AUDIO

MARCH/1966

60¢

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LONDON SHOW SECTION

See page 33

Scott's best solid-state components! Build them yourself and save $160

Now you can enjoy the world's most advanced solid-state engineering, and save up to $160, when you build these Scott solid-state kits. Scott kits give you the same features, performance, quality, and long-lived reliability you've come to expect from their factory-wired counterparts . . . the only difference is, *you* build them.

And building them is easy . . . Scott's exclusive kit construction book with full-size, full-color step-by-step diagrams reduces the possibility of wiring error . . . cuts construction time to a minimum. All critical circuits are pre-wired, pre-tested, and mounted on heavy-duty printed circuit boards at the Scott factory. All wires are color-coded, pre-cut and pre-stripped to the proper length. Here is a preview of the exclusive Scott features you'll find in your Scott Kit Pak:

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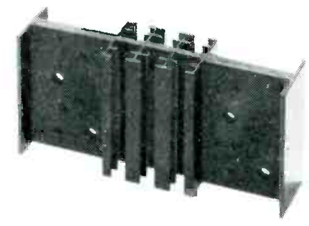
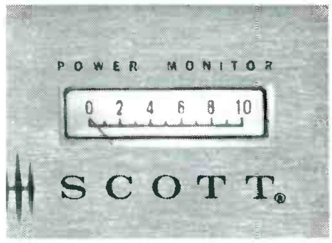
Rugged silicon output transistors give full audio frequency performance at high power . . . drive even the most inefficient speakers.



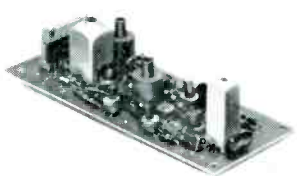
Massive military-type heat sinks keep output transistors running cool . . . assure top performance under high power output conditions.

Rugged pre-wired, pre-tested printed circuit boards greatly reduce the possibility of error . . . stand up under years of strenuous use.



Exclusive Circuit Monitor allows you to set output stage bias and balance for absolutely minimum distortion, without external test equipment.

Ultra-sensitive LT-112 FM Stereo Tuner Kit



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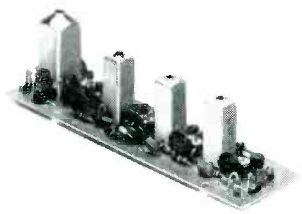

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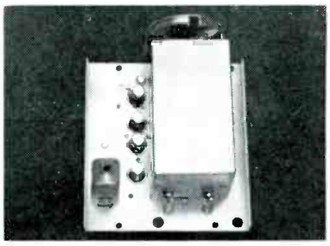
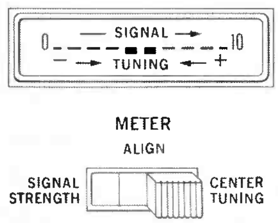


New Scott silver-plated front end gives exceptional sensitivity . . . outperforms and outlasts even the best conventional tube or transistor front ends.



Exclusive "Three-Way" front panel tuning meter serves as a signal-strength indicator, zero-center indicator, or highly accurate alignment meter.

Specifications LK-60: Music Power/Channel @ 4 ohms. 60/60; Frequency Response, 15-30,000 cps ±1 db; Power Bandwidth, 20-20,000 cps. Price, $189.95.
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Circle 100 on Reader Service Card

AUDIO

March, 1966 Vol. 50, No. 3

Successor to RADIO, Est. 1917

AUDIO Articles

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AUDIO Profiles

AUDIO in General

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COMING

Articles

Continuing — A Solid-State Flutter Meter, by **Arthur E. Gladfelter.** Beginning of the actual construction information.

Part 4 of **Norman Crowhurst's** Audio Measurements Course.

Intimations of Irresponsibility, or Circuits for Speculation, by **George Fletcher Cooper.** The author explores some possible — though not necessarily probable — circuit configurations.

Together with the usual departments, record reviews, and

Profiles

Uher 9000 Tape Recorder (announced for this issue, but pushed out by the London Show).

Empire 8000-P Loudspeaker System. Pilot R1100. A new solid-state receiver.

In the April Issue

On the newsstands, at your favorite audio dealer's, or in your own mailbox.

AUDIO CLINIC

Joseph Giovanelli

Send questions to:
Joseph Giovanelli
2819 Newkirk Ave.
Brooklyn, N. Y.
Include stamped, self-addressed envelope.

Signal-To Noise Considerations

Q. I have a problem with which I would like your advice or comment.

I bought a commercial electronic crossover. The theory behind this equipment is wonderful and it almost works. It is a neat, compact piece of equipment. It crosses over perfectly as per settings. It has perfect volume control on both HF and LF systems, but it introduces objectionable noise into both HF and LF circuits.

What type of noise? It is hard to describe—a rushing, or frying noise, but that seems to be it. I have written to the manufacturer several times. The reply hinges around signal-to-noise ratio. It involves incorporating an audio pot of about 500,000 ohms in the output and adjusting it for best signal-to-noise ratio.

You know what I think? This is a poor way to handle hi-fi results, and I think that I'm being pushed around.

On my own, I have designed a standard crossover circuit (crossover about 1000 Hz) which I am now using. No fuss, no muss, just switch it on and there you are, without the rushing, frying background.

Why don't I give up and go back to sleep? The commercial product has so many desirable features, and I am the curious type, but I don't know enough about what is wrong to even start setting it right.

Can you give me some help with this? Please answer by mail if possible. J. R. Simonin, Detroit, Michigan.

A. I always answer all questions by mail regardless of their suitability for use in AUDIOCLINIC. Even those which are used are answered by mail because I do not want to keep my correspondents waiting for long periods of time between the receipt of their letters and the publication of the material in my column. Also, I always make sure that a correspondent wishes his name to be used.

I believe the answer the manufacturer of the electronic crossover network gave you is a valid one. I also believe that it needs some elaboration.

Do your power amplifiers have level controls? If they have, you are all set. What you do is to connect the crossover networks to the amplifier in the normal manner. Adjust the level controls in the power amplifier for reduced hiss. Then turn the preamplifier on and listen to the sound. Is there sufficient signal from the preamp to drive the power amplifier at this new gain control setting? If there is, and there will probably be enough, you are then finished with your adjustments.

But, suppose that you have no level controls on your power amplifier, and I suspect that this was the assumption made by the manufacturer of the crossover network. You can incorporate the controls at the output of the crossover network or at the input of the power amplifier. I prefer that the control be located at the input of the power amplifier because the capacitance of the interconnecting cable from the arm of the control will not result in a loss of high frequencies.

Such a signal attenuating arrangement can be of the conventional potentiometer variety or it may be of the fixed attenuator type, which is nothing more than a voltage divider made from two resistors set to an attentuation of 10 db or whatever value is needed to reduce the hiss to an unobjectionable level.

I am sorry that you feel you have been given a run-around by the manufacturer. But, consider this point. Equipment is made in many different ways. Sometimes it is necessary to compensate somewhat when a particular piece of equipment is added to an existing system. I suppose this is a curse of sorts, but it is a blessing also. It makes available a tremendous amount of flexibility which cannot be obtained in any other manner.

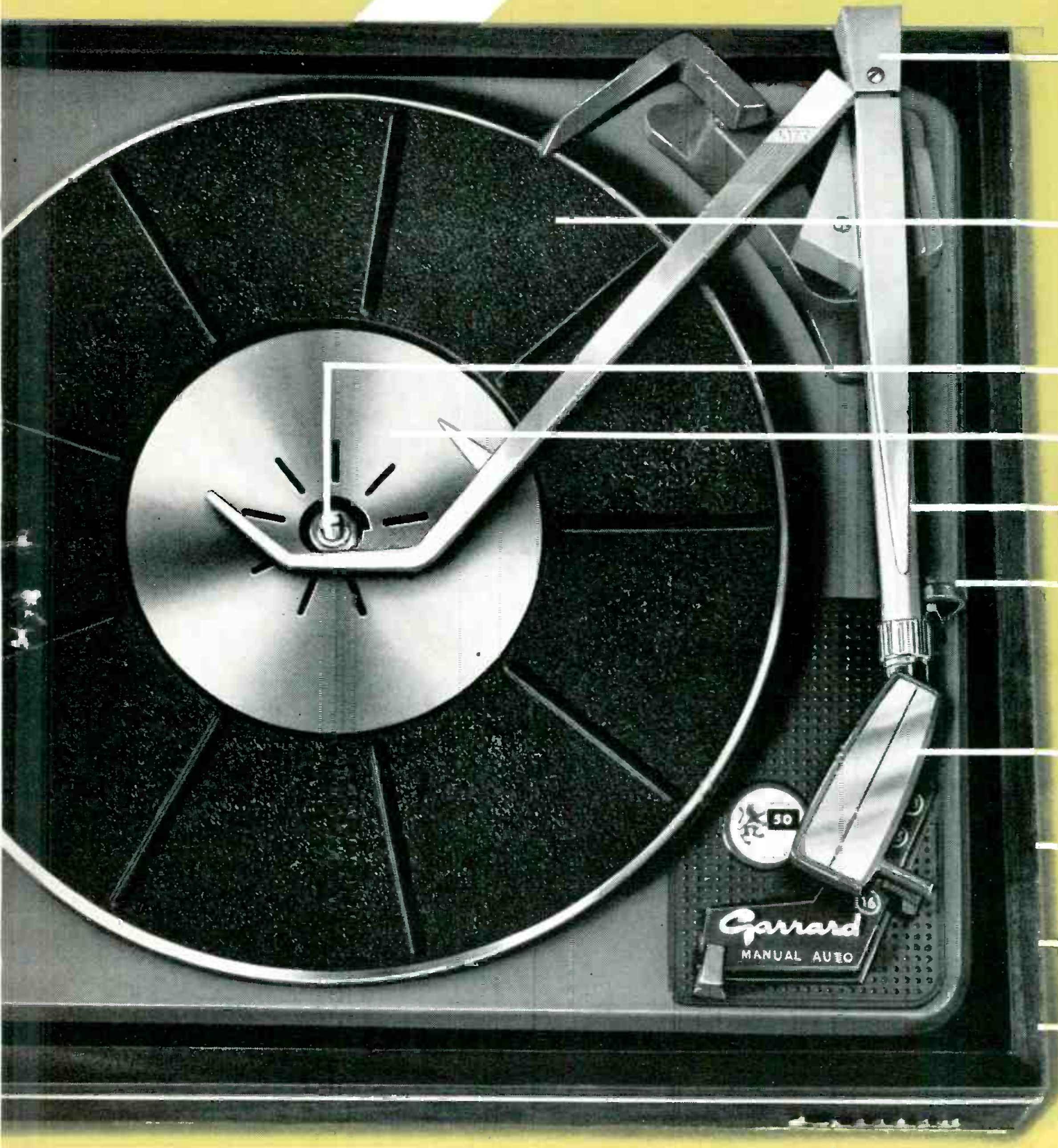
Output Transformer Substitution

Q. In attempting to substitute a Triad HFM-193, 70-volt output transformer, for a conventional 16-ohm unit, I found it impossible to reconnect the feedback loop. I have tried various resistors connected to the 125-ohm tap without any success.

The original feedback circuit incorporated an 8200-ohm resistor, shunted by a 220-pF capacitor. This circuit was connected to the 16-ohm tap of the original transformer and to a point between a 2200 ohm resistor in the cathode circuit of an EF86 tube, and a 100-ohm resistor whose other end is grounded.

Would you please advise me as to how I can complete a satisfactory feedback circuit using a HFM-193 transformer? The EF86 tube is directly coupled to a "long-tailed" phase-inverter tube. A. D. Wadsworth, Ah-Gwah-Ching, Minnesota.

A. I can see three approaches to your problem. The first approach would be to



Graceful cast aluminum tone arm is counterbalanced—first time this type of arm has been available in a popular priced unit. This feature alone gives the Model 50 particular significance—an automatic in the economy field which can track high quality cartridges for finer sound reproduction.

Oversized turntable with handsome mat is reminiscent of previous Garrard models in a considerably higher price echelon.

Two spindles—a convenient short spindle for playing single records manually; an interchangeable center drop spindle for automatic play when desired. Spindles remove for safety and convenience when taking records off the turntable.

In automatic position, Model 50 intermixes records of any size or sequence.

Stylus pressure adjusted with simple, accessible finger touch device, for correct tracking force, according to the cartridge manufacturers' specifications.

Super sensitive trip, with Dupont Delrin® to offset friction, operates with any high compliance pickup at correct minimal tracking force.

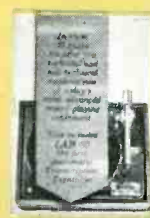
Shell is lightweight cut away type with extended finger lift for safety in handling. It plugs in . . . accommodates your widest personal choice of cartridges . . . can be removed from the arm instantly to change cartridge or service stylus.

Garrard 4-pole shaded "Induction Surge" motor, with dynamically balanced rotor, shielded from hum. Constant speed assured, free from vibration.

Ultra-compact—fits easily into any record changer space. Only 14⅞" left to right, 12½" front to rear, 4⅝" above and 2⅞" below motor board.

Simple installation. Fully wired for stereo, with a 4-pin, 5-wire system utilizing separate connection for ground, to eliminate hum. Leads connect to the changer with a built in Amplok plug (for AC) and a female twin phono socket mounted on the unit plate (for audio). Simply plug in at the player!

Important reading: 32-page Comparator Guide detailing all Garrard models. Write for complimentary copy to Garrard, Dept. GC-16, Westbury, New York 11591.



This is the Model 50 *Garrard's most compact manual/automatic turntable. Despite its modest price of only $44.50, dealers large and small, in every part of the country, think enough of this unit to include it in the overwhelming majority of advertised systems which they pre-select. The dealer knows he can combine the Model 50 with the finest, most expensive brand name amplifiers, receivers, and speakers, and offer them to his most discriminating customers assured that it will be compatible and an enduring credit to his reputation. The dealer's recommendation is important to you. It is every bit as significant as the impressive list of features on this page, which the Model 50 incorporates. This is the lowest priced Garrard automatic . . . but all Garrards meet exactly the same strict standards of quality. Therefore, you can buy a Model 50 with complete assurance, and you will use it with pride as well as pleasure, for years to come.*

Garrard®
WORLD'S FINEST

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use a resistor much higher than the original 8200-ohm feedback resistor, perhaps 10 times higher, or even more. The capacitor should be omitted until you have established some kind of feedback action which appears reasonable. The capacitor will serve to obtain the last possible amount of feedback and to maintain amplifier stability. The capacitor will be something like 1/3 its original value or even smaller. This is a matter of transformer design and of experimentation. A 'scope and a square-wave generator are needed to obtain the best value for this capacitor.

The second approach would be to use a voltage divider across the 125-ohm or 70-volt-line winding. Make the total value of this divider about 1000 ohms and have 100 ohms between ground and the junction of the remaining 900 ohms and the feedback resistor. Under these circumstances I suspect that the feedback resistor and capacitor would be close to their original values. Experimentation would, of course, be necessary to verify this.

The third approach is to reduce the size of the 100-ohm resistor in the low end of the cathode circuit of your EF86 tube, to a value of perhaps 10 ohms. The feedback would be inserted between the high end of this 10-ohm resistor and ground. Again, I suspect that the values in the original feedback circuit would be close to those required in the original amplifier design

I believe that either of these last two approaches is the best one.

In all three methods, a potentiometer connected as a rheostat can be used in series with a fixed resistor. This combination is used as a substitute for the feedback resistor. The potentiometer is adjusted until optimum feedback is achieved. Its value, plus that of any series resistor which has been added, will be equal to the required feedback resistor. A 'scope will be useful when determining the amount of capacitance to be placed across this feedback resistor, as has already been pointed out. Once the square-wave response has been improved, it is possible that the feedback may again be increased by decreasing the value of the feedback resistor. You will want to be sure however, that the amplifier has about 6 db margin of stability. That is to say, if you increase the feedback 6 db beyond the point you select as your optimum, the amplifier will just break into oscillation.

You may find that no capacitor is required.

If all three of these approaches fail, it is very likely that you have connected your output transformer in opposite phase, leading to the introduction of positive feedback rather than the negative feedback which you seek. Merely reversing the two primary leads of the transformer should solve your problem. If there are screen taps on your transformer, these, too, should be reversed.

ONLY 4% OF RECORDED SELECTIONS* TAKE UP MORE THAN ONE DISC.

WHETHER YOU USE A CHANGER OR A MANUAL TURNTABLE, THE REMAINING 96% MUST BE TURNED OVER BY HAND.

Should you buy a turntable or a record changer?

If a good part of your listening is to multi-record albums and you hate to get up every twenty minutes (or if you like to stack records for background music), your best bet is a good changer.**

For playing single records the AR turntable is, if anything, a little more convenient than most automatics because of its operating simplicity. But this is a relatively minor consideration compared to its other advantages—uncompromised professional performance and insensitivity to floor shocks.

Rumble, wow, flutter, and speed accuracy are guaranteed, as a condition of sale, to meet NAB specifications for broadcast turntables. The speed remains accurate within 0.3% (1/20 of a half tone) whether or not you are using a dust cleaner that bears on the record, and no matter how much the line voltage varies.

Literature, including descriptions of the top stereo systems chosen by four magazines (all four chose the AR turntable from a field of competing units costing up to twice as much), is available on request.

**Close to 100% of non-classical titles, and 89% of classical titles are on single discs. Data taken from the current Schwann catalog.*

***In choosing a record changer make sure that it does not slow down from the end of one side to the beginning of the next, or the orchestra will seem to go flat after each record drop. A speed error as small as 1% means a discernible pitch error of 1/6 of a half tone.*

$78.00 complete with arm, oiled walnut base, and dust cover, but less cartridge, 33⅓ and 45 rpm

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LETTERS

Schematics with Profiles?

SIR:

I feel your magazine would be considerably better if you included schematics with your EQUIPMENT PROFILES as you once did.

They were helpful in forming judgments on such equipment.

W. L. GRIFFIN,
192 Alleghany St.,
Roxbury, Mass. 02120

(We would really like to, but since the advent of stereo, they take up a prodigious amount of space. The magazines which specialize in servicing information usually employ "fold-outs" in order to get all the information on one sheet of paper. ED.*)*

Wooden Monster

SIR:

My story on the "Wooden Monster" in the October issue seems to be in good shape with the exception of the graphs in *Figs.* 4, 5, and 6. The frequency scales are all shown ten times greater than they should be. In *Fig.* 4, the curve runs from 10 Hz to 100 Hz rather than from 100 to 1000 as shown. In *Fig.* 5 the curve extends from 20 Hz to 100 Hz, and in *Fig.* 6 the curve should be between 5 and 100 Hz.

C. WILLIAM PHILLIPS,
Spaco, Inc.,
3022 University Drive,
Huntsville, Alabama

"In a Word, Don't"

SIR:

We would like to say "Amen" to the advice given by Herman Burstein in THE TAPE GUIDE in the September, 1965 issue.

In a word, Mr. Burstein said "don't." He might have added "positively."

While it is true that a consumer can save money by purchasing a top-quality recorder in Japan, the consumer is leaving himself open for a lifetime of headaches. Many of the brand names found in Japan are not seen in the U.S. If only for brand recognition purposes, many U.S. importers use their own names on the machines they sell. In addition, the importers often have modifications made on the machines by the Japanese manufacturers.

The owner of a machine bought directly from Japan is probably going to find himself with a recorder which will not be repaired under warranty, if repairs should become necessary, and it is possible that the machine may contain parts which can not be replaced in the U.S.

This situation holds true for nearly all hi fi equipment. American importers and Japanese manufacturers have spent years building their present distribution and service networks, in an effort to ensure consumer satisfaction. Consumers who bypass routine business channels in purchasing hi fi equipment (domestic as well as imported) frequently find themselves with the most expensive "bargains" they ever owned.

ROBERT E. GERSON,
Electronics Division,
Japan Light Machinery Center
437 Fifth Avneue,
New York, N.Y. 10016

Ben L. Arons—1916-1966

AGAIN IT BECOMES our unpleasant duty to chronicle the passing of a well-known member of the audio industry—one who was respected by everyone who knew him. Ben L. Arons, Executive Vice-President of Fisher Radio Corporation, died suddenly on February 6, 1966, while on vacation in Florida.

A graduate of St. John's University, Mr. Arons served as a Lieutenant in the U.S. Navy during World War II, following which he was with the Reconstruction Finance Corporation, joining Fisher Radio Corporation in 1946.

He was active in the high fidelity industry, and a member of the Board of Directors of the Institute of High Fidelity. He is survived by his widow, Syra, and two children, Michael and Jean.

Ben will be missed by the entire industry because of his devotion to it, as well as for his unfailing charm and courtesy.

LIGHT LISTENING

Chester Santon

Skyscraper (Original Broadway Cast)
Capitol SVAS 2422

"Skyscraper" is hardly a towering addition to the current Broadway skyline but it will have to do until something more imposing takes its place. It seems that with each new season, the musicals on Broadway are getting off to a slower start. With all the complications that are an inevitable part of a large production these days, no one expects to find a sizable musical ready to open on the first day of autumn. It probably isn't a coincidence that most of the worthwhile shows in recent years have been opening well along in the winter after the cast has been able to put in months of work following the usual doldrums of summer time show business. A whale of a lot of good professionals have been involved in the preparation of "Skyscraper" but it would be stretching a point to claim they have come up with even a moderately scintillating musical. The star is the well known Julie Harris, appearing here in her first singing role. The absence of an average singing talent on her part is really not too noticeable because the producers have paired her with a leading man just able to get by in his songs. It's a small miracle they manage as much musical interest as they do when you consider the prosaic nature of the plot. "Skyscraper" is based on an old Elmer Rice play called "Dream Girl" and recounts the far-from-exciting story of a stubborn young lady who refuses to sell her tiny Manhattan brownstone standing in the path of a skyscraper slated for her block. I can see how the plans for the show first looked promising to its backers. Producers Feuer and Martin have had their share of musical comedy successes in the past. Composer Jimmy Van Heusen and lyricist Sammy Cahn, jointly and with other writers, have received five Academy Awards for past efforts. Their main contribution here is the song "Everybody Has the Right to be Wrong" and several other tunes that paint vignettes of New York life. In "Local 403" the construction crew working on the skyscraper finds itself being berated by its foreman for conduct unbecoming a Manhattan work gang: ignoring two passing girls. "Haute Couture" and "The Gaiety" has the authors paying tribute to the New York fashion scene and a leading delicatessen in the Times Square area. Among the featured players, Charles Nelson Reilly provides a silver lining of professionalism in a cynical-type song he does so well. The show may not be a block buster but it does offer employment to people outside the building trades.

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*12 Forest Ave., Hastings-on-Hudson, N. Y. 10706

Scottish Heritage
Columbia CS 9207

An up-to-date stereo recording of bagpipes and drums should be able to muster a bit of space at least in magazines whose publishers have some form of "Mc" in their name. Up 'til now the Angel, London, and Audio Fidelity labels have done the most to ingratiate themselves with pipe 'n drum fans seeking sonic thrills in this somewhat specialized musical field. Columbia Records is entering the lists with a recording made in Canada that offers the standard features of clean miking and processing available on most of the label's current releases. The setting for the recording is historic Fort York in Toronto and it would take a pipe expert indeed to determine where the musical content of marches, reels, jigs, and polkas differs from similar material offered by European bands on other labels. Unlike some of the Angel and London productions, however, little effort has been expended by Columbia to create the illusion of an outdoor parade ground. The sound, while not cramped, is more closely miked than average for pipe bands.

Marlene Dietrich in London
Columbia OS 2830

Lets assume the worst. A reader of this column is too young to know what Marlene Dietrich has been all about and he hasn't been enterprising enough to investigate her existing series of records on the Columbia, Decca, and Capitol labels. The fact that many of her recordings are available only in mono sound certainly is no excuse for unfamiliarity with an artist of this stature. Even the youngest and most callow listener, upon sampling Miss Dietrich's list of currently obtainable records, would have to admit this London concert appearance, recorded in beautifully balanced stereo, is the best of the lot. As a full-fledged member of the "Dietrich generation," I wouldn't hesitate to rate this release one of the truly outstanding recordings of the past decade in the field of light entertainment. No matter where one approaches the list of good things on this record, the final accolade must be reserved for the amazing Dietrich personality and the way she can still project it in a song. Some of the outstanding features of the album can be considered man-made, but the Dietrich charm is a phenomenon released by the gods only to a favored few. The smart arrangements, the uncanny rapport between orchestra and star, the unerring taste in the choice of material —most of these things can be worked out with lavish use of money and hard work. The key ingredient is a star's personality no young singer of today could quite duplicate. The singer's ease in handling German and French would be enough to set her albums apart but, along with Miss Dietrich's Continental specialties, there are other surprises in the treatment of typically American standards such as "I Can't Give You Anything but Love" and "Honeysuckle Rose." Much of my enthusiasm for this recording can be traced to the exceptionally deft work of the recording crew that miked the Dietrich performance at a concert in the Queen's Theatre in London. A model job has been turned in during the course of what must have been a very pleasant recording assignment. Æ

Copenhagen Pops
Capitol SG 7253

The dynasty in light music founded by Johann Strauss in Vienna overshadowed quite a few composers of the time who had elected to write in a similar vein. Fellow Austrians were not the only ones to produce music destined to remain in the shade while the glittering works of the Strauss family went out to conquer the world. It took the mushrooming sales of LP records and the search for less well-known light music to bring other composers of the Strauss period into any kind of prominence. Even then, fame was quite slow in coming to the carefree melodies of Hans Christian Lumbye, who could be described as the Danish Johann Strauss.

Lumbye organized his own orchestra in Denmark back in 1839 pretty much for the purpose of playing Strauss concoctions then invading the country for the first time. It wasn't long before he was turning out his own galops, polkas, and waltzes as conductor of the orchestra at the famous Tivoli Gardens in Copenhagen, a tourist attraction to this day. Capitol Records now performs a distinct service to connoisseurs of blithe melody in presenting a representative collection of Lumbye's works that includes some of his best material. The Copenhagen Symphony Orchestra is led with aplomb by Lavard Friisholm in a program that gets off to a bracing start with "The Copenhagen Steam Railway Galop" inspired by the opening of the city's first railway in 1847. In this and other confections (the cork-popping "Champagne Galop" and so on you'll find the Danes most generous in their dispensation of sound effects).

Elke Sommer: Love in Any Language
M-G-M E 4321

Admirers of Elke Sommer's ultra-blonde beauty on the screen of their local theatre will be the first to pay attention to this new release at their record dealer. Such admirers have been busy enough with other matters not to wonder if the girl could also sing. Here is their chance to find out. Marlene Dietrich, another Berlin Girl, may not consider Miss Sommer a logical successor in the field of continental song but any reasonably lenient male will be sure to detect a certain similarity. If for no other reason, Miss Sommer deserves a lot of credit for attempting to rival the great Dietrich in taking on songs in a variety of languages. You'll find lyrics here in German, Spanish, Italian, French, and English. They're handled very nicely for a movie star entering a new line of work. Æ

At last! A solid-state amplifier as great to listen to as it is to talk about.

The relatively young technology of transistor circuits has resulted in quite a number of solid-state amplifier designs that sound better on paper or in conversation than in listening tests. It seems that producing a no-compromise transistor amplifier which equals or surpasses the performance of comparable vacuum-tube models demands a special kind of engineering ability and experience. The Fisher kind.

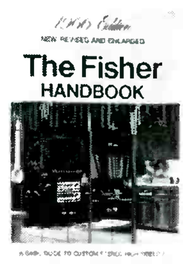
Fisher solid-state amplifier design begins with the elimination of the output transformers. Thus, the bass performance and transient response of the new Fisher TX-200 stereo control-amplifier are not limited by transformer characteristics. And instead of the conventional two output transistors per channel, Fisher engineers put in *four,* to give you conservative operation at high power.

Not only can the rated power of 90 watts (IHF Standard) be obtained at 8 ohms, but almost as much power is available at 4 or 16 ohms, via the special impedance-selector switch. The IHF power bandwidth (half power at low distortion) extends from 12 to 50,000 cps!

As for preamplifier and control features, the TX-200 provides 16 inputs and 12 outputs to accommodate every type of program source, recording instrument, loudspeaker or headphone – plus 16 controls and switches for total control of the sound by the listener.

And, unlike certain hastily engineered transistor amplifiers, the TX-200 works equally well after three hours, three months, or three years. That's Fisher reliability. And that's *really* something to talk about.

Size: 15-1/8″ x 4-13/16″ x 11-7/8″ deep. Weight: 24 lbs. Price: $279.50. Cabinet: $24.95. (The Fisher TFM-200, a transistorized tuner designed to match the TX-200, costs $229.50.)



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FREE! $2.00 VALUE! Send for your free copy of the new 1966 edition of *The Fisher Handbook.* This revised and enlarged version of the famous Fisher high fidelity reference guide is a magnificent 80-page book. Detailed information on all Fisher components is included.

Fisher Radio Corporation
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The Fisher TX-200

Circle 110 on Reader Service Card

ABOUT MUSIC

Harold Lawrence

Recording in the Concertgebouw, Amsterdam (Part I)

Recording for the first time in a 'new' hall is always a challenging experience. You may have heard concerts and listened to recordings made in that hall, but will it respond to your microphones and your general recording approach? You are determined to get the most out of the hall, however, and you are reassured by the fact that your electronic gear has been set up in a legendary concert hall: the Concertgebouw of Amsterdam.

Built in 1888, this center of Dutch concert life ranks high among the world's music rooms. With a reverberation period of two seconds when occupied, the sound is mellow and well blended, ideal for music of the Romantic era. The Concertgebouw seats 2206, is unusually wide (95 feet) and has a ceiling 50 feet above the orchestra. Diffusion is remarkably even: orchestral details emerge with vivid clarity out of a rich homogeneous texture. As in most halls, the sound in the balcony is preferable to that on the floor, where the longer time-delay caused by the hall's width and length reduces clarity for those concertgoers seated on the side or too close to the stage. There is also a falling off of double-bass level due to the audience seated behind the orchestra. But to this listener, the faults of the Concertgebouw are vastly outweighed by the fusion and luminosity of the over-all sound.

The dynamic range of the Concertgebouw is breathtaking. The softest tones will not thin out in their journey through the hall, or worse, die stillborn on the stage. The reverberation period reinforces orchestral crescendos; at no time does the hall "limit" or swallow up the full impact of an orchestra's peak power. The listener is surrounded by a warm mixture of direct and reflected sound. Like a noble wine, the Concertgebouw's "original taste" (direct sound) is enhanced by a lingering aftertaste (reverberation) that bathes the aural palate.

Fig. 1. Willem van Otterloo conducting the Hague Philharmonic in the Concertgebouw during recording session.

A great hall is to the recordist what a great wine is to a viticulturist. Entering the empty Concertgebouw on the brisk January morning a day before the first session, one could almost "smell" the vintage sound of the hall. The house lights spread a golden glow over the old-fashioned elegance of the auditorium. Stagehands had removed hundreds of seats from the floor, laying bare the hardwood surfaces. The conductor's podium, with its red velvet carpet and railing, taken down from the stage, now faced an array of orchestral chairs in the center of the auditorium.

The decision to record on the floor was based on several factors: the steep stadium steps of the stage afforded little or no maneuverability for most instruments; with a full orchestra, the producer is restricted to a limited number of physical arrangements; there is little he can do about percussion, harp, piano, double basses, and other sections except to move around microphones; he must settle for what he can pick up in the positions available to him. And these positions entail sonic penalties: double basses and timpani lose energy on the relatively thin stage floor; horn sound tends to be soaked up by the upholstered audience seats rising up from behind the stage toward the organ pipes, and the close proximity to the stage walls of certain sections can result in a boxed-in sound, in contrast to the open sound of instruments closer to the apron of the stage.

The above hazards virtually are eliminated by moving the orchestra to the floor. Here instruments can be deployed at will on the center of the cleared floor. Winds, brass, and other sections can be raised on platforms according to the needs of the musical score. Baffles can be brought into play to reinforce double basses, horns, and other sections when necessary. Even a Stokowski would have total freedom to carry out the most far-out ideas on orchestral placement.

Another advantage of working on the floor is the fact that sound waves radiate from a centrally located sound source, resulting in an improvement in blend and a more consistent reverberation pattern. Finally, the floor itself provides a sturdier acoustical underpinning due to the five-inch concrete-and-sand base beneath the hardwood planks.

On January 3rd, Philips produced the first of a series of recording sessions in the Concertgebouw using equipment newly designed and built in its laboratories in Baarn. The orchestra was Holland's second symphonic organization, the Hague Residentie, whose musical director is Willem van Otterloo. As the musicians filed into the hall it filled up with the sounds of their greeting each other—this was their first session after the Christmas and New Year holidays. Overlooking the setup was a television camera which was to relay the scene via closed-circuit TV to the monitor room downstairs, where the recording and playback equipment was housed. As van Otterloo ascended the podium, the men applauded; he made a brief speech, signalled the oboist to sound the 'A' and announced the first work to be recorded. In the control room, the Philips recording crew listened to the familiar crescendo of tuning noises, straining their ears for some clue as to the shape of sounds to come.

(*To be continued*)

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Crossover
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Grill comes in 4 colors:
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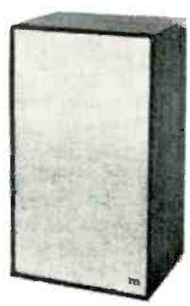

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Edward Tatnall Canby

Pitch and Tempo Regulator

EVERY SO OFTEN I run into what I like to call a double-taker. One of those things that you read about, or look at, ever so casually, and then maybe two seconds (or two hours later—you draw in a sudden quick breath and sputter out, "WHAT??? Now *wait* a minute! *Lemme see that thing again. And* you take another look, a lot longer. a lot closer.

I ran into one of these, a real dilly, a year or so ago. It's been rankling me, in my mind, ever since. Won't let me go. Can't remember just which ad, or technical account, or promotional flyer first hit me with the old one-two, but it could, maybe have been the following. Concerned a certain tape recording accessory, hooked onto your pro recorder for re-recording radio programs and the like. Anything on tape, like, say, music. Or speech. What did it do? This:

"To change program length without changing pitch. To change pitch without changing program length." That's all it says.

WHAT??? Now *wait* a minute. . . ."

You see what I mean. So I determined to do something *immediately*—I couldn't let *that* ride along in my mind unexplained.

Immediately, in my slightly confused world, takes a little longer. But I'm a persistent guy, no matter how slow. And so after a couple of years of sporadic communication with Stephen Temmer of Gotham Audio, I actually got down to business one day last fall and went over to *see* the impossible. And to hear same. It's called the Eltro MLR 38/15 Tempo and Pitch Regulator. (or, at least, the model then in production was so called. A newer streamlined version is now out, essentially the same machine.)

Now, how in the Lord's own name can anybody in this realistic, factual world start speeding up recorded pitch without changing the tempo or speed? And, conversely, how in anybody's name can you do the equally fantastic, and make the recorded music move faster, or slower, while *staying at the same pitch*? And all this via the turn of a convenient knob, repeatably, predictably, accurately?

For those who have not quite yet done the proper double-take, let me remind one and all of the variable-speed turntable (the old acoustic wind-up is the prime example!) whereby the speed AND pitch, indissolubly locked together by Mama Nature herself, go faster/higher, or slower/lower, depending on the table's rpm of the moment. Speed up the table and the music goes up in pitch—as in speed—with a lovely fire-siren effect. Slow down, and the pitch sags most dismally in the familiar groaning manner. Play speech too fast and the speaker changes personality—the virile male baritone becomes a petulant tenor. Slow him down and he turns into a grandfatherly bass, fat and tubby in sound.

(Did you ever discover, by the way, that pitch change is actually far more sensitive for speech than for music? A quarter-tone rise or drop over the normal pitch in music is noticeable to most of us but not at all unpleasant—plenty of record players do it all the time for us. But the same variation in a well-known voice wreaks a devastating change in personality. Don't *I* know—thanks to many misguided recordings and playbacks of my own broadcast tapes!)

. . . So how do we go about detaching speed from pitch? Absolutely unnatural! Like enlarging a photograph without making the figures in it any bigger. Or detaching weight from specific gravity. (Yep, can do. In a centrifuge. Or in space.)

I put the question to one of my younger audio buff friends just now, and got an answer in around 15 seconds. Correct. So I'd better stop stalling around. You do it via rotating heads. Like in a videotape recorder only different.

Wire Brush Scanner

. . . Funny, I just thought of an odd analogy for the latter, and maybe the former too. Know those dizzy rear-steering wire-brush-and-spray street cleaners you see in big cities, zooming along next to the curb, scooping all the dirt and debris, lightly sprayed with water, into a central hopper? Well, those wire brushes, striking sparks (and making your spine shiver sometimes) are "scanning" the street surface somewhat in the fashion of rotating heads on a passing tape (especially, a helical-scan videotape!). They manage collectively with many fast-moving steel wires, to cover a vast mileage of asphalt at a very high sweep speed, though the machine moves along the tape—I mean, the street—at a relatively slow pace. The wires and the brushes do an overlapping job that is supposed to contact all the "information"—i.e., dirt and debris—at a properly vigorous sweep frequency.

(Don't be disturbed if you see a trail of junk being emitted from the rears of these monsters almost as fast as the "information" is picked up at the front. Mere bureacratic inefficiency. The gadget is supposed to clean the street perfectly.)

15 ips Standstill

The Eltro Regulator sweeps the tape surface lengthwise, via a quadruple head, a turning four-banger system, four heads precisely aligned 90 deg. apart on a revolving axis, drum-like. The passing tape wraps 90 deg., or a quarter way, around this drum so that as one head leaves it the next picks up the (taped) story, without perceptible break in continuity.

Indeed, if you will turn this four-header around, with the tape standing motionless, you'll get a fine "scan" of a very tiny piece of taped sound, over and over again, the individual sound-bits joined into a continuous output. Very odd. Turn the heads faster and, of course, like Mama Nature said, the pitch rises.

If you'll turn these heads backwards, thus, at precisely 15 ips on a 15-ips tape, you'll get a steady playback sample of a short segment, *at the correct pitch.* Sort of like a repeating groove on a disc record, only the repeats are a lot faster and blend together.

Backwards? Of course. Matter of relativity. If the tape moves forward over a stationary head, then the head must move backward over a stationary tape.

Aha! Now start moving the tape too. As you begin tape motion—while those heads continue to whirl in reverse at 15 ips.—some interesting things begin to happen. Instead of the same bit of tape, you now begin to get overlapping segments, each one a bit further advanced along the tape than the last. Move the tape slowly and you get a slowly-progressing, over-and-over version of what's on the tape, not so much from *a* to *z* as, say, from *a* to *e* and then *b* to *f* and *c* to *g* and so on. As you move your tape faster, the heads still turning at the fixed 15 ips, your samplings spread out along the recording.

When you reach a tape speed of 15 ips, you will, of course have restored the original continuity of the taped material, at the correct time-sequence speed, exactly as recorded.

(WHAT??? Now *wait* a minute. . . .)

Just that. And *what of the pitch?* That depends on the relative speed between tape surface and head(s). With the tape standing still, remember, and those heads smoothly rotating at 15 ips backwards, abutting on each other (they are all connected in a single-series coil, by the way), the resulting sound was at normal pitch, though taken entirely from one short bit of tape. Move the tape itself also, at 15 ips forward—and the sum total is 30 ips. That's what the collective heads "hear".

So you are now producing a most remarkable playback sound. The duration of the programmed material is normal. Ten minutes of original recording comes out in ten minutes. All the rhythms, beats, note-lengths, all the words, syllables, sentences, are timed normally, as recorded. BUT, thanks to the turning street-cleaner heads, the playing speed is doubled. And so the sound, at normal *speed* (tempo) is heard an octave higher than normal.

You have done the impossible. You have detached playing time from pitch.

Actually, the Eltro does not have this extreme range—it can raise pitch variably

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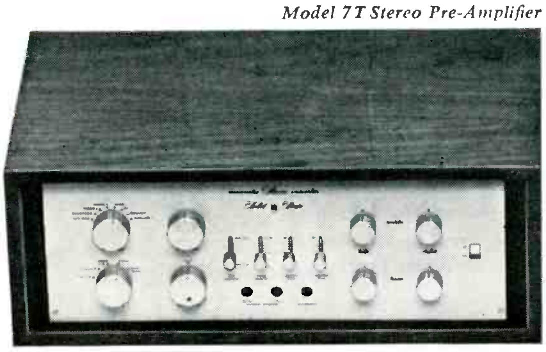
Model 7T Stereo Pre-Amplifier



Model 8B Stereo Amplifier

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upwards (tempo or speed sequence remaining fixed) as far as seven half-tones above normal or an interval of a fifth, a pitch ratio of 1 to 1½ (i.e. 2:3). But by an inverse process—run the heads the other way—it can lower the pitch (speed or tempo remaining fixed) almost to subsonic levels, a full three octaves, a ratio of 1 to ⅛ (8:1). That turns a very high soprano into a very ponderous basso. Quite a trick.

Paradoxically, the Eltro gets its pitch variation by fixing the tape speed itself at standard—running it off the regular capstan of your own recorder. The variable is entirely the rotating head system.

Tempo

But let us continue a slightly theoretical operation here. Now, about the Other Half, the alternative whereby, pitch remaining fixed, tempo or speed is varied, time itself, so to speak, slowed up or speeded ahead. Suppose we take that tape running at normal 15 ips with the heads turning against the tape direction at 15 ips for a tape "scan" of 30 ips—and start doing further tricks. Let's raise the tape speed above normal.

Then the time-sequence goes faster, of course. Always does. Ten minutes are speeded up, maybe to five. Just run the tape at 30 ips.

If you now stop the heads from turning, you'll get a "normal" double-speed playback, at the same pitch we had a moment ago—an octave higher than recorded. Right? But now *turn the heads the other direction,* so their scanning subtracts from the actual tape speed, instead of adding to it. That brings the pitch down, yes?

And so if you do it just right, you'll *bring the pitch back to normal—while the speed of recorded events remains twice normal.* Tempo change.

With tempo control, you may play back a spoken recording in a perfectly normal voice, but twice as fast as recorded. Or a piece of music in the same key as recorded but speeded up to double time. Or you may slow the recording down, similarly.

You may conceive this process in two steps, and it can be done thus quite free of present patent restrictions. (There are other machines which can do it this way, too.) First, you speed up the recorded tape, or slow it down, via a variable capstan speed. Then you speed up, slow down, or reverse the rotating heads to readjust the pitch to normal, i.e. a net 15 ips.

But Eltro doesn't do it that way. Eltro does it automatically, simultaneously and in permanent pitch "sync." You just turn a knob for faster or slower tempo and the music, or speech, goes faster or slower over a wide range while the pitch stays fixed, precisely normal, precisely at 15 ips. This is the exclusive, patented aspect of this particular system. The variable *pitch* system, via rotating heads, is *not* now restricted; other systems can and do make use of it. Automatically controlled variable *tempo* is the Eltro refinement, and it is wonderfully ingenious.

Relativity

The thing is done by a tricky electrical relationship between turning-head speed and tape capstan speed. If these two can be continuously variable in a calculated relationship—when you change one the other changes too—then the combined effect, the actual speed between tape surface and heads can be maintained automatically at a fixed 15 ips—and pitch will remain unchanged. Only the tempo or speed-of-events will vary.

It is done via an ingenious double-acting motor. Both the inside and the outside of this motor rotate. The inner segment, the normal rotating armature, is the tape capstan drive. The outer segment, the usual stator, also rotates and is geared to the revolving head assembly. (Mechanically linked, anyhow—whether by gears or simple pressure wheels I dunno. Didn't take the cover off.)

So now we get into some lovely relativity! A two-element motor, and its own "internal" fixed speed is 900 rpm. Turn on the juice and the inside element rotates at 900 in respect to the outside. If you hold the outside motionless, the capstan goes at 900 rpm. But if you turn the outside, say at 100 rpm the other direction, then the inside runs at only 800 rpm. (It doesn't know the difference, so to speak—it still is producing 900 rpm in its own private inner motor-world.)

If you stop the capstan entirely, the outside shell will run along blithely at 900 rpm in reverse—and the motor is as happy as ever.

Now what is needed in this special situation, is a system whereby when the capstan drives tape at 15 ips, the rotating heads stand still (and we have normal playback), but as the capstan goes either slower or faster in forward tape motion, the heads turn variably, in *either direction,* so as to maintain 15 ips between heads and tape.

Speed up the tape itself, above normal, and the heads must turn in the same direction, to reduce the "contact" speed back to normal. Slow the tape down below normal and you must turn the heads the other way, backwards (as per above) to restore the normal pitch.

The outside element of the double-action motor is the one which can do this job. Your capstan *always* goes forward. (The machine doesn't produce backwards sound, thank you. In fact, the capstan variable is between 350 and 1600 rpm., forward.) On the other hand, the heads go either way, or stand still. So, the set-up is a cinch.

When the outside of the trick motor is motionless, the 900 rpm on the inside drives tape at 15 ips. Normal playback. Turn the outside forward (same turning direction as the capstan) and tape speed goes up. Turn the outside the otherway and tape speed goes down. And since the outside is also geared to the turning heads, the joint electro-mechanical relationship stays neatly fixed. Head turning speed varies inversely with tape speed.

Variable Friction

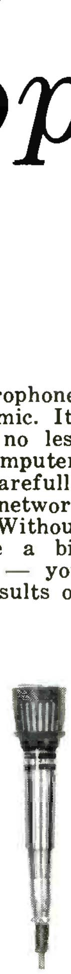
One more link still missing. How do you *turn* the outside of the two-way motor? That's the essential control and obviously it can't be done by hand-turning! Eltro does it via a second motor and a mechanical linkage that does what is needed, i.e.

(*Continued on page 83*)

Let's Look Inside The Dynamic Microphone

THIS is no ordinary microphone. It's a University Dynamic. Its manner of working is no less complex than a modern day computer. Its system of elements is a carefully integrated electromechanical network in a critical acoustical area. Without showing it, it's really quite a bit more than it appears to be — you have to listen to know the results of its performance.

For example — you move toward a flurry of activity on a busy street corner and witness a man-on-the-street interview. To you and other observers the conversation is barely audible above the noise of people and traffic. But to radio listeners the conversation is clear and unaffected by the sounds of the city . . . They are remote . . . in the background where they belong. This is the distinct advantage of a microphone with a good directional pick-up pattern.



Model 8000 Directional (Cardioid) Shock Mounted

To demonstrate another case in point — Imagine yourself an unseen observer in a conference room of a large organization. A tape recorder, fed by a single microphone in the center of the conference table, is in use to store all that is said. Many speak at once; some face away from the microphone; it appears that all that is said may never be recorded, but every word is captured on the magnetic tape for later review.

Model 8100 Directional (Cardioid) With Switch Shock Mounted

Both are University Dynamic Microphones, but they are different in design, to serve different applications. The first is a highly directional (cardioid) dynamic microphone, sensitive only to the areas of sound intended for radio transmission or recording . . . proportionally attenuating sounds emanating from adjacent unwanted areas. The second is a highly omni-directional dynamic microphone sensitive to sounds in all surrounding areas, specifically designed to pick up all sounds.

Model 2000 Omni-Directional

University makes only dynamic microphones, and they have the precision and reliability of modern day computers. Look at the inside to confirm this. The bullet shaped dome of the directional cardioid is a precise and significant component of the system. It smoothes the vital mid-range to provide a more dynamic, natural quality of sound. Filters, in a special configuration, soften sudden bursts of sound, minimize sibilants and protect the inner components from dust, dirt and the elements. A series of ducts further extends the performance of the microphone's transducer element providing gross and fine tuning (similar to the bass ducts of a speaker system) to sharpen the directional characteristics and reinforce the bass response.

Model 2040 Omni-Directional With Switch

The unusual, rugged, yet highly sensitive characteristics of the exclusive University UNILAR diaphragm are responsible for the remarkable high frequency performance of the University Dynamic Microphone—sharp, bright, clear and transparent. The UNILAR diaphragm is not easily seen in the precision cut-a-way shown above. It is extremely light and sliver thin, rugged and virtually indestructible. It could easily withstand torturous bursts of sound and vibration, even without the "extra-measure-of-protection" blast filter screen in the assembly. This feature alone guarantees continued distortion-free and trouble-free performance . . . and, it is only one of many features that make the University Dynamic Microphone the choice of professionals and recording buffs. No matter what the nature of sound, University captures the live natural quality that makes the difference right from the start . . . better than other microphones costing $10, $15 or even $20 more. And, the exclusive University warranty gives you five times as long to enjoy this "lively sound." Stop at a franchised University Dealer today and try for yourself. Get more info too! Write to Desk C62M, UNIVERSITY SOUND, P. O. Box 1056, Oklahoma City, Oklahoma 73101 . . . we'll send you a FREE copy of "Microphones 66."

Model 2050 Omni-Directional With Swivel & Switch

Attache' 6000 Miniature Directional (Cardioid) With Lavalier

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EDITOR'S REVIEW

As this issue is being "put to bed," the Philadelphia High Fidelity Music Show is just beginning. And the Los Angeles show is approaching. In spite of that, this issue is largely devoted to the first United States Department of Commerce High Fidelity and Stereo Components Exhibition to be held in London, starting concurrently with the International Audio Festival on April 14. To make sure that several thousand copies of Audio will be in London in time for the U.S. show, the show issue had to be this one—hence the apparent earliness of the show issue. Over thirty different manufacturers' products are being exhibited in London, which is an important event for these manufacturers and the British hi-fi buffs. More about the show in the special section starting on page 33.

MORE THAN WE COULD CHEW

It seems that we have been listing articles on page 2 under Coming, and then not finding room enough to include them. This is always embarrasing, and we hope that no one has been inconvenienced by the lack of follow-through. We still have the articles on hand, as well as the profiles, and they will come along as fast as possible.

TRUTH IN ADVERTISING

In general, the claims of the legitimate manufacturers in their advertising are usually borne out by the products themselves, but we have recently heard some complaints relative to the advertising of low-priced tape recorders—usually of the reel-drive type—and not really any concern of anyone who wants a good recorder suitable for music, and that includes most of Audio's readers.

It seems that some retailers, notably in the schlock category, are advertising portable tape recorders at prices ranging from less than $20 to as much as just under $40, and then when the customer walks in to purchase one, he is sold the package for some $5 more than the advertised price, "to include the microphone," and possibly an earphone.

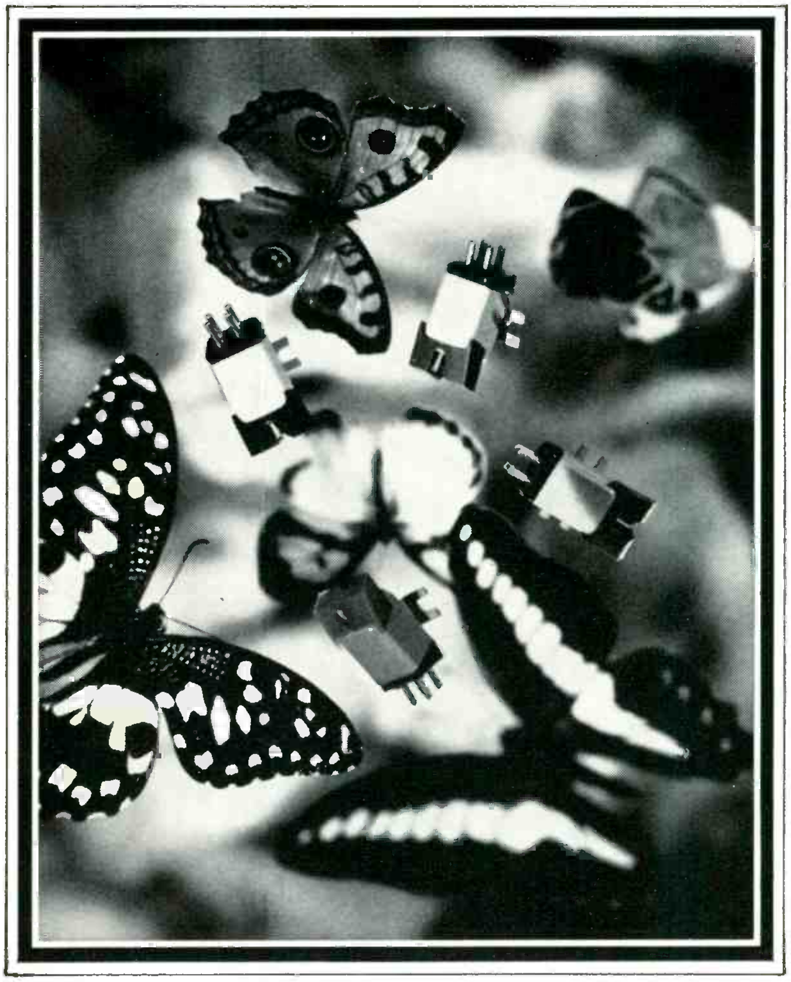
In the same sense that a music *system* invariably includes loudspeakers to reproduce the sound *and* a tuner to provide the source, *and* a record player or changer to provide another source—and all of that at a quoted price, it certainly seems to us that the customer is being "had," when he buys a tape recorder at what he thinks is the advertised or displayed price, and then has to come up with another five dollars or so to get the microphone. A portable tape recorder—no matter how cheap—is of no value unless there is some source of sound signal to record. And once the tape is recorded, the user will certainly want to hear it played back. Most of the small and inexpensive tape recorders do not have speakers, which is understandable if the price is to be kept low. But in our opinion, a "portable tape recorder" *must* include a microphone and either an earphone or speaker in the advertised price to be a complete device. When one buys an electric clock or an electric frying pan, he expects to get a line cord with it—the things are of no use without line cords. Similarly, one should be able to expect that a "portable" tape recorder would be complete.

HIGH FIDELITY TELEVISION

Well, why not? We are not referring solely to the sound aspects of TV, but to the picture as well. Anyone who has lived with a good TV set which has a sound output feeding a typical component amplifier and a high-quality loudspeaker system knows that the sound can be—and often is—as good as that from an FM tuner, as it should be since the sound portion of the signal is FM, although not of the same channel width.

We are thinking primarily of the picture quality. The Conrac "Fleetwood"—while it was on the market—was a fine example of picture quality in a black and white set. Conrac still makes most of the monitors used in TV stations, both black and white and color, and they produce beautiful pictures. Even allowing for the degradation of the picture from transmission over the air, the old Fleetwood was capable of picture quality which came close to studio monitor performance. Such a picture requires a video i.f. pass band of close to 4.5 MHz, but most sets today do not approach that figure—half of it is much more likely.

The time has come when someone will again make such a high-quality TV receiver—one that will produce a picture *almost* as good as a studio monitor. Then we will have a fitting companion for our prized home music systems.



Compare these Sherwood S-7800 features and specs! ALL-SILICON reliability. Noise-threshold-gated automatic FM Stereo/mono switching, FM stereo light, zero-center tuning meter, FM interchannel hush adjustment, Front-panel mono/stereo switch and stereo headphone jack, Rocker-action switches for tape monitor, noise filter, speakers (A) and (B) disconnect. Music power 100 watts (8 ohms) @ 0.3% harm distortion. IM distortion 0.1% @ 10 watts or less. Power bandwidth 12-35,000 cps. Phono sens. 1.8 mv. Hum and noise (phono) —70 db. FM sens. (IHF) 1.6 μv for 30 db quieting. FM signal-to-noise: 70 db. Capture ratio: 2.4 db. Drift ±.01%. AM sens. 2.0 μv. AM bandwidth 7.5 kc. 43 Silicon transistors plus 16 Silicon diodes and rectifiers. Size: 16½ x 4½ x 14 in. dp.

Did you miss our last ad*?

*If you missed our previous ad comparing Sherwood's new S-8800 ALL-SILICON FM receiver with many other receivers, write for your free copy.

S-7800 100-W. FM-AM Receiver
Chassis: $399.50
Wal. Cab. 28.00

Now we've added AM...and the industry's longest warranty —3 years—to our ALL-SILICON 100-watt FM receiver.

How can Sherwood offer this long warranty? Only because we said "No!" to both ordinary Germanium Transistors and old-fashioned tube Nuvistors, insisting on ALL-SILICON reliability. No other receiver has its pacesetting 1.6μv FM sensitivity, its remarkable 0.1% distortion rating, for the most true-to-life sound.

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Sherwood Electronic Laboratories, Inc., 4300 North California Avenue, Chicago, Illinois 60618 Write Dept. A3

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Build your own

Solid-State Flutter Meter

BY: ARTHUR E. GLADFELTER*

This article describes an instrument capable of measuring the Flutter and Wow in sound recorders. Construction, calibration, and method of flutter measurement are included. Measured flutter data from several tape recorders are compared with the manufacturer's specifications.

In Four Parts

Part 1—How it works—and what it does

Front view of the author's flutter meter.

OBTAINING LOW FLUTTER AND wow in a tape recorder is just as important as obtaining low distortion, wide frequency response and a good signal-to-noise ratio. There is not a single element associated with the tape drive that cannot introduce flutter. If you doubt this, record a frequency of about 2 to 3 kHz on the best audio recorder you can obtain. It will be very obvious during a listening A-B test; the signal being played back has some "wiggles" and "garble" the original did not contain. The disturbance, or flutter, that is perceived is actually frequency modulation of the input signal. The modulation is caused by minute variations in the tape speed.

Any mechanical element within the tape transport that is associated with tape motion can cause flutter. Some of the more common causes of flutter include:

1. Eccentricities and mechanical unbalance of reels, rotating guides, capstan, pressure roller, pulleys, and bearings.
2. Irregularities in the surface and variation in compliance of tape, belts, and rubber rims.
3. Changes in motor torque caused directly by the motor and indirectly by variations in power-line frequency and voltage.
4. Variation in friction; such as tape-to-head friction, variation in bearing torque, and so on.
5. Cohesion between successive tape layers and irregularities in width of tape.

Why should a flutter measurement be made when the manufacturer states, for example, it is less than 0.1 per cent? From a reputable firm, this figure would probably be correct—at least when the recorder was factory fresh. But what is the flutter after several thousand hours of operation, or does the flutter change after the machine has been running for several hours and becomes warm? How often should the iron oxide, dust, dirt, and the like be cleaned from various elements? How does flutter vary from start to end of a reel? Answers to these questions can be obtained from accurate flutter measurements. In addition, various mechanical adjustments (hold-back tension, takeup tension, pressure pads, and so on) can be made in an attempt to obtain minimum flutter.

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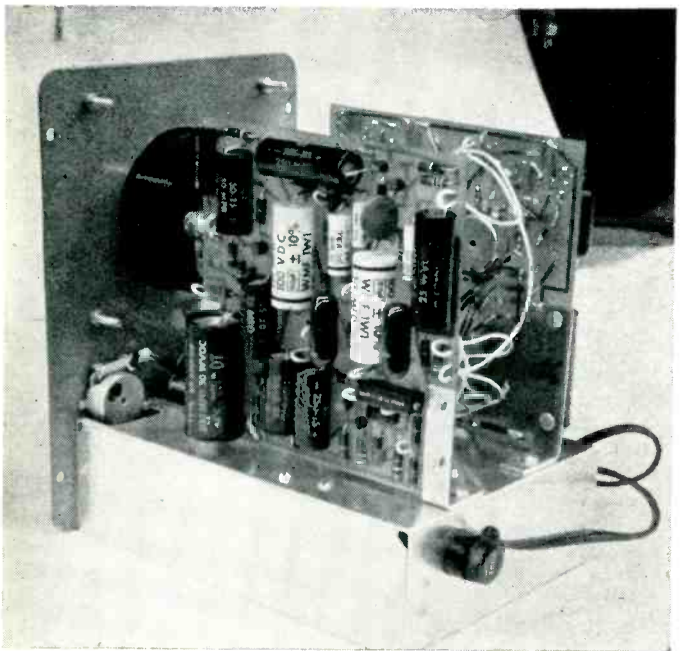
Definition Of Flutter

Per cent of flutter is defined as a ratio of the root-mean-square deviation in frequency of the tone to the mean frequency of the tone.[1] If the deviation is in a sinusoidal pattern, the per cent flutter, f_k, is:

$$f_k = \frac{(100)}{\sqrt{2}} \frac{(d\ f_o)}{(f_{avg})} \qquad (Eq.\ 1)$$

Where df_o is the maximum deviation from the average frequency, f_{avg}. The flutter rate is the number of times per second the frequency deviates. Each complete excursion from maximum to minimum and back again comprises one cycle. A flutter rate of about 1 to 5 H_z



Rear view of the completed flutter meter.

is heard as wow, while above 5 Hz the ear recognizes the variation as flutter.

The instrument used for the measurement of flutter contains a carrier oscillator. The oscillator signal is recorded on the tape via the record circuitry contained within the tape machine. The signal derived from the playback head is processed by an FM receiver that measures the frequncy modulation of the 3000-Hz carrier; that is, the signal passes through a bandpass amplifier, limiter, and discriminator. Following the discriminator, various filters are used to measure the flutter and/or wow spectrums separately. The deviation in frequency and consequent per cent flutter, will correspond to an a.c. voltage, the amplitude of which is measured and displayed by a microammeter. An output jack is provided for observing flutter components with an oscilloscope.

Block Diagram Description

The various front panel functions and basic circuits utilized within the flutter meter can be explained by referring to *Fig.* 1. A stable 3000-Hz tone (f_o) in Eq. 1) is generated and applied to the recorder input. The oscillator input (J_3) amplitude is about 0.75 V rms and can be applied to the recorder high-level input. During playback, the recorder output is applied to the flutter meter input. (J_1) Following a level control (R_1) the signal passes through a three-stage band-pass amplifier. In addition to providing sufficient gain to drive the limiter, the amplifier improves the signal-to-noise ratio by providing more rejection to the frequencies on either side of 3 kHz; i.e., any components from 60 Hz on the low end, or from the bias oscillator on the high end. The symbols Q_1, Q_2, etc. on the block diagram refer to the various transistors in the over-all schematic of *Fig.* 2.

The output signal from the 3-kHz band-pass amplifier is attenuated and then applied to the "level set" position on the "range" switch. When in this position the voltmeter monitors the input amplitude. R_1 can then be used to adjust the incoming signal amplitude to a level sufficient to drive the limiter. The limiter, or more correctly a Schmitt trigger circuit that is utilized as a limiter, converts the incoming sine wave to a square wave. The amplitude and symmetry of the limiter output are virtually unaffected by a wide range (at least 30 dB) of input amplitudes, such as might be caused by tape dropout.

The limiter output or discriminator input will be a 3-kHz square wave that is deviating, at the flutter rate, above and below 3 kHz. The discriminator, which is really the "heart" of the system, converts the frequency changes into amplitude variations. This conversion from frequency to amplitude allows conventional voltmeter techniques to be used to display the percentage of flutter. The discriminator output amplitude will increase for frequencies above 3 kHz and decrease for frequencies below 3 kHz.

The discriminator output amplitude for 0.30 per cent flutter will be of the order of 13 to 14 millivolts rms—exact figures will be given in the calibration procedure. As a result of this relatively low level, a low-frequency amplifier with response deliberately limited to about 1000 Hz is used following the discriminator. The band-width is restricted to 1000 Hz to further attenuate the 3 kHz components that are not rejected by the discriminator and also to assure that the amplifier is not saturated by the 3-kHz signal. Of course, the 1000-Hz low-frequency amplifier, with a voltage gain of about 35 dB, could be eliminated and the sensitivity of the voltmeter circuitry increased. However, if this approach had been used, the signal levels passing thru the following low-pass and band-pass filters would be 35 dB lower, with the possibility of hum pickup,—basically because of the larger number of passive components within the filters and also because of the higher impedance levels in the filter than in the 1000-Hz low-pass amplifier. With 35 dB of amplification prior to the filters no shielding is required, nor is the parts layout critical.

The 250-Hz low-pass filter following the 1000-Hz low-frequency amplifier is used to further attenuate the 3-kHz components and to fulfill requirements established by the I.R.E., (now I.E.E.), that all flutter rates up to 200 Hz should be considered. It should be mentioned that tape recorders may have flutter-rate disturbances introduced by high-frequency frictional vibration up to and beyond 2 kHz[2]. The upper rate limit of 200 Hz appears to be an outcome of the limit that was used for the 96-Hz potential flutter and its second harmonic (192 Hz) caused by sprocket-holed disturbances in 35-mm film-drive systems. However, to adhere to previously established standards, a 250-Hz low-pass filter is used, to obtain relatively flat response up to 200 Hz.

For the purpose of analyzing the cause of flutter in a recording system, it is often desirable to make measurements in several ranges of flutter-frequency. By knowing the flutter rate, and then comparing this with the known rotational rates of the elements in the drive system, it is easier to correlate a given flutter disturbance with its mechanical cause. This then is the purpose of the 6-Hz low-pass and 6-Hz high-pass filters that are inserted betwen the 250-Hz low-pass filter and the dual emitter-follower-voltmeter. S_1 can then select any one of three bands that cover 0.5 to 6 Hz, 6 to 250 Hz or 0.5 to 250 Hz.

To prevent appreciable loading on the three filters, a dual emitter follower is used to increase the input impedance of the voltmeter circuitry. In addition, the "range" rotary switch S_2 is incorporated in the emitter-follower output circuitry. The voltmeter is a two-stage amplifier, with a microammeter in the feedback network. This will respond to the average voltage (or deviation in frequency); however, the meter is calibrated to read the rms value with a sinusoidal flutter rate. The voltmeter low-frequency response must extend to below 0.5 Hz, thus eliminating many existing rms voltmeters as a substitute indicating device.

The remaining block in *Fig*. 1, the power supply, provides +33 V d.c. at about 53 mA. All blocks, except the filters and attenuators, are connected via decoupling networks to the regulated power supply.

Before leaving the block diagram discussion, one further item should be mentioned. In some systems, a low-pass filter with a cutoff frequency slightly above 3 kHz is inserted between the limiter output and the discriminator input. The purpose of the filter is to remove the odd harmonics (9 kHz, 15 kHz, etc. and so on) from the average 3 kHz or the "carrier" frequency. A low-pass filter was not used because of the inherent filtering from the discriminator tuned circuits and also because of the decreasing amplitude of the higher harmonics. That is, the third harmonic will be reduced 10 dB, the fifth harmonic 14 dB, and so on, relative to the amplitude of the 3-kHz carrier. The over-all system tests, to be described later, justify the omission of a 3-kHz low-pass filter.

Circuit Description and Design Consideration

First consider the 3000-Hz oscillator, Q_{17}, which is of the Colpitts[3] configuration. Feedback from the tank circuit (L_5, C_{33}, and C_{34} in series) is provided by C_{33} and C_{34}. The base bias current is supplied by R_{65} and R_{66}. The Colpitts scheme was selected in preference to a Hartley because of the ease in adjusting the feedback; that is, the feedback fraction could be changed during the design phase merely by selecting C_{33} and C_{34}. In contrast, the Hartley scheme would have required a tapped inductor.

It is not necessary to have the oscillator frequency precisely 3000-Hz. In fact, the frequency can be within a few per cent of 3000 Hz as long as the exact frequency is known and used during the calibration procedure. It is, however, desirable to come as close as possible to 3000 Hz if for no other reasons than to: 1. Conform with existing standards. 2. Simplify the calibration procedure. 3. Assure the fact that the frequency is at the design center frequency of the discriminator, even though d.c. coupling is not maintained in the amplifiers following the discriminator.

Using the values in the schematic diagram of *Fig*. 2, the frequency of oscillation will be about:

$$f = \frac{1}{2\pi\sqrt{\dfrac{L_5\, C_{33}\, C_{34}}{C_{33} + C_{34}}}}$$

$L_5 = 37\text{mH}$

$C_{33} = 0.10\mu\text{F}$

$C_{34} = 0.33\mu\text{F}$

$f = 3.06\ kHz$

The components in the tank circuit have a tolerance of ±10 percent. Even if the tolerance on the tank circuit components is reduced to ±5 percent (or even ±2 percent) the error in the oscillator frequency could be ±5 percent (or even ±2 percent). For this reason, ±10 percent capacitors are used, and L_5 is tailored to obtain exactly 3000 Hz. L_5 is made by winding 2400 turns of No. 36 wire on a 2 watt, 240 k ohm resistor, as shown in *Fig*. 3. Using an accurate frequency detector, such as an electronic counter, turns are removed (about a turn per cycle) until the frequency is exactly 3000 Hz. Of course, a variable inductor can be used, but was ruled out because of the cost *vs*. size compromise for many readily available inductors and, to a lessor extent, because of the change in inductance with temperature.

The frequency stability is almost entirely dependent on changes in the capacitance of C_{33} and C_{34} with temperature. Changes in h_{fe} have virtually no affect on the frequency. For example, decreasing the temperature of Q_{17} to −32° F increased the frequency from 3000 to 3004 Hz. Increasing Q_{17} temperature to +150° F decreased the frequency to 2995 Hz. Similarly, variations in the oscillator d-c supply voltage (although a regulated power supply provides +25 v.d.c at 3.5 mA to the oscillator) from +16 to +28 V d.c., or even variations in the output load (at J_3 to a dead short, provide about 2-Hz change in frequency. While it is not important that the oscillator output waveform be extremely low in distortion, the total harmonic distortion measured 1.4 percent.

The signal from the recorder output is applied, via J_1 and R_1, to a two-stage R-C coupled common-emitter amplifier (Q_1 and Q_2) which is directly coupled to an emitter follower (Q_3). With R_1 in the maximum-gain position, the input

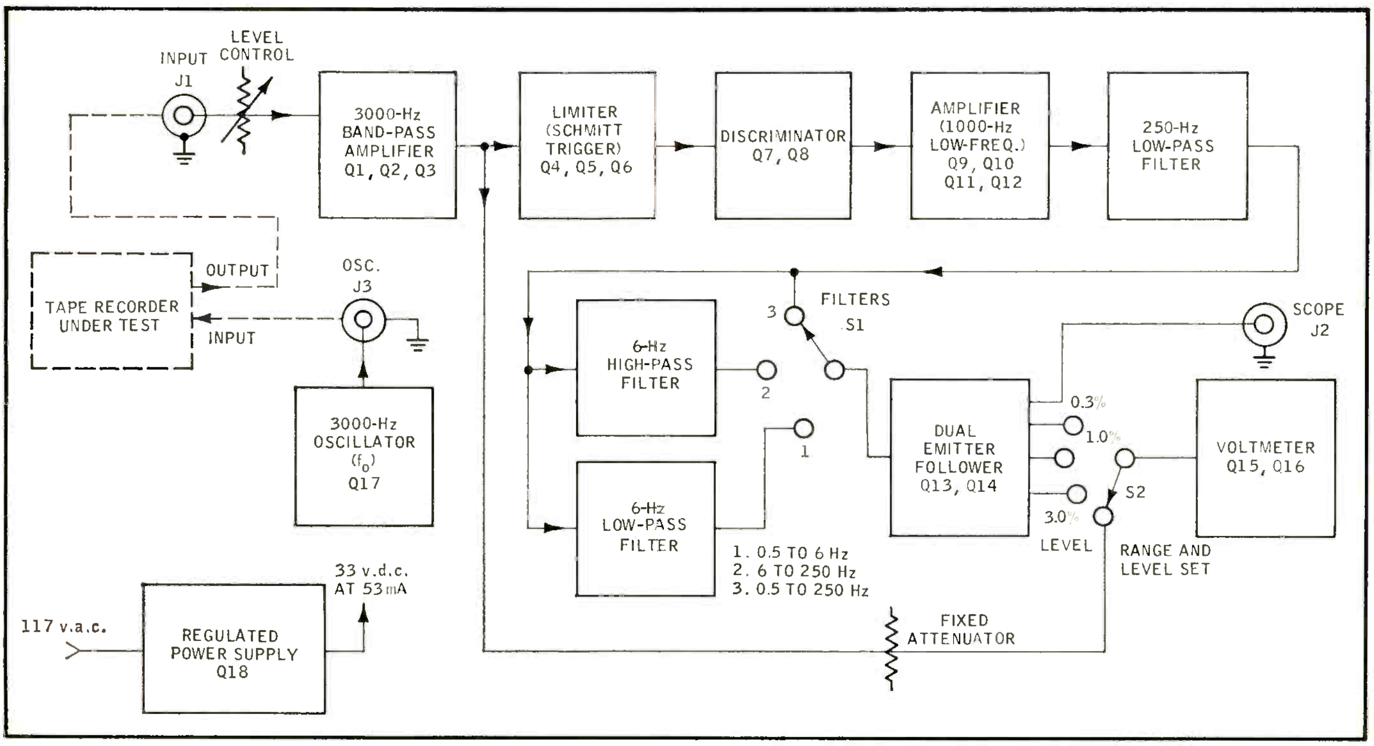


Fig. 1. Block diagram of the author's flutter meter.

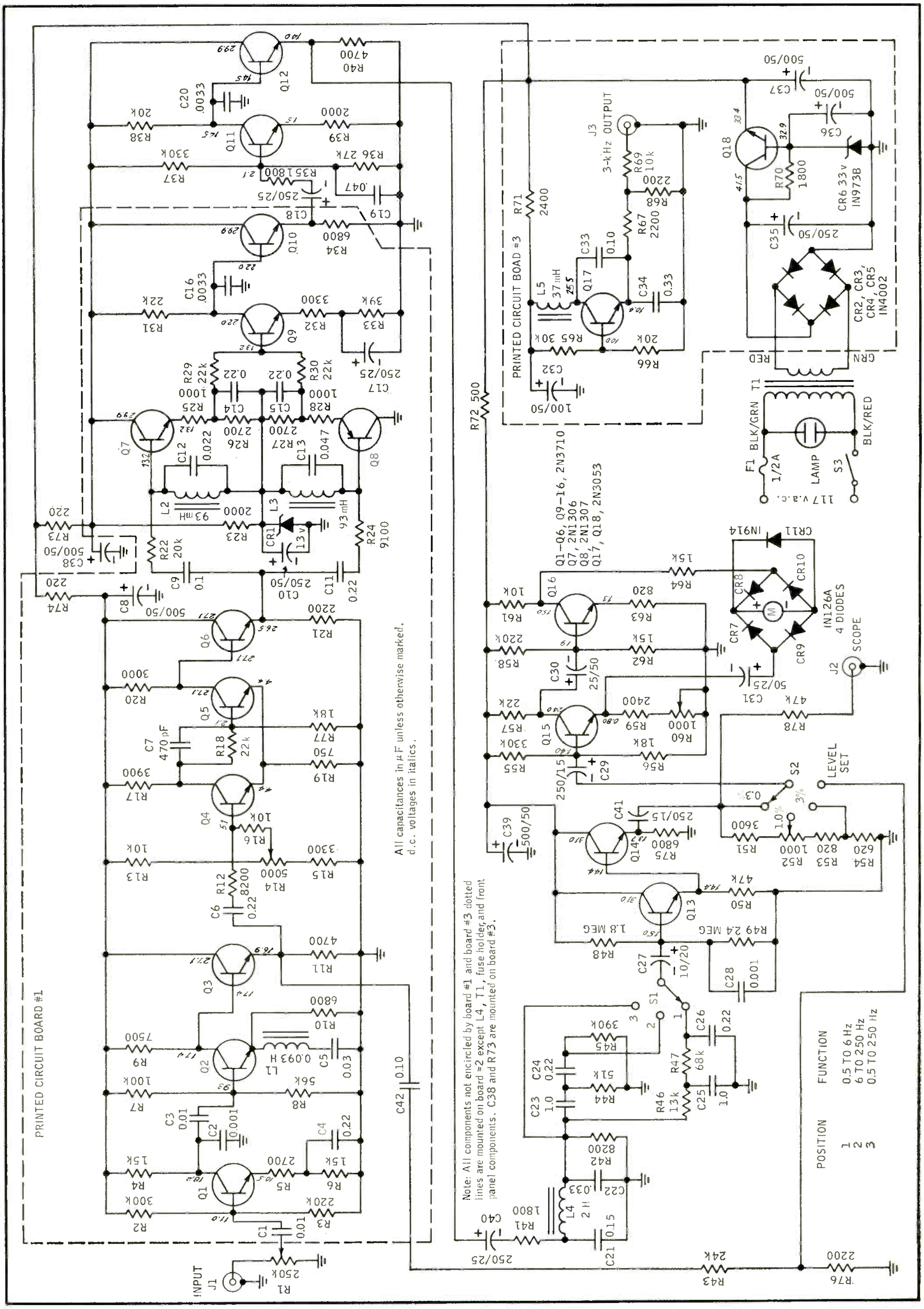


Fig. 2. Complete schematic of the flutter meter and its self-contained power supply.

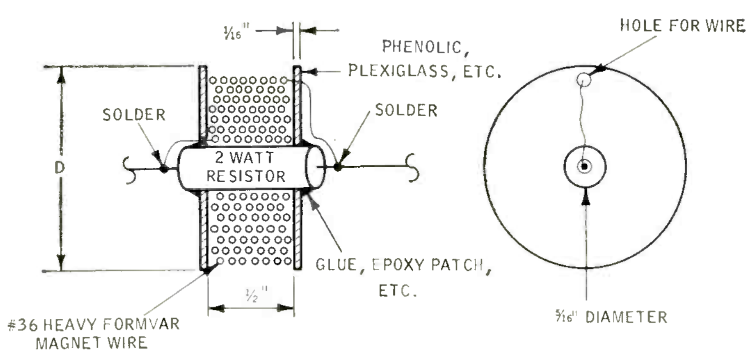
The Parts List

Recognizing the interest this project may instill in our readers, and yet being unable to include the entire article in one issue, we are furnishing the complete parts list with this installment so that readers may begin to collect all the required material in readiness for the concluding installments.

Parts List

Fixed Resistors—½-watt, 5 per cent	
R_2	300 k
R_3, R_{58}	220 k
R_4, R_6, R_{62}, R_{64}	15 k
R_5, R_{26}, R_{27}	2700
R_7	100 k
R_8	56 k
R_9	7500
R_{10}, R_{34}, R_{75}	6800
R_{11}, R_{40}	4700
R_{12}, R_{42}	8200
R_{13}, R_{16}, R_{61}, R_{69}	10 k
R_{15}, R_{32}	3300
R_{17}	3900
R_{18}, R_{29}, R_{30}, R_{31}, R_{57}	22 k
R_{19}	750
R_{20}	3000
R_{21}, R_{67}, R_{68}, R_{76}	2200
R_{22}, R_{38}, R_{66}	20 k
R_{23}, R_{39}	2000
R_{24}	9100
R_{25}, R_{28}	1000
R_{33}	39 k
R_{35}, R_{41}, R_{70}	1800
R_{36}	27 k
R_{37}, R_{55}	330 k
R_{43}	24 k
R_{44}	51 k
R_{45}	390 k
R_{46}	13 k
R_{47}	68 k
R_{48}	1.8 Meg
R_{49}	2.4 Meg
R_{50}, R_{78}	47 k
R_{51}	3600
R_{53}, R_{63}	820
R_{54}	620
R_{56}, R_{77}	18 k
R_{59}, R_{71}	2400
R_{65}	30 k
R_{72}	560
R_{73}, R_{74}	220
Variable Resistors	
R_1	250 k, linear. Mallory U-46
R_{14}	5000, linear. Mallory U-14
R_{52}, R_{60}	1000 linear. Bourns E-Z Trim, 3067-P
Fixed Resistors, 2 watt, 10%	
3	270 k (for coil forms)

Capacitors	
C_1, C_3	.01 μF, ±20%, disc ceramic, Sprague 5GABS10
C_2, C_{28}	.001 μF, ±10%, disc ceramic, Sprague 10TSD10
C_4, C_6, C_{11}, C_{14}, C_{15}, C_{24}, C_{26}	0.22 μF, ±10%, 100V. Sprague 192P22492
C_5	.03 μF, ±10%, 100V. Sprague 65P30352
C_7	470 pF, ±10% Sprague 192P47192
C_8, C_{37}, C_{38}, C_{39}	500 μF, 50 V. Sprague TVA1315
C_9, C_{33}, C_{42}	0.1 μF, 100 V. ±10%. Sprague 192P10492
C_{10}, C_{17}, C_{18}, C_{40}	250 μF, 25 V. Sprague TVA1208
C_{12}	.022 μF, ±10%, 100 V. Sprague 192P22392
C_{13}, C_{19}	.047 μF, ±10%, 100 V. Sprague 192P47392
C_{16}, C_{20}	.0033 μF, ±10%, 100 V. Sprague 192P33292
C_{21}	0.15 μF, ±10%, 100 V. Sprague 192P15492
C_{22}	.033 μF, ±10%, 100 V. Sprague 192P33392
C_{23}, C_{25}	1.0 μF, ±10%, 100 V. Sprague 118P10502S2
C_{27}	10 μF, ±10%, 20 V. Tantalum; Sprague 109D106X9025C2
C_{29}, C_{41}	250 μF, 15V. Sprague TE-1138
C_{30}	20 μF, 50V. Sprague TE1305
C_{31}	50 μF, 25 V. Sprague TE1209
C_{32}	100 μF, 50 V. Sprague TVA1310
C_{34}	0.33 μF, ±10%, 100 V. Sprague 118P33492S2
C_{35}, C_{36}	250 μF, 50 V. Sprague TVA1312
Transistors	
Q_7	2N1306 RCA, TI
Q_8	2N1307 RCA, TI
Q_{17}, Q_{18}	2N3053 RCA
All others (14)	2N3710 TI
Diodes	
CR_1	13 V. ±5% 400 mW Zener, 1N964B
CR_2, CR_3, CR_4, CR_5	100-V, 1.0A. Motorola 1N4002
CR_6	33V. ±5% 400 mW Zener, 1N973B
CR_7, CR_8, CR_9, CR_{10}	1N126A
CR_{11}	1N914
Inductors	
L_1, L_2, L_3	93 mH, 210 ohms (see text)
L_4	2 H, 170 ohms max (see text)
L_5	37 mH, 130 ohms (see text)
Miscellaneous	
S_1	1-pole, 3-pos. rotary switch, Centralab 1461
S_2	2-pole, 5-pos. rotary switch, Centralab PA-1002
S_3	SPST toggle switch
T_1	Transformer, 32-V. sec, 100 mA. Allied Radio, 64-U-732
Lamp	Drake Type 6073-534 "Glo-Lite"
Meter	100 μA, Simpson Model 1329
Chassis	5" x 7" x 2" Bud AC-402
Cabinet	8" H x 6⅛" W x 8" D Bud WA-1540
J_1, J_2, J_3	Phono jacks, Switchcraft Type 11
Misc: Knobs 3	Harry Davies 1920-C
Heat Sink (Q_{18}) 1	Wakefield Type NF205 (27¢)
Printed Circuit Boards	1/16" x 5" x 5" (2 required)
	1/16" x 4¾" x 3¼" (1 required)
Printed Circuit Tape Resist,	1/16" wide



Circuit Symbol	Inductance Nom. mH	d.c. resis. (Ohms)	Diameter (inches)	Approx. no. turns	Wire size
L1, L2, L3	93	220	1.0	3400	#36
L5	37	130	0.781	2400	#36

Note: A 240 k (minimum) 2-watt resistor is used as a coil form. The inductance of L5 will be about 37 mH with 2300 turns. 2400 turns are wound, and then turns are removed as described in text.

Fig. 3. Coil winding data.

impedance is 60k ohms. At 3 kHz, Q_1 has a voltage gain of 10 dB and Q_2 a gain of 28 dB. L_1 and C_5 form a series-resonant circuit in the emitter of Q_2 and provide maximum gain at 3 kHz. The emitter follows (Q_3) provides a low driving impedance for the Schmitt trigger (Q_4 and Q_5) and also the resistive attentuator R_{43} and R_{76}. The response of the band-pass amplifier is shown in *Fig.* 4. The rejection is 25 dB at 80 kHz and about 43 dB at 120 Hz.

The Schmitt trigger[4] (Q_4 and Q_5) is a regenerative bistable circuit, the state of which depends on the amplitude of the input voltage. To explain the circuit operation, assume that no base bias is supplied to Q_4 from R_{14}. Q_4 would then be OFF and Q_5 would be biased ON by the base current through R_{17} and R_{18}. The voltage at the emitters of both transistors is then determined mainly by R_{19} and R_{20}, and is about 5.5 V d.c. If the input level to Q_4 base rises above 5.5 V d.c. plus the base-to-emitter drop of 0.6 V d.c., or about 6.1 V d.c., Q_4 begins to conduct and regeneratively turns OFF Q_5. Q_4 is then ON, and the voltage at the emitters is now about 4.5 V d.c. and is less than the initial value of 5.5 V d.c.—because R_{17} is larger than R_{20}. When the input voltage is reduced to 4.5 V d.c. plus the base-to-emitter drop, or about 5.1 V d.c., Q_5 will again conduct. During the transition period, the change in Q_5 collector voltage will be about 19 volts. Potentiometer R_{14} which selects the trip point on Q_4, is adjusted to provide a symmetrical square wave at the limiter output emitter follower, Q_6.

The limiter output is coupled to the discriminator[5] input by the d.c. blocking capacitors C_9 and C_{11} L_2, and C_{12}, connected to base of Q_7, have a parallel resonance of 3520 Hz and the waveform at the base of Q_7 (which is very nearly sinusoidal) will have maximum amplitude when the incoming frequency is 3520 Hz. Q_7, which is nonconducting in the absence of a signal, is connected as an emitter-following-detector and will rectify the positive portion of Q_7 base waveform and provide a voltage across R_{26} and C_{14}. The voltage will be a maximum at 3520 Hz and will decrease as the frequency is decreased below 3520 Hz. The low side of R_{26} and C_{14} are clamped to a fixed voltage of +13 V d.c. by zener diode CR_1. For the incoming signal, the common tie point of R_{26}, R_{27}, CR_1 cathode, and so on, can be considered as a signal ground, with the output signal being coupled by R_{29} to the base of Q_9.

L_3 and L_{13}, connected to the base of Q_8, have a resonance frequency of 2420 Hz and will detect the negative portion of the incoming waveform. This will provide a voltage drop across R_{27} and C_{15} that will decrease as the frequency is increased above 2420 Hz. The outputs from the two detectors are then combined by the two summing resistors, R_{29} and R_{30}, and applied to the base of Q_9. The over-all discriminator response, for an input squarewave of 19 volts peak-to-peak, is shown in *Fig.* 5. Note the output voltage at the base of Q_9 represents a change in voltage, relative to the reference voltage of about 13 V d.c., and does not indicate an absolute voltage.

Q_9 through Q_{12} comprise a low-frequency amplifier with a voltage gain of 35 dB. The bandwidth extends from about 0.2 Hz to 1000 Hz, with the high-frequency response being deliberately limited by C_{16}, C_{19} and C_{20}. The upper cutoff frequency of 1000 Hz was chosen in order to have virtually flat response to 250 Hz. At 250 Hz the voltage gain is 34.7 dB, or a decrease of 0.3 dB. At 3000 Hz the voltage gain is 22 dB. To prevent loading on the discriminator output, the impedance looking into the base of Q_9 is typically 450 k ohms, with a "worst" case minimum value of 300 k ohms. The base bias voltage for Q_9 is derived from zener diode CR_1. The direct coupling of stages from CR_1 anode to the emitter of Q_{10} may, at a first glance, appear to be unstable with variations in the zener voltage of CR_1 and changes in temperature. This, however, is not the case because the d.c. voltage gain of stages Q_9 and Q_{10} is less than unity, and any change in the voltage at the anode of CR_1 will appear as a smaller change at the emitter of Q_{10}. The emitter-follower Q_{12}, provides a relatively low output impedance (about 150 ohms) for the following 250-Hz low-pass filter.

The 250-Hz low-pass filter[6] has three poles and is terminated by R_{12}. Although the filter has been designated as a 250-Hz filter, the actual cutoff frequency was designed to be 600 Hz—the reason being that when the 35-dB amplifier and low-pass filter are combined, the over-all response will have a cutoff frequency of about 250 Hz. The frequency response of the combined low-frequency

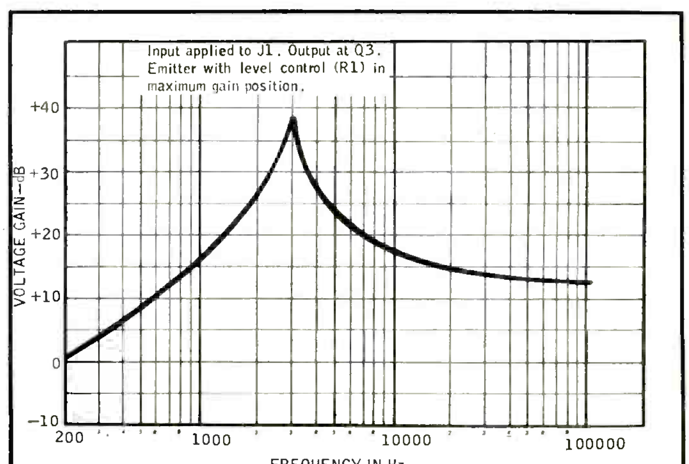


Fig. 4. Response of the band-pass filter.

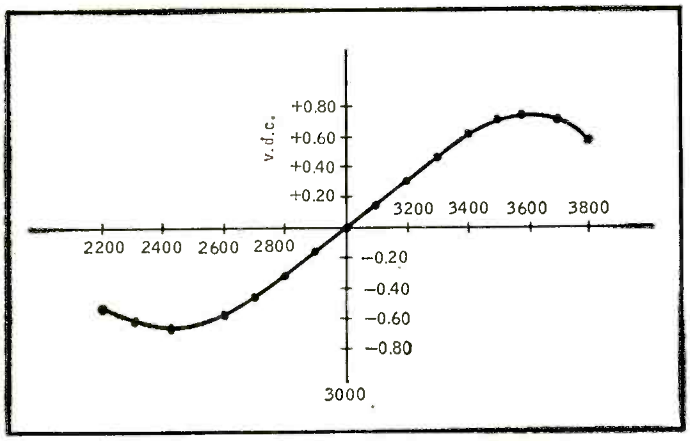


Fig. 5. Response of the discriminator circuit.

Portacab case. The front panel controls and input connections were positioned as functionally as possible. For example, all input-output jacks are mounted at the bottom of the front panel and below the three controls. With this arrangement, the various connecting jacks and wires will be less likely to obscure the front-panel controls.

All electrical components, except those on the front panel, L_4 and T_1 are mounted on printed-circuit boards, which are attached to a basic 5x7x2-in. aluminum chassis. The front panel and chassis are then fastened together to form an assembly which can be slid easily into the shell of the Portacab meter case.

amplifier and low-pass filter is shown in *Fig.* 6, which represents the response from the base of Q_9 to R_{42}. The over-all gain is less than 35 dB because of the insertion loss of the low-pass filter.

The 6-Hz low-pass filter and 6-Hz high-pass filter consist of the R-C components between R_{48} and positions 1 and 2 on S_1. Each is a two-pole filter and has an ultimate slope above (or below) the cutoff frequency of 12 dB/octave. Measured data from the filters are shown in *Fig.* 7. In addition, the relative response from *Fig.* 6 has been replotted on *Fig.* 7. Thus, a glance at *Fig.* 7 will readily indicate the response for any one of the three positions on the flutter rate (or filters) selector, S_1.

The voltmeter or indicating circuitry consists of stages Q_{13} to Q_{16}. Q_{13} and Q_{14} provide an input resistance of about 750k ohms. C_{41}, connected to the emitter of Q_{14}, removes the d.c. voltage from the range resistors, R_{51} thru R_{54}. C_{41} (and R_{75}) could be eliminated; however, this will result in a much longer meter-settling-time, when switching to various positions on the range switch.

Q_{15} and Q_{16} comprise a conventional two-stage R-C coupled common-emitter amplifier, with an open loop voltage gain of about 25 dB. Feedback is applied from the collector of Q_{16} to the emitter Q_{15} via the full-wave bridge and microammeter. The closed loop voltage gain is about 15 dB, with the exact value determined by the setting of R_{60}, which is used to calibrate the 0.30 percent range and R_{62} the 1.0 percent range. No calibration is provided for the 3.0 percent range; however, the error should be no more than 5 percent on the full-scale reading—the tolerance on the resistors. If the percentage of flutter is high enough to warrant use of the 3.0 percent range, a 5 percent error should be of little concern. CR_{11}, in parallel with the meter, limits the maximum meter current to about 300 microamperes, or three times the full-scale value of 100 microamperes. Typically, the input sensitivity at the base of Q_{13}, is about 0.5 V rms required for full-scale deflection.

The power supply consists of a full-wave bridge rectifier followed by a series regulator. Taps are selected on power transformer T_1 to provide a nominal output voltage of 32 V rms (34 V rms measured). After rectification, the average voltage at the collector of Q_{18} will be about 40 V d.c.-with an input voltage of 115 V a.c. Q_{18} is merely an emitter follower, with the base voltage determined by the zener voltage (33 V d.c.) of CR_6. The d.c. output voltage, due to the base-to-emitter drop in Q_{18}, will be about 32.5 V d.c.

Using the 0.30 percent flutter range and 115 V a.c. as a reference, an increase in the line voltage to 125 V a.c. will cause less than a 1 percent increase (or error) in the percentage of flutter. Reducing the voltage to 105 V a.c. will cause a decrease of about 0.6 percent and 100 V rms will yield a decrease of about 2 percent; i.e., the meter will read 0.294 percent for 0.30 percent.

Packaging Concept

To make a professional looking unit, a BUD "Portacab" meter case was selected to house all components. The indicator, a Simpson 4½-inch Wide-Vue meter, was chosen for accuracy, ease of reading, and compatibility with the

The design objective for the internal layout was to have easy access (for test purposes) to all electrical junctions. This is achieved by mounting two printed circuit boards vertically and with the components facing outward. The third board is mounted horizontally with the components facing the open side of the chassis.

The first board contains the band-pass amplifier, Schmitt trigger, discriminator, and a portion of the low-frequency amplifier. On the second board are the last stages of the low-frequency amplifier, filters, and voltmeter circuitry. The third board contains the 3-kHz oscillator and regulated power supply. Printed circuit boards No. 1 and No. 2, and L_4 are mounted vertically (with angle brackets) on the top of the basic chassis. The third board and power transformer are mounted underneath the chassis. The interconnections between boards (and the front panel) are made with No. 20 or No. 22 stranded wire. The input lead and 3-kHz oscillator output are, however, routed with RG-174/U coaxial cable.

Photographs of the unit are shown in *Figs.* 8 and 9.

Parts Considerations

A list of the materials required to make one unit is given in the PARTS

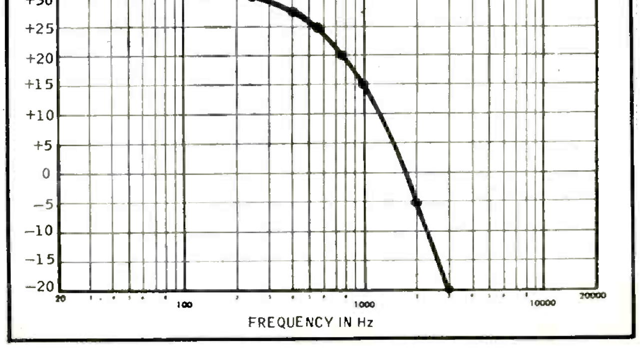


Fig. 6. Frequency response of the low-frequency amplifier and the low-pass filter.

LIST. All parts except the inductors, are off-the-shelf items, and can be purchased from Allied Radio and Newark Electronics. (Neither firm lists all the parts in their catalogs.)

L_1, L_2, L_3 and L_5 are fabricated, and L_4 can be purchased from Barry Electronics, 512 Broadway, New York, N.Y. 10012. L_4 is a two-henry inductor described by Barry as an FTR Mini-Choke, catalog No. 11-38, and is priced at 40¢. The choke, obviously a surplus part is a staple item and has been in the Barry catalogs for several years. A commercial equivalent can, of course, be used. A UTC VIC-13 variable inductor will work very well, although the price is $7.20 and it would have to be adjusted so the inductance was 2 Hy. An alternate 2-Hy fixed inductor would be the UTC MQB-7 priced at $14.70.

The cost of parts, for one unit, will be about $99. Of this figure, the meter and cabinet cost about $27, capacitors $24, resistors and pots $15, transistors $11, diodes $8 and so on.

At a first glance the cost of parts may appear high. But remember, only one bargain part, L_4, has been used. Besides, one commercially available vacuum-tube flutter meter sells for about $500. The unit was designed for performance and not to be sold for a particular price. The cost also reflects the use of 5 percent resistors, compared to 10 percent resistors that are often used. The use of 5 percent resistors increases the cost about $4.50. After considering the initial tolerance and the effects of temperature and aging on resistors, it is felt the additional cost can be justified easily.

All transistors, except Q_7 and Q_8; are NPN planar silicon. The 2N3710, made by Texas Instruments, was selected because of the price (49¢ each) and size. It has a plastic enclosure, a minimum h_{fe} of 90 and a maximum collector-to-emitter voltage of 30 V d.c. Because the 2N3710 is relatively new and has a different base configuration, the base connection is shown in *Fig.* 9. The 2N3053, made by RCA, was selected because of the cost *vs.* performance. Other transistors that can be used, for Q_{17} and Q_{18}, but at greater cost, are the 2N2102 or the 2N2270. An old standby, the 2N697 can also be used, but because of the type of construction, the dissipation of the 2N697 is less than the three previously described transistors.

During the early design phase it was not known exactly what the limiter peak-to-peak amplitude would be. For this reason germanium transistors were selected for Q_7 and Q_8, because of the lower base-to-emitter voltage in comparison to silicon transistors. (At the time, a delivery problem was also encountered with the silicon complement of the 2N3710, the 2N3702). As it turned out, the limiter amplitude is large, about 19 volts peak-to-peak, in comparison to the difference in base-to-emitter voltage of germanium and silicon transistors (0.2 volts *vs.* 0.6 volt). If the reader wishes to make the flutter meter an all-silicon unit, the 2N3702 may be substituted for the 2N1307, and the 2N3710 for the 2N1306, providing the printed circuit board layout is modified.

All capacitors in the parts list except the disc ceramics, are called out by a manufacturer's part number.

With many solid-state devices, there are vast differences in price. This is the case of zener diodes CR_1 and CR_6. Of the firms making readily available zener diodes, International Rectifier appears to have the lowest prices on the 1N964B and 1N973B.

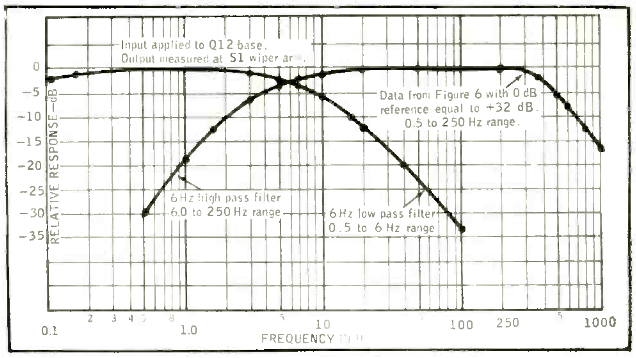


Fig. 7. Frequency response of both filters.

Winding the Coils

Data for winding L_1, L_2, L_3 and L_5 are given in *Fig.* 3. A 2-watt resistor, with a minimum resistance of 240k ohms, is used as a coil form. The sides of the coil form are circular discs made from an insulating material such as Bakelite, plexiglass, or any phenolic material. These discs are fastened to the resistor using an epoxy adhesive, such as Eocobond 26. Small holes are then drilled in the sides of the coil form. The wire is then passed through the holes and soldered to the resistor leads with the solder joints close to the body of the resistor.

The coils can be made with the aid of a ¼-inch electric drill and a Variac to control the speed. The coil form is secured to the drill by putting one end of the resistor lead into and firmly against the end of the drill chuck. It is also helpful to place a small washer between the drill chuck and the body of the resistor.

In the absence of a suitable counter to indicate the number of turns, there are many ways the builder can wind the approximate number of turns. Obviously, turns can be added and the inductance or d.c. resistance measured until the values shown in the table of *Fig.* 3 are obtained. Alternately, turns can be added and the reasonance frequency of an L-C network can be measured. That is, L_1 can be tailored with C_5 (0.03 uf) So the resonance frequency is 3 kHz; L_2 can be tailored with C_{12} (0.22 uf) so the resonance frequency is 3520 Hz; and L_3 can be tailored with C_{13} (0.47 μf) so the network frequency is about 2420 Hz.

Two of the frequencies just given, 2420 Hz and 3520 Hz, are the design center values for the discriminator. Even if the inductance values specified in the table of *Fig.* 3 are obtained exactly, the network resonance frequency can be in error by about +5 per cent because of the ±10 per cent tolerance on the capacitors. Variations in the discriminator network frequency up to and even slightly above 5 per cent will have virtually no effect on the final performance.

Making the Printed Circuit Boards

The printed-circuit board layouts for all three boards are shown in *Figs.* 10, 11 and 12. The board layouts are reproduced full scale, so that no intermediate steps are required to reduce the size. Boards 1 and 2 are 5 in. square, and board 3 is 3¼ by 4¾ in. These measurements are also specified in the parts list and can be verified by measurement of *Figs.* 10 through 12.

To show how the printed-circuit boards are made, board No. 3 will be used as an example. This is the easiest board to make and contains the least number of components. After the board has been cut to size, the copper clad side should be cleaned to remove any dirt or film that has accumulated. Cleaning is most easily accomplished with crocus cloth. Ajax cleanser or a large eraser. The board is then laid on the workbench or flat surface, with the copper side up. SCOTCH or masking tape is used on alternate corners to hold the board in position. The sketch of board No. 3 (*Fig.* 12) is then placed squarely on top of the printed-circuit board. A center punch, with a very fine tip is used to locate all holes. Alternately, if you do not wish to have a

(*Continued on page 88*)

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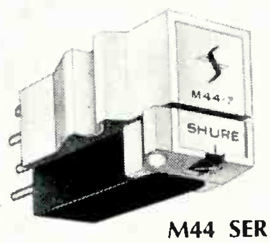

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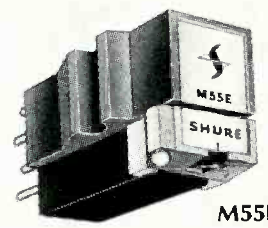

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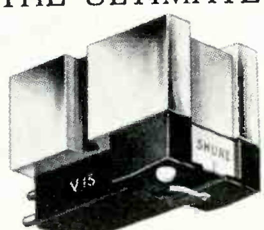

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High Input Resistance with Stability

L. D. SMITHEY*

When the need for an amplifier of very high input resistance arises, you do not necessarily have to use special tubes, or even tubes at all. The suggestions offered here show how you can work out the circuitry easily and effectively.

THE SERIOUS EXPERIMENTER is occasionally confronted with the need for an amplifier having very high input resistance at low frequency. In such instances it may be necessary to design and construct the amplifier because most audio preamplifiers available are designed for moderate-to-low input resistance. This paper discusses the basic requirements and limitations inherent in obtaining high input resistance with acceptable stability of the amplifier operating point. Both vacuum tube and transistor circuits are discussed, with emphasis on capacitive sources.

Basic Considerations

A typical input circuit with a capacitive signal source is depicted in *Fig.* 1. Here C_g is the capacitance of the generator, C_s is the total shunt capacitance, R_c is the bias return resistance, and R_i is the resistance seen looking into the amplifier input terminals. This may be taken as the equivalent of a crystal or ceramic microphone input circuit when the mechanical constants are neglected.

Low-Fequency Performance

We derive the input transfer function to be

$$\frac{e_i}{e_g} = \frac{\omega C_g R\,(\omega R\,(C_g + C_s) + j)}{1 + \omega^2 R^2 (C_g + C_s)^2} \qquad (1)$$

*16911 Dulce Ynez Lane, Pacific Palisades, Calif. 90272.

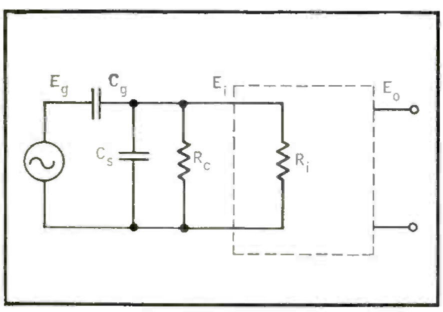

Fig. 1. The capacitive source.

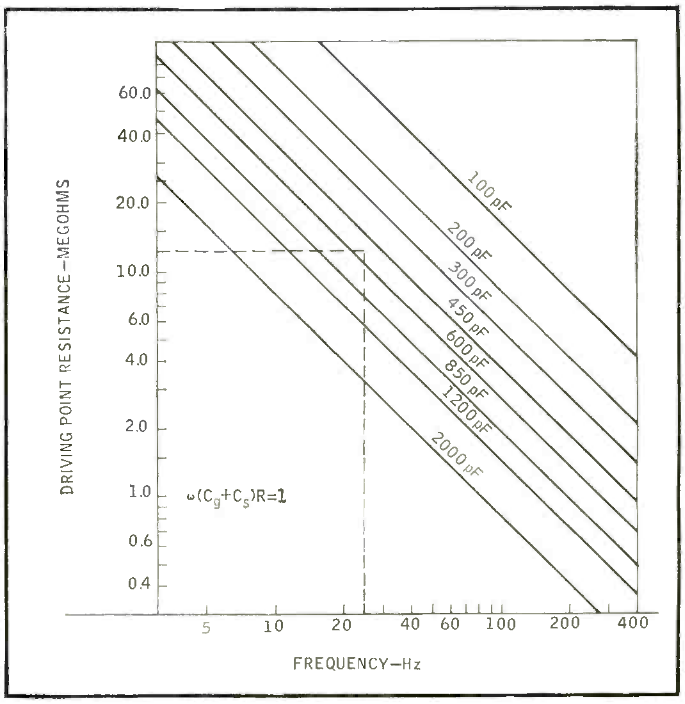

Fig. 2. Half-power frequency vs. driving - point resistance.

where the driving point resistance is

$$R = \frac{R_c\,R_i}{R_c + R_i} \qquad (2)$$

From Eq. (1), the half-power frequency is found to be

$$f_1 = \frac{1}{2\pi\,R\,(C_g + C_s)} \qquad (3)$$

The half-power frequency as a function of driving-point resistance is plotted in *Fig.* 2 for several values of total capacitance. It is noted that half-power frequencies of the order of 20 to 30 Hz require unusually high values of driving-point resistance for typical capacitance values of the order of 500 to 600 pF.

The bias-return resistance and the amplifier input resistance are combined in parallel to determine the driving-point resistance. It is clear from Eq. *(2)* that the driving-point resistance is smaller than either the bias-return or input resistance unless the input resistance is negative. Thus, the driving-point resistance may have any value, depending on the input resistance.

Noise Performance

Middlebrook has shown[1] that the optimum source resistance for a transistor

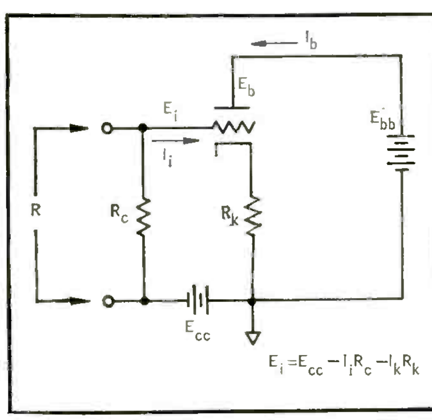

Fig. 3. Bias-voltage components.

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input circuit is about 1000 ohms. The optimum noise figure cannot be improved by any form of feedback, but can be degraded. He has also shown that the signal-to-noise ratio obtainable with reactive sources is independent of the transistor input resistance and is inversely proportional to a function of the bias-return resistance. Similarly, for vacuum tubes it can be shown[2] that increasing the value of the bias return resistor improves the signal-to-noise ratio when the source is reactive.

Bias Components and Stability

The quiescent bias-voltage components are shown in *Fig.* 3 for constant excitation voltage. The bias voltage is expressed by

$$E_i = E_{cc} - I_i R_c - I_k R_k \qquad (4)$$

in which the grid-current component of cathode current may be neglected. Here input current is taken as positive when it has the same sign as anode (output) current. If now we allow E_i to increaase by an increment Eq. (*4*) becomes

$$E_i + \Delta E_i = E_{cc} - (I_i + \Delta I_i) R_c - (I_k + \Delta I_k) R_k \ (5)$$

since I_i and I_k are functions of E_i. Subtracting Eq. (*4*) from Eq. (5) and dividing the result by ΔE_i we have

$$1 = -(g_i R_c + g_m R_k) \qquad (6)$$

This expresses the conditions necessary for a new operating point of neutral stability resulting from a small (transient) change in bias voltage. This condition cannot be satisfied with any value of positive input conductance, since transconductance and both resistances are positive. Hence we conclude that the stability of the operating point is positive for any value of bias-return resistance when the input conductance is positive. But for negative input conductance the stability is positive when

$$R_c \leqq \frac{1 + g_m R_k}{-g_i} \qquad (7)$$

This is the largest value of bias-return resistor that may be used in any circumstances and the magnitude clearly depends on the characteristics of the amplifier in question.

In general, both I_i and I_k are direct functions of the excitation voltage. This is of no particular consequence except as the magnitude of g_i and g_m change. In the practical case both magnitudes change in the same direction and the ratio tends to remain constant. Suffice to say here that the presence of a cathode resistor has a degenerative influence, therefore stability is improved.

The foregoing considerations apply equally to semiconductor devices, given appropriate changes in notation. The input current is taken as positive when a portion of the emitted current flows out of the base, whether the device is of the P or N type. It should be observed that stabilizing the operating point against changes in operating temperature is quite another matter.

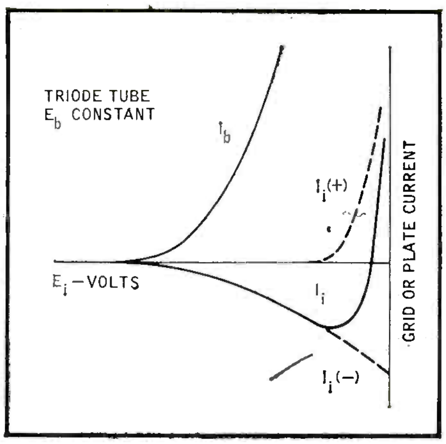

Fig. 4. Typical grid-current characteristic.

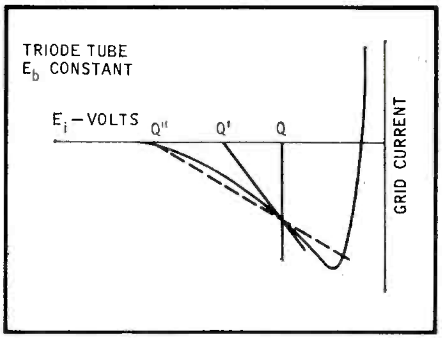

Fig. 5. Composite grid characteristics.

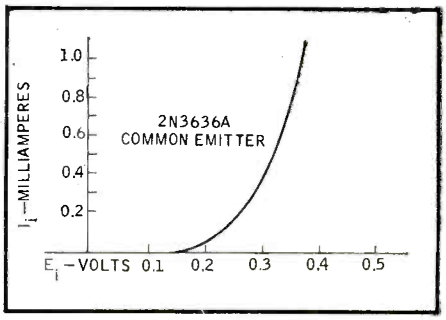

Fig. 6. Transistor input characteristic.

Effects of Feedback

Equation (*2*) gave the driving-point resistance as

$$R = \frac{R_c R_i}{R_c + R_i} = \frac{1}{g_c + g_i} \qquad (2)$$

in which R appears larger than R_c for any value of negative input conductance, and conversely. If feedback is applied to the cathode

$$g'_i = \frac{A'}{A} g_i = \frac{g_i}{1 - A\beta} \qquad (8)$$

where A' and A are the amplifier gains with and without feedback, respectively, and β is the feedback fraction. Equation (*2*) now becomes

$$R' = \frac{1}{g_c + \frac{A'}{A} g_i} \qquad (9)$$

which shows that the driving-point resistance is reduced by the application of negative voltage feedback to the cathode of an amplifier operating in the negative input conductance region, and conversely.

INPUT AMPLIFIERS

The foregoing considerations show that good frequency and noise performance require large driving-point and bias-return resistances, respectively. To determine the degree to which both requirements may be satisfied simultaneously with acceptable stability of the operating point we must examine the nature of the amplifier input.

Vacuum Tubes

In examining the input resistance of vacuum tubes we find a rather complicated mechanism. Of course, the nature of the input conductance is determined by the grid-current characteristic of the particular tube under consideration. We shall now examine a typical characteristic and the mechanisms producing it.

Grid interceptions of electrons and ions give rise to positive and negative components of grid current, respective-

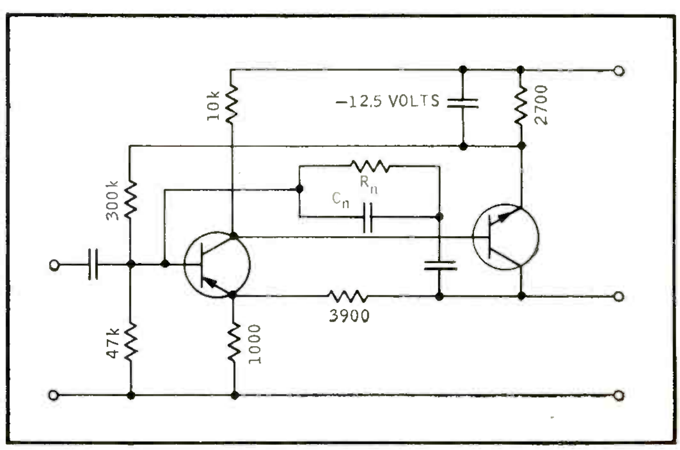

Fig. 7. A transistor feedback amplifier.

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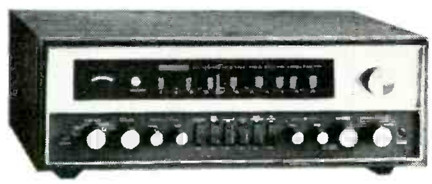

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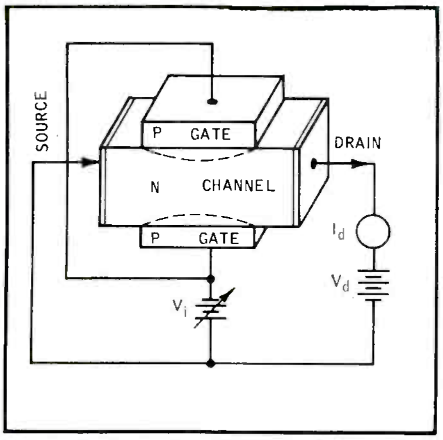

Fig. 8. The field effect transistor (FET)

ly. Other sources, such as leakage, are usually negligable in small audio tubes and will not be considered in detail. The intrinsic relations are shown in *Fig.* 4.

Thermionic emission is a statistical process resulting in a significant distribution of electron kinetic energies. Some fraction of emitted electrons is sufficiently energetic to overcome the field gradient produced by a slightly negative grid. These electrons may or may not be intercepted by the grid, depending primarily on the tube geometry. Thus the inception of positive grid current occurs at some negative grid potential ranging from a fraction of a volt to one volt for the tube types of interest here. Positive grid current increases precipitously as the grid is made more positive.

Negative grid current results principally from grid interception of ionized molecules of residual gas. The preponderance of ionization results from electrons colliding with gas molecules in the interelectrode space. Since a determinable minimum of energy is required to ionize a gas molecule not all collisions result in ionization. Hence positive grid current tends to be proportional to residual gas density, electron density (plate current), and to the square of the plate voltage. This mechanism is relatively independent of cathode temperature, hence of heater voltage.

Figure 5 shows a typical composite grid-current characteristic for constant plate voltage. When the grid voltage is increased from below plate-current cutoff the initial grid current is negative and displays negative slope with respect to grid voltage. The grid current continues to increase negatively until the positive component of grid current becomes significant. The positive component now increases rapidly, causing a negative peak and a transition to large positive slope. The zero-current (floating-grid) point normally occurs when the grid is a fraction of a volt negative.

The input conductance will be negative and relatively small to the left of the current peak, and conversely. Operation in the negative-conductance region is clearly indicated if small loading on the driving source is a design objective. Operation near the current peak results in a highly nonlinear conductance and will give rise to serious distortion, even for very small signals.

With a resistive bias return the negative grid current causes the grid voltage to be more positive than the bias source, and conversely. As shown in *Fig.* 5, the actual operating point, Q, is located by the intersection of the current curve and the grid-return load line projected from the bias-return point, Q′. This effect may be very significant for large values of the grid-return resistor. In passing it should be noted that the bias-point, Q′, lies at the origin of coordinates for "zero-bias" operation. This causes the operating point, Q, to lie in the positive grid current region with a slightly negative grid voltage.

Any combination of bias point and load line may be employed, at least theoretically. However, the consequences of certain combinations may be undesirable. To examine this, let us establish an operating point in the linear negative conductance region and choose a zero value of grid-return resistance. This gives a vertical load line, as depicted in *Fig.* 5, with bias and operating points being coincident. Now increase the value of R_c, causing the bias point to move to the left and the load line to rotate about the grid-current intersection in a counterclockwise direction. The bias point, Q′, will reach a position causing the load line to lie parallel to the grid characteristic at the operating point, Q. Now the load presented to the driving circuit is zero, for the input conductance is equal to the negative of the bias-return conductance. Further increase in the value of R_c will produce the ambiguous situation resulting from multiple intersections suggested by the dotted load line. While it is possible to proportion the circuit in such a way that only one of the intersections will produce a stable operating point, no purpose will be served unless negative loading of the driving source is required. In general the use of a value of R_c larger in magnitude than the reciprocal of the maximum negative conductance should be avoided. Even this large a value serves no purpose for operation in the positive conductance region.

Conventional Transistors

Conventional transistor action[3] depends on the current injected by the emitter being diffused through the base region, collected at the output, and returned to the emitter in the external circuits. The device is normally cutoff, requiring forward bias between the emitter and the base for operation. This results in a fraction of the injected current being diverted to the base, hence it is said to be current operated. This causes the intrinsic input resistance to be low.

Transistor action is highly sensitive to variations in operating temperature, hence care must be exercised in stabilizing the bias current to obtain satisfactory performance. Reference 3 provides an excellent treatment of this problem.

A typical input characteristic of a small transistor in common-emitter connection is shown in *Fig.* 6. The conductance for large current is about 8 mA/volt; it decreases toward zero as the current is reduced. Thus the largest obtainable input resistance is determined by the smallest input (bias) current at which stable operation can be achieved with acceptable gain. In practice this limit will provide a few thousand ohms input resistance at best. It is significant that negative input resistance is not inherently available.

The common-collector configuration provides an increase in input resistance because of negative voltage feedback (emitter degeneration). Large increases require gains significantly larger than unity, however, so two or more transistors are needed. In addition, the larger gains and a signal inversion obtained with two stages allow bootstrapping and other forms of feedback.

Middlebrook[1] has examined this problem thoroughly. A practical circuit resulting from his work is shown in *Fig.* 7. Here, feedback is applied to the emitter and base of the first transistor to increase the input resistance and decrease the shunting effect of the bias-return resistance, respectively. The base feedback (positive) can be adjusted to remove the shunting due to the bias return (infinite resistance) and the input resistance is in the order of ten megohms or more, which, in this case, is the driving-point resistance. How-

(*Continued on page 91*)

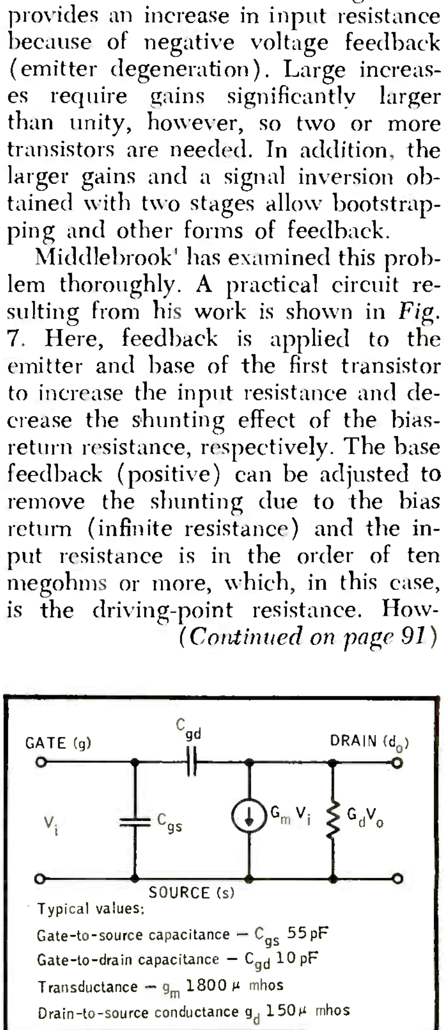

Fig. 9. FET low-frequency equivalent circuit.

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American High Fidelity Equipment Exhibition Shows U.S. Gear to British Buffs

While most knowledgeable audio buffs in England will have become familiar with the specifications and appearance from U.S. magazines, they may not have a first-hand knowledge which comes from handling the actual products. They will get the opportunity during the eight-day show which opens on April 14 at the U.S. Trade Center, 57 St. James St., London, S.W.1. Located only a short block from Piccadilly and in the heart of the "West End," the building is pictured above.

High Fidelity Exhibitions staged previously by the Department of Commerce have proved to be most successful for the U.S. manufacturers participating. At the Frankfurt show in 1964, twenty-seven equipment manufacturers participated—nine new to the market—and they

Left, the facade of the United States Trade Center in Milan, Italy, scene of the 1965 exhibition. At the right are shown some of the enthusiasts, dealers, and distributors who attended.

signed up eleven agent/distributors, made off-the-floor sales of over half a million dollars, and chalked up an estimated additional sales total of $2,139,000 within a year of the show's close. A similar show held in Milan in February, 1965 had a total of thirty hi-fi manufacturers, including eight new to the market, resulted in sales from the floor of $152,000, and an estimated additional total of $877,000 in business within a year. The products of thirty manufacturers are being shown this year, and a business total in excess of the Frankfurt figure is expected.

Department of Commerce Help

The Bureau of International Commerce of the Department has 39 field offices from Alaska to Puerto Rico, each staffed with foreign trade specialists who can provide full assistance and information on international trade promotion activities. Many American products are shown for the first time in Britain at the United States Trade Center, which is located as shown on the small map below .

The Center is maintained by the United States Department of Commerce as a permanent showplace and is under the direction of Donald S. Kilby. The show hours are as follows:

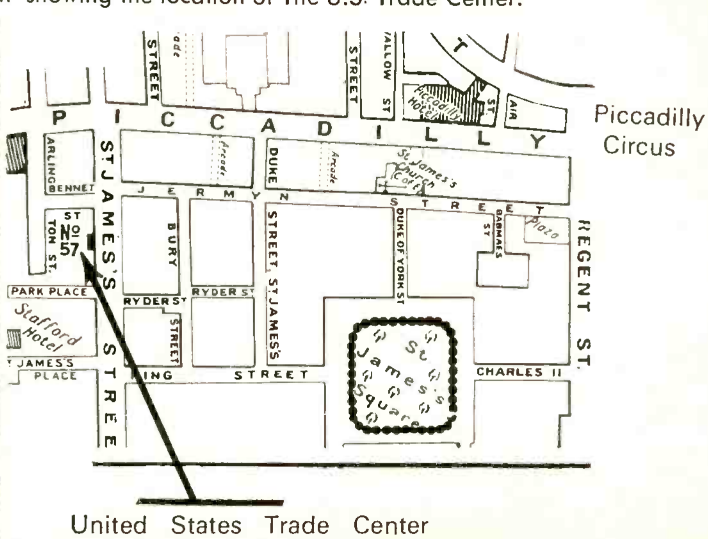
April 14 10:00 am. to 9:00 p.m. Trade only.
April 15 10:00 am. to 5:00 p.m. Trade only.
April 16 10:00 a.m. to 5:00 p.m. Trade and public.
April 18-22 10.00 a.m. to 5:00 p.m. Trade and public.

This represents a departure from usual Trade Center Exhibitions, in that the public is generally not admitted. Since high fidelity is largely a consumer industry, the custom is changed, and dealers throughout Great Britain have been given tickets which they distribute to hi-fi enthusiasts who request them.

American visitors to London during the first days of this exhibition may also want to take advantage of the International Audio Festival, which is being held from the 14th to the 18th of April at the Russell Hotel in Russell Square. This show is an annual event, and has been held regularly since 1957. This need not keep anyone away from the U.S. exhibit, however, since the latter is not open on evenings or Sunday.

On page 41 will be found a floor plan of the exhibit showing the general arrangement of the booths and the products being displayed while a description of some of the products being shown follows on page 44. It is likely that a number of unfamiliar names will be encountered, along with the familiar ones. These are the U.S. exporters who are agents for the manufacturers in those instances where the companies do not have export departments within their own organizations. To exhibitors and visitors alike, we hope it will be a "Good Show."

Below, left, A scene indicating that hi-fi interest is just as great in Italy as it is in the U.S. This picture was also made at the Milan exhibition. Right, a street map section showing the location of The U.S. Trade Center.



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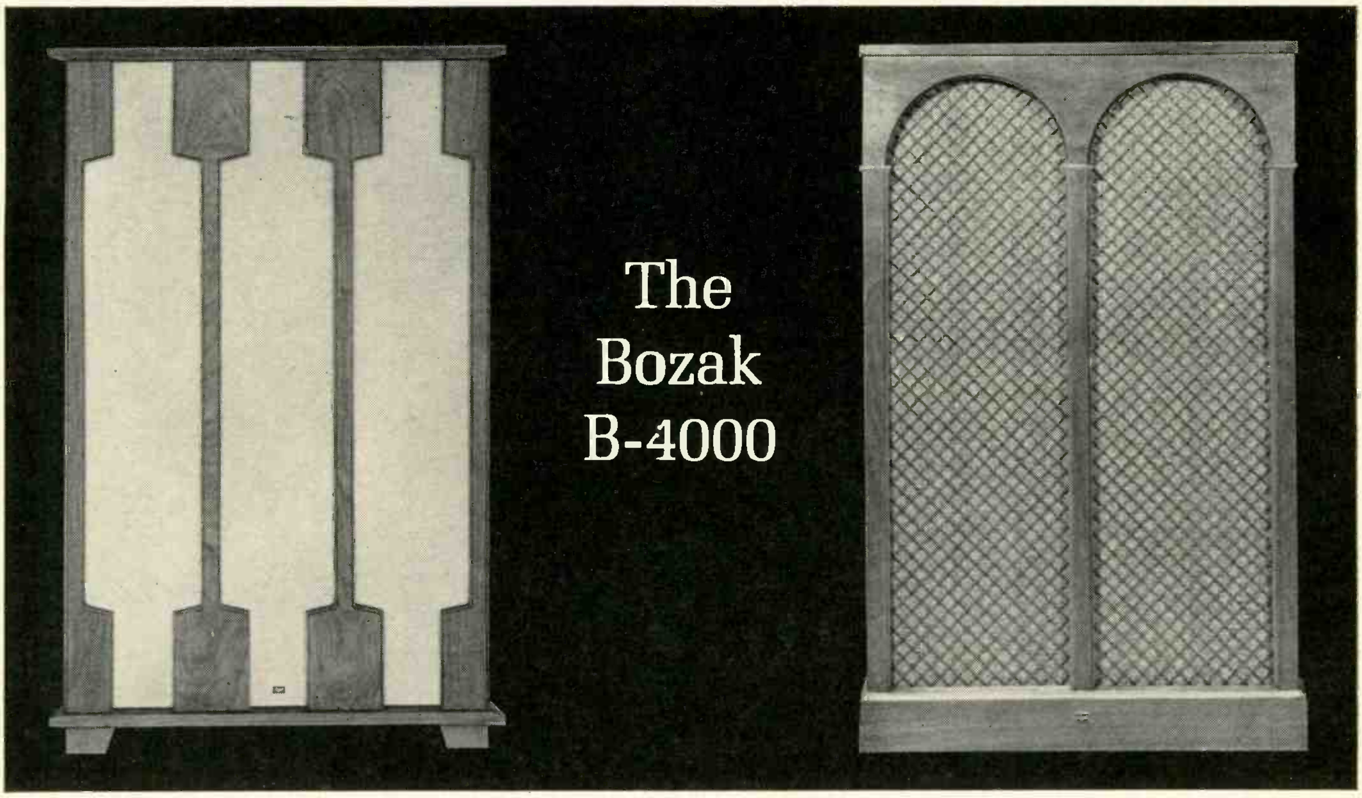

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If there's a certain indefinable something missing from your own music at home, perhaps you should listen to the Bozak Symphony No. 1. Your dealer will gladly demonstrate.

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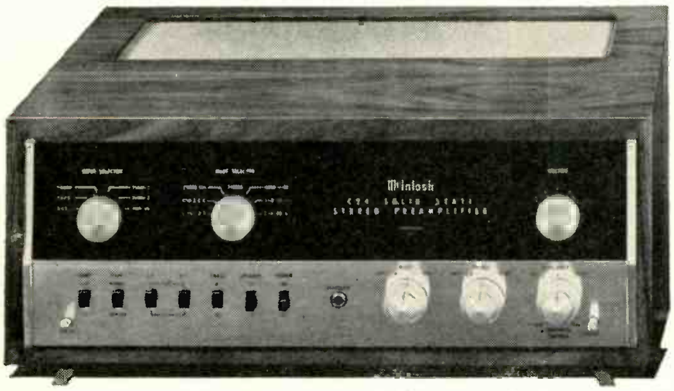

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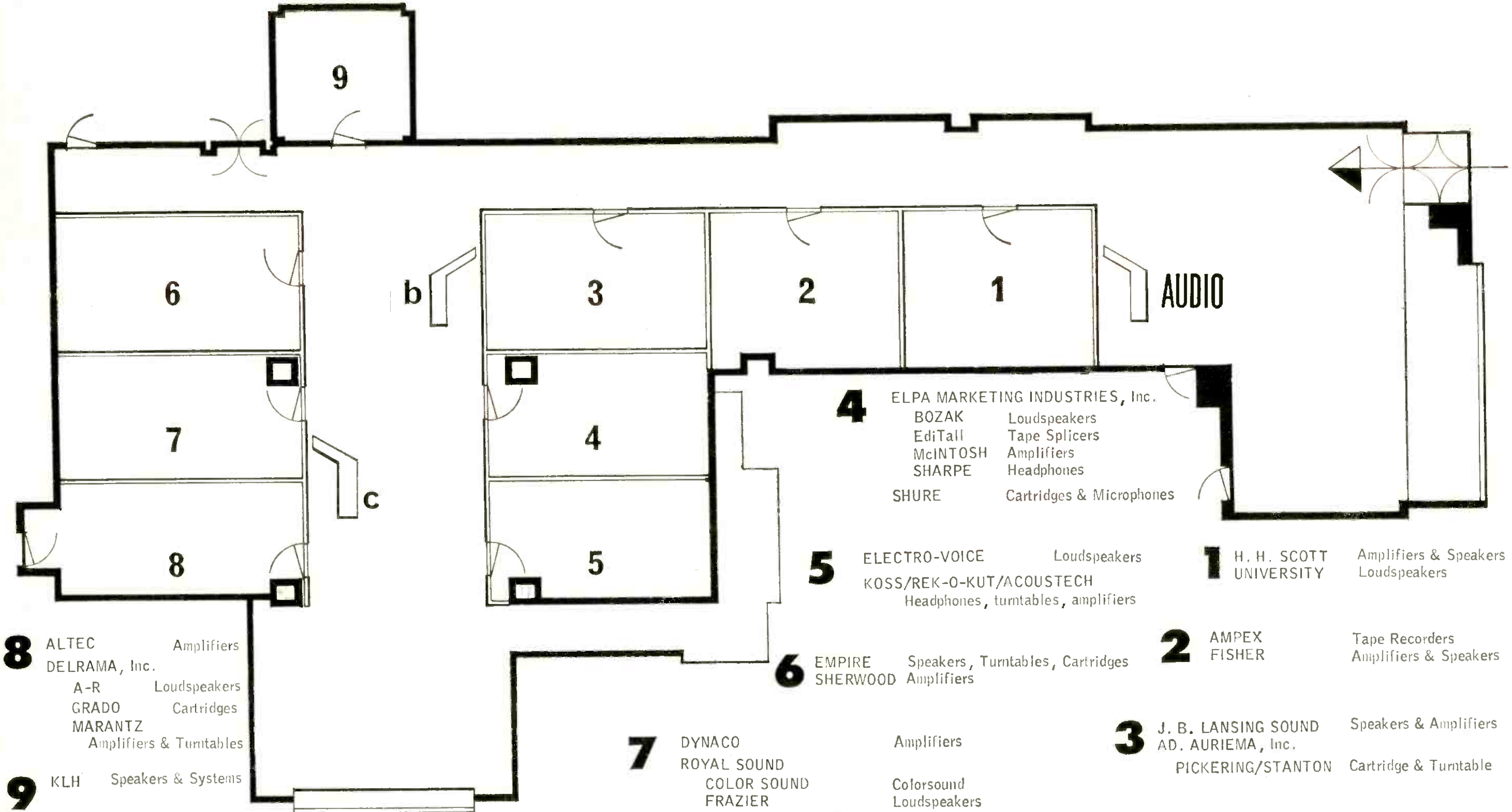

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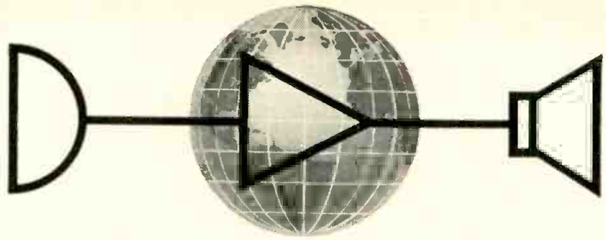
Where to find your favorite U.S. Products

Floor Plan of the United States Trade Center



ALTEC COVERS THE WORLD OF MODERN COMMUNICATIONS

Altec Lansing Corporation designs and manufactures an across-the-board array of quality sound products now serving every area of the communications industry. Whatever *your* particular area of specialization may be, there is a specialized line of quality, proved-in-the-field Altec equipment to serve you.

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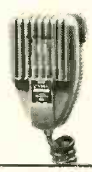

NOISE-CANCELLING COMMUNICATIONS MICROPHONE

MICROPHONES

Altec manufactures over 15 different types of microphones to meet every industry requirement: from broadcast condenser microphones the size of a lipstick to push-to-talk, high discrimination, noise-cancelling dynamic models. We even have dynamic microphone/amplifier assemblies that *triple* the frequency range potential of G1-type handsets and headsets!

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Our broad line of amplifiers and control amplifiers range from 14 watts to 260 watts power output. Each is built to uncompromising standards of precision, accuracy and efficiency with a frequency response of ± 1db, 5-30,000 cps being typical.

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The superiority of Altec loudspeakers and horns has long been recognized and used as the standard in more than 50% of the motion picture theaters, stadiums and auditoriums throughout the U.S. Types available range from 8", 12" or 15" cone type speakers to giant multicellular horns which provide clear sound coverage for vast indoor-outdoor areas.

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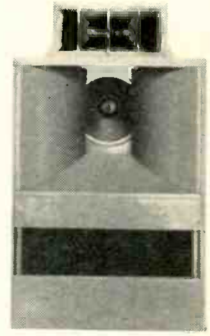
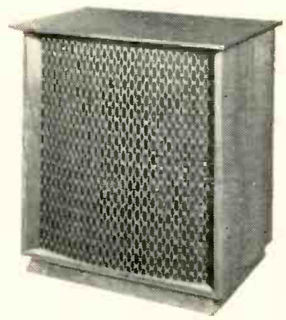


Long the standard of the professional recording studios and theatres, Altec Playback stereo components bring the same superior performance to the home.



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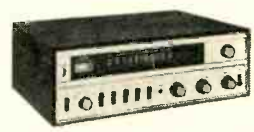

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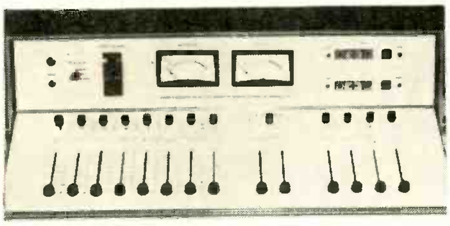
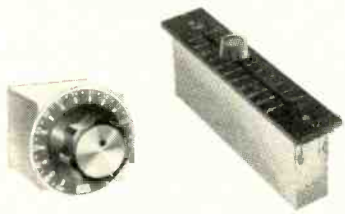
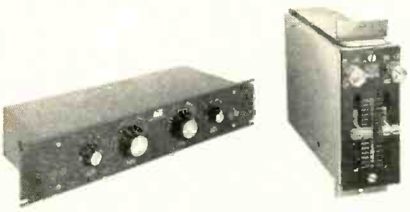


The engineers who design America's studio consoles have come to rely on Altec audio controls for the most advanced, trouble-free performance. Before building a console, one should consider the unique advantages of Altec's most recent studio components.

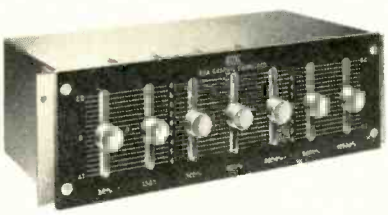
Following is but a small sampling of Altec's complete line, which also includes microphones equalizers, notch filters, fixed low-pass and fixed high-pass filters, variable low-pass and variable high-pass filters, and precision networks.



ALTEC ATTENUATORS, MIXERS, VU EXTENDERS, AND STEREO PAN POTENTIOMETERS come in more than 300 types, both rotary and straight-line. New rotaries use pure-silver dual brushes, independently sprung to eliminate "stumble."



ALTEC PROGRAM EQUALIZERS provide continuously variable equalization at selectable frequencies. Passive circuitry, plug-in mounting or standard rack mounting.



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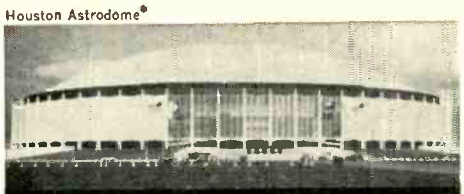

INDOOR STADIUMS. Largest Altec sound system in history is also judged to be the finest in the world. Here, Altec amplifiers deliver 6,000 watts to power gigantic garage-size Altec speaker systems suspended from the roof of the structure.

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OUTDOOR STADIUMS. No roof here, but wind drift is added to the problem of making the announcer heard clearly. High-level Altec multicell speakers cut through wind and crowd noise to deliver the message.

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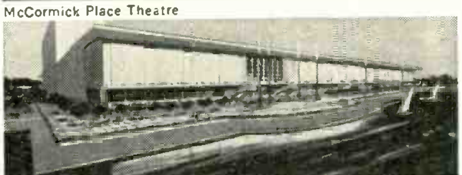

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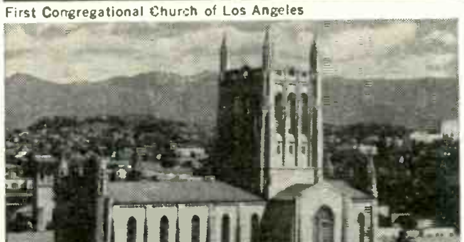

CHURCHES. The voice of the pastor, the music of the choir and organ reach every member of the congregation in absolute clarity. And, Altec's fidelity provides face-to-face intimacy so essential in church applications.

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Through the years, leading architects and engineers have specified custom Altec sound systems whenever sound is an important consideration. Altec's experience with specialized sound requirements of a great variety of structures pays off in systems of unmatched clarity and reliability.

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Here is an unique opportunity to carry the world-famous line of Altec audio and communications equipment. Altec is the U.S.A.'s largest single-source manufacturer of audio and communications equipment, and it backs up its size with a 35-year-old reputation for quality. Write for further information.

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THE U.S. TRADE CENTER, LONDON, ENGLAND, APRIL 12-23

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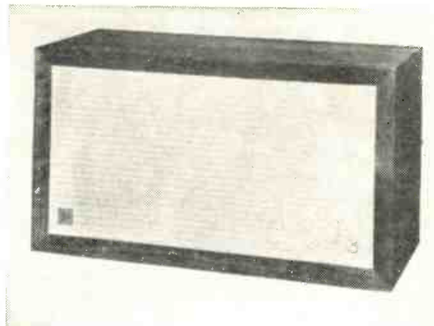
Products shown by U. S. Manufacturers

With over thirty participating exhibitors, it is not possible to describe every item that will be displayed. V to include at least one product of each manufacturer, knowing that literature will be available in each dis

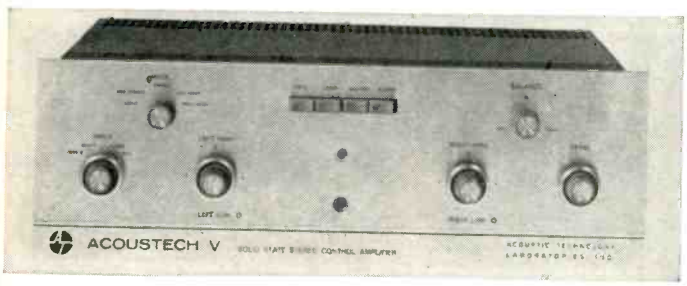
ACOUSTIC RESEARCH

AR-3 Speaker System. In the years since its introduction the AR-3 system has undergone revisions to one or more of its three drivers, as the manufacturer found a better way to do things. Thus, this system remains a "standard" among compacts, if not among all systems. It is a true three-way system with a 12-inch acoustic-suspension woofer, a 2-inch mid-range, and a 1⅜-inch tweeter. The last two named drivers are not conventional cone units; rather the diaphragms resemble nothing so much as a fried or poached egg yolk (of a very fresh egg). This unconventional appearance and construction, the domes are made of a phenolic material, is responsible for the wide dispersion and smooth response of the upper musical registers. Mid-range and tweeter drivers are controlled in output by rear panel shafts that allow a wide range of tailoring of the speaker to acoustical conditions. If it is so desired, a rear-panel strap may be removed converting the system into a woofer-only operation—up to about 1000 Hz. Impedance of the entire system is 4 ohms and efficiency is low. Recommended power is 25 watts minimum per stereo channel. A wide variety of wood finishes is available including walnut, cherry, mahogany and teak. Weight of the system is 60 lbs.



AR Two-Speed Turntable. The AR turntable is of integrated design, that is, the arm and table are a single unit. They are in fact, linked together on a subplate, thus isolating them from shocks received by the base. Drive is from an hysteresis-synchronous drive motor (and a smaller starter motor) via belts. Speed change is effected by shifting the belt on the larger pulley. The arm is moderately viscous-damped. This is "butter-finger" protection; if the arm should be dropped it would gently float down to the disc. At playing angles, the viscous substance is disengaged and there is no restraint on the arm. The arm itself is of low mass with a removable plastic cartridge shell. Stylus force is attained by moving a rear counterweight back or forth. Toward that end, a high-precision plastic balance force guage is included with the system. Also included is a plastic dust cover. The table is mounted on an oiled-walnut base. Dimensions are 12¾" x 16¾" x 5¼".

ACOUSTECH

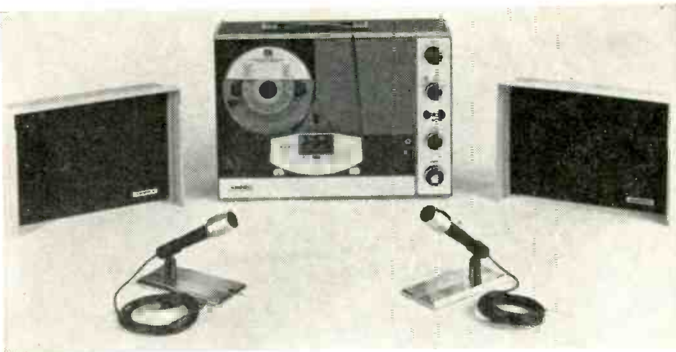


Acoustech V. A massive power supply is only one of the features that make this all solid-state control center/power amplifier unique. The power transformer alone weighs 9½ pounds. This is partly responsible for the ample capacity and regulation that makes possible full amplifier power under the most adverse conditions. With both channels operating simultaneously, the Acoustech V will deliver 45 watts average per channel at less than 0.25 per cent IM distortion. The preamplifier section uses plug-in circuit boards that are made of glass epoxy and meet the USA military specification G-10. A four-bank pushbutton switch on the front panel incorporates switching facilities for tape monitoring, muting loudspeakers, a.c. power, and engaging the tone controls (which are out of the circuit unless this control is depressed. Other important specifications include: frequency response at normal listening levels of 5-75,000 Hz ±1dB; power response at full power of 20-20,000 Hz at under 0.25 per cent total harmonic distortion; 1¾ microsecond rise time; hum and noise below rated output in phono (RIAA compensation) of –55 dB, –75 dB in high-level inputs; phono sensitivity for full output is 2½ or 10-mV. Shipping weight is 25 lbs.

ALTEC

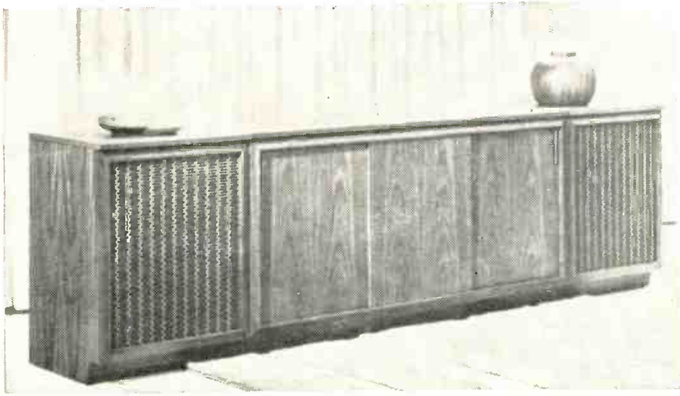
711A FM Stereo Receiver. This is an all-transistor stereo receiver that provides 50 watts of power per channel IHF (35 watts per channel, rms) and is equipped to receive FM mono and stereo signals. In addition it has the input facility for stereo tape head, magnetic phono and an extra high-level input. Unusually flexible front-end controls are provided. Switches are included that allow the user to play either the regular or a remote pair of speakers. A stereo low-impedance earphone jack may be used in conjunction with a switch that shuts off all speakers for fully private listening. FM tuning is by signal-strength meter. A separate light ignites in the presence of an FM multiplex signal and the circuitry then switches automatically from mono to stereo. Important specifications include: IHF FM sensitivity is 2.2 μV; stereo separation at 1000 Hz is stated as 40 dB; amplifier frequency response is ±1 dB 10-100,000 Hz; phono sensitivity for full output is 5 mV; hum and noise is 77 dB down from full output; and full-power total harmonic distortion is 0.5 per cent. Weight is 19 lbs.

AMPEX



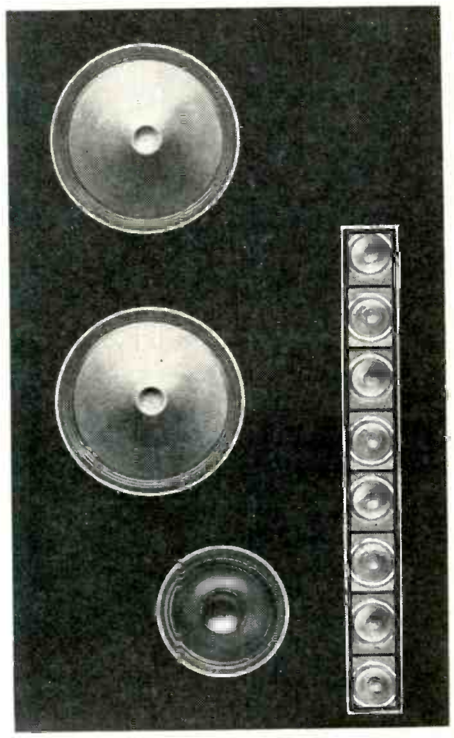
Stereo Tape Recording System. The Ampex 2061 is a complete tape music system for the home. It consists of the Ampex 2060 recorder, two model 2013 speaker systems and two model 2001 microphones. The model 2060 recorder has the same features as Ampex's model 2070 except that it does not have built-in speakers for monitoring. Preamplifiers and power amplifiers are included. A reel of tape will load automatically by simply having the end dropped into a waiting slot. This unit will reverse automatically at the end of a reel of 4-track tape and will play the second set of tracks in reverse operation. Recording is also 4-track, though the machine will not record while in the reverse play mode. 50-15,000 Hz response is claimed; speeds offered are 7½, 3¾, and 1⅞ ips; wow and flutter averages under 0.12 per cent at the highest speed. The speakers provided each contain one infinitely-baffled 6-inch woofer and 3-inch tweeter. They may be used attached to the recorder or separately. When mounted the entire unit forms a one-piece portable unit, up to 30 feet of separation may be had for maximum stereo effects with the speaker wire provided. Also included with this system are the two model 2001 microphones. These are omnidirectional in characteristic, and are high-impedance dynamics with a frequency response of 50-15,000 Hz. Microphone stands are included.

BARZILAY



Equipment Cabinet Kits. The cabinet pictured is only one of a line of equipment enclosures that are delivered in kit form. This is the Design One model. All of the kits have walnut exterior surfaces. Step-by-step instructions are provided. Also included are complete finishing materials so that the final product will exactly resemble a fine-furniture work. This particular cabinet model can contain a complete stereo system including the larger tape recorders. The speaker enclosures are separate and will accommodate drivers as large as 15 inches. The main section is fronted by disappearing tambour doors. Almost five feet of record and tape storage space is available in the lower sections. All components mount from the top down. The entire center section top may be raised for access. As an alternate, the cabinet can be constructed for front mounting components. This center section can be purchased separately. However, if the system is purchased at one time, the speaker enclosure top panels will form one continuous grain pattern with the center section.

BOZAK

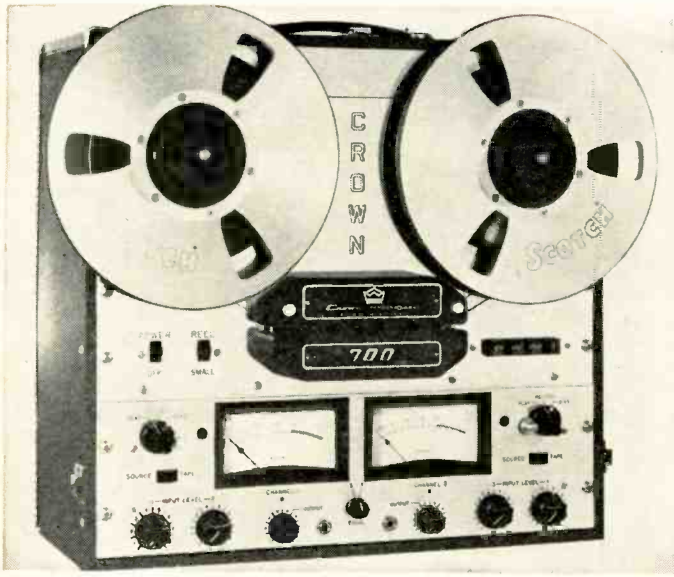


P-4000-P Speaker System. This model designation is for a complete full-audio-spectrum speaker system mounted on a wooden board for insertion into an appropriately sized cabinet of your choice. Two 15-inch bass speakers, one 8-inch midrange, and a vertical array of eight treble units are employed. Also included is a crossover that operates at 6 dB/octave at 200 and 1500 Hz. Over-all fundamental response is stated as 35 to 16,000 Hz. The tweeter array employed is instrumental in providing a dispersion figure of 150 deg. at the high end. The system is designed to be used in a totally closed housing of 8 cubic feet. Impedance of the system is 8 ohms. This speaker system can also be had in Bozak enclosures of contemporary or Moorish design.

C/M LABORATORIES

Integrated Stereo Amplifier/Preamplifier. It is usual for integrated units to sacrifice one or another features and performance characteristics in order to achieve compact dimension and a reasonable price. Nevertheless, C/M claims for this Model CC-50S that it represents state-of-the-art performance characteristics. Economies have been achieved by paring controls to the minimum necessary to do an effective control job. Still, full input and output versatility is not completely lost. Design is all solid-state. Inputs are provided for magnetic phono and tape head, and the usual high-level sources. Continuous power output per channel rms is 50 watts into 8 ohms, 45 watts into 4 or 16 ohms. This full power is available over a 20-20,000 Hz bandwidth at less than 0.5 per cent harmonic distortion. IM distortion is less than 0.5 per cent at 45 watts equivalent power. Frequency response is 5-60,000 Hz ±3 dB at one watt. The damping factor to speakers is better than 200 at 8 ohms over 20-20,000 Hz. Rated phono input is given as 3 to 15 mV, equalization is for RIAA response. Total hum and noise is 70 dB below a 10 mV low-level input or 70 dB below a 0.25 volt high-level input. Full amplifier output protection against mismatch or shorted conditions is provided.

CROWN



SX700 Tape Recorders. There are two versions of this machine. The model SX722 is equipped for two-track stereo record and play. The model SX724 is identical except that the heads supplied are of the quarter-track (four-track) variety. All circuitry (there are separate record and play amplifiers), uses silicon transistors and other solid-state devices exclusively. Four push-button controls are provided for fast forward, rewind, stop, and play. Standard NAB-type reels of 10½-inch size or smaller are accommodated. A switch adjusts reel tension as appropriate. A separate microswitch will stop the system if the tape should run out or break. High-impedance microphone and high-level inputs are provided for each channel. They may be mixed as needed since each input has its own gain control. Large VU meters indicate input or output signal levels. Output is at 600 ohms balanced with outputs up to plus 10 dBm. Other important specifications include: speeds of 7½ and 3¾ ips with equalization switched at the same time speed is changed; overall frequency response at the higher speed of 30-20,000 Hz ±2 dB; signal-to-noise ratio is 54 dB; flutter and wow is 0.09 per cent. At 3¾ ips response is 30-15,000 Hz ± 2dB; s/n is 45 dB; and flutter and wow is 0.18 per cent.

DYNACO

SCA-35 Integrated Amplifier. This unit is, by American standards, relatively low powered. Still, it has been built to uncompromising requirements in an effort to provide a top-quality product at the lowest possible price. The SCA-35 is even more economical if purchased in do-it-yourself kit form. Much of the most tricky wiring is done at the factory on three-printed-circuit boards that need only be wired into the chassis. Only about eight hours are required to place the unit into service. If you are not of the soldering-iron school Dyna does offer this unit completely factory wired as the model SCA-35/A. Kit or wired the final unit will deliver a total of 35 stereo watts (17½ watts per channel). Total harmonic distortion within 1 dB of this power will be under 1 per cent from 20 to 20,000 Hz. At average listening levels this distortion is less than 0.2 per cent. 20-20,000 Hz frequency response is ±0.25 dB. IM distortion is under 1 per cent at maximum power.

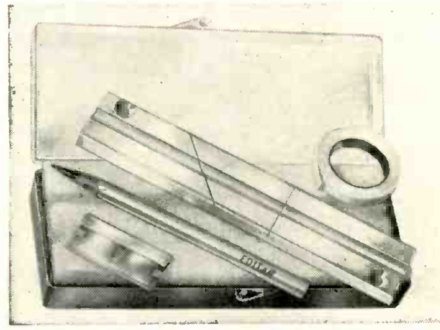
ELECTRO-VOICE

Solid-State Receiver and Model Seven Speakers. These three components make up the heart of a stereophonic music system. The Electro-Voice Seven speakers are each two-way systems with an eight-inch acoustic-suspension woofer and a wide-dispersion frequency tweeter of 3½-inch diameter. The enclosure is of oiled-walnut finish with a natural-cane grille material at the front. Impedance is 8 ohms and response is claimed at 50-15,000 Hz. The E-V 1177 is a complete FM, mono or FM-Stereo, tuner, stereo preamplifier, and stereo 50-watt power amplifier on a single chassis of compact design. All-transistor design makes it possible to offer such a unit with a total height above the shelf of 3¾ inches. Important specifications include: frequency response of ±1.5 dB 20-50,000 Hz, total harmonic distortion of less than 1 per cent at full power, phono sensitivity of 3.5 mV; noise is 70 dB down in high-level inputs; tuner sensitivity is 3 μV IHF; FM stereo separation is 30 dB and switching from mono to stereo is automatic in the presence of a stereo signal. A stereo light indicates the reception of a stereo transmission. Weight of the receiver is 14 lbs; of the speakers 19 lbs. each.

EDITALL

EdiTabs for Splicing Magnetic Tape. These splicing tape tabs are particularly designed to be used in splicers such as the Editall blocks. In use, the pre-glued and cut tab is directly applied to the trimmed magnetic tape to be joined. There is no splice overlap, nor does the adhesive flow and cause tape layers to stick together. Since the splice tab is slightly narrower than the magnetic tape it is to join, the use of these tabs precludes the need to trim excessive tape after the splice has been made. The package holds 50 Editabs; there are five cards each holding 10 tabs.

Tape Splicing Block. The KS-2 editing kit consists of a 4-inch by ¾-inch by 1¼-inch aluminum block, marking pencil, roll of splicing tape and cutting blade. The block itself is precision cut to accept standard ¼-inch magnetic tape without the need for additional hold-down devices. The standard 45-deg. splicing cut is possible as is a 90-degree cut for special splicing needs. Countersunk mounting holes facilitate the mounting of this splicing block.



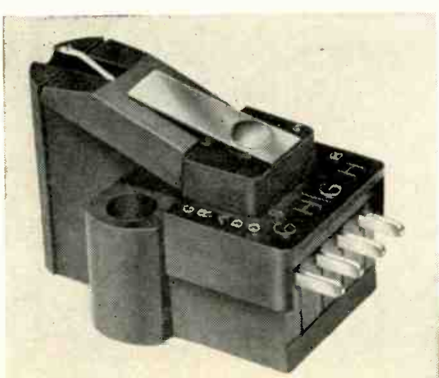
EMPIRE

Troubador System. This is a quality manual system consisting of turntable, arm, base, and cartridge. The turntable itself is of heavy aluminum construction. It is driven by a resilient belt around its exterior rim. Three speeds, 33 1/3, 45, 78, are available by manually moving the belt up or down on the motor spindle (under the heavy plate. The tone arm features precise stylus-force adjustment from one to eight grams. In use, the arm is first zero balanced and then the force desired dialed at the vertical pivot. Accuracy of the calibration is claimed at 0.1 gram. The cartridge mounts in a slide and may be moved forward or back to minimize tracking error. Maximum tracking error can thus be stated as 0.65 deg. with all cartridges. These units, turntable and arm, are premounted on a walnut-wood base. Also available from Empire is the new 888 cartridge of moving-magnet design offering a sharp-attack square wave for lowest possible distortion of music. Stereo separation is in excess of 30 dB. The 888P has a conical stylus, tracks at the new standard of 15 deg. and has a compliance of 15 x 10^{-6} cm/dyne. Tracking is as low as one half gram. There is also a version fitted with an elliptical diamond. This is designated as the 888PE and offers improved groove tracing in comparison with the standard 888P.

FISHER

Integrated Stereo Amplifier. Artful camouflage of seldom-used controls is the most obvious feature of this amplifier. Only the basic program selector buttons, the mode switch and volume control/a.c. off control are visible with the trap-door closed. Beneath that flap, though, is a full range of seldom used, but necessary functions. Included are bass and treble tone controls, an output selector, and equalization, high filter, tape monitor, and loudness compensation switches. There is also a stereo balance control. Music power output of the amplifiers is 30 watts per channel (27 watts per channel rms). Total harmonic distortion is stated as 0.5 per cent at 30 watts. The IHF power bandwidth at 1 per cent THD is 25-40,000 Hz. IM distortion is 0.5 per cent at 30 watts. Over-all frequency response is stated as 20-20,000 Hz ± 1 dB. The damping factor to the speakers is 10. Hum and noise is 60 dB below rated output in phono; it is 0 dB down in high-level inputs. Ten vacuum tube: are used: six 12AX7 and four 7591 power-output tubes. There is a derived third-channel output that will directly feed a center channel speaker. Also included is a low-impedance stereo earphone jack on the front panel. There is a speaker silencing switch. Weight is 26 lbs.

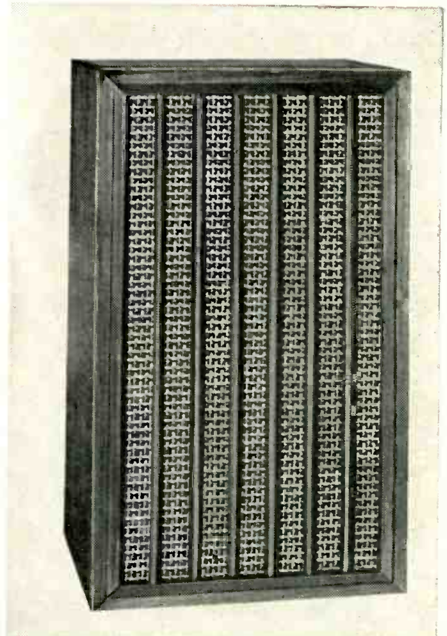
GRADO



Model B Solid-State Stereophonic Cartridge. This new cartridge utilizes two ultra-high-quality subminiature laminated solid-state strain generators to provide the stereo output. Frequency response is claimed flat from d.c. to 50,000 Hz, after which response begins to rise slightly. The generators are impervious to normal home environmental conditions no matter how extreme and are completely time-stable. Output voltage is 5.5 mV at 3.54 cm/sec recorded velocity per channel. Stereo separation averages in excess of 20 dB over the full frequency range. Styli are user-replaceable and are available with a 0.6-mil spherical diamond, 0.6 x 0.3-mil elliptical diamond, or 3-mil spherical diamond installed. Compliance for all types is claimed at 25 x 10^{-6} vertical or lateral. The cartridge will track over the range of 1.5 to 5 grams force. It should see an input load of 47,000 ohms for flattest response. D.c resistance of the elements is 12,000 ohms and the weight of the over-all cartridge is 3.5 grams.

FRAZIER

Model XII-D Speaker System. A new-type 12-inch driver is used as the low-frequency component of this two-way system. The upper musical registers are propagated by two special cone-type drivers. There is a built-in crossover network. Best possible bass response is achieved from the box by fixed acoustical tuning. Over-all, an unusual smoothness of the extended frequency response is claimed. Also claimed, and readily seen in the accompanying illustration, is the handsome visual aspect of this system. The manufacturer's literature rightfully states that it will minimize "wife trouble." The finish is oiled walnut that has been hand rubbed to a fine finish. Impedance of the system is 8 ohms. Dimensions are 14-inches wide, 24-inches high, and 12-inches deep. Weight is 54 lbs.



KOSS

KO 727 Stereo Headphones. These highly sensitive stereo headphones will accept up to 60 watts per channel from any normal program source and can be used with any system having a 4- to 16-ohm output. Foam-filled ear cushions are removable for easy cleaning. The phones are provided with an 8-foot coiled cord that is terminated in a standard stereo plug. Distortion is rated as less than 1 per cent at the maximum output of 143 dB S.P.L. The headband is cushioned and is fully adjustable for head comfort.

KLH

Stereo Music System. The KLH Nineteen is a compact high-quality complete music system for records and FM (mono and stereo) radio. In addition, it offers inputs for auxiliary sources and has tape recorder feed outputs. The all-transistor circuitry allows for a compactness and quality not possible with tube units. The wide-range, low-distortion speakers will fit almost anywhere because of their compact (14" wide x 8" high x 8¼" deep) dimensions. The automatic turntable is a four-speed Garrard unit specially modified to KLH specifications. It is fitted with a Pickering V-15 cartridge to which the preamplifier electronics have been carefully matched. The KLH Nineteen also incorporates a high-sensitivity solid-state tuner that will receive FM mono and stereo broadcasts. A light will ignite in the presence of a stereo station. Full controls are provided to allow adjustment of the FM (or any) signal to individual tonal preferences. All components are mounted in hand-finished oiled-walnut enclosures.

J. B. LANSING SOUND

Solid-State Integrated Stereo Amplifier. JBL states that this SA600 is the first high-fidelity product to make use of analog computer-type circuit design. The power amplifier is actually a direct-coupled d.c. operational amplifier. As a result low-frequency response extends uniformly to direct current. JBL's claim is that low-frequency phase shift is non-existant within the circuit, resulting in complete stability and tight coupling to the loudspeaker. Because transfer characteristics are inherently linear in all stages, high-order distortion products are not produced regardless of power level or signal complexity. It is also stated that the amplifier will not be damaged by short circuit, open circuit, or overload. Another unusual feature is a three-position phono-cartridge input switch. This is designed to provide the best possible dynamic range and signal-to-noise ratio regardless of individual cartridge output characteristics. Important specifications are: output power of 40 watts rms per channel; THD at full power of 0.25 per cent, at one watt it is 0.18 per cent; IM at full power is 1 per cent, at normal listening levels it is under 0.5 per cent; over-all frequency response is stated as 3 to 60,000 Hz ±3 dB; hum and noise is 79 dB below rated output; phono input sensitivity is 5 mV and the preamp will not overload until 200 mV is reached. There is a low-impedance headphone jack on the front panel. Weight is 27 lbs.

(*Continued on page* 54)

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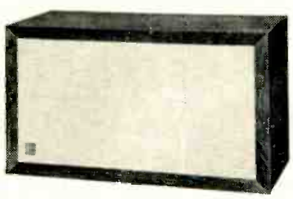

GL

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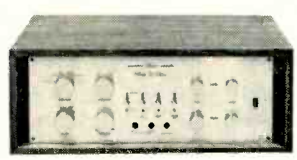
Amplifiers
Preamplifiers
Tuners
Turntables



Literature is available on request.

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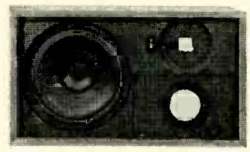
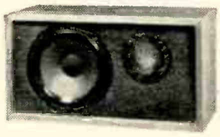
more ▶

Circle 128 on Reader Service Card

AR-2x (new model of the AR-2)



AR-2ax (AR-2x plus super-tweeter)



AR-4x (new model of the AR-4)

AR-3

[Speakers are shown with grille cloths removed.]

why AR INC. guarantees its speakers for 5 years

(covering all repair costs, including freight):

1. It's fair.

2. It's good business.

3. It keeps our quality control department on its toes.

*4. Because of #3, it doesn't cost us very much.**

AR turntables are guaranteed for one year, with freight and repair costs covered.

The superior performance of AR speakers and turntables, attested to almost universally in equipment reviews,** is not likely to change after years of use. If the unlikely does occur, we take care of it.

Literature on AR products will be sent on request.

**The return rate of some models over the entire 5-year life of the guarantee is less than 1%.*

***Lists of the top equipment choices of four magazines are available on request. All four chose the AR turntable, and three of the four chose AR-3 speakers.*

ACOUSTIC RESEARCH, INC., ***24 Thorndike Street,*** ***Cambridge, Massachusetts 02141***

Circle 129 on Reader Service Card

Circle 130 on Reader Service Card →

GRADO

MODEL "B" SOLID STATE STEREOPHONIC CARTRIDGE

Since the beginning of the recorded disc the consumer has been plagued by a series of apparently unsurmountable problems in phono reproduction. This was due mainly to the inability of the phonograph cartridge to cope with the recorded velocities (loud levels) cut into the record. These problems have been especially aggravated with the introduction of the stereophonic record.

Many years of research and development, between both manufacturers of records and the designers and manufacturers of phonograph pickups, have succeeded in reducing these problems to a bearable degree. However, no one has ever manufactured for consumer use a pickup which contained all of the properties which would eliminate completely the problems inherent in stereophonic disc reproduction.

The Grado Model "B" solid state stereophonic pickup is such a device. When design of the Model "B" was undertaken, the performance standards were set so that stereophonic discs could be played with absolutely no problem whatsoever.

The Grado Model "B" has a frequency response range well in excess of 50,000 cycles per second. This frequency response is achieved primarily through excellent mechanical coupling from the diamond stylus to the generators and more important, through the sharp reduction in tip mass at the stylus. The resulting reduction of intermodulation distortion of multiple high frequencies is to say the least, quite amazing. This extremely wide frequency response gives the overall sound reproduction (to use the description of many experts who have heard the cartridge) "a fantastic clarity never before experienced in any pickup," either mono or stereo.

Audibly, one is almost stunned by the overall improvement in reproduction. The general comment being "One would think it impossible that the change of one small part of a system could make it sound so much better."

Illustration No. 1 shows frequency and separation curves of the Model "B" pickup, needless to say they are superb by any standards and superior to other pickups in the consumer market (regardless of price).

Illustration No. 2 shows a square wave of the right channel of the Model "B" using the CBS STR III Test record. The notch on the left side of the square wave is cut into the record and may easily be determined by running the record at various speeds (the notch remains at all speeds). The square wave produced by the Model "B" is virtually perfect.

The Grado solid state stereo pickup does not contain any wires, coils or solder joints. Its quality of construction is of the highest order, utilizing 24 karat solid gold ribbon connectors, military specification reliability, thermo compression bonded electrical joints, ultra lightweight gem quality diamonds, with closely maintained dimensions, and with the stylus tip radius lapped and hand polished to a mirror finish.

The Grado Model "B" stereo pickup has the longest expectant life reliability and stability of any cartridge ever manufactured for consumer use, completely insensitive to normal temperature changes and atmospheric conditions, including the high humidity of the Tropics. Quality control is phenomenally good since each channel (during production) can be and is individually adjusted for voltage output, frequency response, damping characteristic and compliance.

The Grado Model "B" may be used for years and then readjusted at the factory to perform *exactly* as new. Since there are no coils or wires, and since there is no magnetic circuitry, the Grado Model "B" is completely insensitive to magnetic hum pickup and magnetic attraction to steel turntables. Except for the stylus assembly, which is easily replacable by the consumer in a matter of seconds, the Grado Model "B" is virtually indestructible under normal use and should last a lifetime. In fact the stylus is so easily replacable, that one may use this feature as a means to convert the cartridge immediately for playback of 78 R.P.M. records.

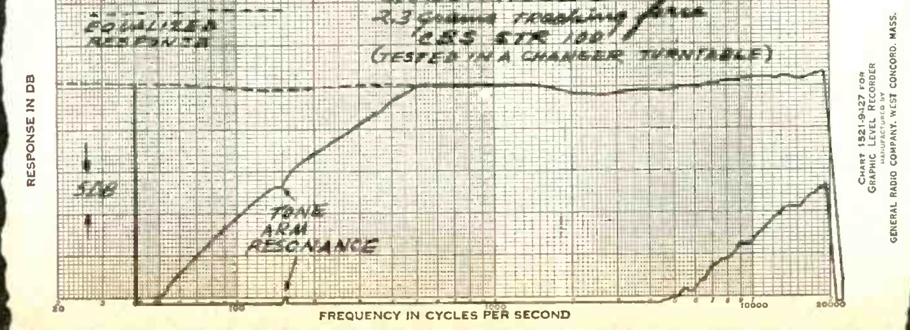
Mini-Duster Model B Cartridge

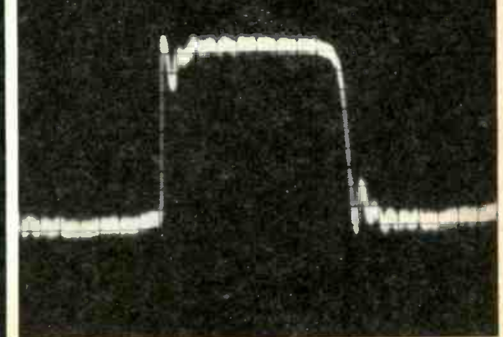
When using a cartridge in a record changer, dust accumulation becomes a major problem. Unless every record is meticulously cleaned before each playing, dust will build up under the stylus and eventually lift the stylus right out of the record groove causing severe playback distortion.

The Mini-Duster positions itself accurately during the record changing cycle and is ever ready to clean the record surface.

Although attached to the cartridge the Mini-Duster operates independently of the cartridge and in no way impairs the optimum performance characteristics of the cartridge itself.

GRADO LABORATORIES, INC., 4614 Seventh Ave., Brooklyn 20, N.Y. USA





Perfection is worth waiting for...

A year ago Saul B. Marantz made this statement: "Only when the development of solid state electronics has reached the stage wherein it can match the dependability and performance of Marantz-designed vacuum tube circuitry will our equipment be transistorized."

Now the Marantz Company is bringing out its first solid state component. With the development of the Marantz solid state 7T stereo preamplifier completed and ready for the market, Mr. Marantz is proudly able to state: "After 2 years of research, we know that at last a transistorized component can perform with the established quality we demand."

Until now, when a transistorized preamplifier was operated for the best signal-to-noise ratio, it was most readily subjected to overloading. Thus, you had the unhappy choice of undue noise or clipping and distortion.

As of today, that is no longer the case. The Marantz 7T matches the previously unequalled signal-to-noise ratio of the Marantz 7, yet the widest dynamic range from any sound source will not overload even its sensitive low-level phono stages.

And now, discriminating audiophiles, who waited for the best, can reap the rewards of their patience . . . the new Marantz 7T.

GAIN: Phono to main output; 64.5 db.
Phono to recording output; 42.5 db.
High level to main output; 22.5 db.

FREQUENCY RESPONSE: 20 to 20,000 cps $\pm$ 0.1 db.

TOTAL NOISE: 20 to 20,000 cps, 80 db below 10 mv input. (1 uv equivalent broadband noise input).

I.M. DISTORTION: 0.15% at 10 volts RMS output.

DYNAMIC RANGE, PHONO INPUT: Approx. 100 db above 1 uv equivalent noise input. (1 uv to 100 millivolts at less than 0.15% I.M. Distortion).

NEW FEATURES:

2 Front Panel Jacks: For recording, copying or playback with an external tape recorder.

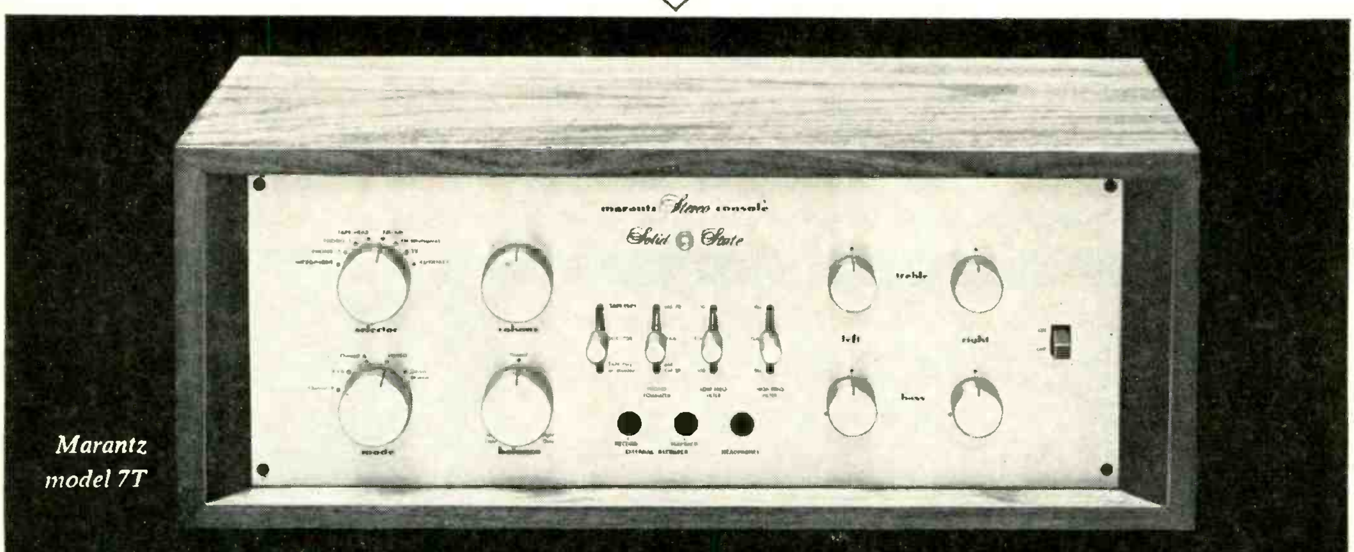
Panel Headphone Jack: Built-in circuit drives 500 ohm or higher impedance phones.

Center Channel Output: Separate A + B mixing circuit with level control.

Tape Play/Tape Copy Switch: Permits tape recording playback or monitoring, plus duplication of tapes.

OTHER FEATURES: Selector Switch with automatic equalization insertion. Mode Switch, Precision Volume Control, Wide Range Balance Control, Selectable-curve Feedback Tone Control, High Filter, Rumble Filter, Power Switch, Output Level Adjustment for high or low efficiency speakers, Tape-head Equalizer adjustment, 6 AC Convenience Outlets. Panel Headphone Jack, Panel Tape Recorder Jack, Panel Tape Playback Jack, Center Channel Output. All outputs match 500 ohm inputs at very low distortion.

THE NEW
marantz
Solid State
7T



Marantz model 7T

MARANTZ, INC. • SUBSIDIARY OF SUPERSCOPE INC. • 25-14 BROADWAY, LONG ISLAND CITY, NEW YORK

Circle 131 on Reader Service Card

Hi-Fi and the British: Salesmanship

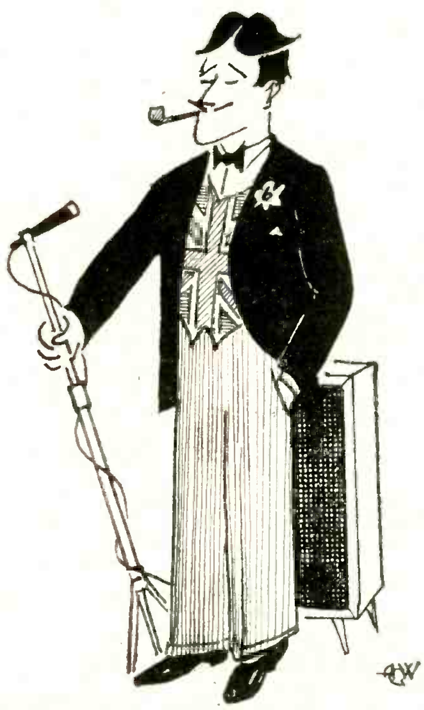
ALAN WATLING*

It just goes to show that salesmen, as well as people, are about alike on both sides of the Atlantic, at least in the realm of high fidelity.

Illustrations by the author

SALESMAN are an acquired taste, and I have no evidence to suggest that the British Variety is any easier to acquire than yours. Of course, they have national characteristics, like integrity, subtlety, dogged perserverance, pride of craft and, well, craftiness. But one thing I'm sure is International is their dead-eye efficiency in finding your weak spot. You may be able to spot his type at 200 yards, but his infra-red snooperscope has spotted your bulging bill-fold at 210,—and by 180 he has classified you as a Possible Probable, or Don't-Waste-My-Valuable-Time-Mac. If you are carrying Hi-Fi equipment he has drawn up a job estimate (165), proved you obsolescent (94) and sorted this year's models into a graded attack on your capital. With logarithmic suddeness he now assumes the mask of camaraderie and unless you have a tactical advantage you are a dead duck.

Seeker after Truth

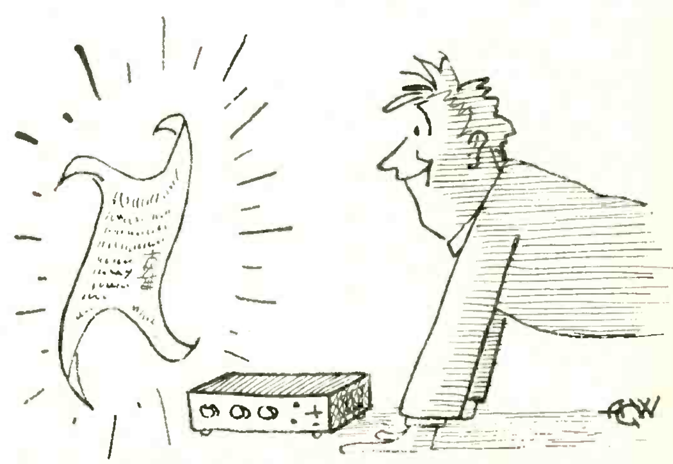


National Characteristics

Over here, the accent on personal service (from our Resident Audio Consultant) means that the salesman is also part serviceman. The ability to hard-sell an awkward line while explaining that spares are unobtainable, breeds a hardy type who doesn't believe his wife when she tells him he's a nut. He wants to see the parts list.

The most infuriating encounter with one of these is when you bring in your treasured equipment, still in guarantee by about three hours, and complain of flutter on your lows or some equally degrading disease. He fixes his gaze on a point ten feet beyond your left shoulder while wiping the tubes distastefully. "You haven't been looking after this, sir, have you?" Checkmate in one, and you can (a) apologize, (b) look vacant, or (c) drop it on his toe. Remedy—anticipatory attack. Thrust it in his midriff and bellow "This shouldn't happen to a dog—Service after Sales it says here (wave scruffy bits of paper)—let's have it back by Friday, or my mastiff will be set on you!" It gives you a hell of a

Whizzbang of a Specification



*32A Pleasant Valley, Saffron Walden, Essex, England.

reputation, but gets rid of the flutter on your lows.

Before they descend on me in their company cars, I hasten to admit that salesmen have their own problems. One is that their showrooms are frequently filled with Seekers after Truth who always look earnest, buy nothing and listen eternally to background noise. He has to discard these while bolstering Damsels in Distress and fostering Rich Possibilities. The first two are peculiarly British, but the last must be international or Hi-Fi would never survive. As in all luxury trades, these rare birds are the target of the plush ads and must frequently be reconverted from the current ad to the one you have in stock. This demands great tact and a careful use of discounts. In Britain it even involves selling American amplifiers—patriotism is not enough. . .

Salesmen, they say, can't possibly be two-faced or they would use the other one. But they are, you know . . . Between the poetry of the "spiel" and the stark reality of a store-room full of Mark 1 amplifiers is the thin red line of conscience. The hardest of front-room men will look close at his shaving mirror one morning and say "You'd sell that stereo set-up to your mother for *money*?" Then he might even go and listen to the thing playing "1812" and find that Tchaikovsky was a better salesman than he was. But he couldn't escape the still, small voice . . .

If all the ads in all the world
All said just what they meant,
And all the watts were R. M. S.,
Then bang goes ten per cent. . .

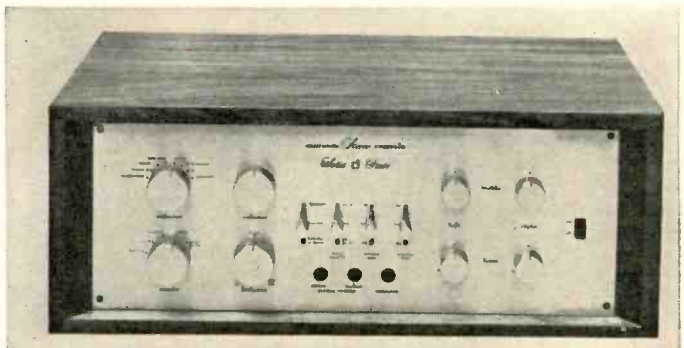
Which is just about as poetic as a blown fuse. But still a cynic's honest comment on the way High Fidelity is taken to the cleaners in stores all over both our countries, every day of the working week. The honest men of the trade sound, like all honest men, a little unconvincing at time because the opposition is so colourful, chromed, and calculated. If only we could chuck out the "substantially flat" and the "solid-state response" and replace them by a supersonic whizzbang of specification that meant what it said. But there, the mugs like the glitter to be just that little bit fake—it says so in the book.

Now I really must go. My new five-inch speaker has arrived and the response is absolutely *unbelievable*. . . Æ

What To See (*Continued from page* 48)

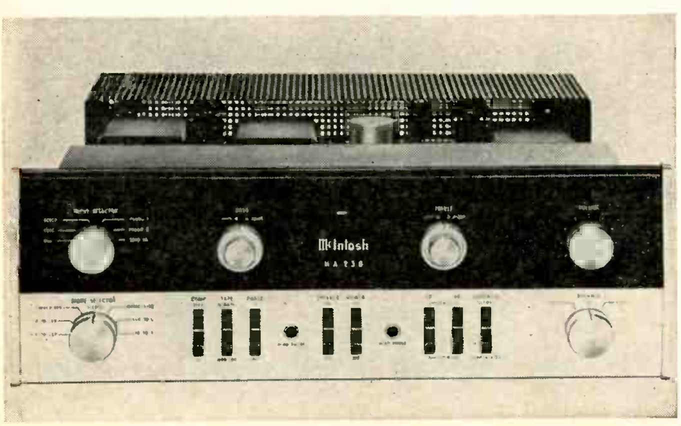
MARANTZ

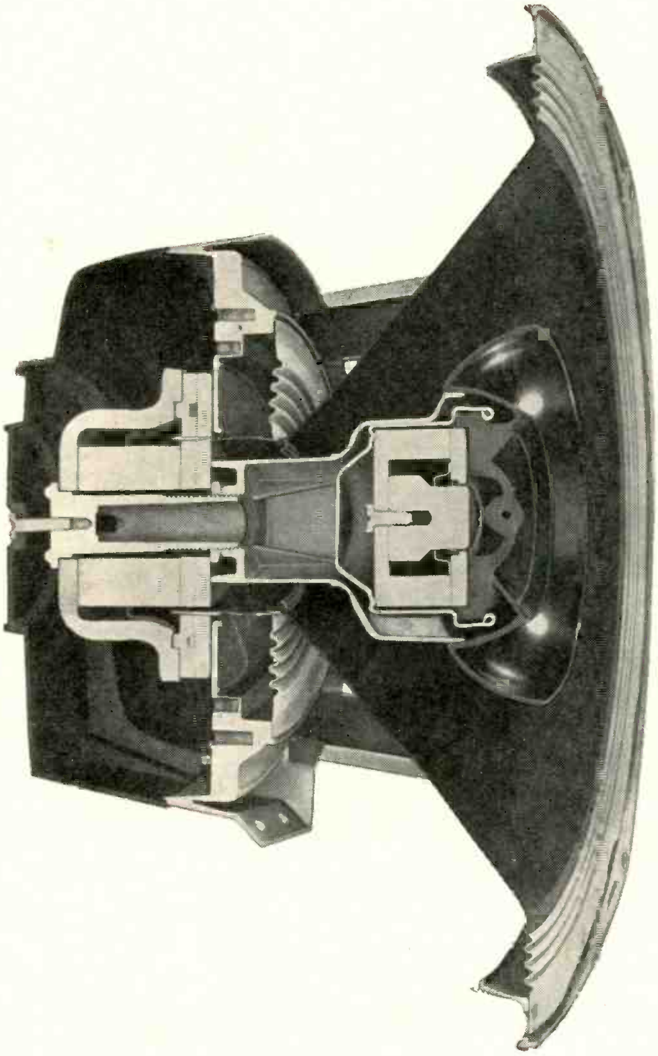
Model 7T Stereo Console. This preamplifier is the first all solid-state product for this company known for its high-quality vacuum-tube units. In appearance it is much the same as its predecessor, the Model 7. In point of fact, the company claims that the *raison-d'etre* of the new unit is that it is the first transistor unit that can equal all the capabilities of the earlier unit. In particular, Marantz points to the phono-input dynamic swing. Where most transistor units are severely limited, overloading easily with high-output cartridges on musical peaks, the 7T will accept up to a 100 mV at less than 0.15 per cent IM distortion. New features added to the 7T include front-panel output jacks for feeding a tape recorder and a front-panel high- or low-impedance earphone jack. There is also a derived center-channel output for feeding a third amplifier. New circuitry and switching permits recording playback or monitoring plus duplication of tapes with tape-recorder front-panel and rear-panel recording outputs. Other important specifications include: 64.5 dB of gain—phono to main output; frequency response of 20-20,000 Hz ±0.1 dB; total noise in phono of 80 dB below a 10 mV input; IM distortion of 0.15 per cent at 10 volts output. The feedback-type tone controls are individually operated with step switches that remove the control from the circuit in the neutral position. Volume controls continue to be selected on the basis of accurate two-channel tracking. Maximum input selection versatility is augmented by six a.c. convenience outlets.



McINTOSH

McIntosh *MA230 Integrated Amplifier.* Ruggedness and spacious construction are two of the reasons for the claim that no sacrifice of quality exists because of this combination of basic stereo amplifier and preamplifier. Another reason is that this is a hybrid unit utilizing vacuum tubes in the power amplification stages and silicon planar transistors in the preamp. Full flexibility is provided by the front-panel controls. The combination of turnable controls and rocker switches allows every possible flexibility of separate preamplifiers to be retained. Two low-impedance earphone outputs are provided with facility for completely private listening. Power output is rated at 30 rms watts per channel with both channels operating simultaneously. Music power available is 44 watts per channel. Over-all response is +0, –3 dB from 15 to 70,000 Hz. Total harmonic distortion is under 0.5 per cent at full power at any frequency from 20-20,000 Hz. The damping factor is given as 10. IM distortion is 1 per cent at full power and 0.1 per cent at one watt. Phase shift is quoted as ±5 degrees from 20-20,000 Hz. Sensitivity in either of the two magnetic phono inputs or tape-head input is 3 mV for full output; it is 0.25 volts in the high-level inputs. Hum and noise in phono is 76 dB below full-rated output. Weight is 40 lbs.





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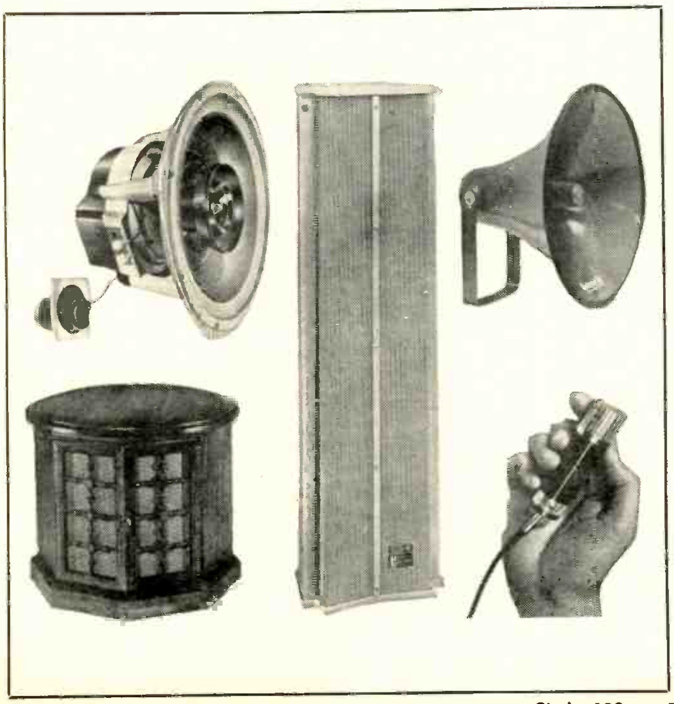
of the world's largest line of all purpose speakers... UNIVERSITY!

Yes . . . this is a picture of University precision . . . representative of a leadership with the world's largest line of electroacoustic products for all applications: Home Entertainment . . . Commercial Sound . . . Military and Defense . . . Marine, Aircraft and Ground Transportation . . . Industrial and Institutional Communications. Yes . . . where ever there is people-to-people communications . . . LISTEN . . . UNIVERSITY SOUND'S BETTER!

A picture of University precision—total craftsmanship for total performance. Throughout the world, the lively sound of the University 312 — the largest selling hi-fi multi-speaker—fills applications in all areas of home entertainment and commercial sound. Here are just a few outstanding features: Patented exclusive University Sphericon with a response to 40,000 Hz—Award winning unitized die-cast frame for life-long, trouble-free performance—Hi-compliance woofer for clear reproduction down to 28 Hz—Exclusive University Diffusicone Mid-range for crisp, articulate and balanced dynamic sound. All ranges precisely maintained in perfect balance with an exclusive electrical network with adjustable control.



For further details, write Desk TC-66 University Sound, 9500 W. Reno, Oklahoma City, Oklahoma

LISTEN—UNIVERSITY SOUNDS BETTER

UNIVERSITY SOUND

A DIVISION OF LTV LING ALTEC, INC.

SEE AND HEAR FOR YOURSELF . . . SEE UNIVERSITY AT THE U.S. TRADE CENTER EXHIBIT.

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PICKERING

V-15 Stereo Cartridges. The Pickering V-15 is actually a cartridge *system*. There are several different stylus assemblies, each with its specific use. The appropriate assembly is mounted in a "V" guard holder which is easily slipped in or out of the cartridge body. In each case, the entire moving assembly is being changed. Operation is by the moving-magnet principle; the entire moving structure is in the stylus assembly. The V-15AME offers 20-20,000 Hz response at under 2 per cent distortion. The stylus itself is an elliptical diamond with radii of 0.25/0.85 mils. Tracking is at the standard 15 deg. Stereo separation at 1000 Hz is stated as 35 dB; at 10,000 Hz it is down to 25 dB. The cartridge will track at forces as low as ¾ gram. Weight of the entire system is 5 grams making this cartridge a good choice for taking advantage of low-mass arm principles. There are also lower compliance conical styli for use in changers and/or manual players. These are all fitted with 0.7-mil diamonds. There is also a 3-mil assembly available for the playing of large groove 78-rpm discs.

RSC Audio Products Div.

Mobilepage Portable Electronic Lectern. Speakers on the go will find real value in this sort of product. The Mobilepage 660B is a compact public-address system built into a portable lectern which can be set up in less than 30 seconds. Amplifier construction is all-transistor. The in-line speaker system is usable attached to the lectern or as a separate component. Thus, it may be positioned wherever is best for minimum feedback pickup. A 20-foot speaker cord is provided. Operation is from self-contained batteries or from a separately available a.c. power pack. In either case, warmup is instant. Weight of the complete system is 16 lbs.

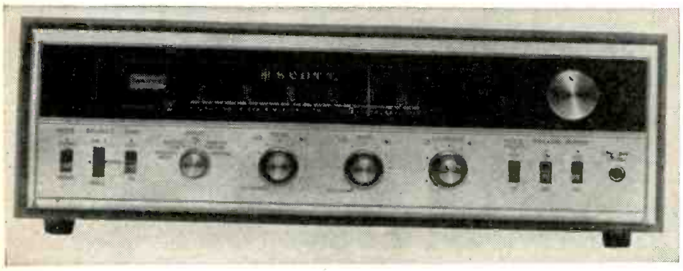
RSC Magnetic Tape Div.

Award Tape Line. Two types of base material are being offered as part of this new professional tape line. Either 0.001 or 0.0005 polyester stocks or 0.001 and 0.0015 polyvinyl cloride are available. To these figures must be added a standard coating thickness of 0.00035 inches. Break elongation for the PVC types will be about 40 per cent. With the polyesters, elongation will be 100 per cent. Electro magnetic properties for the four stocks are the same. Coercivity is 310 Oersteds. Retentivity is 940 Gauss. A.c. noise is –70 dB and d.c. noise is –63 dB. Print-through is quoted at –52 dB for these tapes. These Award tapes are to be available on all standard reel sizes.

REK-O-KUT

B-12H Turntable. This is a heavy-duty, three-speed turntable providing the standard 33 1/3-, 45-, and 78-rpm speeds. Drive is from a hysteresis synchronous motor that drives the platter via an inner-rim idler. Noise level is 59 dB below an average recording level. Wow-and-flutter is 0.08 per cent. There is a built-in but removable 45-disc hub. The speed selector is also the power on/off switch. Further indication of power application is offered by a deck-mounted neon light. The finish is grey and two-tone aluminum. The deck is drilled and tapped for the Rek-O-Kut arm but it will fit other arms. Deck dimensions are 14 inches by 15 22/32 inches. Also available is the identical-looking B-12-GH. This is fitted with a lighter-duty synchronous motor. Specifications are only slightly derated, however. Either unit is supplied less tone arm and base.

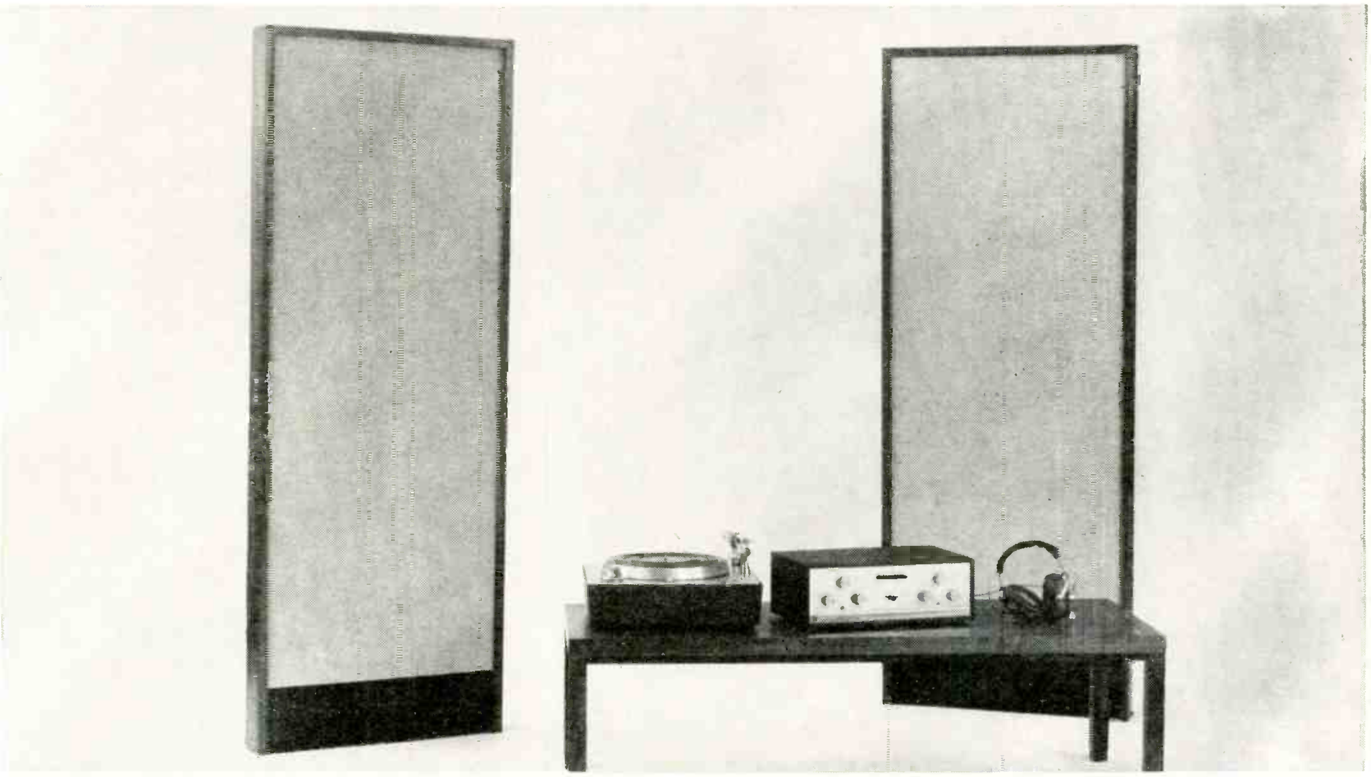
H. H. SCOTT



342 Solid-State Stereo Receiver. Full versatility is the prime feature of this new receiver. The tuner portion is FM both mono or stereo. The silver-plated front end offers 2.7 μV sensitivity per IHF standards with a cross-modulation figure of 75 dB. The stereo multiplex section utilizes time-switching circuitry for a mid-band separation figure of greater than 35 dB. A special circuit automatically switches the tuner to the stereo mode in the presence of a multiplex signal. The claim is that the switching circuit can discriminate between noise and multiplex. It will not switch on noise components. The amplifier section is constructed without driver or output transformers. Output is direct-coupled, using silicon transistors for optimum reliability. Silicons are also used in the tuner i.f. section. It is claimed that superior stability, selectivity, and wider bandwidth result. The amplifier section of the 342 delivers 22.5 watts of music power per channel into an 8-ohm load. 32.5 watts per channel are available for 4-ohm loads. Scott states that transistor reserve capabilities assure even higher peak performance in actual use.

"The finest stereo reproduction that it has ever, and anywhere, been my good fortune to witness . . . the new system is some five years ahead."

Percy Wilson, The Gramophone, September 1965



In every field there is always one name that is associated with the finest

Acoustech

Solid state amplifiers, kits, and electrostatic loudspeaker systems ". . . the most nearly perfect amplifier it has ever been my good fortune to come across . . ." **The Gramophone.** ". . . outclasses all its vacuum-tube competitors and even more its transistor competitors. Never in fact had we heard with so much pleasure as with this amplifier, the best recordings of our record library." **Toute l'Electronique,** France. These are just examples of the acclaim that has greeted the extraordinary Acoustech solid state amplifiers. Acoustech equipment is available factory wired or in kit form at all price ranges from moderate right up to the matchless Acoustech X electrostatic loudspeaker/amplifier system.

Koss Stereophones

The name "Koss" is synonymous with quality stereo headphones. There are more Koss phones used with fine home music systems than all other stereophones combined. This unquestioned leadership is the result of the highest standards of design and production. Shown here is the renowned PRO-4 professional headset. Engineered to meet the most rigid requirements, it incorporates high quality drivers in acoustically designed enclosures which furnish an unusually smooth frequency response.

Rek-O-Kut

Turntables and Tone Arms

For over 25 years, Rek-O-Kut has been the standard with which other turntables are compared. Broadcasting stations, recording studios, and similar professional users have automatically selected Rek-O-Kut for their most demanding requirements. For this reason, the serious music lover with a large record collection has found that a Rek-O-Kut turntable and tone arm is the surest way to safeguard his investment. Rek-O-Kut equipment is available at varying price levels from the moderately priced R-34 to the professional B-12GH shown here.

Acoustech, Koss and Rek-O-Kut are all divisions of:

KOSS ELECTRONICS, INC.

2227 N. 31ST STREET, MILWAUKEE, WISCONSIN 53208

In United Kingdom and Continental Europe write: Koss-Impetus, 2 Via Berna, Lugano, Switzerland

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SHARPE

HA-660 Stereo Headphones. These stereo earphones have been originally designed for audiometric laboratory use. Frequency response is thus claimed to be flat ±3 dB over the full 20-20,000 Hz range. Environmental conditions of temperature, humidity, and atmospheric pressure will have no effect on performance. The drivers are hand-made dynamic units with metal fabricated cones. The ear seals are liquid filled. This serves the double purpose of adding wearing comfort and providing a good ear seal—instrumental in the low-frequency capability. The headband is adjustable and cushioned for comfort. Maximum acoustical output of the phones is 110 dB S.P.L. These phones may be had in either 50-ohm or 500-ohm driver sets. The 4-conductor cord is terminated in a standard stereo plug. Weight is 26 oz.

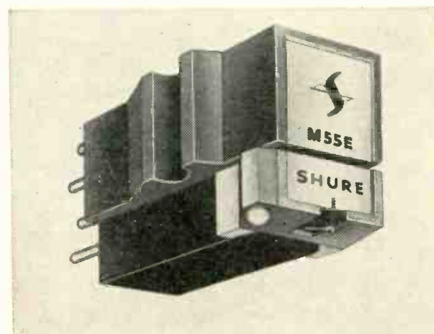
SHERWOOD

7800 Solid-State Stereo Receiver. Sherwood has combined on one compact chassis AM radio, FM mono and stereo radio, and an integrated amplifier system. Power output of the amplifiers is rated at 40 watts per channel of rms power at 0.5 per cent

(or less) total harmonic distortion. IM distortion is stated as 0.1 per cent at 10 watts power or less. The 1 per cent power bandwidth is 12-35,000 Hz. Maximum hum and noise (weighted) is –75 dB below rated output in aux. inputs; it is –63 dB on phono. Phono sensitivity is 1.6 mV for full output. FM sensitivity is given as 1.6 μV IHF, FM distortion is given as 1/3 of 1 per cent at 100 per cent modulation. Automatic noise-gated mono/stereo-FM switching is provided. An indicator light is ignited in the presence of a multiplex signal. FM tuning is accurately done with the aid of a zero-center meter. Full control versatility is here for all program sources—magnetic phono, tape head, tape recorder monitoring, and auxiliary inputs. There is adjustable loudness compensation. An earphone jack for stereo phones and a speaker silencing switch are also included. Also available are front-panel FM interchannel hush adjustments and preamplifier gain.

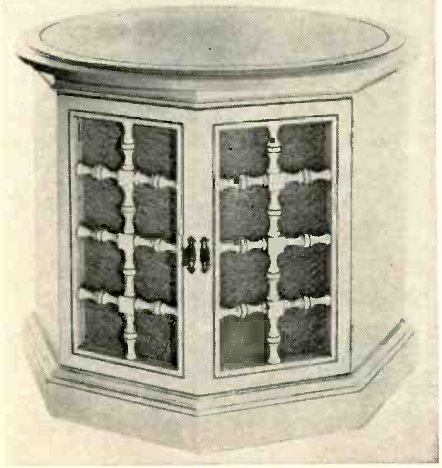
SHURE

M55E Stereo Cartridge. This cartridge features the moving-magnet principle of operation. The user-replaceable stylus assembly is fitted with an elliptical diamond of 0.2/0.7 radii. Tracking is at the standard 15 deg. and forces as low as ¾ of a gram may be used. Vertical and lateral compliance figures are given as 25 x 10^{-6} cm/dyne. Frequency response is 20-20,000 Hz. 1000 Hz stereo separation is stated as 25 dB; at 10,000 Hz it is 20 dB. Output is 5 mV per channel based on a recorded velocity of 3.54 cm/sec. Weight of the cartridge is 7 grams.



TRUSONIC PRODUCTS

Stephens Trusonic Speakers. Long absent from the high-fidelity scene, Stephens Trusonic was a name to be reckoned with some years ago. So it is a particular pleasure to report that the name and the products are back. Included are drivers of every description and pre-packaged speaker systems; many old friends are here. Stephens is offering full-range drivers, woofers, midrange units, ring-tweeters, crossovers, handsome enclosures, and enclosure plans. All large drivers feature the Stephens free-cone suspension—a special plastic-impregnated cone movement compliance offering extremely free and linear cone movement. Further, Stephens offers an unlimited warranty, repairing or replacing at its California factory any performance impairment during the life of the product that has been caused by an event beyond the control of the owner.



UNIVERSITY

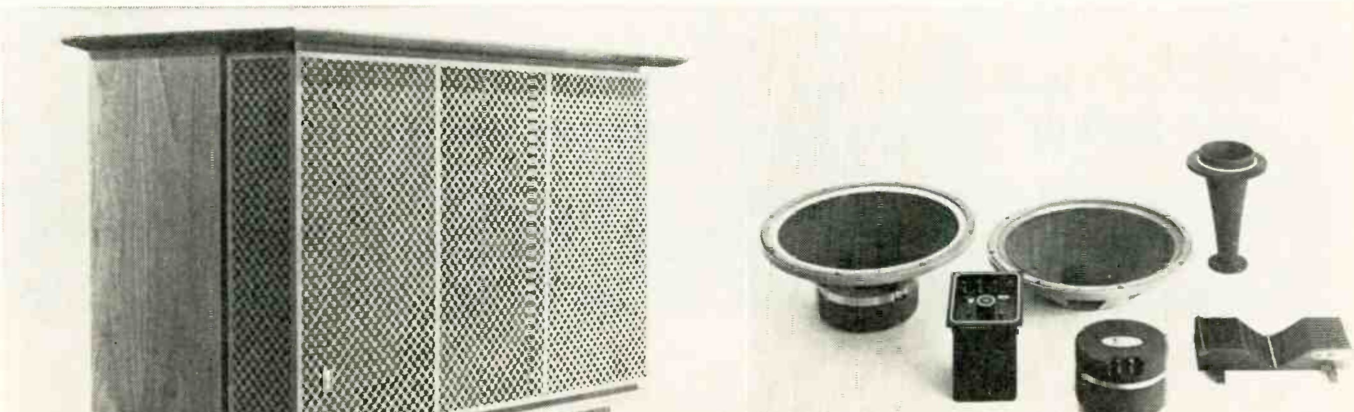
Mediterranean Speaker System. This new system from University represents a departure for this company. The shape of the system is a clue to the qualities to be found here. The Mediterranean is a three-way speaker system. Bass is developed by a high-compliance 12-inch driver. The midrange emerges from a specially designed 8-inch driver and the treble end is dispersed by a reciprocating-flare horn tweeter. This system is claimed to be the first to include a three-way adjustable crossover that allows complete control over the tonal output of the three drivers. In this way, the total output of the speaker, rather than just midrange and tweeter can be tailored to the individual room acoustics. The enclosure itself is a variation of the RRL principle put forth by University. Four inches of damping material in a predetermined pattern eliminate resonances, standing waves, and low-frequency hangover. Decor is also considered in the furniture finish. It is available either in grained butternut wood that has an antiqued pumice brown finish or hand-rubbed antique white. Both are accented with antique-type hardware. The grille cloth is appropriate to the type of wood finish. Diameter is 24¾ inches and height is 22½ inches. Weight is 74 lbs.

Discover what sound is all about!

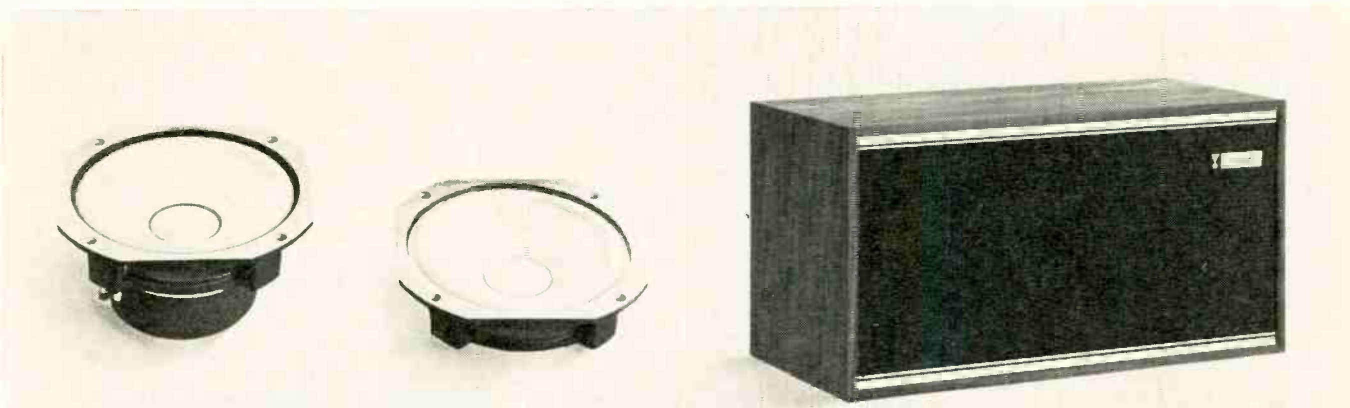
JBL

These JBL speaker systems include a special passive radiator. It effectively doubles the size of the low frequency loudspeaker for richer, more robust bass performance, greater dynamic range, and smoother response well up into the mid-range. JBL loudspeakers and other component parts are meticulously crafted to work together as an organic unit, to express the widest spectrum of sound you can experience.

JBL LANCER 77
14" x 23½" x 11¾" deep



JBL OLYMPUS
26½" x 40" x 20" deep



JBL LANCER 44
23½" x 12¾" x 11¾"

JAMES B. LANSING SOUND, INC., LOS ANGELES 39, CALIFORNIA, U.S.A.

JBL products can be seen in the United States Trade Center at the High Fidelity Components Show, April 12-23, in London.

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In this age of extravagance we set out to build the sensible receiver!

We assume your first interest is in the music, not the machine—with no zest for unneeded bulk, excess cost, or useless gewgaws in your equipment.

That's why controls are uncomplicated on the E-V 1178 receiver, despite its versatility.

That's why it is one of the smallest all solid state receivers you can find, despite its 50 watt amplifier power and full AM/Stereo FM capabilities.

And that's why our performance standards meet the most critical musical taste, not some theoretical ultimate of perfection in printed specifications. The sound is just exceedingly good.

The crisp decorator look of the E-V receiver with integral walnut-paneled enclosure is your extra bonus. Guaranteed for two years—the new Model E-V 1178.

See Electro-Voice High Fidelity Components at the U.S. Trade Center, April 10-25.

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Electro-Voice®
SETTING NEW STANDARDS IN SOUND

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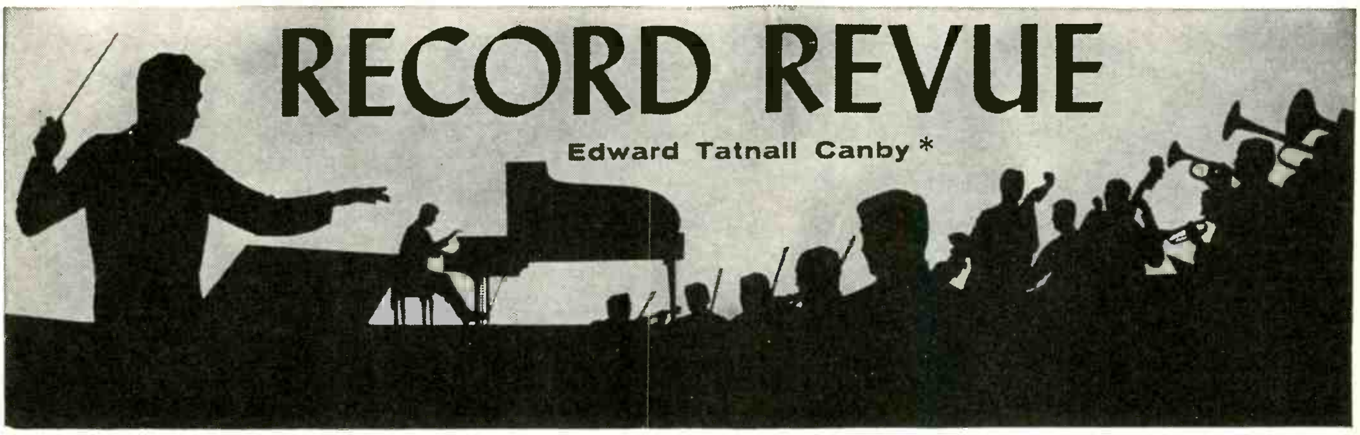

Tchaikowsky: Second Symphony ("Little Russian"). Vienna Philharmonic, Maazel.
London CS 6427 stereo

Absolutely first rate! And not as "little" as the title might suggest, either. The not-so-familar music is on the largest symphonic scale, full of the best of Tchaikowsky orchestral brilliance (even to a tune suspiciously like one in the "1812" Overture!) yet minus the morbidity in the later works (of which we can so easily tire). And there's an unmistakeably youthful zip that is very winning—when the work is as well played as it is here.

The combo of the Vienna Philharmonic (which can be stodgy when somebody let's it) and the dynamically youthful Lorin Maazel is just perfect. The music is full of verve, plastic in its expression, imaginative, enthusiastic, fresh, brilliant as all get-out, but never hard. It's a once-in-a-hundred bullseye, I'd say.

The ever-familar London sound is a variant of our American multi-mike symphonic effect (or maybe I should say vice-versa. . .), close-up and distant all at the same time. In comparison to Columbia's similar big Tchaikowsky, this is more extreme, the fiddles closer and even more to one side and the same with other forward elements, the "big-hall" sound, behind, even more distant. I think I like Columbia's sense of ensemble unity better; but this sound makes for fascinating detail-listening, always worthwhile in Tchaikowsky's brilliant orchestrations.

I'd name it record-of-the-year if I had heard all the competition. Record-for-this-month, anyhow.

BIG ROMANTIC BY-WAYS

Tchaikowsky: Piano Concertos Nos. 2 and 3. Gary Graffman; Phila. Orch. Ormandy.
Columbia MS 6755 stereo

No—not *THE* Tchaikowsky Piano Concerto. That's what makes this disc interesting.

THE Concerto is No. 1, which everybody knows, whether he wants to or not. Strange that No. 2 is relatively a total stranger. And No. 3 even more so. I'd never heard that one at all, to my immediate memory. Tchaikowsky himself wouldn't be too happy, I suspect, at the inverse ratio of popularity. He tried hard.

So what you have here is predictable after a fashion. The music is very, very much T. You couldn't miss that. But where Concerto No. 1 has those big, swinging, sure-fire themes, just ripe for the popular song-picker, Concerto No. 2 is much less of a popularity blockbuster in impact. All to the good in many respects! Frankly, I shudder at the thought of still another Concerto No. 1. This was the inevitable reaction on Tchaikowsky's part, too.

As for No. 3, it is unknown because it is the first movement of a symphony that didn't pan out in that form. T. rewrote it, or one movement of it, as a truncated third concerto. It has made a fine ballet score for Balanchine—*Allegro brillante* is the name of the recent ballet, in case you've seen it. Just as well we have these odd, unused bits of big-time music lying around here and there—they can be very handy, at the right moment.

Performance? Well, natch, with the big. well-oiled Philly machine and the highly proficient Graffman muscle, Tchaikowsky can't go wrong. I'd put it this way—Tchaikowsky asks for it and he gets it. Powerful, slick, super-pro, and generally very good for the music. Same goes for the equally slick, well-oiled Columbia production, in 375-deg. stereo.

Franz Berwald: Symphonies in G Minor ("Sérieuse"), C Major ("Singulière"). Stockholm Philh., Schmitt-Isserstedt.
Nonesuch H 71087 stereo

He's just marvelous, this rediscovered Early Romantic (about 1840). This is his second appearance on discs hereabouts, to my knowledge, and Nonesuch has more of him coming later. I can't get enough of these two symphonies myself, and neither can many of my friends, including the "all-Baroque" sort, who—surprisingly—find Berwald quite acceptable; whereas his contemporaries Wagner, Schumann and Liszt don't have a chance with them.

The reason is compound. First, Berwald, though Romantic in idiom, is an extraordinarily nervous, jittery, modern-tensioned composer, minus any bombast and fustian, full of rapid-fire rhythmic energy. Second and more important, the man is *honest*, confiding, trusting, and a born melodist of an almost Schubertian sort. Also a most ingenious harmonizer. Also a terrific orchestrator, but in an unassuming way, never show-off. All this is why he didn't appeal to his own age (except to the more perceptive big musicians, who thought well of him—Liszt, for example). And it's why we today find him unusually congenial.

Finally, there is his peculiar style, German-trained and symphonic but heavily French-influenced, in particular by Berlioz. That's what comes of living in Sweden. It is an excellent combination, again, for our present ears. Just hits the spot like Coke—I mean Pepsi. Better try Berwald. You'll like him. He likes you. (What *am* I saying?)

Liszt. Jeanne-Marie Darré, piano.
Vanguard VSD 71150 stereo

Well she's France's greatest woman pianist, gray-haired and vigorous, the sort of healthy, maturely feminine powerhouse you see on the ski slopes these days, all aglow with energy. She plays Liszt almost like a man—there isn't any other way for a lady to play the stuff, after all.

But I found the enormous, introspective B Minor Sonata a huge disappointment. She just doesn't get the point, *any* of the points.

I fear it is simply her being French. Liszt, remember, is the ultimate in Germanity in the profoundly thought-out work of towering German Romanticism. Darré plays it the way French conductors (and pianists) often play big Beethoven. All furious, in the loud parts, too lightly in the soft parts, missing the knitted brows, the pregnant pauses, the triumphant soul-raisings, that are the very Germanic essence! Not at all easy for the French mind to encompass. Darré misses them cold.

The shorter, more brilliant and showy pieces on Side 2 are another story. *Valse oubliée*, the familar *La Campenella, Sonetta 123 del Petracha*, such works as these flow effortlessly from the pianist's very potent French fingers.

Champagne, Roses & Bonbons. Minneapolis Symphony, Philharmonia Hungarica, Dorati.
Mercury SR90444 stereo

Fredrick Fennell Conducts Carousel Waltz and other orch. dance favorites.
Mercury SR90440 stereo

With these, a welcome back to Mercury! Good while ago, somebody over there quietly took us off the List, maybe because we didn't review enough. (Can't. We don't have room.) So—no Mercurys, until the President of the company, all unknowing, wrote me sorrowfully to wonder why a colleague like me did him so very wrong, ignoring his product. That's Harold Lawrence, in case you didn't know. Read him in AUDIO, every month.

Left hand, right hand. So now we're back with Mercury and all is hep. To be sure, these two items aren't exactly earth-shaking musically. Waltzes for listening, or maybe for skating. I almost skated right 'round the living room when I heard "Champagne, etc.," which is recorded, on the Minneapolis Symphony side, at least, in a huge, arena-type place, just perfect for skating. The Hungarian orchestra (other side) doesn't sound so very different, come to think of it. Maybe they were caught on tour, on the hoof, in Minneapolis?

Nice, loud, pleasantly commercial waltz sound, not exactly gentle, nor very Viennese—but whaddya want for skating?

As for the Fennell London "Pops" disc, I only observe that Mercury sticks by its long-time artists, wherever they may go. Fennell's Eastman band music was superb. These third-line waltz "favorites," from Rodgers to Rimsky, Bolzoni to Benjamin, are too slick for my oversensitive ears. The playing is slick, too. (*Some* of the items are OK, like, say, Wm. Tell and Le Cid. You'll probably like 'em all.)

SOPRANOS AND BARITONES

Elena Gerhardt. Hugo Wolf Songs. Coenraad Van Bos, pf. (1931)

Angel COLH 142 mono

Technically this is an astonishing recording, for its early-electric time. Musically, the record is also remarkable, and benefits no end from the high technical quality of the 1931 engineering. This record has *highs,* clean ones. You can hear the lady's every breath; you can get all her sibilants—and so she is extremely real and very communicative. Talk about "presence"!

Of course, Elena Gerhardt isn't every 1966 listener's feminine musical meat. She dates from the early times of the soprano *Lied* singer, the time of the young Elizabeth Schumann and before Lotte Lehmann had entered that field in force. Singing then wasn't like singing now. At first you'll think she's a dreadful ham, and a lousy technician—but after a while, (with such beautifully recorded sound), you'll adjust, and hear Elena G. for the fine musician she is.

The discs, all made in late 1931, divide between London and Berlin studios. The British studios do the best job. Really amazing. I didn't know those old mikes (and associated electronics and transducers) could encompass such a clean dynamic range, nor with such excellent highs, as well as lows. One thing for sure—they never heard them played back as we hear them now.

Hugo Wolf: Morike Lieder. Evelyn Lear, soprano; Erik Werba, pf.

D. Grammophon 138979 stereo

There aren't too many good German *Lied* sopranos around now, and especiially Wolf singers. He's tough. Tough as they come. This lady, who is new to me (is she American?) has the honor of acceptance by Deutsche Grammophon, which means plenty, let me tell you. And she lives up to it, though I have a few reservations. Her superb piano accompanist is the well known Erik Werba, who has accompanied Irmgard Seefried on many a record and in many a concert.

Compared to Seefried, with her vibrantly supple little-boy voice, Evelyn Lear is relatively less of a colorist, if a very accurate singer. Seefried achieves meaning—and drama—sometimes at the expense of a uniform tone. Only great singers get away with that. This one doesn't risk it and that is her privilege! Her Wolf songs are always beautifully accurate and intelligible in the sound; but I found them occasionally a wee bit less profound then they might be. Small criticism—as I say, not many singers can get the sense of Wolf clear even to themselves, much less get it over to their audiences.

Don't like the recording arrangement. Not enough piano; it's there, but in the background.

Schumann: Dichterliebe, Op. 48; Kerner Lieder, Op. 35; Liederkreis, Op. 39. Hermann Prey, bar. Karl Engel, pf.

Vox SLDL 5562 (2) stereo

The German Romantic *Lieder* were originally sung mostly by men—but that was "live," of course, and usually at small, home-style gatherings rather than big concerts. For years, we've preferred sopranos for the songs. The tunes are easier to hear and stand out more clearly from the piano accompaniment, particularly in big concert halls. And the soprano can sing louder and carry further without messing up the sense of the music.

But now the male singer is coming back. First, because male singing has changed in style enough so that, increasingly, we can *understand* the music, "get the tune." That means a simpler, less wobbly, cleaner tone quality, so you can can tell what note the guy is singing. That helps. Prey is this type. Second, of course, is the hi-fi (i.e. the phonograph, as was). It makes the original male sort of singing once again practicable.

Prey, the young German genius, has a superbly even voice, lots of drama and plenty of musicianship, all that is needed for this Schumann survey. You'll still find the listening a bit harder physically than the soprano sort—the male voice, in the low register, simply cannot stand out as sharply. You'll have to listen with more direct attention. (No harm in that!) If you do, then the Prey-Engle team is terrific. Really excellent.

Phyllis Curtin, soprano. Faurè: Le Chanson d'Eve, 6 Songs (Verlaine). Debussy: 6 Songs (Verlaine). Ryan Edwards, piano.

Cambridge CRS 1706 stereo

This is for those who know a bit of this sort of music—it isn't an easy style to barge into unprepared, nor is Miss Curtin's singing of the sort that "listens" easily. For a lot of ears, this is likely to be just so much song-singing—a mess of gargly, meaningless soprano noises! Let's be honest.

On the other hand, once you have an idea what these songs in French are really like, once you are "in gear" with their melody, rhythms, harmonies, it's another story. Fascinating stuff, especially as a sort of other-side-of-the-coin to the German *Lied.* (Natch, the French have to be as opposite as possible.)

So—getting down to brass tacks, we have an interesting set of comparisons here between the Debussy and the Fauré settings of the same Verlaine poems, all composed in the 1880's and 90's, the Debussy songs being slightly earlier though he was much the younger man. The parallel songs aren't next to each other on the disc; rather, the Faurés are together and the Debussys the same. Musically a proper way.

In terms of this music, Curtin is good but not outstanding. She is somewhat too operatic (she has sung a lot of opera and oratorio) and her French diction has a solid American twang here and there. (Reminds me a bit of the standard American "Carmen," à la Gladys Swarthout, so unlike the French!) Still, this is micro-criticism; the singing is plenty fine enough to get over the music and to make the interesting Fauré-Debussy comparison, and so is the pianism. Singers in particular will enjoy the record. Or would-be singers.

QUARTETS, SEXTET

Haydn: String Quartets, Vol. 1. (Op. 1, Nos. 1 and 2; Op. 20 complete). Dekany Quartet.

Vox SVBX 555 (3) stereo

Vox still maintains an inspired monopoly on the splendid "Vox Box" idea, huge, fat, reasonably priced editions of *complete* works. And Vox is one of the few outfits with the persistence to carry such projects all the way through. This one says on the cover—"Vol. 1. Complete in Ten Volumes." And, barring war and nuclear revolution, I expect that Volume Ten will be along after awhile, right on schedule. It won't be the first such.

The big question, in these enormous series, is the performance. All your musical eggs are in one basket. As Vol. 1 goes so will Vol. 10. Once again I'm happy to enthuse. This new-ish quartet, apparently assembled for the express purpose of making this recording, is youthful, vigorous, precise, imaginative, musical. Unlike the excellent Hungarian Quartet, this group plays with unusually light vibrato and, therefore, a smoother, more accurately in-tune ensemble. Much easier on the ears, especially the untrained sort! But best of all, the quartet has what many another lacks—a real first-violin leader, who is both dynamic as an artist and extremely accurate in his playing. That would be Béla Dekany, Concert Master of the "Philharmonic in London" (as Vox puts it). He is excellent.

So have no fear—you'll find few Haydn quartet performances more grateful in the listening. And as with the Haydn symphonies, the early works will disclose their own special charms, even without the heavier "content" of the later quartets.

Very sensible system. Each volume will have one complete opus—six quartets here in Op. 20—plus two or three of the shorter early works to fill out the mileage.

Dvorak Chamber Music, Vol. III. The Berkshire Quartet; Gyorgy Sandor, pf., Murray Grodner, double bass.

Vox SVBX 551 (3) stereo

Another Vox Box, another huge project, en route. In this one the performers vary from Volume to Volume. Perhaps it's just as well for this very Romantic composer.

This box includes a very early string quartet, B.17 (new catalogue system) in B flat, and a late and familiar Piano Quintet in A, B.155. Then there's a string quintet with double bass and twelve short "Cypresses"—a set of early songs which the composer transcribed and recast for string quartet. Very good cross section.

The Berkshire Quartet, one of America's best, has managed to avoid recording since early Concert Hall Society days (¾ of them were then ¾ of the old Gordon Quartet.) This is mainly due to the players' temperaments; they don't like such modern folderols as canned music. But they are very good, just the same, with one mild reservation: the strong players are at the bottom, the cello and viola. The two fiddles follow along, expertly.

The early B flat quartet is amusing—it has been skillfully cut but remains a

(Continued on page 81)

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The new ADC *Six Hundred* all solid-state 60 watt stereo receiver

From the people who scored that astonishing breakthrough in phono cartridges . . .

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THE NOVEMBER, 1965, INSTALLMENT of the TAPE GUIDE had an item about a tape that acquired wavy edges and serious wow after several months in storage. Reader Gil Daney of Anchorage, Alaska, has the following suggestions for the unhappy recordist: 1) Play the warped tape on the best machine available. 2) store the tape for at least one month in a cool, dry transformerless area. 3) Repeat the above process if the warpage is still partly present. 4) After playing the tape never, *never* subject it to fast winding or rewinding. 5) Check the tape tension of the machine on which the warped tape was originally recorded.

One Channel "Shattered"

Q. On playback of stereo recorded tapes, my machine (which uses the same head for recording and playback) is nearly flawless. But on my own recordings, the right channel sounds "shattered" and intermittent. Do you have a solution?

A. The fault would have to be in the right channel record electronics. There may be a faulty connection between this electronics and the tape head. There may be a defect in the switch that alternates the record-playback head between the record and playback modes. There may be a poor connection to the bias oscillator. Etc. To discover the exact cause would require a systematic check of the machine itself.

7½ vs 3¾ Playback Equalization

Q. I feed the output of the playback head on my tape transport directly into the tape-head input of my amplifier. But the amplifier is equalized only for 7.5 ips. What will happen if I play 3.75 ips recorded tape?

A. If a tape recorded at 3.75 ips is played back with 7.5 ips equalization, bass will be somewhat excessive and treble somewhat deficient. Probably this can be satisfactorily remedied by a touchup of the bass and treble controls in your audio amplifier.

Pressure Pads vs None

Q. I am trying to make a choice between two machines, one of which uses a pressure pad against the record-playback head, and the other not. Would there be a significant difference in head wear?

A. The general rule is that pressure pads should be avoided, particularly in the case of the record and playback heads. Pads tend to increase head wear and flutter. Reduction of head life can be quite appreciable. Because of its very narrow gap, the playback head (or record-playback head) is the most susceptible to the deteriorating effect of a pressure pad.

Microphone Choice

Q. I am trying to choose a microphone but am confused by the various choices available. Each salesman has a different recommendation, although their suggestions seem to point to a dynamic cardioid mike. What would you recommend?

A. AUDIO's policy prohibits me from commenting on or recommending specific audio components. However, I can in general agree that a cardioid is apt to be a wise choice and in a number of situations the best choice. For example, if you are recording in your living room, a cardioid may prevent the pick-up of interfering sounds in another room, such as water running, dishes cluttering, or conversation going. The dynamic microphone is a very popular choice for a combination of good quality, low price, ease of use, and ruggedness. On the other hand, condenser microphones as a group have won high acclaim, but at the same time tend to be highest in price and are more complex devices to use (because of the need for a power supply). I suggest that you listen to various types, brands, and model of microphones and decide for yourself which one is the smoothest and most natural sounding. If this is the highest priced one, or close to it, and the price beyond your reach, use this microphone as a reference. Then try to ascertain which of the microphones you *can* afford comes closest in sound characteristics to the reference mike.

Separate Heater supplies

Q. I am building a stereo tape electronics. I notice that some commercial amplifiers use separate filament supplies for the two channels. Is this necessary?

A. There may be cases where so many tubes are used and so much heater current is drawn that two heater windings (and therefore two supplies) are desirable. But I see no need of this in your case.

Recording Fadeout

*Q. I have a **** tape recorder, and after it has been recording for about an hour the signal on the tape (both channels) becomes very weak. I turn the gain control all the way up, but even this isn't enough. Where might the trouble lie?*

A. From your description I take it that the volume loss occurs only in recording and not in playback; that is, there is no loss in volume when playing a recorded tape. If so, there may be trouble in the oscillator circuit. Perhaps the oscillator tube (or transistor) requires replacement. Perhaps the turns of the oscillator coil short after heating up. The B-plus supply may be defective; the rectifier may be bad, or there may be a leaky filter capacitor which is draining the B-plus. A systematic check is in order and probably requires the services of a technically qualified person.

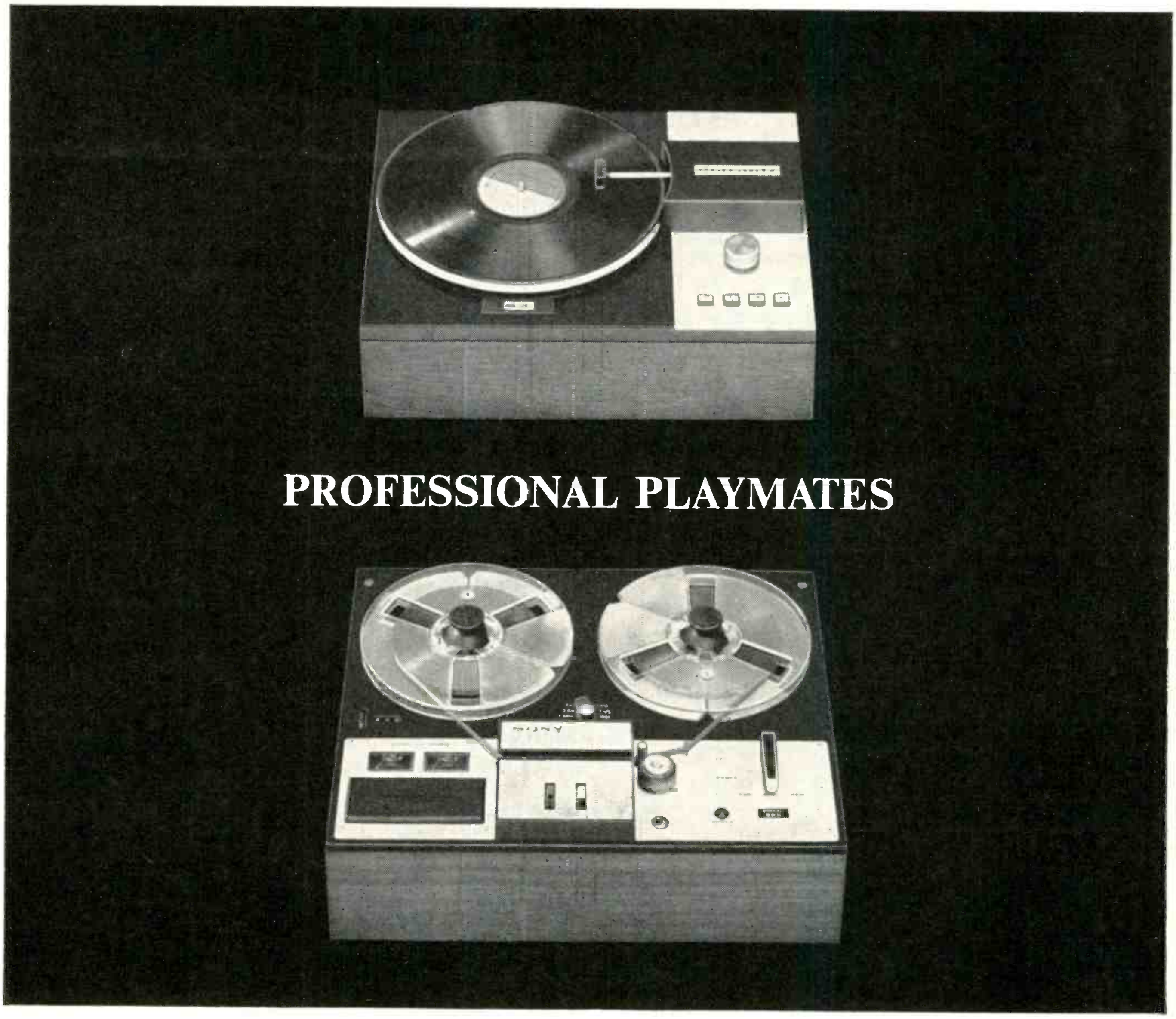
Echo Effect

*Q. I have a **** tape recorder and would like to get echo effect with it. However, I don't want to have to install another playback head. Can this be done?*

A. As you apparently recognize, echo effect requires separate record and playback heads and amplifiers, so that you can simultaneously record and play back, with the output of the playback head being returned to the input to the record head. If your tape recorder does not already have separate heads and amplifiers, it would be a substantial amount of work to install the additional facilities. This kind of task should be undertaken by those knowledgeable and experienced in audio construction.

Q. I do a lot of outside recording in various locations, and my problem is this: I sometimes get a very bothersome hum when I am plugged into a line that is not isolated from the rest of the electrical equipment in the building. I've had my tape machine checked, as well as the mikes and mike transformers I'm using with it. They are all OK. There is no problem when I use high-impedance mikes into the high-level inputs of my tape recorder. But the problem occurs when using low-impedance mikes, which are connected to my tape recorder via mike transformers. Is there some kind of filter or transformer that I can use, located at the machine or a.c. outlet, to eliminate the hum?

A. Does your tape recorder have a capacitor (such as 0.1 μf, 500 volt) between each side of the a.c. line and chassis ground, Are you using a balanced (3-wire) cable to connect your low-impedance mikes to the mike transformers? If such measures don't help, I suggest that you contact a first-class electronic supply house for information on filters that can be connected between your tape machine and the a.c. supply. Perhaps you are operating the recorder in a spot where there is a strong a.c. field. Try moving it a few feet in various directions.



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Audio Measurements Course

NORMAN H. CROWHURST

In Five Parts. Part 3

In this installment, the author discusses various methods of measuring distortion, the effect of residual distortion in the signal source and methods of its elimination, and the relative levels of distortion used to determine maximum power output

In our opening questions about distortion measurement, raised at the end of the previous installment, one factor was omitted: the relative level of the distortion to be measured. This can make a big difference to the ease or difficulty of measurement, by any method. Distortion figures around 5 percent are relatively easy to measure, with any meter. At lower distortion percentages the validity of the result may depend on the harmonic structure of the distortion and the design of the meter, but all will give somewhat similar readings, especially if the input is reasonably pure —less than 1 per cent distortion component.

Choice of Method

But when you are concerned with greater purity, and some amplifiers claim distortion figures far below 1 per cent, different methods are essential. Good audio oscillators have a harmonic content less than 0.5 per cent while superior ones have a figure of better than 0.1 per cent. If the amplifier to be measured claims a distortion of 0.01 per cent (and some have claimed lower figures than this) how do you check it?

Box 651, Gold Beach, Ore. 97444

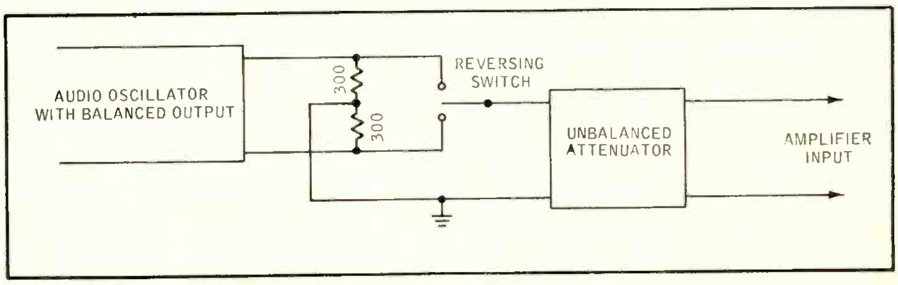

Fig. 3-2. Method of reversing input signal, to resolve ambiguity of reading on even order (asymmetrical) harmonic distortion.

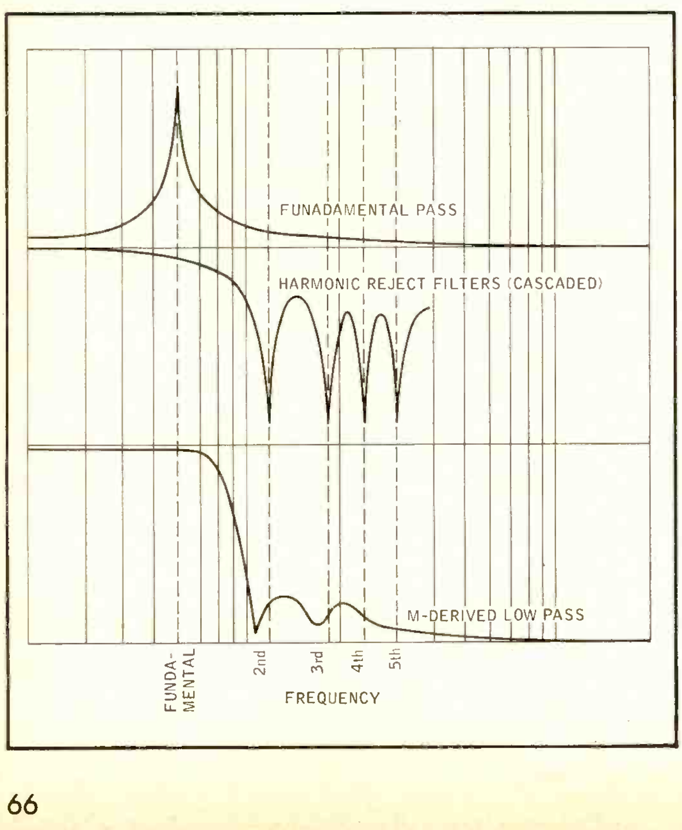

Fig. 3-1. Responses of the three kinds of filters that may be used to purify input signal for distortion measurement.

With either the harmonic distortion meter or the analyzer, the first step must be to reduce the distortion in the input to far less than the figure to be measured. Then you can measure the output either way, provided the meter is sufficiently sensitive to register such small remainders.

In the harmonic meter, it has to null out the fundamental extremely perfectly, requiring high-precision bridge components. Often the resolution with which the bridge can be balanced, or some distortion-producing element in the bridge, such as an inductance, will cause more distortion than is in the output to be measured. Then measurement at lower output levels may also be limited by hum or noise, either from the amplifier being tested, or from the test set itself.

In the analyzer, the attenuation of the fundamental, when checking individual harmonic amplitudes, must be greater than the amount by which harmonics are below the fundamental in level. If a distortion of 0.01 per cent is to be read, the analyzer must reject the fundamental by more than 80 dB, which is quite a requirement. Even if the set is capable of it, which requires a lot of gain, and an extremely sharp filter, very critical adjustment is needed to "find" it.

Either method of measurement requires extremely sensitive adjustment of the instrument and, even with the best "fingers," may not be capable of get-

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*Acoustics Research Laboratory, Harvard University, Dr. F. V. Hunt in "The Rational Design of Phonograph Pickups"; subsequently published in the Journal of the Audio Engineering Society.

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FACTS ... Semiconductor vs. Magnetic

Miniconic gives best tracking through lowest effective tip mass: approximately .3 milligram as established by resonant test method; less than .6 milligram by calculation. The most exotic magnetic does not approach this.

Miniconic Banishes Groove Destroying Mass to Give Stylus Groove Resonance of 47 KHz. The best magnetic known is about one-half this and most of the fine ones are between 12 and 15 KHz. Easily determined by testing with CBS STR-120 Test Record.

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Best Bass in the world because Miniconic Semiconductor responds uniformly to DC! No magnetic cartridge can do this because magnetic output diminishes as the frequency goes down.

Miniconic Inherently Distortion Free. Uses resistive principle —no distortion in resistors. Magnetics are inherently reactive and thus distortion prone.

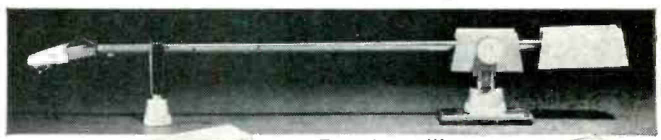
Miniconic maintains Noise-free Groove Contact at High Levels: Impossible for even the best magnetics at levels encountered on present LP recordings. Low magnetic stylus groove resonance will not allow tracking of vertical recorded frequencies above 10 KHz without chatter.

Miniconic Basically Hum-Free because it has 10,000 times the output of the best magnetics.

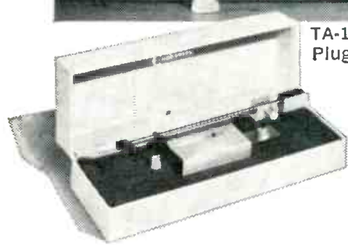
Miniconic is Flat to RIAA. Magnetics must use 38.1 db of costly, hum inducing equalization to play RIAA.

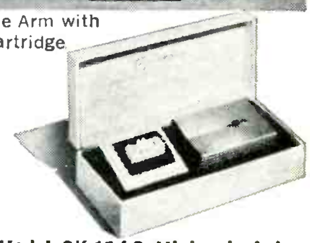
U-15-LS or U-15-P Cartridge with Bracket for Standard Heads

PS-15 Power Source.



TA-15 Tone Arm with Plug-in Cartridge





Model TK-15-LS Miniconic Laboratory Standard Phono System. Consists of U-15-LS plug-in cartridge with biradial diamond stylus. TA-15 low-mass tone arm and PS-15 power source. Works into magnetic or auxiliary inputs. With instructions. Shpg. wt., 3½ lbs. USER NET..........$87.50

Model TK-15-P Miniconic Professional Phono System. As above, but with U-15-P plug-in cartridge with .5 mil diamond stylus. Shpg. Wt., 3½ lbs. USER NET...$71.50

Model CK-15-LS Miniconic Laboratory Standard Phono Conversion Kit. Consists of U-15-LS cartridge (with biradial diamond stylus) for standard heads and PS-15 power source. Works into magnetic or auxiliary inputs. With instructions. Shpg. wt., 2 lbs. USER NET $55.00

Model CK-15-P Miniconic Professional Phono Conversion Kit. As above, but with U-15-P cartridge with .5 mil diamond stylus. Shpg. wt., 2 lbs. USER NET.....$39.00

NOTE: For broadcast and recording studio use, 16" low-mass tone arm and/or power source with 600-ohm output also available. Write for details.

The Experts Say:

Hirsch-Houck Labs, in ELECTRONICS WORLD. "...most basically hum-free cartridge on the market . . . rivals anything we have heard."

Jerry Wesson, hi-fi columnist for U.S. CAMERA. "I've really heard that passage in the Sibelius 3rd Symphony for the first time, with the Miniconic . . ."

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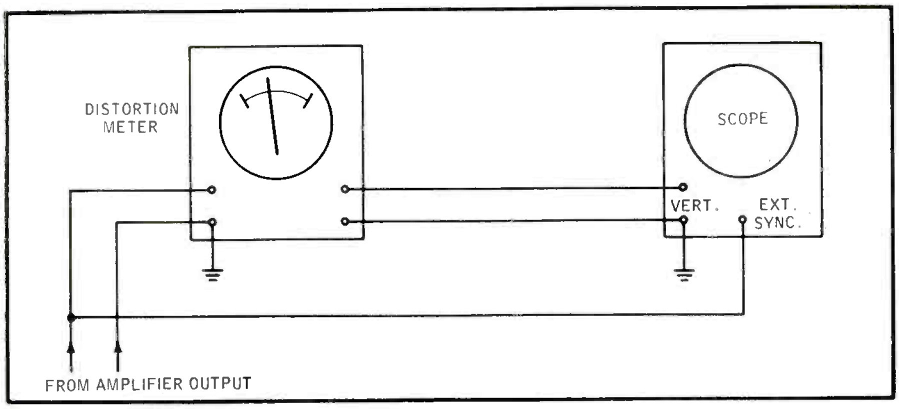


Fig. 3-3. Using a 'scope to interpret the meter readings on a harmonic distortion test set.

ting a true result. Let's explore some possibilities. Then you can take your pick.

Input Filtering

To purify the fundamental at the input, you have the choice of three types of filter (*Fig.* 3-1): fundamental-pass (single-tuned); harmonic-reject (individual rejection of various harmonics, one after the other, in cascaded filters); or an *m*-derived low-pass filter.

The fundamental-pass must reject second harmonic (and successive ones) by not less than 40 dB, preferably much more. This requires one or more tuned circuits have a Q of 100 or better, which means magnetic-cored inductors, or R-C filters employing active elements. With either comes the problem of ensuring that the frequency-selective elements do not generate more distortion than they're employed to reject!

An inductor with a Q of 100 must use a core of quite high permeability, and to avoid generating its own harmonic, it must hold that permeability with extremely tight tolerance as its magnetization changes over the audio waveform. A feedback circuit with R-C elements must have a gain well in excess of 40 dB and generate less than the allowable degree of distortion, which requires additional feedback of considerable magnitude and presents an almost impossible design assignment.

But assuming one or another method has been satisfactorily achieved, you have a tuned circuit with a Q of 100, in effect. This means it has a bandwidth, assuming a resonant frequency of 1000 Hz, of about 20 Hz (to the half-level points). So tuning is quite critical.

The harmonic-rejection filter, with individual circuits to reject each harmonic of the particular frequency used, is too involved in operation to consider seriously. This leaves the low-pass filter, which has been used. This, too, requires high-Q elements to get better than 40 dB rejection within less than an octave frequency interval. It also requires that these elements shall not themselves generate distortion. And it can only be used for a small range of frequencies, immediately below, and well within a octave of its cut-off frequency. It may not be so critical as the single-frequency version, but it is rather restricted in use.

Working Without Filtering.

If we dispense with filters at the input, we shall have to accept the harmonic content of the oscillator as part of our measurement. Assume this is 0.5 per cent. If you use an oscillator with 0.1 per cent, this makes it just five times better, before you encounter the same troubles. With an oscillator having 0.5 per cent distortion, this will most likely be dominantly second. Typical figures might be 0.48 per cent second and 0.14 per cent third, the rms combination of which happens to be 0.5 per cent.

Now assume the amplifier under test actually produces 1 per cent second and 0.5 per cent third. These will usually be either in-phase or out-of-phase with the components already present in the input, so the output will contain 0.52 or 1.48 per cent second and 0.36 or 0.64 per cent third. According to the way these combine, we have four possible readings, based on these calculations and assuming no error in the meter test set.

TABLE I

Second	Third	Combination
0.52%	0.36%	0.63%
0.52%	0.64%	0.825%
1.48%	0.36%	1.52%
1.48%	0.64%	1.61%
when the correct reading should be:		
1.00%	0.5%	1.12%

Note that none of the possible readings comes near the correct one.

Reversal of phase at the amplifier input can change the combination of second, but third will be unchanged and there is no way of resolving this ambiguity with either a harmonic distortion meter or a wave analyzer. The wave analyzer will separate components, so very accurate determination of second harmonic distortion in the amplifier is possible (*Fig.* 3-2).

For example, if test on the oscillator gives 0.2 per cent second and 0.15 per cent third, with higher harmonics negligible, reversing the amplifier input connections should change output second (as measured on a wave analyzer) by 0.4 per cent. If the readings so found are 0.3 and 0.8 per cent, the difference is 0.5 per cent, which is close to the predicted 0.4 per cent, and the

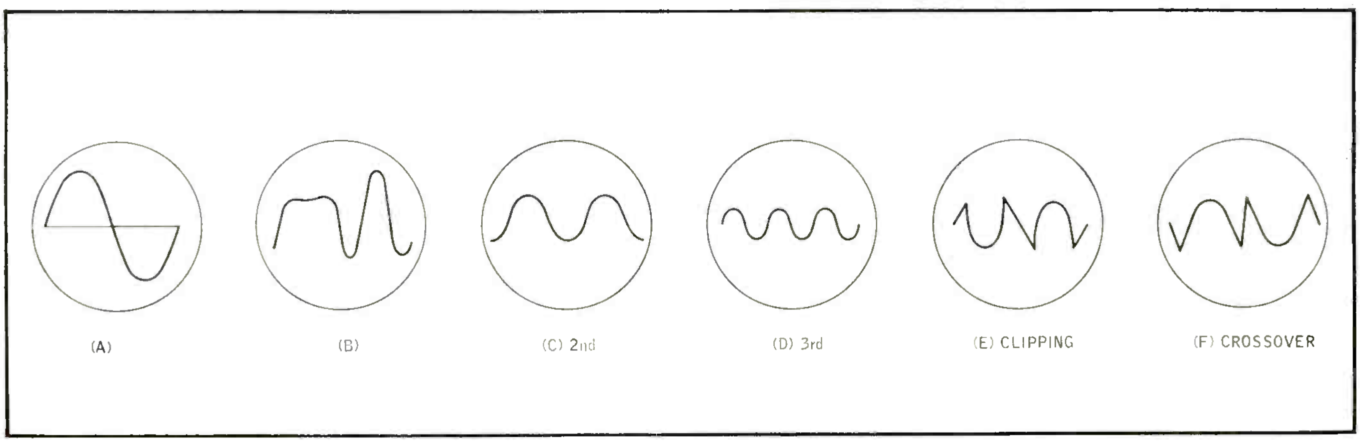
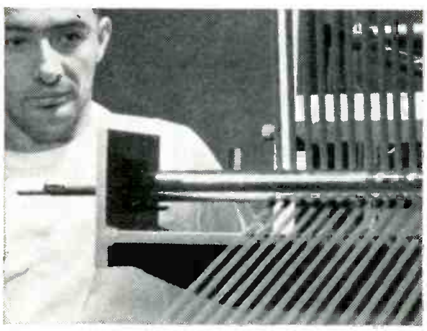


Fig. 3-4. Some of the traces obtained with the arrangement of Fig. 3-3.

Some plain talk from Kodak about tape:

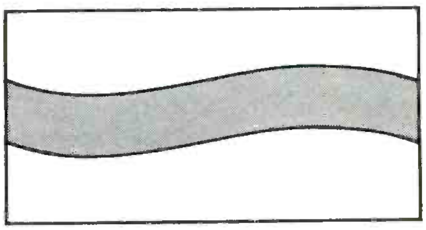
Sobering thoughts about slitting... and making the best basically better

A wise man once said, "Baloney's basic worth is unaffected by the manner in which you slice it." Maybe so for baloney...but certainly not for sound recording tape. Slicing, or to be technically correct, slitting quarter-inch ribbons of tape from the 42-inch-wide master web in manufacture takes a pretty sharp eye. This slitting operation is important to your pleas-



ure since the closer the tape comes to being dimensionally perfect, the better is the azimuth relationship between the recorded signal and the reproduce head. Like it in plainer English? Then consider some examples of poor slitting...and what they sound like.

"Drunken" slitting and others. Variations from the ideal occur if tape is too wide, too narrow, or if its width varies. If the tape is too wide, it may actually override the guides on your tape deck. If the tape is too narrow, it may see-saw as it passes by the head. Either way, you're in trouble. Variations also occur if the edges are not straight. One such variation goes by the name of "drunken" slitting. Sound bad? You bet. The edges snake even though the width is constant (see drawing). As a result, on playback the output varies as the tape weaves past the reproduce head...causes a warbling of the signal. This is a type of distortion the human ear is most sensitive to. You wouldn't like it.



Drunken slitting, a dramatization

Quality-control makes the difference. Standard industry specification calls for a tolerance on width of ± .002 inches. To start, we hold ours to ± .001 inches. And to make things more interesting we make our test over a twelve inch span to equal or exceed guide spacing on most tape recording equipment. Next, not relying on eyeball tests as others do, we test for drunken slitting or fluted edges by actually running the tape with a recorded short wavelength signal through a tape recorder. This "drunkometer" test helps us spot any tape that's had even one beer. The slightest whiff, and out it goes. Lastly, Kodak Sound Tapes have to go under the microscope where we watch for rough or dirty edges. When you buy Kodak Tapes, you know they're clean.

Best base better? Strength and toughness sound like they mean the same thing...but they don't quite when it comes to a tape base. Take a piece of spaghetti. It's stronger when it's dry...but tougher when it's wet—harder to break, that is, and not just because it's slippery. Designing a tape base, you're always up against the problem of making it strong so it doesn't stretch...and tough so it doesn't break. Today's DUROL base, the best there is, is now more resistant to shock abuse and carelessness. It's even tougher than before while it still retains the strength that made it famous.

Kodak tapes—on Durol and Polyester bases—are available at most electronic, camera, and department stores. To get the most out of your tape system, send for free, 24-page "Plain Talk" booklet which covers the major aspects of tape performance. Write: Department 8, Eastman Kodak Company, Rochester, N.Y. 14650.

EASTMAN KODAK COMPANY, Rochester, N.Y.

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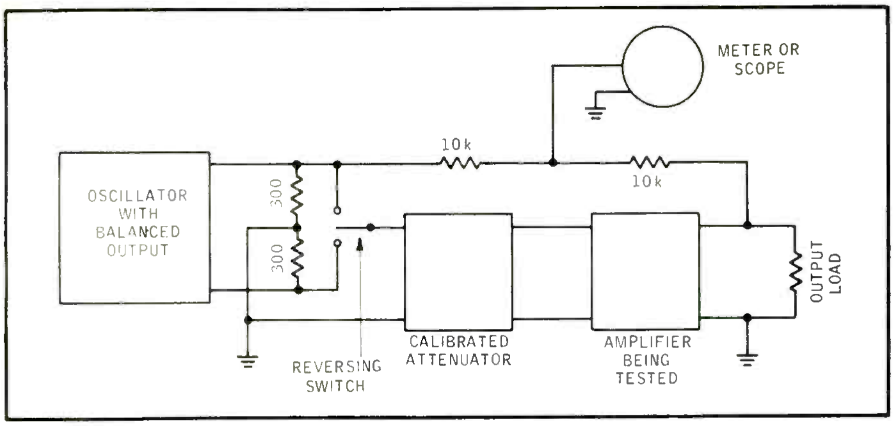


Fig. 3-5. The basic input/output bridge set-up for measuring harmonic distortion.

amplifier distortion can be figured at the mean value, or 0.55 per cent second.

But if the second-harmonic readings at the output are 0.15 and 0.35 per cent, there is obviously a cancellation in the first reading, because the *sum* of the readings (not their difference) is 0.4 per cent. So the mean value, taken algebraically, is 0.15 per cent—the distortion from the amplifier. With third and other symmetrical distortion components, this kind of deduction cannot be made, because reversing the fundamental also reverses the symmetrical distortion.

For third and other harmonics, careful interpretation with a 'scope connected to terminals provided on the distortion meter to look at the distortion residue may help, especially if the 'scope's external sync is connected directly to the output, so the trace remains locked to the fundamental waveform being analyzed (*Fig.* 3-3).

Figure 3-4 shows, at (*a*) the waveform (either input or output) without filtering; this is used for sync on all waveforms viewed; at (*b*) is one possible residue seen, representing the harmonic content referred to earlier—1 per cent second and 0.5 per cent third (or any values where the second is twice the magnitude of the third); from (*c*) on are a succession of output-residue displays with their interpretations.

Of course these displays do not help too much with precise evaluation of the readings, but they can help quite intelligent "guesswork," and they do enable a qualitative evaluation to be made.

If the amplifier distortion is smaller than the harmonic content of the oscillator, it is virtually impossible to guess at how much it has. By some fluke you may get a reading of about 0.001 per cent, when actually you have distortion almost identical with the harmonic content of the oscillator, but of opposite phase.

Input/Output Bridge

That is the reason that many amplifier manufacturers prefer a different form of instrumentation, although they have had to make their own meters, because all of the commercially available types use the traditional methods. With the latter, added to the error due to harmonic content in the input (from the oscillator) is possible error due to the nulling circuits themselves, as well as the operational difficulty in balancing them, particuarly at the lower and higher audio frequencies.

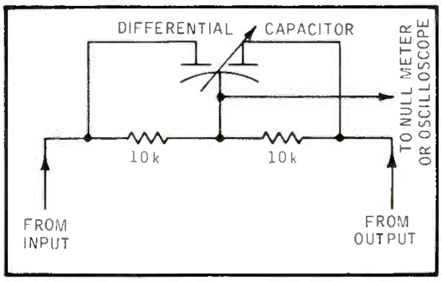


Fig. 3-6. Adding a differential capacitor to the bridge of *Fig.* 3-5 will correct for phase errors.

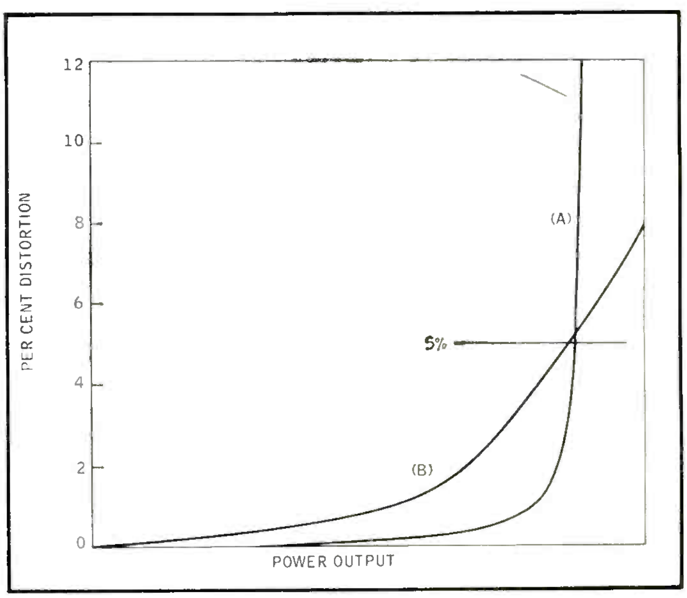
The method adopted in the new form is basically quite simple, and seems to have been thought of by several engineers independently. Because the trouble arises due to nulling out the *fundamental,* why not null the *input signal,* instead? This is simple to do, and merely involves making the amplifier under test part of a relatively simple bridge network (*Fig.* 3-5).

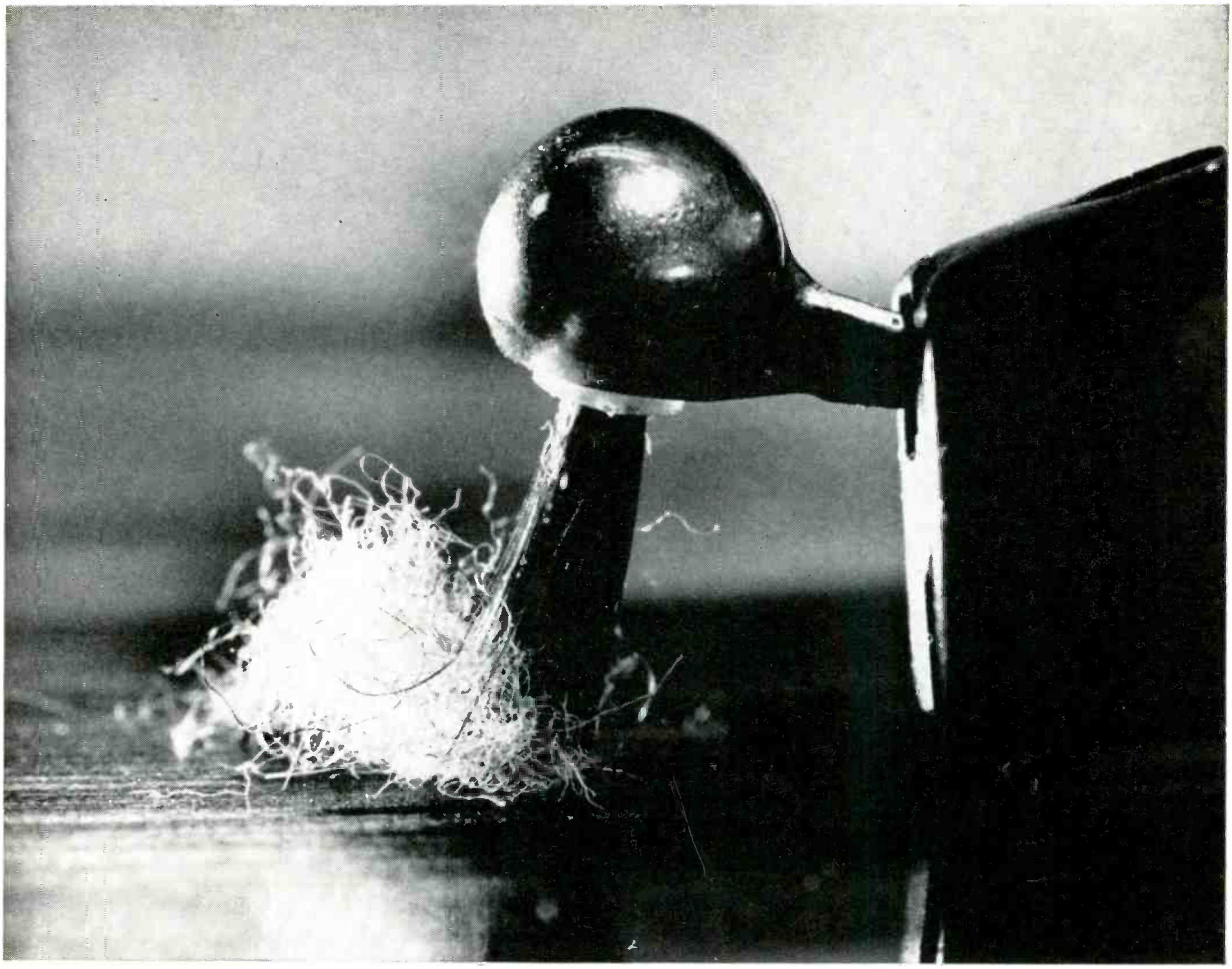
Over the majority of the mid-band frequency range and, with feedback amplifiers, even relatively close to ultimate cut-off, there is little phase shift in an amplifier from either in-phase or precise phase-reversal, from input to output. If we start with an input signal equal to the ultimate output, and of opposite phase, according to whether the amplifier includes phase reversal (in the over-all picture, not merely from stage to stage) or not, then a couple of equal resistors will produce a null, except for any slight phase shift. The reversing switch enables the correct phase to be chosen, according to the phase relation between input and output in the particular amplifier being tested.

All that is needed to achieve a null, assuming no phase-shift, is a continuously variable attenuator, so the attenuation can be made very exactly equal to the gain at the frequency being measured. What now remains is the possibility of small phase shifts, which inevitably exist at all but one frequency, but they will usually be not more than a degree or two. This can be compensated for, without invalidating the basic 1:1 relationship appreciably, by a differential capacitor (*Fig.* 3-6).

Now how much better off are we, assuming the same oscillator is used as we were discussing earlier? For an example, let's take a "worst" case: assume a phase correction of 11.3 deg. (arctan 0.2) for fundamental, in an amplifier using three-stage cut-off with identical turnovers (which couldn't use much feedback and remain stable): the error from balance at second harmonic (go-

Fig. 3-7. Two typical distortion/power level curves for different kinds of amplifiers.





You are looking at the world's only true longhair cartridge.

In this unretouched photograph, the long, black hair of the brush built into the new Stanton 581 is shown in action on a rather dusty record. Note that all the loose lint, fuzz and dust are kept out of the groove and away from the stylus. That's why the Longhair is the ideal stereo cartridge for your Gesualdo madrigals and Frescobaldi toccatas. Its protective action is completely automatic, every time you play the record, without extra gadgets or accessories.

The stem of the brush is ingeniously hinged on an off-center pivot, so that, regardless of the stylus force, the bristles never exert a pressure greater than 1 gram and always stay the right number of grooves ahead of the stylus point. The bristles provide just the right amount of resistance to skating, too.

But even without the brush, the Stanton 581 Longhair is today's most desirable stereo cartridge. Like its predecessors in the Stanton Calibration Standard series, it is built to the uniquely stringent tolerances of Stanton professional audio products. Its amazingly small size and light weight (only 5 grams!) make it possible to take full advantage of the new low-mass tone arms. And its frequency response is factory calibrated within 1 db from 20 to 10,000 cps and within 2 db from 10,000 to 20,000 cps. Available with 0.5-mil diamond (581AA) or elliptical diamond (581EL); price $49.50.

For free literature, write to Stanton Magnetics, Inc., Plainview, L.I., N.Y.

Stanton

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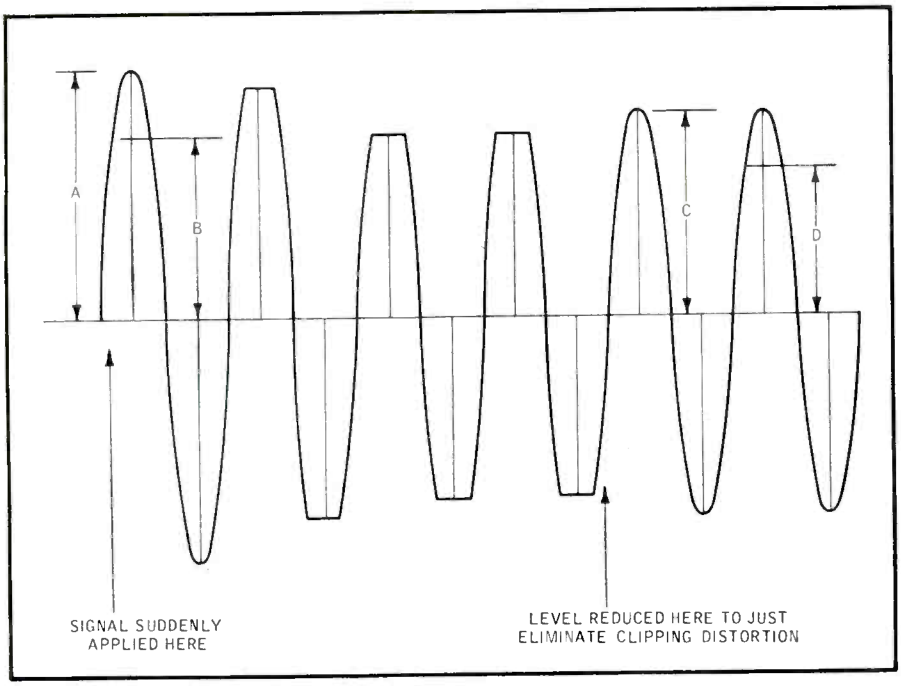


Fig. 3-8. Waveforms to illustrate the significance of different power measurements. At the left is represented a signal suddenly applied, of level that does not distort initially, but causes overload clipping when maintained. At the right, the level is reduced to allow overload to disappear.

ing further into the phase-shift region) is 0.3 dB, 0.9 deg., and at third harmonic is 0.7 dB, 2.9 deg. These figures represent vector transmissions of harmonic of less than 4 and 10 per cent respectively. Remember these are fractions of the input harmonic content, so the error they can introduce into the output would be less than 0.019 second and 0.014 per cent third.

That is a "worst" case, yet it is much better than the traditional method. In mid-range measurements, the error would be quite negligible. Actually, for intermodulation tests of either type, by using a more sophisticated type of bridge intended for use with more than one frequency, the error on harmonics could be reduced to vanishing point by matching the curvature and phase shift in the amplifier more accurately over the range involved by the fundamental and its harmonics.

Possibly the more important advantage of the simpler bridge method is its ease of use at different frequencies, compared with either of the traditional methods. Once the bridge has been balanced for one frequency, a change of frequency does not immediately unbalance it, as happens with the harmonic distortion meter or the wave analyzer, even with only a few Hz.

Although precise balance, when measuring to extremely low-distortion figures, takes careful handling, one of the highly critical elements—frequency—ceases to be critical with this method, making it surprisingly easier to perform. When you're using one of the frequency sensitive types (either distortion meter or wave analyzer), a line-voltage fluctuation may shift the oscillator frequency by half a Hz. This is enough to cause several degrees phase shift in the fundamental, which causes just as much unbalance as a relative amplitude change, and the null is completely lost. With the input/output bridge, this critical feature vanishes.

Power

Power measurements involve interrelation with distortion and frequency. At what distortion level should maximum power be measured? There are standards on this, established by various technical bodies, and these are usually spelled out in terms of harmonic content, such as 5 per cent or 1 per cent. How valid are these standards as a basis for such measurement? This depends on another question about distortion measurements, as to how valid they are as an indication of distortion.

Something can be determined from the distortion/level characteristic of an amplifier (*Fig.* 3-7). If this shows sudden increase of distortion, as curve (A), the probability is that the distortion is in the form of clipping, in which case the distortion residue consists of quite sharp peaks, that are heard as clicks on the wave, rather than as an audio spectrum like the more usual overtone structure. On this basis, the actual amplitude of a clip may be reduced by the harmonic meter by more than 10:1 by the averaging process, over the duration of the wave.

So with this kind of distortion, a reading of 1 per cent means there is a distortion having an audible effect of more than 10 per cent. A reading of less than 0.5 per cent is needed to bring the audible distortion component down to 5 per cent and even then it is more audible than second harmonic, with which this level was once established as a minimum audibility point. Sharp, sudden clipping can be quite audible, using some test frequencies, at a distortion reading of 0.1 per cent.

On the other hand, another amplifier gradually runs into overload, as curve (B), increasing the curvature and its corresponding distortion reading quite gradually as power is increased. In such

(*Continued on page 87*)

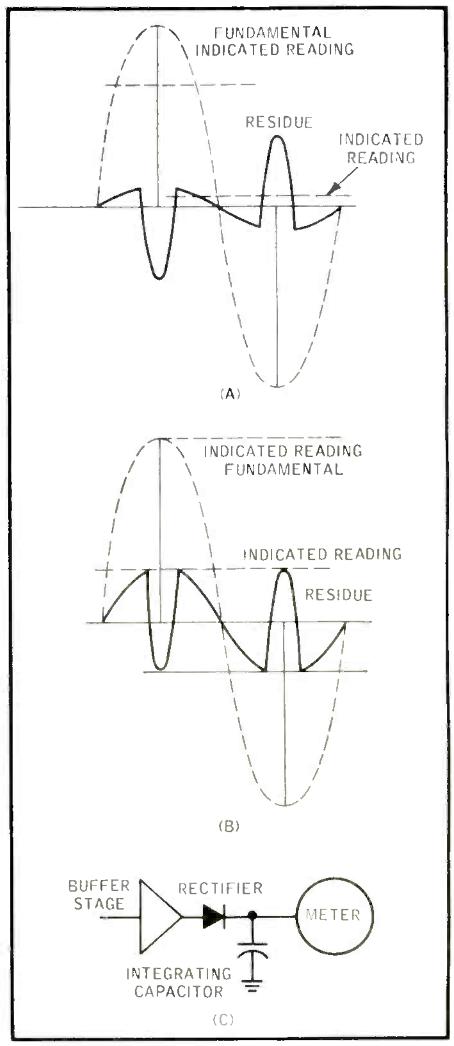
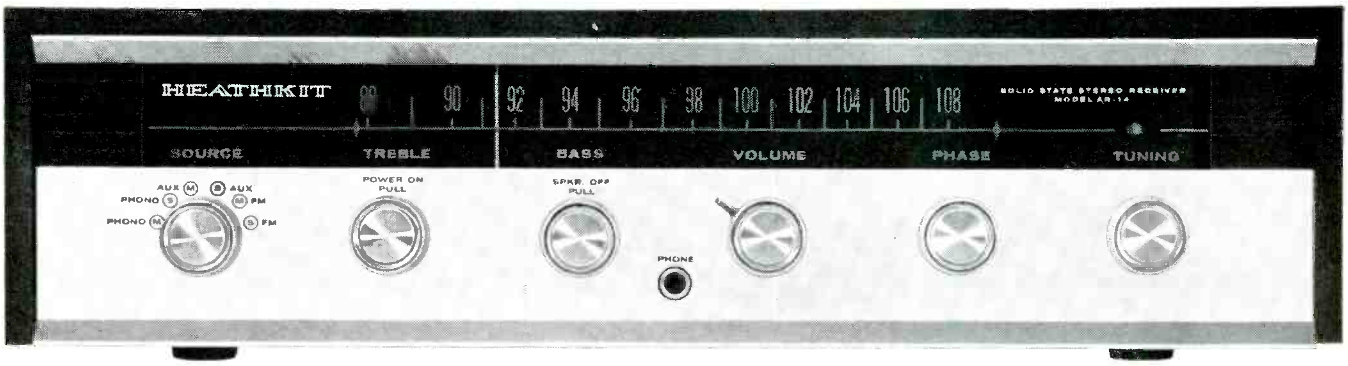


Fig. 3-9. Advantage of peak readings in distortion measurement: (A) fundamental and clipping, as displayed when balanced by an average-reading meter, with reading indicated (horizontal dashed line); (B) the same, as displayed when balanced by a peak-reading meter, with relevant readings; (C) basic change needed to provide peak readings on a meter equipped as an average-reading meter.

Over-Engineered & Under-Priced!



This Remarkable New HEATHKIT® FM Stereo Receiver Has 5 uv Sensitivity, 30 Watts Music Power, All-Transistor Circuitry, and Costs Just $99.95*

Only Your Pocketbook Can Tell The Difference . . . between the superb solid-state performance of this new Heathkit AR-14 Receiver and its low price. Here for the first time is a truly fine stereo receiver for under $100. With *no* component skimping. And *no* circuit short-cuts.

How Can We Do It? First, famous Heath know-how that's been responsible for the best value in hi-fi components since 1949.

Second, you buy direct from the factory (delivered right to your door) . . . *no* middleman profits to add to the price.

Third, you build it yourself in around 20 hours. Thus, labor costs are eliminated. And building it is half the fun. Takes no special skills or knowledge. Simple Heathkit step-by-step instructions and large pictorials show you what to do, and how to do it . . . even how to solder! The tuner "front-end" is already preassembled & aligned. You just assemble two circuit boards, mount some parts on the chassis, and wire the controls. So easy anyone can do it. And what better way to see what it's made of?

Advanced Solid-State Circuitry. The AR-14 uses 31 transistors and 11 diodes for that clean "transistor sound", cool operation and long life . . . *no* tube deterioration.

Its new transformerless output circuit is known as complementary design. Each channel uses two output transistors—a PNP type, and an NPN type—complementary. This has proven superior, exhibiting lower phase shift, wider response, and lower distortion. All power transistors are adequately heat-sinked for long life.

The FM multiplex tuner circuit uses a 3-transistor "front-end" and a 4-stage IF section.

15-50,000 cps Response . . . Sensitive Tuning. Two preamplifiers and two power amps provide a frequency-power response of ± 1 db from 15 to 50,000 cps . . . and at *full power* in both channels, thanks to a generous power supply design. And there's plenty of power to drive all but the most inefficient speaker system . . . 30 watts IHF music power or 20 watts RMS at 4 and 8 ohms output, slightly less at 16 ohms. Its sensitive FM tuner eagerly seeks stations, far and near . . . and you'll like the easy way the flywheel dial glides across the band. For beat-free tape recording, the tuner outputs are filtered.

Front-Panel Controls For Full Command! Include a 6-position source switch to handle the tuner, plus your tapes and records, stereo or mono; dual-concentric volume control to individually adjust each channel; a tandem treble control with push-pull AC power switch; tandem bass control with push-pull speaker on-off switch for use when listening with stereo headphones from the convenient front panel jack; stereo phase control for 45 db or better separation; and automatic stereo indicator light.

Bookshelf Size, 3-Way Installation. Measures just 3⅞" H x 15¼" W x 12" D . . . a boon for limited spaces. Its handsome anodized extruded aluminum front panel fits neatly in a wall, your custom cabinet, or in either optional Heath walnut veneer or beige steel cabinets. Marry it with two speakers and enjoy. Use the coupon to order yours now.

Kit AR-14, 15 lbs., less cabinet. . . . **$99.95**
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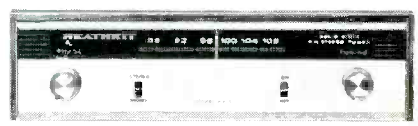

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Sound & Sight

HAROLD D. WEILER

SINCE THE VIDEO CAMERA is the "eye" of the video recorder and the "heart" of the camera is the vidicon tube, some knowledge of its operation is essential if the full potential of any video recorder is to be realized.

The reflected light rays from the object or image to be recorded are picked up by the lens system of the video camera, pass through it, and are focused and projected onto the vidicon tube. This tube consists of three basic sections as illustrated in *Fig.* 1: an electron gun (A) which emits electrons in the form of an extremely fine beam; a scanning section (B), consisting of a cylinder (C) closed at the far end by a fine metal mesh screen (D) in which the movement of the electron beam from the gun is controlled, and a target section (E) on which the optical image of the scene or object to be recorded is focused. The target section illustrated in *Fig.* 2 consists of a photo-conductive layer (J) deposited on a transparent conducting film (K) on the inner surface of the tube's glass face-plate (F).

The beam produced by the electron gun (A) passes through the minute aperture (0.002 in. in diameter) at its faceplate end and enters the cylinder (C) and is focused onto the target (G) by the combined action of a magnetic field, created by the external focusing coil (H), and the electrostatic field within the cylinder. The movement of the electron beam is magnetically controlled by two sets of deflecting coils (I) placed within the focusing field.

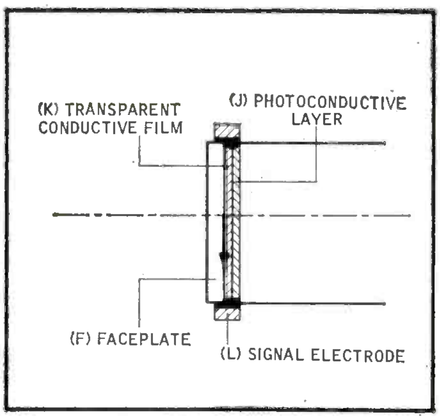

Fig. 2. Section of the Vidicon showing the relation between the face plate, transparent conductive film, the photoconductive layer, and the signal electrode—all in the target section of Fig. 1.

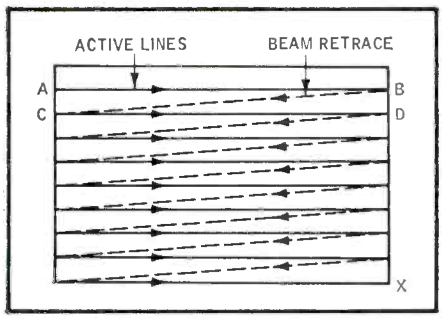

Fig. 3. The basic plan of scanning, in this case without interlacing.

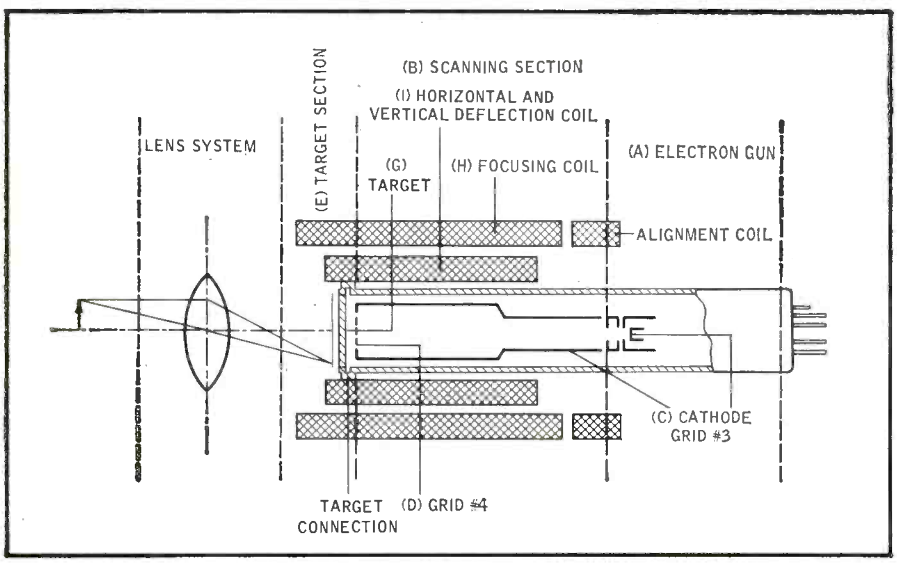

Fig. 1. Cross-sectional diagram of a Vidicon tube such as is commonly used in TV cameras used with video recorders.

One set controls the horizontal movement of the beam while the second set is simultaneously controlling the vertical movement, so that it completely scans the target in a sequential pattern of movement from left to right and from top to bottom similar to the movement of the eye scanning the words on this page. Should the movement of the electron beam be stopped at any point during the scanning process, it would appear on the inner surface of the photo-conductive layer as a single dot. However, due to its rapid motion and our persistence of vision, this dot appears as a continuous line rather than a series of individual dots. The mesh screen (D) at the faceplate end of the cylinder provides a uniform decelerating field.

The target is scanned in the following manner: the electron beam is focused onto the upper-left corner of the photoconductive layer, point *A* in *Fig.* 3. Through the influence of the horizontal deflecting coils, the electron beam is moved to the right, as indicated by the solid line, until it reaches point *B* where it is automatically cut off or "blanked out" during the period it rapidly retraces its movement, along the path indicated by the dashed line, to point *C* which is the beginning of the following line.

Just as the eye delivers no information to the brain on retracing its path across a page after reading a single line, the electron beam carries no information during this "blanked out" period. This blanking effect is removed when the electron beam arrives at point *C* and again begins to move to the right to scan the second line which ends at point *D* where it is again blanked out. This sequence continues until the end of the bottom line, point X, has been reached, when the beam is again blanked out, this time for a longer period, until it returns to the starting point A.

In actual practice, however, the action of the electron beam differs slightly from our simplified examples. This is the direct result of combined action taken in 1941 by the Federal Communications Committee and the National Television System Committee which resulted in the establishment of standards for the Television Industry. This incidentally, was the first time that an important public service had acquired a set of standards before the service had become generally available. This action averted the chaotic conditions which were prevalent in early railroading, and the power, light, and radio industries due to the lack of such standards.

Details of these standards and how and why they were decided upon are well

(*Continued on page* 79)

Leadership PERFORMANCE

ELECTRONIC ADVANCES

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- Extremely low noise Control Center
- Plug-in etched circuit modules

TRANSPORT ACHIEVEMENTS

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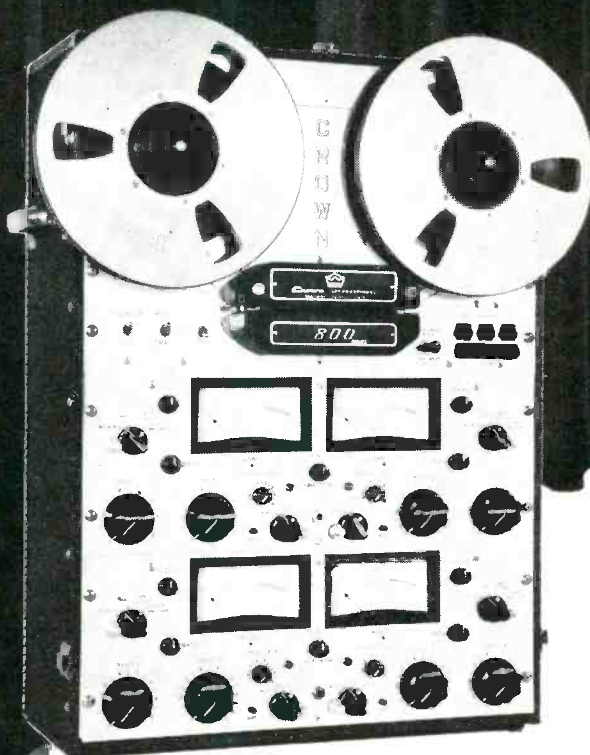

SS844 Four Channel from $3060.

ips	db	cps	s/n	w & f
7-1/2	±2	50—25,000	54db	0.09%
3-3/4	±3	50—15,000	50db	0.18%
1-7/8	±3	100—9,000	42db	0.30%

SS822 Two Channel from $1770.

ips	db	cps	s/n	w & f
15	±2	50—20,000	57db	0.06
7-1/2	±2	30—20,000	55db	0.09
3-3/4	±2	30—10,000	51db	0.18

Write to **Crown** INTERNATIONAL
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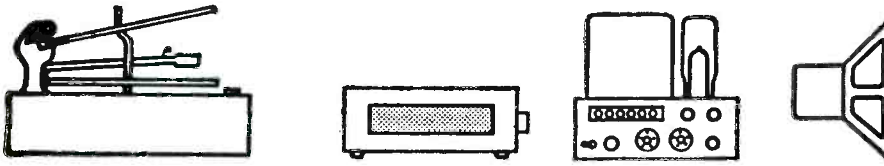
Circle 142 on Reader Service Card

EQUIPMENT



PROFILE

ADC Six Hundred Stereo Receiver

Here is a company that has a line of fine cartridges, backed up by a line of splendid speakers and now—a receiver?

Certainly, there has been no hint of electronics skills at ADC. The engineering of transducers is completely different, requiring different talents and skills from those needed to design tuners and amplifiers. Yet, here is the Six Hundred. (ADC spells out the number.)

This is a product that could only be made with transistors. ADC has assembled stereo 20-odd watt amplifiers, preamplifiers, and an FM-stereo tuner in a cabinet 14¼" wide by 5" high and with a depth of 8½" including knobs. Weight is all of 16 lbs.

Let us not beat about that proverbial bush. ADC has themselves a fine start here. This is a first class product with performance far in excess of that which we would have expected from a receiver that is to sell for $248.00.

We were not able to receive a schematic or circuit description in time for this report. ADC is apparently not supplying schematics with this set, a deplorable practice of all too many manufacturers today.

But we are certainly able to tell what our instruments and ears reveal about this component. And what they tell is impressive indeed.

This is not a high-power amplifier. Maximum power into an 8-ohm load is 22 watts per channel at mid-band frequencies. Power bandwidth ± 2 dB is 20–15,000 Hz. 4- and 16-ohm loads are reduced in output, usual in many solid-state amplifiers. At 4 ohms, 1000-Hz maximum is 18 watts per channel. 16-ohm loads reduce output at that frequency to 13 watts per channel. Of course, power bandwidth is also appropriately reduced.

Amplifier frequency response is *very* wide-band. +0, –2 dB from 5 Hz to 60,000 Hz. Square-wave observations confirm this, what with a 50-Hz wave showing a mere 10-degree tilt.

The preamplifier offers RIAA equalization that is within a single dB of accuracy down to 100 Hz. Below that figure the maximum deviation is –3 dB at 50 Hz. Sensitivity is 2.85 mV in (at 1000 Hz) for full output. The phono-overload point is at 67 mV, high enough for the current crop of magnetic-type cartridges.

IM distortion is usually the downfall of transistor-amplifier outputs. Not so here. There was no characteristic camelback curve, either.

Figures obtained are as follows:

1 watt	0.14%
5 watts	0.44%
10 watts	0.63%
15 watts	0.86%
20 watts	1.12%

These figures represent the better of the two channels at 8 ohms. The poorer channel was only slightly so, however. It was, as an example, 0.35 per cent at 1 watt, reaching a maximum of 1.8 per cent at 20 watts.

Signal/noise ratios were 77 dB in high level inputs and 56 dB in phono. Noise will be no problem here.

The tuner is in keeping with these qualities. Sensitivity is high enough to pull in stereo stations on an indoor antenna in our suburban location. Stereo separation is in excess of 30 dB up to 5000 Hz dropping to 22 dB at the higher frequencies.

Those are the splendid specifications that we are able to derive from this sample. It need hardly be mentioned that sound is as pure as you would expect it to be.

One small feature did annoy us, however. This receiver has, as is common industry practice, loudness compensation. That is, it has a bass-boost circuit tied to the operation of the volume control. It is at maximum effect with the control at about 9 or 10 o'clock. Beyond 12 o'clock, the compensation disappears and the control functions purely as a volume (gain) control. This is fine; we have no quarrel with these circuits as such. What we don't like is, as is the case here, the fact that the circuit is always "in." You must have bass boost for low-level listening whether you want it or not. However, in defense of this circuit we did find that the compensation is minimal (compared to usual industry practice). Only about 6-dB boost at 50 Hz is present.

Controls are as simple as possible. There are bass and treble tone controls offering the usual boost and cut. Both channels are controlled at the same time, which is all right by us. There is no separate function switch. Rather, you select, via slide switches the function you wish. Magnetic-phono and hi-level inputs are provided in addition to the internal tuner position.

There are two *pairs* of speaker outputs. Front panel switches select either pair or both (or neither for earphone listening, for which there is a front-panel jack). Power on/off is also a separate slide switch.

Tuning is flywheel-balanced and smooth, with little backlash. Stereo indication is by a light when in the FM mode and circuit switching is automatic. A center-tuning meter is provided.

The ADC Six Hundred makes a most handsome package in its optional walnut enclosure. Add to this the fine performance capabilities and we are inclined to guess safely that ADC will sell a lot of them. Certainly, this is an auspicious entry into electronics for them.

Circle 201

Fig. 1. ADC Six Hundred solid-state receiver.

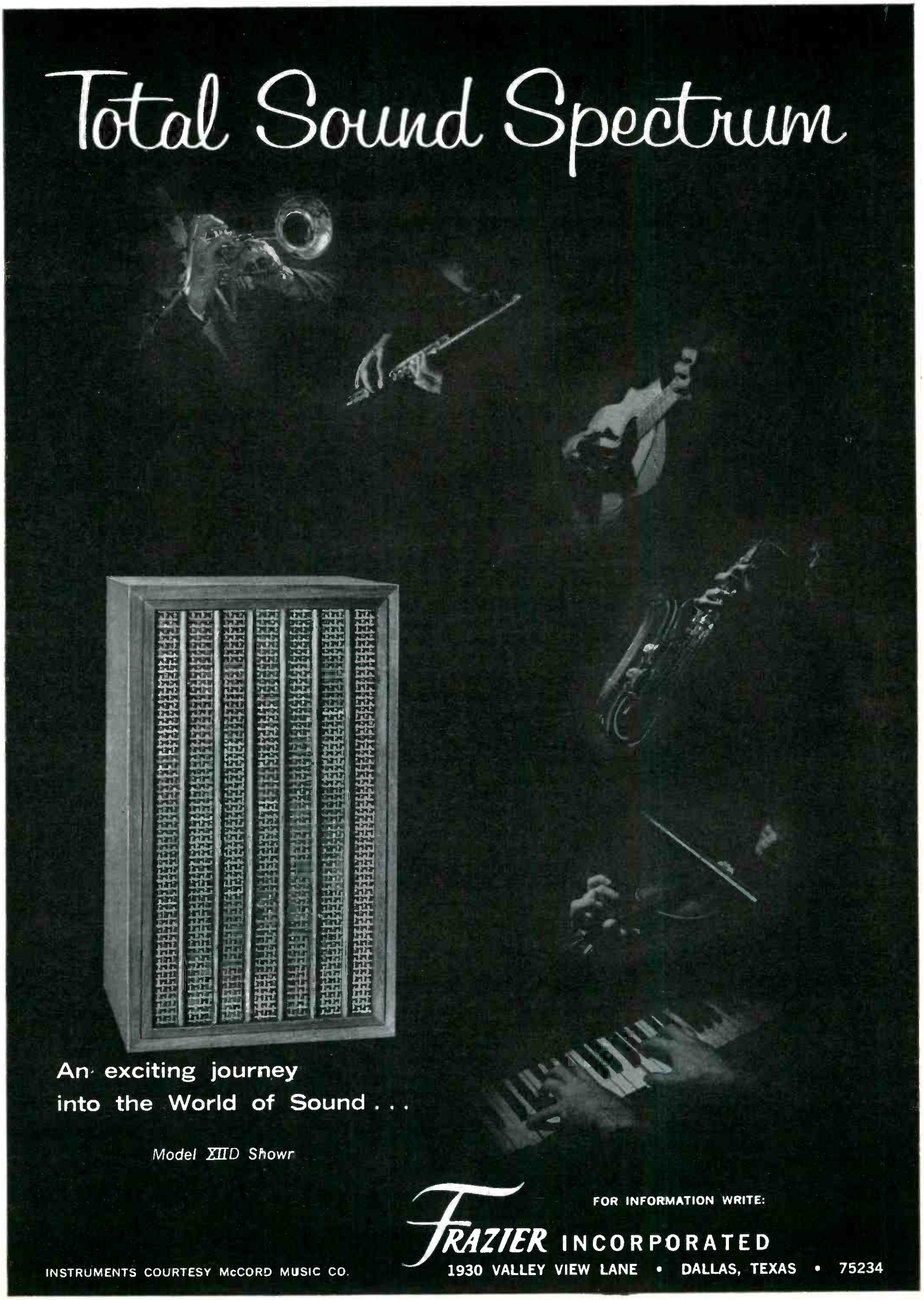
Grado Model "B" Phono Cartridge

The history of Grado Laboratories has been wrapped around cartridges of moving-coil design. They have developed this method of transduction to the high levels discussed in the report on the still current Grado Model "A" (July, 1965). So it was with considerable interest that we awaited the issuance of this "B" since this has been announced as a "solid-state strain generator" system. Well, it is indeed that. "Strain generator" is but a new term for that old standby, the piezo-electric generator, otherwise sometimes known as a crystal or ceramic cartridge.

We feel that a new name is indeed called for, if only to indicate that this is a cartridge that must be judged on absolute standards of performance and not on the means used to achieve those ends. That is only just and fair.

The Grado "B" lists at $19.95 with a conical 0.7-mil stylus that is user replaceable. An elliptical version, presumably offering superior tracking ability, is offered at $32.50. It is the lower-priced conical version that is the subject of this test.

We believe that we are divorced from that prejudice against piezo types *per se*.



Circle 143 on Reader Service Card

It is thus with this understanding that we listened to and measured this cartridge. This is further heightened by the fact that the cartridge is designed to feed a standard preamplifier with RIAA equalization. Output is, in fact, 4.8 mV left and 4.95 mV right from a 1-kHz signal at 3.54 cm/sec recorded velocity (stereo).

The Model "B" was installed in a quality manual system and listened to on a wide variety of program materials. Let us state immediately that there is nothing in the sound to make us suspect that this is not a magnetic. The cartridge will track all but the most heavily modulated grooves at a stylus force of 1.5 grams. In direct A-B comparisons against the high-priced Grado "A," a sound we like very much, the "B" proved to be very close indeed in sound quality and character. That character is neutral, neither what would be called *bright* or soft. The "B" is brighter than the "A," there *is* just the touch of brittleness on highly-modulated high-frequency-rich recordings with the "B," but these are small differences indeed, heard only when one cartridge is played against the other.

The "B" is, in fact, a splendid-sounding cartridge, with a rich full bass, exceptional transparency and smooth, wide range. Though this is a "strain generator" there is absolutely no trace of "strain" to sound. Judged on the basis of sound (the only real test, after all) the "B" must be considered top-grade.

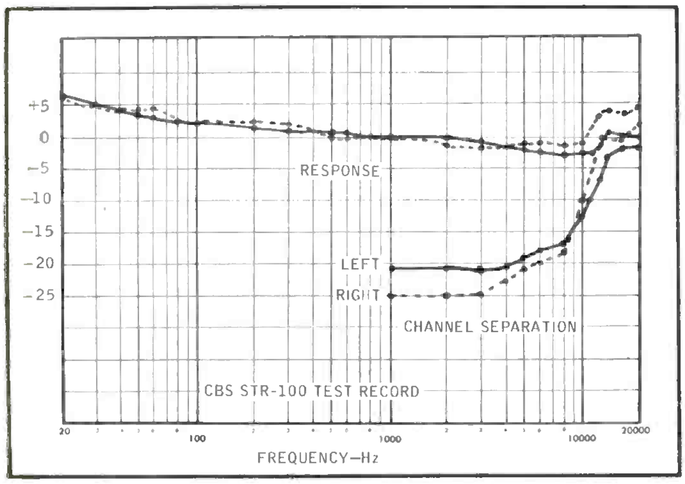


Fig. 3. Curves showing performance of the Grado "B" cartridge.

Tests Results

The number of meaningful tests that can be performed to evaluate a cartridge's true qualities is very small. For one thing, it has been our experience that a good lab score does not necessarily equate itself with what our ears consider good sound. This is the big problem in evaluating transducers, both speakers and cartridges.

Still, certain figures do relate to performance. Take for example IM measurements with the CBS STR-111 test disc. Lateral IM at the +6-dB level is 1.5 per cent, lower by far than many high-cost magnetics. This, we believe, is responsible for the over-all clarity and lack of effort produced by this cartridge. Now note this: at the +9-dB test groove, IM rose to 7.3 per cent. This is *higher* than most. (The Grado "A" sample we have is 2.6 per cent, one of the lowest IM cartridges we have measured.) This second measurement is indicative of peak-play conditions and is responsible, we believe, for the slight edginess we hear when this cartridge is used on over-modulated discs.

Dynamic compliance measurements have proven, for us at least, to have little relationship to any sonic character. The "B" measured 2 x 10^{-6} cm/dyne, again lower than the "A," or most others, but still enough to track perfectly at low forces.

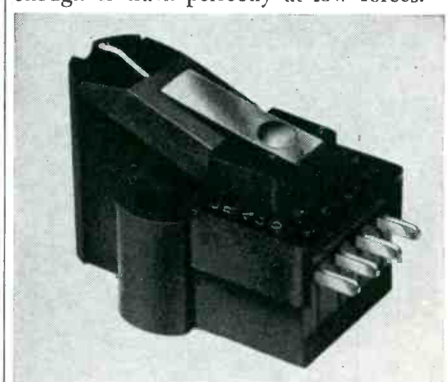


Fig. 2 The Grado "B" phono cartridge.

The curves in *Fig.* 3 shows frequency response and channel separation. The over-all smoothness and high resonance point is what we have come to expect of the best cartridges.

Make no mistake about it. This Grado "B" is one of those "best" cartridges. It is suggested for use with any system that seeks quality. Add to that its non-magnetic characteristics and you have a cartridge that is induced-hum immune, making its use mandatory for some installations. Add to all this that $19.95 list price and we find ourselves reporting this cartridge as an outstanding value indeed.

Circle 202

(*Continued on page 84*)

SOUND & SIGHT

(*from page 74*)

chronicled in "Television Standards and Practice" published by McGraw-Hill.

In actual practice the electron beam is moved downward gradually as illustrated in *Fig.* 4 and brought back almost straight across to begin the following line. In this manner the electron beam scans 525 individual lines, the United States Television Standard, which cover the entire photoconductive layer of the target in each 1/30 of a second.

However, when the beam scans the entire 525 lines in a single continuous sequence such as we have described, we encounter the same problem which proved so annoying to the early motion picture experimenters—flicker. In order to eliminate this flicker completely they broke up the presentation of each individual frame into two equal parts, thus actually showing each frame twice.

A similar result is obtained in television by employing a technique known as interlaced scanning, as illustrated in *Fig.* 5. Instead of scaning all 525 lines in sequence, from top to bottom, as in our previous examples, the electron beam is made to scan every other line. First, the odd numbered lines, 1, 3, 5, 7, and so on, are scanned, starting at point *A* and ending at point *B* as illustrated in *Fig.* 5 by the solid line. The blanked-out retrace path is indicated by the dashed line. This sequence continues until the end of the bottom line, point *B* is reached. This complete trace pattern forms one field of 262.5 lines and is completely scanned in 1/60 of a second.

The again-blanked-out electron beam is returned to the top of the photo-conductive layer, from point *B* to point *C* where the "blanking" effect is removed and it begins to scan the second field consisting of the even numbered lines, 2, 4, 6, 8, and so on, in the same manner as the first; this time ending at point *D* and completing the second field which is also scanned in 1/60 of a second. The beam then returns to point *A* once more where it is ready to begin scanning the following frame. The second field trace pattern is indicated by the dotted lines and its retrace path is shown by the combination dot-dash lines.

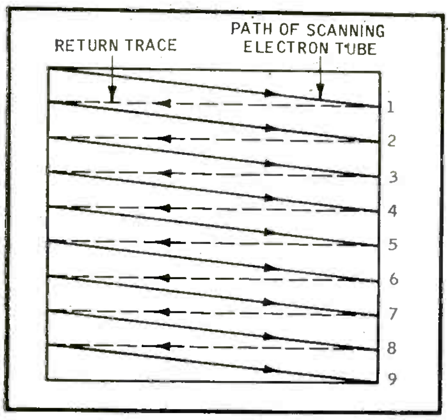
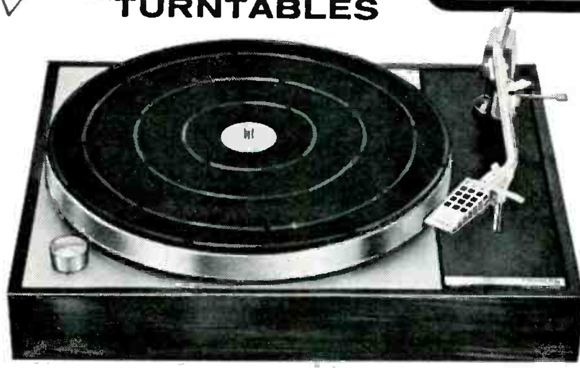
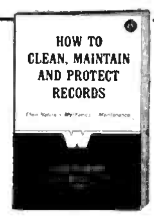


Fig. 4. Showing the practical scanning of the first field in an interlacing-scan pattern.





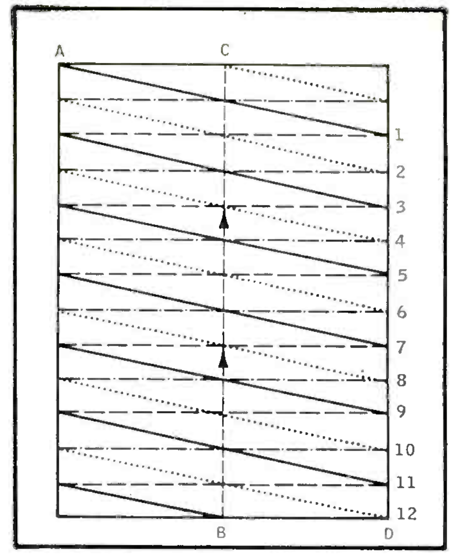


Fig. 5. The over-all scanning pattern showing the two fields in the interlacing-scan pattern.

As indicated earlier, two of these fields are required to provide one complete picture which is the counterpart of a single motion picture frame.

If the eye is to be presented with a complete picture, it is essential that the final picture element of the second field at point *D* be presented to the eye before the impression of the initial elements of the first field at point *A* fades away, within 1/30 of a second.

In order to create the illusion of motion, video recording—like motion pictures—must provide a series of still pictures one after the other in rapid succession.

In consequence, the entire scanning process must be repeated 30 times each second, and a new picture differing slightly from the previous one must be scanned in exactly the same fashion. At the end of one second, 30 complete pictures will have been scanned. Any motion occuring in the scene during that period is thereby divided into 30 individual still pictures which, when viewed in rapid succession, provide the illusion of continuous motion as in motion pictures.

The target section (E) of the vidicon tube illustrated in *Fig.* 2 is formed by evaporating a photo-conductive material, such as amorphous selenium, onto the inner surface of the glass faceplate which has been coated previously with a transparent conductive film.

This photo-conductive layer is an insulator in the dark but becomes conductive when it is exposed to light. When an optical image of the scene or object being recorded is focused on the front of the photo-conductive layer, the conductivity of each of the individual elements which is illuminated increases. The greater the intensity of the light on each element, the more conductive it becomes. This increases the potential on the opposite side of that element in direct proportion to the amount of light falling on it.

In consequence, the rear surface of the entire photo-conductive layer displays a varied electrical potential pattern which corresponds to the optical image patterned on its front surface.

When the rear surface of the target is

scanned by the electron beam, the beam deposits electrons until the surface potential is reduced to that of the cathode.

The electrons deposited on the scanned surface of each individual element of the layer cause a change in the difference of potential between the two surfaces of that element. When these two surfaces of the element are connected through the external target connection (signal electrode), (L) in *Fig.* 2, and the scanning beam, a current is produced which is then used to develop the video signal voltage.

When this varying video signal voltage plus other pulses required to reconstruct the picture are fed into a monitor or transmitted, the entire scanning process is essentially duplicated to provide the image. When the signal is to be recorded, the signal voltage and other pulses, which will be discussed next month, are converted into varying magnetic impulses and impressed on the tape. Æ

RECORD REVUE

(*from page 62*)

dreadfully windy piece in a youthfully pleasant way. You can positively *hear* the Bershire Quartet puffing and blowing, trying hard to make it sound convincing! They are quite right, and the listening experience is rewarding—especially when you turn to the latter, better Dvorak and hear how easily it flowers forth via these good players. Nice study of a composer's self-advancement.

Brahms: String Sextet in B flat, Op. 18; Allegro from F. A. E. Sonata. Y. and H. Menuhin, Masters, Aronowitz, Wallfisch, Gendron, Simpson.
Angel 36234 stereo

Wonderful early Brahms here—but I don't think much of the performance, in a high-level sort of way.

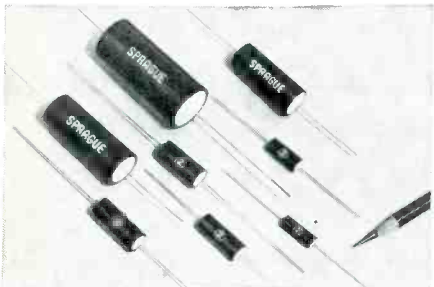
Yehudi Menuhin, out of the U. S. A., has curiously become more British than the British. Too ofen, his projects, like this, have a certain well-intentioned British heaviness that is very opposite of the often hard, too-fast, too-intense New York style of playing. It's all very high-level here, as I say, with fine players. But the music just doesn't incandesce. It sags. (Maybe I'm getting to be too much of New Yorker, myself!)

The "F.A.E." Sonata ("Frei aber einsam"— Free but Alone) was a joint work by Dietrich, Brahms and Schumann, presented in 1853 to the violinist Joachim, who used the F. A. E. phrase as his own motto. Yehudi's sister Hepsibah plays the piano part here. Good to have this early Brahms around; it isn't often played.

Æ

NEW PRODUCTS

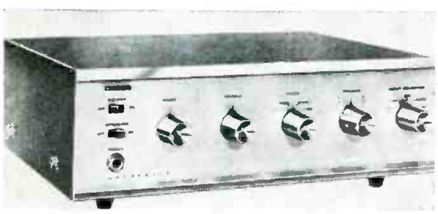
● **Crossover Network Capacitors.** Hobbyists and do-it-yourselfers will want to know that Sprague Electric Company has just announced a line of non-polarized capacitors of both plastic-case and metal-case design. Their small size and working-voltage ratings up to 50 volts d.c. make their use in speaker crossovers ideal. Typical 30 WVDC



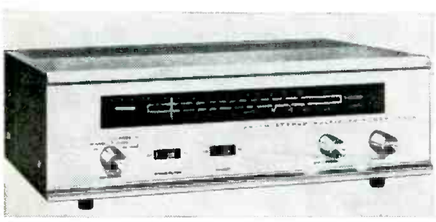
values run from 1 μF to 70 μF. In units with 12 WVDC, ratings of as high as 165 μF may be had. Rated life under working conditions is estimated at five years. Information may be had by writing to Sprague Electric Company Executive Offices, Technical Literature Service, 241 Marshall Street, North Adams, Massachusetts. Requests should be on company letterheads.

Circle 210

● **Separate Amplifier and Tuner.** Lafayette Radio has just released two new components: an all-transistor amplifier and a stereo- FM/AM tuner of matching design and low cost. The amplifier is the LA-340A, featuring 20 watts IHF power per channel. Five pairs of stereo inputs accommodate a tuner, phono with magnetic or ceramic cartridge, tape recorder,



and auxiliary sources. Other features include: a front-panel earphone jack, speaker-defeat switch, dual-concentric volume control, and a separate a.c. on/off switch. Frequency response is ±1 db from 30-20,000 Hz, THD is 1 per cent, hum and noise is –56 dB in phono. NAB and RIAA low-level equalization is provided. The LT-325A tuner has a "stereo search" circuit that produces an audible signal when a stereo broadcast is tuned in. Tuner sensitivity is 2 microvolts for



20 dB of quieting. Frequency response is stated as 15-15,000 Hz ±1 dB and channel separation is 38 dB at 400 Hz. A variable AFC control and a multiple noise filter are featured. AM reception is aided by a built-in ferrite loopstick; FM has a 300-ohm input. Prices are $79.95 for the LA-340A amplifier and $89.95 for the LT-325A tuner.

Circle 211

● **Step-Type Audio Generator.** The new EICO 378 is a sine-wave audio generator of wide range and low distortion. Frequency is selected by means of three step switches. The first is a multiplier, the second is in steps of ten, and the third in single unit steps. All told, one Hz to 110 kHz may be selected. Frequency accuracy at any step is stated as ±5 per cent. A 4½-inch output meter calibrated in volts and dB is provided.

Output level is controlled by means of a range switch and is selectable between –70 and +22 dB (0 to 10 volts). A fine control allows exact settings. Below 1 volt output, a switch-selected internal 600-ohm load can be added if desired. Distortion of the sine-wave signal is less than 0.1 per cent from 20-20,000 Hz. The 378 is available factory wired or as a kit. Price for the wired unit is $69.95; the kit is $49.95.

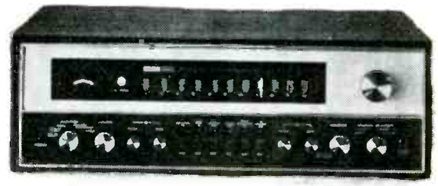
Circle 212

● **Improved Preamplifier.** Dynaco has announced the first major modification to their PAS-3 preamplifier kit. Now known as the PAS-3X, the unit utilizes a unique tone control configuration (on which Dyna has patents pending) in which the phase and frequency controlling elements are removed from the circuit when the control is in the mechanical center of its rotation. In other words, Dyna now states that their new tone controls are out of the circuit in their flat position. They claim this system to be superior to the step-switch type in that it retains the versatility of

the smooth continuous control. Both harmonic and IM distortion are now claimed to be below 0.05 per cent at 3 volts output in the range of 20-20,000 Hz, with up to 10 volts out at less than 0.15 per cent distortion into loads as low as 10,000 ohms. Other specifications includes less than 2mV of noise through the equalized RIAA input with 60 dB gain, and the three-position blend switch that has become a hallmark of the Dyna preamplifiers. The PAS-3X is available as a kit for $69.95 and factory assembled at $109.95. This represents no increase of price from the PAS-3 series.

Circle 213

● **Improved Receiver.** Harman-Kardon's Stratophonic SR-900B now has 100 watts of power available over its entire frequency spectrum of 5-100,000 Hz. Their claim is that the use of germanium diffused-junction output transistors is responsible for this extraordinary bandwidth. They claim too, that the use of germanium output devices has resulted



in cooler operation and a virtual elimination of output device failures from sudden overloads. In addition to this improved performance, the SR-900B features a new, easy-to-read D'Arsonval tuning meter and a positive-action, automatic FM-stereo indicator light. List price of the receiver is $449.00 (slightly higher in the west). An oiled-walnut cabinet is optional at $29.95.

Circle 214

● **Low-Cost Broadcast Microphone.** The Electro-Voice 635A is an omni-directional microphone originally designed (and in actual use) for TV and recording studios. Its low price of under $50.00 makes it a suitable choice for the home recordist. The matte-chrome, turned-steel case is three-quarters of an inch in diameter and weighs only six ounces. It is designed for hand-held use or as a lavalier. Internal shock-absorber damping reduces the pickup noise of cable,

stand, or hand impact. A filter eliminates 'pops' and wind noise while acting as a mechanical guard of the dynamic diaphragm. The 635A is stated to be practically indestructible with normal use. Response is 60 to 15,000 Hz and the output is –55 dB into low-impedance inputs only. Matching transformers to the usual hi-Z tape recorder inputs are available.

Circle 215

AUDIO ETC.

(from page 14)

turns the outside at varying speeds ranging from zero, in either turning direction.

What sort of linkage? Well, it sounds clumsy, and I'll bet there's a fancier, more electrical way—but this system works and that is what seems to matter. It's an old fashioned variable friction drive, one of those little wheels that runs on a flat turning plate and can be moved all the way across, picking up the turning motion fast at the outside of the plate, slower towards the center, no motion at all on dead-center, then reverse motion out to the other side of the plate. Mechanically rather inefficient, but it gives precisely what is needed.

So, motor No. 2, a very ordinary excellent little unit, turns its flat plate at a fixed speed and the variable friction arrangement drives the outside of the trick motor—and thereby drives the rotating heads as well as controlling the capstan speed that drives the tape. Very ingenious. And eminently workable.

All you do is turn a pointer knob across a scale, to right (faster tempo) or left (slower tempo), the center being normal playback. It controls the friction drive. Normal means dead-center on the friction system, no motion of the outside trick motor element, hence no motion of the rotating heads—and 900-rpm capstan speed. "Faster" turns the outside element and the heads one way, "slower" drives them the other way.

Rotation Bias

Oddly enough, that internal 900-rpm motor speed is a kind of fixed bias, in terms of motion rather than current. It means that whereas the control element and the heads center at the zero, or motionless, position and turn in both directions, the inner capstan varies entirely within the forward-motion area, with 900 rpm the center point. Nice idea, that! Like a d.c. bias in a tube circuit. We might call this one F. F. R. (Fixed-forward rotation) bias.

'Nuff said in the explanation department. I must add that though the mechanical friction drive surely sounds clumsy and might seem an unlikely arrangement for maintaining accuracy in such a touchy area as pitch, the plain fact is that it does. As one moves the tempo control on the Eltro machine, the musical playback remains rock-steady in pitch; the tempo changes so naturally that you might think you were hearing a "live" sound, the musicians speeding up or slowing down their music at your command, the speaking voice rushing forward in pell-mell sentences or dawdling laboriously over every word, all according to the Eltro pointer's commands. It works, it really does. And, of course, so does the other element, the fixed-speed, variable-pitch drive.

(To recapitulate, variable pitch is achieved by driving the tape not from the special variable Eltro capstan but via the associated tape machine's own original capstan—fixed speed. With capstan speed fixed, the variable-speed heads change only the pitch of the playback sound.,

One final item on this installment. You may have a nagging sense of uncertainty about those rapid, four-headed scanned information bits played off the tape. How do they ever blend into an acceptable and recognizeable continuous sound? Note that when the heads run "backwards" the samplings—as we have seen—overlap and repeat the same material, advancing each sample a bit over the last; but with head motion the other way, same direction as the tape, the samplings are spaced apart, *omitting* little bits of tape. (How else could you go faster than normal?)

The answer is in the fact that these samplings are both very small and very rapid (as well as smoothly dovetailed together via the contiguous heads), and they blend together for the ear somewhat as the visual samplings of movies and TV blend, via persistence of vision. The sound-segments are never quite as long as the shortest useful sound in speech or music. Another analogy is, it may occur to you, the half-tone screen system of printing, where "sampling" dots or shapes blend into a continuous spectrum of black and white or color. There, too, the individual elements are never quite as long, say, as the length of a model's lovely nose. (Otherwise you wouldn't be able to see her nose.)

Anyhow, as I can vouch myself, not only is pitch—the crucial element—accurate enough in all the Eltro performing modes to satisfy any musical ear, but the actual sound-continuum is, as far as any listener can tell, 100 per cent normal in quality, out to a considerable distance either way—pitch raised or lowered, tempo fast or slow.

* * *

I've reserved for another installment (giving you frustrated inventors lots of time to ponder) some of the wonderfully varied uses to which this Pitch and Tempo Regulator may be put—given the rather large pile of wherewithal required as a down payment. Nope, it isn't ready for the home yet, though I suppose you can afford one if you go around buying yachts and mammoth swimming pools and what-not. But in many another area, scientific and commercial, it is a fascinatingly practical tool. Will tell how, next month—and meanwhile, *you* might be thinking hard . . . Æ

EQUIPMENT PROFILE

(*from page 78*)

HEATHKIT TRANSISTORIZED RECEIVER, MODEL AR-14

Although it is seldom the policy of this department to use superlatives in describing any individual piece of equipment, this is one time when it is possible to say that the unit in question is undoubtedly one of the best values we have encountered to date. At a kit price of $99.95, the AR-14 represents an exceptional value. For where else can one obtain an FM-Stereo receiver at such a price?

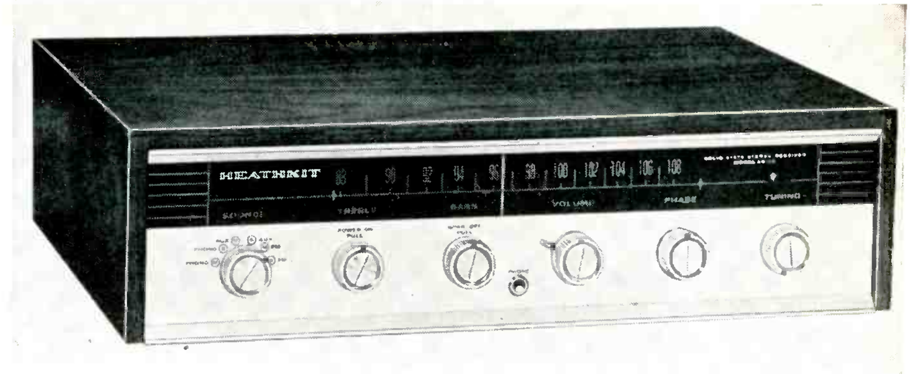


Fig. 4. Heathkit AR-14 Transistorized Receiver

And the low price has not been reached by any apparent sacrifice in quality. True, the unit is not a "high-powered" receiver by any means, nor is the tuner extremely sensitive, but it is perfectly safe to say that it is adequate in the great majority of urban locations, and it does have sufficient power output for any but the very-low-efficiency loudspeakers.

Circuit Description

The antenna input accommodates a balanced 300-ohm line. The secondary of the input transformer is tuned, and feeds an r.f. amplifier stage employing a 2SA240 transistor, which is in turn coupled by a second tuned circuit to the 2SA240 mixer. The oscillator is a 2SA239, with AFC being accomplished by a diode fed from the ratio detector. The entire front end is factory assembled and aligned, simplifying that portion of the work. Four i.f. amplifier stages follow the mixer, each employing a 2N2654, and the ratio detector diodes are incorporated in the last i.f. transformer can. Four 2N2712's serve as the multiplex section, and two more provide the stereo indicator signal. One feature of the Heath multiplex circuit is the provision for ensuring that the phase of the reinserted 38-kHz signal from the local oscillator is exactly in step with that of the transmitted signal, thus ensuring maximum separation. This adjustment is made by pulling out a knob which cuts off the main-channel signal and allows only the sub-carrier to pass. The knob is then turned to the point where the maximum sound is heard, then pushed in again.

Eight transistors are used in each channel of the amplifier section—a 2N3391 as the first preamplifier, three 2N2712's as second and third preamplifiers and the first predriver, a 2N3416 as the second predriver, a 2N3053 as driver, and one each of TA2577A and 2N2148 in the output stage, a complimentary-symmetry configuration with the first an NPN type and the second a PNP type.

The power supply uses four diodes as rectifiers, with RC filtering for the output stages and the drivers, and also for a lower voltage for the tuner, while an electronic filter is used for the preamplifier stages.

The front panel is graced by six knobs, one of which has a lever-operated control concentric with it. In the interest of simplification, the SOURCE knob has six positions—phono (mono), phono (stereo), aux (m), aux (s), FM (m), and FM (s). This knob is at the far left. The next knob combines the treble tone control with the push-pull power switch; the next combines the bass tone control with the speaker on-off switch, also a push-pull operation. The next knob controls the level in the left channel, while the concentric lever controls the right-channel volume, thus eliminating the need for a separate balance control. The next is the stereo-phase control previously described, and the last is the tuning control. A stereo headphone jack is provided on the front panel, with dropping resistors to ensure the proper listening level.

Construction

The output transistors are mounted on the rear panel, along with the input and output terminals, the a.c. fuse, and the two convenience outlets—one switched and the other "hot." All controls are mounted on the front sub-panel, and an attractive extruded aluminum dress panel provides the decorative appearance. The softly illuminated tuning dial scale is 7½ in. long, and the stereo indicator light is at the right of the scale. Most of the circuitry is then accommodated on two printed-circuit panels—one for the tuner section and the other for the amplifier portion of the receiver. The over-all dimensions are 15¼ in. wide, 3⅞ in. high, and 12 in. deep. In its accessory oiled-walnut housing it is an inch wider and half an inch higher. One unusual feature is that it can be mounted vertically—that is, with the front panel horizontal—for those applications in which this mounting is desirable.

Performance

Heath's claims for the AR-14 are relatively modest—5-μV sensitivity, 10-watt continuous power outputs (15-watt music power), channel separation of 45 dB or better and so on. We found that the continuous power output at 1 per cent distortion measured 12.5 watts per channel (both channels operating), sensitivity nearer 3.5 μV, and channel separation 47 dB. Frequency response at 1 watt measured 10 to 65,000 Hz $\pm$1 dB, and 5 to 112,000 Hz $\pm$3 dB. At 10 watts output, the two figures changed to 15 to 55,000 Hz and 8 to 92,000 Hz.

While this receiver ought not to be compared with units costing three or four times as much, it does give an excellent account of itself in all particulars. So far we have not yet seen a comparable unit at anywhere near the price, even taking into account the nearly 20 hours required to build it. That's part of the fun, though, and sometimes we build kits for the sheer relaxation that results. And this one was well worth it.

Circle 203

TAPE GUIDE

(*from page 64*)

Stereo Mixer

Q. Can you advise me on the construction of a stereo mixer?

A. You may find some useful ideas in the article by Peter A. Stark, "Transistorized Stereo Microphone Mixer," in the October, 1963, issue of AUDIO.

Sound-on-Sound

Q. I am very much interested in true sound-on-sound recording. I have read that "some machines have add-a-sound, meaning the erase head can be deactivated so one recording can be imposed over a previous one, but there is no means for exact synchronization." What is exact synchronization? Please explain the requirements for sound-on-sound.

A. True sound on sound can be achieved either by a mono machine with separate record and playback amplifiers or by a stereo machine with or without separate record and playback amplifiers. Through internal switching or through an external cable, the output of Channel A can be fed into the input of Channel B. The machine must permit one channel (A) to be used for playback while the other is used for recording (B). It must further provide a mixing facility, so that two signals can be simultaneously fed into Channel B; one is the playback signal from Channel A, and the other is the new signal to be added. The output of Channel A can be monitored from the machine's own speaker (if it has one), from an external hi-fi system, or from earphones. The roles of Channel A and Channel B should be reversible, so that one can add a third signal, a fourth, and so on. Exact synchronization refers to the fact that the new signal being added can exactly correspond to the old one in the sense of time. Thus one person can produce a duet, trio, quartet, and so on, sounding as though all voices had been recorded at the same time.

Tape Duplicating

Q. When duplicating tapes, should both tape machines be of equal quality. If only one top notch machine is available, should it be used to play the original tape or to record the tape copy?

A. Desirably, machines of equal (and good) quality should be used. Inasmuch as noise tends to be more prevalent in playback than in recording, it may be desirable to use the better machine for playback.

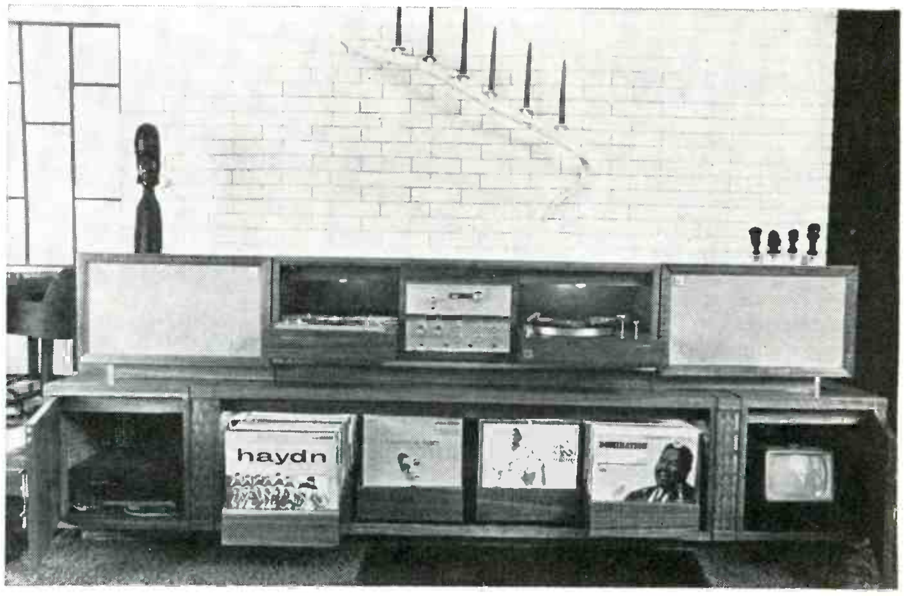
THIS MONTH'S COVER

The attractive installation shown on the cover is in the home of Walter and Hazel Berry, in Manhattan. Mr. Berry is the manager of the Acoustic Research Music Room in the west balcony of Grand Central Terminal where thousands of commuters have become acquainted with high fidelity for the first time while listening to AR speakers and turntables reproducing Dynaco-amplified music.

Mr. Berry designed and built every piece of furniture and decoration in the room pictured, and his wife, Hazel, actually made the hooked rug which covers the floor. The small photo at the right is a straight-on view of the "rig" proper, which —as would be expected—comprises a Dyna Stereo-70 power amplifier, a Dyna PAS-3 preamplifier, an A-R turntable/arm combination with a Shure M-55E stereo cartridge, and two AR-3 loudspeaker systems. In addition there is Sony/Superscope 263E tape deck, and an RCA TV receiver which is used primarily as a monitor from the closed-circuit TV camera in the lobby of his apartment house.

Not every hi-fi hobbyist is fortunate enough to be able to "work" at his hobby; neither does everyone who works all day with hi-fi products continue his audio activity as a serious hobby.

However, if one must work, it seems that the ideal condition is that he may be privileged to be employed in some activity related to his hobby. It also seems that the employer of such an individual is fortunate in having a man who pursues this hobby on his own time. Our congratulations to Mr. and Mrs. Berry, as well as to Edgar Villchur.



AUDIO MEASUREMENTS

(*from page 72*)

an amplifier, it may well be that as much as 5 per cent distortion is an acceptable limit for measuring maximum power. Thus it will probably be found that, although both amplifiers rate the same output for 5 per cent distortion, the one with curve B sounds superior, working at that output level.

For this reason, some amplifier manufacturers, instead of using a standard percentage of distortion as a reference point for maximum power, prefer to observe distortion on a 'scope and measure power at the point just before clipping commences, whatever that is: it may be 0.1 per cent or it may be 4 or even 5 per cent. They then specify the distortion as well as the power at the limit point chosen.

A power-response curve uses whatever distortion criterion is taken as the limit, adjusts input at each frequency to just reach that limit, and measures power. Some amplifiers maintain full power capability over the full audio range. Others, although their frequency response measured below the distortion limit may be essentially flat, have considerably curtailed power capability at either the low- or high-frequency end.

Unless otherwise specified, power is invariably measured and considered on the basis of a steady single sine-wave signal. For handling musical and other audio program material, this is not the true criterion. The power reported in a measurement is the mean value (rms in terms of the component voltage and current) of a sinusoidal power wave. What is important for signal power handling, on program, is the peak power.

Peak Power

Peak power can have two or three meanings, due to the somewhat ambiguous significance of measuring a mean value as "maximum" power on single steady tone. Peak power can mean the instantaneous peak power, which will be twice the average power, on a single steady tone based on voltage (*C* in *Fig.* 3-8). It can also mean the instantaneous peak power that can be reached, when the time taken to reach it is not sufficient to deplete the amplifier's power supply in the same way that running steadily at full power may do. This is based on voltage A. And it can mean the maximum average, or mean power delivered in the same "instant" (based on voltage B). And D is the voltage on which the usually specified maximum power (average) is based.

Thus there are four possible interpretations of maximum or peak power, even with a single-frequency measurement. *Figure* 3-8 shows the relationship of the voltages on which these are based in a typical case, although the amount by which available power falls off after an initial peak varied from amplifier to amplifier. The one we have marked maximum average instantaneous (B)—which sounds like a contradiction of terms, until you see what it means—was originally adopted by the Institute of High Fidelity Manufacturers as "Music Power Rating." (*Recent measurement standards, soon to be published, have changed the method of specifying maximum "IHF" power.* Ed.)

This seems a little unrealistic from one viewpoint: the true limit is the peak, not the average, especially when a signal composed of many frequencies is considered. Quite apart from transients, which we will discuss later in this course, a composite musical tone, made up of many instruments playing different notes, contains many sine waves, superimposed. The total power in these sine waves is the sum of their individual average powers. But the total handling capacity needed by an amplifier is the sum of their peak voltages or currents, which is quite a different thing.

For example, suppose there are ten individual sine waves in a composite musical signal, all of equal magnitude. In an actual case there are likely to be more than this, but they are unlikely to be of equal magnitude, so it's a fair simplification. The amplifier will need ten times the voltage- or current-handling capacity of any one of them, which represents 100 times the individual power requirement, whether referred to peak or average. But the total power is only 10 times. Thus, ignoring the different peak or maximum relationships characteristic of individual amplifiers, just discussed, it will need a 50-watt amplifier to handle 5 watts of musical power, based merely on the analysis of musical power.

Weighted Distortion Readings

Revert for a moment to distortion measurement. The accepted value for the total distortion content is the rms combination of its components. Where an analyzer is used, this is calculated from the individual readings for the various harmonics. Where the distortion meter is used, an average reading is taken on a meter calibrated in rms. This means a form factor (ratio of rms/average) of 1.11 is assumed. If the form factor of the residue differs from this, then the reading is in error by this difference.

Some have proposed the use of a weighted meter, to give more emphasis to the higher order harmonics, because they produce more audible effect. The main objection to this has been that distortion is rated in percentage. It would make sense to weight a characteristic rated in dB, but how can a percentage, which is purely an arithmetical proportion, be weighted and yet be called a percentage: is it that percentage or isn't it?

Peak/Peak Distortion

One way around this would be considerably more realistic, but has not yet been adopted: to use peak readings instead of average or pseudo rms. It would be particularly indicative on clipping, where the ten or more times amplitude would show up properly. It is also easy to do. On either the distortion meter (conventional type) or the input/output bridge, substitution of peak reading throughout, just by changing the meter circuit, will effect the change (*Fig.* 3-9).

In the next installment, after some more discussion of power readings, we will complete dynamic range consideration by discussing noise measurements on amplifiers, followed by more detail about the various intermodulation tests and their relative validity. Meanwhile, to get your thinking oriented, try to figure out what kinds of distortion each kind will satisfactorily indicate and which will "catch" the most. Æ

(To Be Continued)

FLUTTER METER

(from page 26)

series of small "pinholes" on the magazine pages, *Figs.* 10 through 12 must be retraced, and the tracing used as a template to locate the holes. The various connections of *Fig.* 12 are then made by placing 1/16 in. printed-circuit tape resist on the printed-circuit board.

The two most common etching solutions for printed circuit boards are ferric chloride and ammonium persulfate. Ferric chloride is normally bought in solution form, and one pint is more than enough to etch all three boards.

Ammonium persulfate is a powder, and to make a solution, 2.5 pounds of Ammonium Persulfate are added to one gallon of water. In addition, a minute amount of mercuric chloride (a poisonous powder) is added, as a catalyst, in the amount of 26.7 milligrams of mercuric chloride to one gallon of water. Both of the etching solutions just described have their advantages and disadvantages. Rather than elaborate more, I suggest those who are undecided use the ferric chloride solution.

A plastic or glass tray can be used to hold the solution to etch the boards. The boards are then submersed in the solution, and to speed up the etching process, the tray can be heated (to about 160° F) and agitated. The time to etch a board will vary, but with heat and agitation, the time will range from about 15 to 30 minutes. After etching, the boards should be washed with water and the printed circuit tape resist removed. The boards can then be cleaned (as described previously) and appropriate holes drilled for the various components.

When soldering the components to the boards it is a good idea to heat-sink the 1N126 germanium diodes and also the resistors associated with the resistive divider in the range switch. All components, except the 2N3710, are mounted flush against the printed circuit boards. Because of the close spacing of the leads on the 2N3710, no attempt was made to have the printed-circuit board layout coincide with the wire leads on the 2N3710. The outside leads are spread apart and the 2N3710 is mounted about one-eighth of an inch above the board. Most of the other parts should fit on the boards fairly well; however, because the boards were originally laid-out using a 1:1 scale (as opposed to a 4:1 that is often used) some of the parts may not fit as well as a commercial board. The layouts should suffice, however, and are by far easier to use than point-to-point wiring. The components can be mounted on the boards with the aid of *Figs.* 13, 14, and 15.

Preliminary Printed Circuit Board Tests

After the parts are mounted on a printed circuit board, it is advisable to perform some preliminary electrical tests on each board before it is fastened to the chassis. The reason for this is that if a circuit is not functioning normally, it is easier to isolate troubles on the board level.

To test board No. 3, the output leads from the power transformer, T_1, can be soldered temporarily to the bridge rectifier, CR_2 thru CR_5. The voltage at the emitter of Q_{18} should be about 33 V d.c., indicating the regulator is functioning. Q_{17} should oscillate at 3 kHz and the output amplitude at R_{69} (or J_3) should be 0.75 V rms.

To test board No. 1, +33 V d.c. from board No. 3 can be used to supply the d.c. voltage. The d.c. biasing on the stages can be checked with the aid of the voltage readings on the schematic. The voltages were measured with no signal input. Note that the measurements at the collectors of the Schmitt trigger may be reversed, depending on the states of Q_4 and Q_5. The discriminator-detector can be checked as follows: the d.c. voltages measured *across* R_{26} and R_{27} should be close to zero, with a maximum upper limit of about 50 millivolts. This measurement will assure that neither Q_7 or Q_8 is leaky. A 3-KHz, 0.1-V rms minimum signal is then applied to the input. The d.c. voltage *across* R_{26} should increase to 1.1 V d.c. and *across* R_{27} the voltage should be about 1.6 V *d.c.*

Board No. 2 can be given a preliminary test by measuring d.c. voltages. Except for the voltages at the collector of Q_{15}, which depend upon the setting of R_{60}, most measurements should be within about ±10 per cent of the values shown on the schematic.

$500 OFFERED FOR PREAMPLIFIER

$500 in cash awaits the first person who can supply Bob Tucker (Dynakit's Sales Director) with a stereo preamplifier which can outperform Tucker's present unit, a Dyna PAS-3X.


Bob Tucker

When asked about his offer, Tucker explained: "Like most hi fi fans, I have always wanted to have the best equipment available. Over the years, as a hobbyist, a dealer, and now as a manufacturer, I've owned or had access to virtually all of the high-priced name brands; and on comparative listening tests as well as laboratory checks, the Dyna still comes out on top. Over 6 years ago I first made a personal offer of $300 on the same basis, and while I met a few "bounty hunters", none of the units submitted could outperform my Dynakit. Now, with inflation sending the cost of audio equipment up, and with the latest improvement to the PAS-3X, I've upped the ante to $500."

Queried on the criteria for choosing a preamp, Tucker gave the following:

- *Harmonic distortion and spectrum analysis
- *Intermodulation distortion
- *Flatness of frequency response
- *Accuracy of equalization
- *Gain
- *Signal-to-noise ratio, both audible and inaudible
- *Transient performance, including square waves and tone bursts
- *Thermal stability
- *Channel separation
- *Ability to maintain performance specs at any setting of the volume control
- Freedom from switching transients
- Convenience and flexibility of controls
- Freedom from control interaction
- Service accessibility
- Conservative operation of components
- Listening comparison

He further explained, "I'll be glad to supply more details to anyone who wishes to pursue this, but to save needless correspondence, I suggest that some preliminary test results be submitted so that those units which obviously do not measure up can be eliminated. An offer like this is feasible only because a preamplifier is the only audio component whose performance can be effectively defined by such established, easily reproducible criteria as the (*) items above. The last one is the simplest and most significant test, though—a listening test which anyone can perform: reproducing a "live" tape, using a first-class recorder, power amplifiers, and speakers; first through the preamplifier, and then bypassing it, going directly from the recorder to the power amplifiers. A truly fine preamplifier, like the PAS-3X, will be undetectable."

JAZZ and all that

Bertram Stanleigh

With the introduction of its new series *Swinging Sounds of the 40's*, EmArcy has started to make available a group of important jazz recordings many of which never had wide distribution in their original 78-rpm versions. Recorded for Keynote and produced by Harry Lim, these waxings have been reprocessed for stereo and transferred to long-playing discs by Mercury for its subsidiary label. The technical quality is quite good, seldom betraying its 78 origins. One of the chief problems with many Keynote discs was the poor pressing material out of which they were stamped, and the quiet surfaces of the new reissues suggests that these transfers were made from acetates or metal mothers, rather than shellac pressings.

For their reprocessed stereo, only the slightest amount of aural alteration seems to have been attempted. There is a noticeable attenuation of low frequencies on the left channel and a comparably perceptible bass boost on the right. There is also a trifle more high emphasis on the left. This arrangement does provide a touch of stereo effect, but it is gentle enough so that it does no harm to the original quality of the recording, and it is hardly an improvement on what can be created by manipulating the bass and treble controls on an average preamp. It seems to this reviewer that failure to indicate that these recordings are not true stereo on the front cover is a somewhat deceptive practice. The back liner does bear the words, "electronically reprocessed stereo," but the front merely carries the word "stereo" and the record number in the upper right corner.

Musically, this series offers a wealth of fascinating material, particularly the Lester Young disc that offers four previously unreleased versions, together with the originally issued takes. While these first takes are clearly less satisfactory than the master takes, they provide real insight into how a performance gestates, and we can hope that more of these alternate performances are available in their archives for inclusion in later releases in this series.

Lester Young: Pres at His Very Best
EmArcy Electronically Reprocessed Stereo SRE 66010

Young is heard with two different groups: a 1943 quartet with Johnny Guarnieri, piano, Slam Stewart, bass, and Sid Catlett, drums; and a 1944 group with Buck Clayton, trumpet, Dickie Wells, trombone, Count Basie, piano, Freddie Green, guitar, Rodney Richardson, bass, and Jo Jones, drums. *Just You, Just Me, I Never Knew, Afternoon of a Basie-Ite,* and *Destination K.C.* are all heard in first takes as well as in the previously issued final versions. The remaining four numbers are *Sometimes I'm Happy, After Theatre Jump, Six Cats and a Prince, and Lester Leaps Again*. It is in the pieces with the Basie group that the finest music making is heard, Lester is completely relaxed, and Basie swings with elegance.

Coleman Hawkins and the Trumpet Kings
EmArcy Electronically Reprocessed Stereo SRE 66011

Coleman Hawkins is heard with Teddy Wilson, piano, Billy Taylor, bass, and Cozy Cole, drums. Three groups are included: one with Roy Eldridge on trumpet, another with Joe Thomas on trumpet and Trummy Young on trombone, and third with Charlie Shavers on trumpet and Denzil Best replacing Cole on drums. Things move along briskly no matter what the changes in personnel, with Wilson and Hawkins doing the most noticable work. Everything fits beautifully as these magnificent performers swing freely.

Out of the Herd
EmArcy Eectronically Reprocessed Stereo SRE 66012

Flip Phillips, Neal Hefti, Chubby Jackson, Shelly Manne, and Bill Harris are all heard in a number of different groups that were chiefly composed of personnel from Woody Herman's First Herd. Their performances are small-scale versions of the kind of steam and precision that was generated by that great Herman band. While there is more opportunity for solo lines to come through than on the big band arrangements, these men were all essentially oriented to the mass sound tradition, and what emerges is more closely related to big band rather than combo jazz. Two numbers with Red Norvo groups that feature Teddy Wilson and Slam Stewart are included, but while Norvo later played with Herman, there is no connection in style, or with the other members of the Norvo groups and the Herman band.

Monty Alexander: Spunky
Pacific Jazz Stereo ST 20094

A youthful pianist with a light touch and an airy style, 21-year-old Monty Alexander hails from Jamaica in the West Indies. He has already scored successes in both New York and Los Angeles, and it is likely that his audience will continue to grow. His performances are marked by an infectious rhythm, bright, colorful harmonies, and light, rapid decorative embellishments that are well integrated into the melodic line. Heard with a neatly balanced rhythm group of guitar, drums, and bass, he presents a widely varied program that goes from blues to rock and includes a bit of West Indian rhythm and a highly individual rendition of *I'm an Old Cowhand*.

Milt Jackson at the Museum of Modern Art
Limelight Stereo LS 86024

A live recording of one of the outdoor concerts held last summer in the sculpture court of the Museum of Modern Art in New York, Jackson is heard on vibes along with James Moody, flute, Cedar Walton, piano, Ron Carter, bass, and Candy Finch, drums. Perhaps *overheard* might have been the more advisable word because the audience noises and poor mike orientation do much to detract from what were probably fine performances. The album, which is one of the new creations of Daniel Czubak, is a handsome, lavish affair with a pop-out center and an elegant illustrated booklet. If it were used to contain a recording of acceptable commercial quality, it would be a fine thing, but in this instance it merely serves to point out the discrepancy between its own highly professional craftsmanship and the bumbling ineptitude of the recording.

Jose Borges, Valentina Felix, Plinio Sergio: Fados of Coimbra
Monitor Stereo MFS 454

To this reviewer whose limited knowledge of the Portugese *fado* has been acquired on a couple of junkets to Lisbon, fado was a product of that old section of Lisbon called Alfama. If I had actually listened to any of the fados of Coimbra, Portugal's third largest city, I probably wasn't even aware of a difference, but this fascinating collection make it clear that there is a difference in pacing between the two styles. Fados from Coimbra appear to be slower and even melancholy than those in the Lisbon style. Another feature of this style would appear to be the interjection of long, expressive pauses at strategic moments. In the present collection, three excellent singers are joined by a virtuoso guitar trio to produce one of the most agreeable of folk music recordings.

Boris Frank and his "Kranjci" Slovenian Polkas & Waltzes
Monitor Stereo MF 450

A hearty collection of simple, mountain songs performed by a small and skillful instrumental and vocal group. The stereo recordings, made in Yugoslavia by Jugoton, are bright and clear with excellent presence and a good spread. The instrumental group features some particularly merry brass playing that calls to mind some of the fooling around that was characteristic of the old New Orleans jazz bands. I don't recall any other example of similar high jinks in European folk music.

Coleman Hawkins: Wrapped Tight
Impulse Mono A-87

The ever-fresh Coleman Hawkins is just as vigorous and maintains the same superb control of his instrument on this 1965 recording as on the 1944 reissue. Playing with a group of able young performers—Bill Berry, trumpet, Urbie Green, trombone, Barry Harris, piano, Buddy Catlett, bass, and Eddie Locke, drums—he turns in solid, deeply felt solos that tend to dominate the group. Possibly the choice of titles has something to do with the essentially solo quality of this platter. It's a pretty romantic grouping that includes *Intermezzo, Indian Summer, Marcheta, Beautiful Girl,* and *And I Still Love You.* When the tempo picks up on *She's Fit* and *Bean's Place,* everyone starts to swing and the results are quite exhilarating.

Noel Boggs: Western-Swing
Repeat Stereo RS 310-8

On the theory that anything so far out of style must be on the way back, Repeat has issued a platter full of the kind of swinging cowboy music that has been largely absent from the music scene since the 1940's. Whatever the potential for such a renaissance, it must be noted that the technical interest in their new release is substantial due to their special no-microphone recording technique. The method is particularly well suited to stringed instruments, and sound enthusiasts will be properly impressed with the clarity, low distortion, clean bass, and absence of background noise. Noel Boggs, on steel guitar, is clearly a master of the western style, and the accompanying fiddles and rhythm are handled most ably Æ

INPUT RESISTANCE

(*from page 32*)

ever, the physical value of the bias-return resistance is about 40k ohms. Thus good low-frequency performance can be obtained with this circuit, but noise performance is considerably less than optimum. For significant improvement in noise performance one must turn to other devices.

Field-Effect Transistors

The Field-Effect Transistor (FET), in contrast to the conventional transistor, is a voltage-operated semiconductor device. It possesses many similiarities with the triode vacuum tube. For the

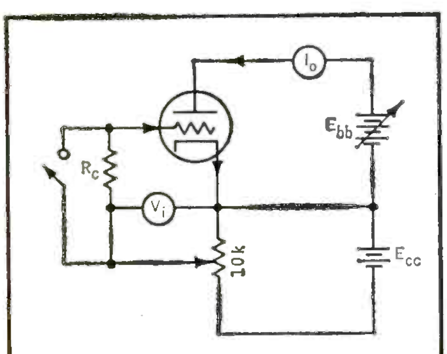


Fig. 10. A measurement circuit.

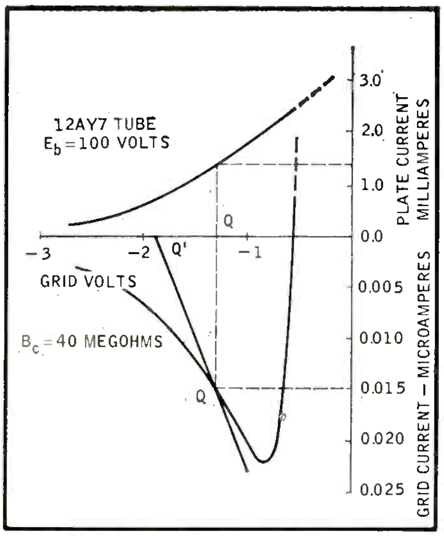


Fig. 11. Plate- and grid-current characteristics.

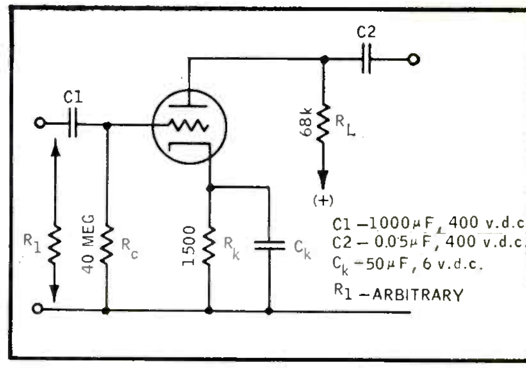


Fig. 13. The 12AY7 test circuit.

present purpose the three principle attributes are high input resistance, good noise performance, and a cutoff frequency well into the megacycle region.

The FET consists of a drift channel of semiconductor material (N or P) with the gate electrodes of opposite polarity material placed along the length. This is shown schematically in *Fig.* 8. With a voltage applied along the length of the channel (gate open circuited) current will flow from source to drain. Reverse bias of the gate will effectively reduce the cross section of the drift channel and the current reaching the drain, in a manner analogous to increasing the source-to-drain resistance. If this biasing is continued the current will cease to flow when the "pinchoff" voltage is reached, except for a very small leakage. The control action of the gate is analogous to that of the control grid of a vacuum tube. Of interest here is the fact that no current flows in the gate circuit except for a very small leakage. Hence the input resistance in the common-source connection is very high. The output resistance is quite low.

A caution at this point. The device is characterized by one P-N junction, that between the gate and drift channel. Evidently the source and drain connections are determined by the geometry of construction. The device will perform approximately as advertised if the source and drain connections are interchanged. This is not recommended since the characteristics may be altered in the process.

The low-frequency equivalent circuit shown in *Fig* 9 has been developed by Betchel.[5] Typical values of parameters and nomenclature are included. Note that he has omitted the input conductance as being negligably small. The device is characterized by capacitive input and conductive output admittances. The relatively large capacitance from gate to drain is particularly significant for sources with large internal resistance. However, this should not be troublesome with capacitive sources. As with conventional transistors, negative input resistance is not inherently available.

FET devices are temperature-sensitive, and stabilization considerations should be given. However, the drift-channel material has a positive temperature coefficient; the drain current varies inversely with temperature for fixed bias and excitation voltages. This is in contrast to the performance of the conventional transistor, hence stabilization in hybrid circuits is simplified. Also, quite large bias-return resistances may be employed because of the high input resistance and still achieve satisfactory bias stabilities. This fact, together with the low inherent noise of the device, should allow significantly better noise performance than is obtainable with conventional transistors. Positive feedback is not needed to raise the driving point resistance, hence better operating stability is inherently available.

We may combine the input circuit of *Fig.* 1 with the equivalent circuit of the FET and a load, R_L. With some starightforward tedium we find the ratio of the output to open-circuit generator voltages to be closely approximated by

$$\frac{V_o}{V_g} = \frac{-g_m C_1 \mu [\mu (g_o + a_g) + j g_o]}{(C_1 + C_2)[g_o^2 + \mu^2 (g_o + a g)^2]} \tag{10}$$

where

$g_o = g_d + g_e$,

$g = g_o + g_m + g_c + g_i$, $a = \dfrac{C_3}{C_1 + C_2}$

$$\omega_1 = \frac{g_i + g_c}{C_1 + C_2}, \ \mu = \frac{\omega}{\omega_1} \tag{11}$$

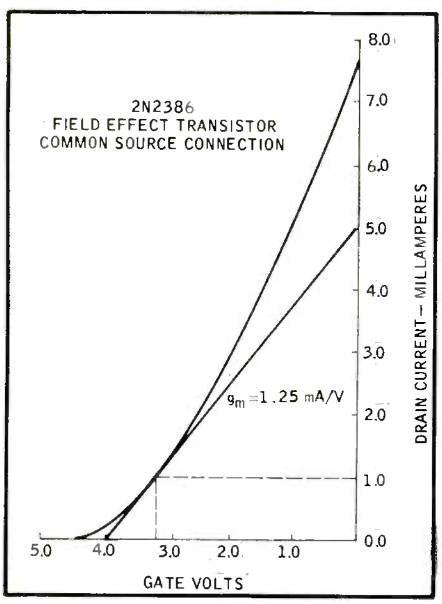


Fig. 12. Gate-to-drain transfer characteristic.

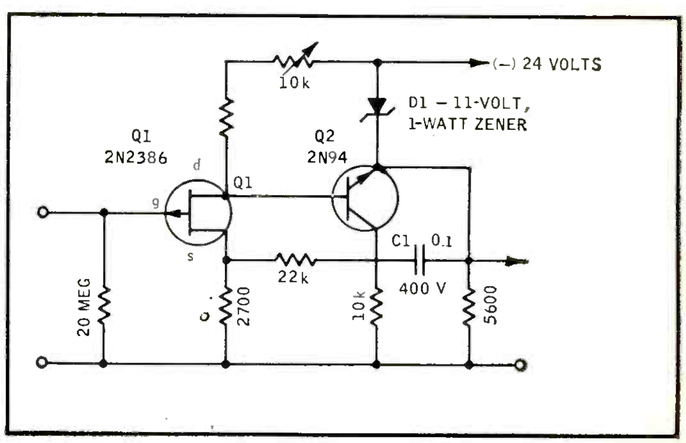


Fig. 14. The 2N2386 FET test amplifier.

In some available devices, the gate-to-drain capacitance is small enough to be neglected without appreciable error. In that case Eq. *(10)* is simplified to

$$\frac{V_o}{V_g} = \frac{-C_1}{C_1 + C_2} \cdot \frac{g_m}{g_o} \cdot \frac{\mu(\mu + j)}{\mu^2 + 1} \quad (12)$$

The output impedance is found to be approximately

$$Z_o = \frac{g_o + \mu^2 (g_o + a_g) - j\mu a g}{g_o^2 + \mu^2 (g_o + ag)^2} \quad (13)$$

when the feedback capacitance is present and is the reciprocal of the output conductance otherwise.

It is noted that the presence of the gate-to-drain capacitance results in voltage feedback; as one would expect, this reduces the gain and the output impedance.

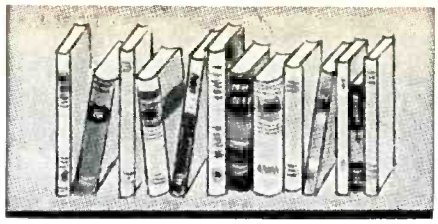
MEASUREMENTS

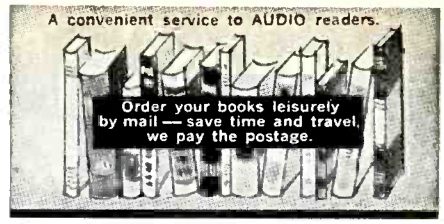
The necessary input characteristic may not be readily available. It can be obtained with simple equipment and a little patience. One suitable circuit is shown in *Fig.* 10. The excitation voltage is chosen and set. With switch S_1 closed, selected values of output current are obtained and recorded, together with the corresponding values of bias. With S_1 open the previous values of output current are obtained and the corresponding values of bias are recorded. Since the input voltage was the same in the two cases for a given current, the difference in bias readings is the voltage across the bias-return resistor. From this information the input characteristic can be derived. A family of curves for selected excitation voltages can be developed if desired. The method is equally applicable to vacuum tube and semiconductor devices.

The 12AY7 Tube

The 12AY7 tube was developed for low-level audio service. Small grid current and other low-noise characteristics were expected. Preliminary measurements suggested it was a good choice for this application. Operation at 100 plate volts offered a good compromise between high transconductance and small grid current. The results of one set of measurements are presented in *Fig.* 11.

The grid-current curve exhibits a negative peak of about –0.025 microamperes near –0.8 grid volts. The grid conductance is substantially constant over a good range of positive and negative regions. As previously stated, one must choose an operating point in the negative grid conductance region to





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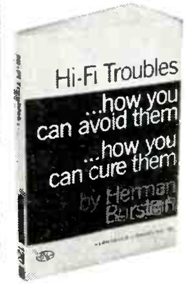

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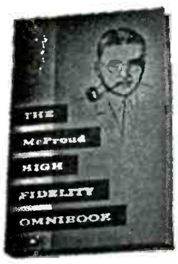

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obtain high input resistance. In this instance a grid voltage of –1.3 is a good choice, in that it gives an acceptable value of transconductance and an operating point well within the linear portion of the negative grid conductance region. The maximum negative grid conductance is approximately –0.018 micromhos, while transconductance is about 1.25 mA/V. Grid and plate currents are –0.015 microamperes and 1.35 milliamperes, respectively. The negative reciprocal of the grid conductance is about 55.5 megohms.

The 2N2386 Transistor

Several manufacturers are now marketing Field Effect Transistors. Several types of units are available in both germanium and silicon. Prices range from three to three hundred dollars per unit. Generally speaking, the cost and performance of the germanium units are inferior to those of silicon material. For experimentation the writer selected the least expensive silicon unit available, the 2N2386.

The 2N2386 is a P-channel planar silicon field effect transistor produced by Texas Instruments and is obtainable at $7.20 per unit. It has quite small input conductance and the transconductance is quite good. Data sheets are available from vendors and from home and field offices of Texas Instruments.

The gate-to-drain transfer characteristic of *Fig.* 12 was obtained for constant excitation of –10.0 volts. The maximum transconductance is about 2.3 mA/V and is approximately 1.25 mA/V at one mA of drain current. The output conductance is about 130 micromhos at this current. The resolution of the measurements would not permit determining the input conductance; it was only ascertained that the input resistance is well above 100 megohms at d.c. The data sheet gives the input shunt capacitance as 50 pF.

EXPERIMENTAL AMPLIFIERS

The writer was concerned with amplifying signals derived from a ceramic microphone. The manufacturer provided the series and shunt capacitance data at 400±50 and 120 pF, respectively. Thus the total capacitance was 520±50 and 570±50 pF for the vacuum tube and the FET amplifiers, respectively. Entering *Fig.* 2 for a half-power frequency of 25 Hz, one determines the need of a minimum driving-point resistance of about 12 megohms. One each of vacuum-tube and FET amplifiers were built up and tested, primarily to demonstrate the feasibility of obtaining relatively very large driving-point resistance with adequate stability. They are not offered as "good' general purpose audio amplifiers.

The 12AY7 Amplifier

We refer to *Fig.* 11 to select the operating conditions for the 12AY7 amplifier. As previously pointed out, a grid voltage of –1.3 is a good choice. The grid and plate currents are –0.015 microamperes and 1.35 mA respectively, while the grid conductance is –0.018 μA/V. The writer selected a 40-megohm bias-return resistor.

We now construct the bias-return load line from the intersection of the grid-current curve and the selected grid voltage. It intersects the bias abscissa at –1.9 volts, the negative of the cathode voltage. Note the single intersection with the grid-current curve, indicating uniqueness of the operating point. We now calculate the required cathode resistor as 1410 ohms and determine the maximum permissible grid return resistor as 98 megohms. Thus 40 megohms is a conservative choice. The driving-point resistance without feedback is about 143 megohms.

The circuit shown in *Fig.* 13 was constructed to verify the design procedures. Cathode and plate voltages were within a few per cent of those calculated; measurement of the grid voltage was not attempted for obvious reasons. No evidence of instability was observed. No distortion could be detected in listening tests when the unit was employed in series with equipment of known good quality. The noise level was acceptably low. It was found convenient to strap R_I across the input terminals to determine the best value of driving point resistance with which to load the microphone. This having been done the correct values of R_c and R_k were inserted, allowing removal of R_I and C_I.

The 2N2386 Amplifier

One milliampere drain current was selected for the FET amplifier at some sacrifice of the g_m in the interest of using larger resistances. Also, the zener-stabilized direct-coupled hybrid circuit of *Fig.* 14 was chosen to assure control of the operating points over the ambient temperature range of interest. The potentiometer was insterted in the load of the FET to allow precise adjustment of the operating points. The actual load after adjustment was 13.5k ohms compared with the estimated 13k ohms. One can eliminate the potentiometer by dressing the load to the right value of course.

The open-loop gain was measured at 200, while the closed-loop gain is about 9 due to large negative feedback. The input resistance of the amplifier is exceedingly high; the driving point resistance is esstentially R_c, 20 megohms in this case. That there was very small input current was verified by shorting

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the bias return resistor while observing the change in voltage across the output load. No instability was observed other than attributed to body-capacitance coupling due to inadequate shielding. No attempt was made to determine the largest practicable value of bias-return resistor, but apparently 50 megohms or so could be used without undue difficulty.

The unit sounded clean and solid in listening tests. No undesirable effects were noted. The noise level was quite low. On sanction of the distaff side the amplifier was baked at 160° F until the output load voltage stabilized; it changed from –7.2 to –9.0 volts. This voltage returned to normal within five minutes after removal to room ambient temperature. No deleterious effects could be discovered.

Conclusion

We have shown that low-frequency performance of capacitive signal sources requires an amplifier with large input resistance while a large bias-return resistor improves the signal-to-noise ratio. Bias-return resistors in conventional transistor amplifiers are limited to relatively small values, while quite large resistances may be employed with vacuum tubes and Field Effect Transistors, with adequate operating-point stability. Demonstration amplifiers were designed and constructed using the 12AY7 tube and the 2N2386 FET. These were tested with satisfactory results. Finally, one may achieve sensibly any desired value of driving-point resistance by using feedback at the expense of an adverse effect on best available signal-to-noise ratio and/or operating-point stability.

Lest the reader be misled by the foregoing theme, it is always prudent to use the smallest driving-point resistance consistent with design requirements. It is also prudent to examine meters and ambient conditions, when the driving-point resistance is to be larger than a few megohms. To this end perhaps this discussion will prove useful. Æ

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5. Norbert G. Betchel, Jr., *"A Circuit and Noise Model of the Field Effect Transistor,"* Doctoral Thesis, Stanford University, April, 1963.

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