rack mount also available. Outstanding features and flexibility.

FOR FIDELITY
No other recorder offers such high fidelity at such a low price! Frequency response 53-15 kc ± 2 db. Signal-noise ratio: 50 db. Flutter less than 0.3%. Meets N.A.B. standards.

FOR FLEXIBILITY
For delayed studio or network broadcasts, a Magnecorder can be mounted in a rack or console cabinet. For remotes, slip it into its really portable cases. Amplifiers for every purpose—single or multi-channel.

FOR FEATURES
Magnecord sets the pace! New or old, your Magnecorder can have 3 heads (separate erase, record, and playback heads) to permit monitoring from the tape. 3 speeds (15" and 3/4" — up to an hour on a 7" reel) now available on both PT6 and PT63 equipment. Magnecorders are fail-safe, sturdy! Features to fit your every need.

Write for NEW CATALOG

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Send me latest catalog of Magnecord equipment.

Name

Company

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Audio Engineering • September, 1950
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**SOUND IS NOT DELAYED AND PLAYED BACK, BUT DIES AWAY NATURALLY!**

**THE RATE OF DELAY IS ELECTRONICALLY CONTROLLED**

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ized 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 away-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 forms 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 labeled as "high fidelity" have become unpopular because of this. Some audiophiles state that they prefer a
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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 whistle 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,

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32

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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 liveliness 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 directivity 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 transparent: no acoustic fog veils the ensemble, and each instrument stands out with clarity. If the sound system unduly emphasizes the lower middle, 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,
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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 liveliness of the program material, which, when properly adjusted, results in a broad, non-localizable source from which the sound flows out. With too much liveliness the sound appears to come from an adjacent live room, while too little liveliness 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 middle, the sound may also have a megaphonic, hollow quality, appearing to come out of a barrel. Increased liveliness can ameliorate, but not remove this quality entirely. With the proper combination of liveliness, apparent source size and lack of directionality, some critics have referred to big and well-focused tones of great volume (not loudness).

Realistically reproduced sound is natural, life-like, and pleasing. That is, one cannot detect a caused 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 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 nonotypical 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


34

AUDIO ENGINEERING • SEPTEMBER, 1950

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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**

<table>
<thead>
<tr>
<th>Class</th>
<th>Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>Localization, mass of sound; advance, come forward, stand out; distant, dead, recede, lost.</td>
</tr>
<tr>
<td>Presence</td>
<td>Intimate, rapport.</td>
</tr>
<tr>
<td>Detail</td>
<td>Transparent, translucent; clarity; opaque, acoustic fog, veiling, muddy.</td>
</tr>
<tr>
<td>Source</td>
<td>Liveness; broad, volume, floods out, big tones. well-focused tones; dead and flat, compressed, from a hole in the wall, out of a barrel.</td>
</tr>
<tr>
<td>Size</td>
<td>Presence sound; intimate, rapport.</td>
</tr>
<tr>
<td>Reproduction</td>
<td>Realistic, perfect, adequate.</td>
</tr>
</tbody>
</table>

**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.

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FINE-GROOVE
[from page 13]

studies* made years ago to improve the operational characteristics of the recorder. The recording head MI-11850-C was changed from the "vertical" to the "hat" 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 groove 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 degrees 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. 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.

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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.

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low-frequency variations due to hard spots or record warpage are not evident. The horizontal force, \( F_x \) of Fig. 10, at the stylus tip while cutting, creates a moment \( M_1 \) about the pivotal axis which tends to raise the record. Opposing this is the downward moment \( M_2 \) created by the vertical force \( F_v \) also acting about the same axis. \( F_v \) 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 sharpened cutting stylus show these two moments to be equal. The product of the horizontal and vertical forces, \( F_x \) and \( F_v \), 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 the following 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 0.6 inch-ounce. If \( b \), Fig. 11, 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 recording head may be of the same order of magnitude as this balancing force. Likewise, the additional vertical force required for burning through a sapphire is used may be greater, and so result in a depth-regulation problem.
Obtained with variations of the disk, as an example of 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. 12. Lacquer hardness variation of a 16-inch blank.

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 disc are shown in Fig. 13.

Fig. 13. Lacquer hardness variations obtained with a coated paper-base disc.
morass of primitive ancestry. We can therefore junk such romantic posh-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 undisturbed noise, no matter what form is involved. There is an infinite number of ways of making noise, better 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 or a symphony orchestra. The distinction between the noise-making machine and the noise-making orchestral simply involves the fact that the mechanism 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 most of the music of serious composers. Jazz harmonies and harmonic treatments can be found in Debussy in Cesar Franck and even in Tchaikovsky (although not as crudely and without the innocuous melodic line). Such specific jazz treatments which can be found in Milhaud's Création du Monde and the Ravel Piano Concerto are novelty treatments which bear no relation whatsoever to jazz or 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 instrumental 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 baggage of the quality of jazz is thoroughly different from and even opposed to that of serious music. An understanding of and appreciation for jazz is dependent upon the recognition of this one intrinsic point and no amount of both 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

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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 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 not thinking of the music that he is playing. The particular way he feels, the particular sounds that appeal to him at a certain moment, the tempo, and the environmental conditions 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 the music evolves around a consistent and unchanging rhythmic base.

The jazz listener is involved in a diametrically opposite situation. While 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. Where 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 the requirement 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 chameleonlike 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 ego 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 expresion of $0,000 c.p.s. down to 0.05) 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.

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By S. Young White

The rapid increase in the use of ultrasonics during the last few years makes it essential that the well-trained sound engineer should work to learn some of the applications and potentials of this amazing new art. But interest in ultrasonics is not only limited to the scientific world; it is also gaining greater importance to the industrial engineer for he is the one who will have to use its uses in his own processes.

CHAPTER HEADLINES

ULTRASONIC FUNDAMENTALS
By S. Young White

36 pages, 40 illus., 8½ x 11, paper cover

Book Division, Dept. A
RADIO MAGAZINES, INC.
342 Madison Avenue, New York 17, N. Y.
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 flutter. 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 on 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.
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Fig. 3 (left): Type of core assembly liable to damage from tape abrasion. Fig. 4 (right): Core design not injured by abrasion.

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

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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 traveling 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 run 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.

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dipation of heat by a resistance. In the electronic case

\[ r = e \]

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:

\[ r = \text{resistance, in all systems, in ohms absolute} \]
\[ f_m = \text{mechanical force, dynes} \]
\[ f_R = \text{torque, dynes-centimeters} \]
\[ \theta = \text{angular velocity, radians per second} \]
\[ p = \text{pressure, dynes per cm}^2 \]
\[ U = \text{volume current, cm}^3 \text{ per second} \]
\[ w, v \text{ or } x = \text{velocity, cm per second} \]

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 inerterance may be expressed by the following equations:

\[ f_R = \int \frac{d\theta}{dt}; e = L \int \frac{du}{dt}; f_m = M \int \frac{du}{dt}; \theta = M \int \frac{dU}{dt} \]

where \( I \) is the moment of inertia; \( du/dt \) is the acceleration; and \( M \), the inerterance, is defined as \( M = m S^2 \) in which \( m \) is the mass and \( S \) is the cross-sectional area over which the driving pressure acts to drive the mass in \( cm^2 \).

The equations for capacitance or compliance in the analogous cases are

\[ e = \frac{g}{C}; f_m = \frac{x}{C_m}; f_R = \frac{\theta}{C_R}; p = \frac{X}{C_A} \]

In the last equations \( C_A = \frac{1}{p^2} \) and \( X = \text{volume displacement, cm}^3 \).

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
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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

\[ Z_{EM} = \frac{RI}{Z_m} \]

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 inerterance 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)
HARTLEY-TURNER
REPRODUCTION
AT LOW FIDELITY COST

Our new amplifier and pre-amplifier recently announced are going to cost you very little considering their superlative performance. At the time of writing this copy we think we shall be able to supply the pre-amplifier with independent non-disturbing bass and treble control, and which can be used remote from the main amplifier, for about $25.00 and the 20 watt high-fidelity amplifier, with overall feedback and flat response from 30 to 30,000 cps, for about $102.00.

Added to this it seems likely that our new lightweight pickup for both standard and microgroove records will work out at about $10.00 including sapphire.

These items used with the 215 speaker at $40.00 will give you record reproduction quite exceptionally outstanding, and if you have a motor you can now reckon that the very last word in phonographs can be yours for a total cost of around $175.00, and less if you are a member of a Speakeasy.

Send a dollar bill today for "New Notes in Radio", a regular mailing of data sheets and details of the Speakey marketing scheme. All names on our mailing list will receive full details and data sheets on the new products without the need for writing to us.

H. A. HARTLEY Co. Ltd.,
152 Hammersmith Road,
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**

**APPLICATIONS**
- MAGNETIC AMPLIFIERS
- PULSE TRANSFORMERS
- NON-LINEAR RETARD COILS
- 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 ½” to ½” high.

**RANGE OF TYPES**
These standard core sizes are available in each of the three magnetic materials named, made from either 0.004”, 0.002” or 0.001” tape, as required.

**ARLOR**

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**of DELTAMAX 4-79 MO-PERMALLOY SUPERMALLOY**

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 license agreements with Western Electric Company.*

**THE ARNOLD ENGINEERING COMPANY**

**SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION**

General Office & Plant: Marengo, Illinois
UTC was the largest supplier of transformer components in World War II. Present UTC production is on a similar basis. Illustrated below are a few of the thousand military types in UTC 1950 production.