RADIOTRONICS

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ARTICLES ON AUDIO-FREQUENCY APPLICATIONS

Commencing with this issue, it is hoped to include each month at least one article on audio-frequency equipment or design. In the current issue there is an article on Loudspeaker Impedance, while the subjects to be covered in succeeding issues include diamond and sapphire stylus wear, the use of multiple small loudspeakers, feedback amplifiers, loudspeaker divider networks, and a series of articles on high-fidelity sound equipment.

A PRECISION "SLICK WHISTLE" FOR 3.5 TO 4 Mc.

500-Kc Band Covers Approximately 500 Dial Divisions *

By F. S. BARKALOW,† W2BVS

After several contacts with hams who are "rock bound", one wonders why these operators handicap themselves by not employing a VFO. After receiving a few compliments on the operation of this VFO, the author asked a few of these hams why they didn't build a VFO. Most answers indicated that these hams postponed building a VFO because they assumed that frequency drift and questionable accuracy of calibration characterize all home-made VFO's.

Stability and Accuracy.

These were the watchwords! The VFO described in this article features rugged mechanical design plus voltage regulation to help insure frequency stability. Further assurance against frequency drift is obtained by operating this unit with its plate voltage on continuously during transmission, i.e., as a non-keyed VFO

The problem of obtaining useful frequency calibration was solved by using a straight-line-frequency tuning capacitor together with a precision dial. Using this scheme and readily-available components, a roughly linear frequency-calibration curve has been obtained (see Fig. 1). Furthermore, the 500-Kc band (3.5-4 Mc) covers 497 of the 500 dial divisions. Thus, the actual frequency of the VFO (in Kc) is roughly equal to the dial reading plus 3,500.

This VFO has a high-impedance output circuit and works nicely into the crystal socket of a pentode oscillator; however, it has sufficient output to drive such tubes as an 807 or 6146 on 80 meters. For operation on 40 or 20 meters, external doubler stages are required.

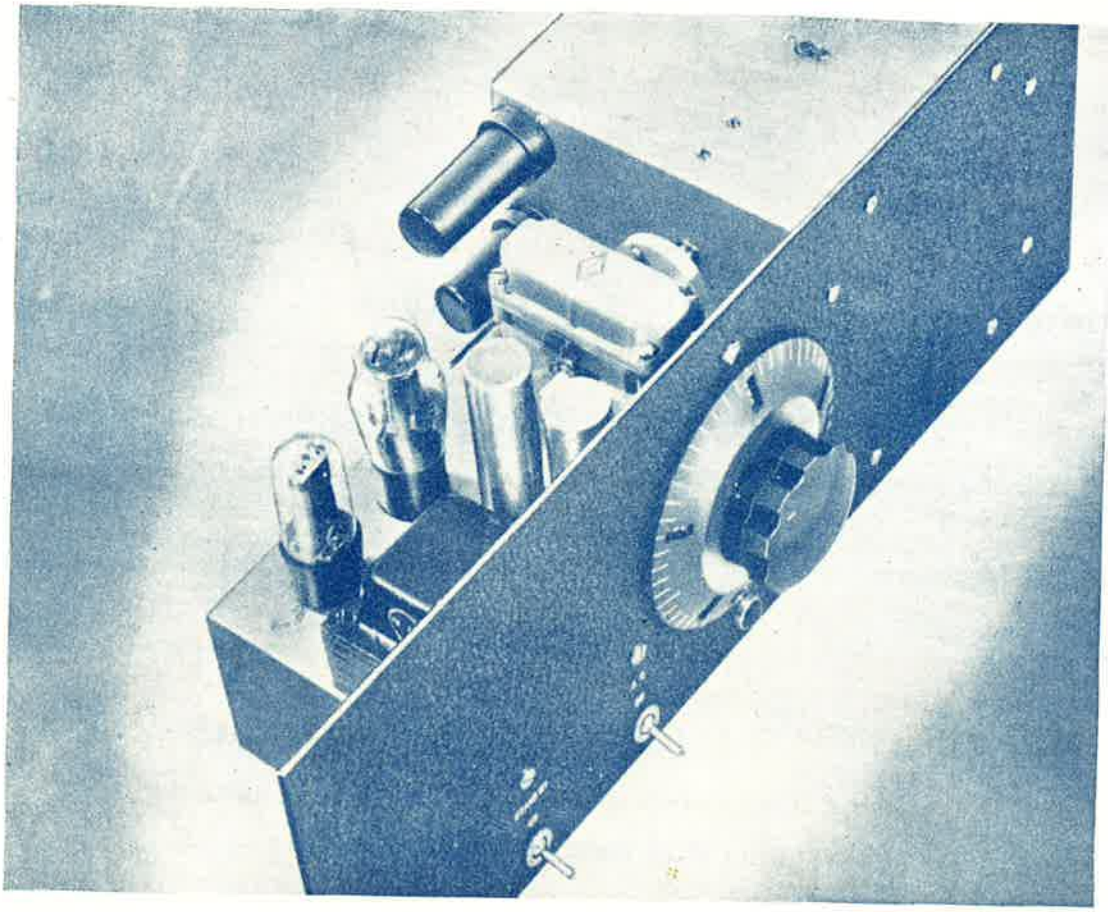
General Description.

The first stage employs a 6J5 in the widely used and reliable Clapp oscillator circuit. For additional output and isolation of the oscillator, a 6AG7 buffer is used. There is no tracking problem because the buffer employs an untuned tank circuit having low Q. The VFO has a conventional self-contained power supply utilizing a 5Y3-GT rectifier and an OD3 voltage regulator.

Because of the shielding provided by their metal shells, the oscillator and buffer tubes are mounted outside the oscillator box where their heat dissipation cannot affect the frequency stability. The use of silver-mica fixed capacitors, rugged, bus-bar wiring in the frequency-determining circuit, and regulated voltage on the oscillator plate and buffer screen, further contributes to the frequency stability of this unit.

* See caption for Fig. 1.
† RCA Tube Dept., Harrison, N.J.

Reprinted from Ham Tips with acknowledgments to RCA.



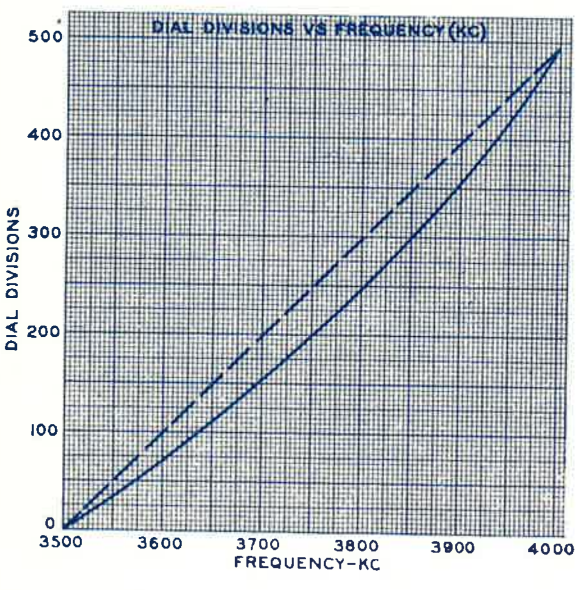


Fig. 1. Calibration curve showing frequency vs dial reading. If the calibration curve coincided with the straight line shown, the dial reading plus 3,500 would equal the VFO frequency in kilocycles. However, the dial readings have more utility than those on an arbitrary scale in that they roughly indicate the number of kilocycles above the low-frequency end of the band.

Because the 500 divisions of the dial correspond to 180° of rotation, only a 180° portion of the 270° of rotation of the straight-line-frequency tuning capacitor C_2 is used. Originally, this VFO employed a tuning capacitor of the straight-line capacitance type. Substitution of the only available (locally) straight-line-frequency capacitor did pose a problem, however. The dial-shaft rotation (clockwise for an increase in number) did not correspond with the rotation of the tuning capacitor (counterclockwise for a decrease in capacitance, or increase in frequency). This problem was solved by removing the rotor and stator plates from their respective mounts and turning them over 180° and replacing them exactly in the order in which they were removed. Before this modification, the pigtail wire which passed through the rotor was carefully unsoldered. *If the original plans had included the use of this capacitor, the whole layout would have been reversed, i.e., the oscillator box would be located behind the left-hand side of the panel and the power supply on the right-hand side.*

Constructional Details.

There are several reasons for the unusual layout; however, the two-unit construction was decided upon mainly because it permits easy wiring within the VFO box and also because the power-supply chassis provides a convenient spot for mounting the dial gear box.

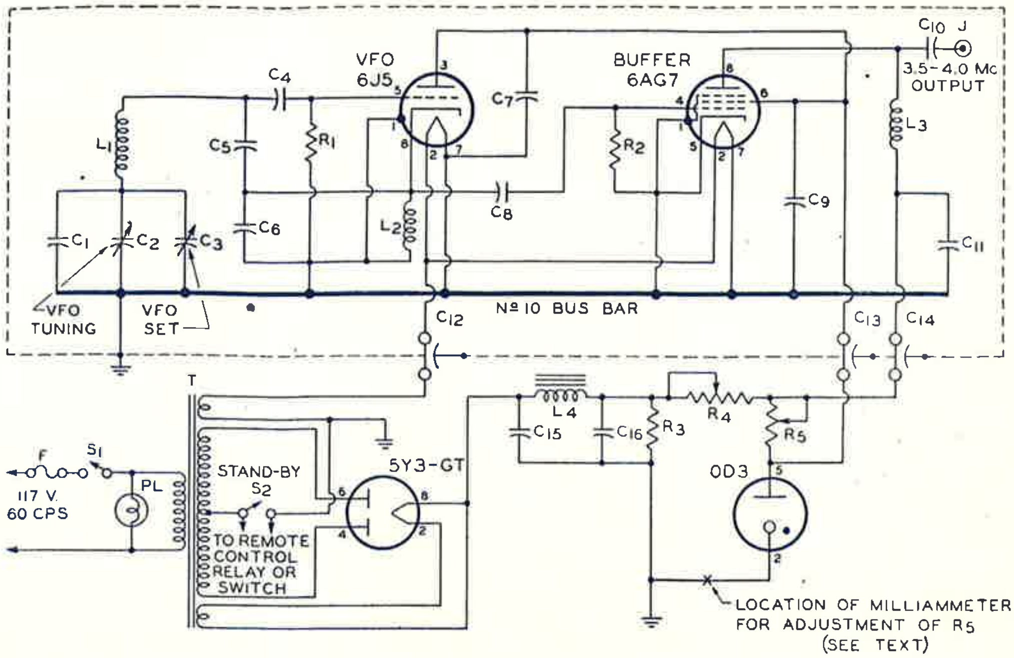


Fig. 2. Schematic diagram of the VFO and power supply.

C_1, C_4, C_8, C_{10}	100 μμf silver mica (El-Menco CM-15E-101-J).
C_2	75 μμf, variable (National SE75).
C_3	50 μμf, variable (Bud LC2079).
C_5, C_6	.001 μf, silver mica (El-Menco CM-30-102).
C_7, C_9, C_{11}	.01 μf, disc ceramic (El-Menco).
C_{12}, C_{13}, C_{14}	.0015 μf, feed through (Erie 362-152).
J	Connector (Cinch-Jones S-101).
L_1	23 turns, No. 16 enamelled, spaced to occupy 2½ in., 2 in. diam. (B & W 3907 coil stock).
L_2	RFC, 2.5 mh (National R-100).
L_3	RFC, 5.0 mh (National R-100).
PL	Drake No. 10.
R_1	100K, 1 watt.
R_2	50K, 1 watt.

Power Supply

C_{15}, C_{16}	16 μf, 450 wv (Cornell-Dubilier KR516A).
F	3AG, 1 amp (for Littlefuse 342001 holder).
L_4	12 h, 80ma (Thordarson 20C53).
R_3	30K, 10 watts.
R_4	2K, 25 watts (Ohmite Dividohm 0377).
R_5	5K, 25 watts (Ohmite Dividohm 0382).
S_1, S_2	SPST, toggle, 125 v, 3.5 amp.
T	300-0-300 v, 70 ma; 5 v, 2 amp; 6.3 v, 3 amp (Thordarson T22R02).

Miscellaneous

Chassis	3" x 5" x 7", aluminium (ICA 29047).
Dial	National PW-O.
Flexible coupling	National TX9.
Panel	7" x 19", ⅛" aluminium (ICA 8603RS).
VFO shield box	6" x 6" x 6", aluminium (ICA 29843).

NOTE.—The appearance of a manufacturer's name following the description of a particular component should not be interpreted as a recommendation to use that particular brand. Brand names are included only to fully identify the components which are visible in the photographs. In almost all cases, equivalent components made by other manufacturers may be substituted for those shown in this parts list.

The oscillator box is a standard 6 by 6 by 6-inch item, and the power-supply chassis measures 5 by 7 by 3 inches; these are fastened to a 7 by 19-inch panel. For additional strength, the oscillator box is also fastened to the power-supply chassis by means of the bakelite block shown in Fig. 4. The power supply is fastened to the panel with three machine screws. One of these screws (not visible in the photograph) is located under the dial; this screw is a flat-head type. Both units are mounted on the panel after wiring. Care must be exercised in mounting the oscillator box and power-supply chassis in order to obtain perfect alignment of the gear-drive and tuning-capacitor shafts.

Careful examination of the photos will show that paint on the back of the front panel has been removed from those areas where each unit makes contact with the panel. This was done to insure a good ground connection between the units and the panel.

The special attention and care which were exercised during the construction of the oscillator box have "paid off" — the VFO produces a vibration-free note. If the oscillator components are mounted and wired while the oscillator is detached from the front panel, a much better job will result.

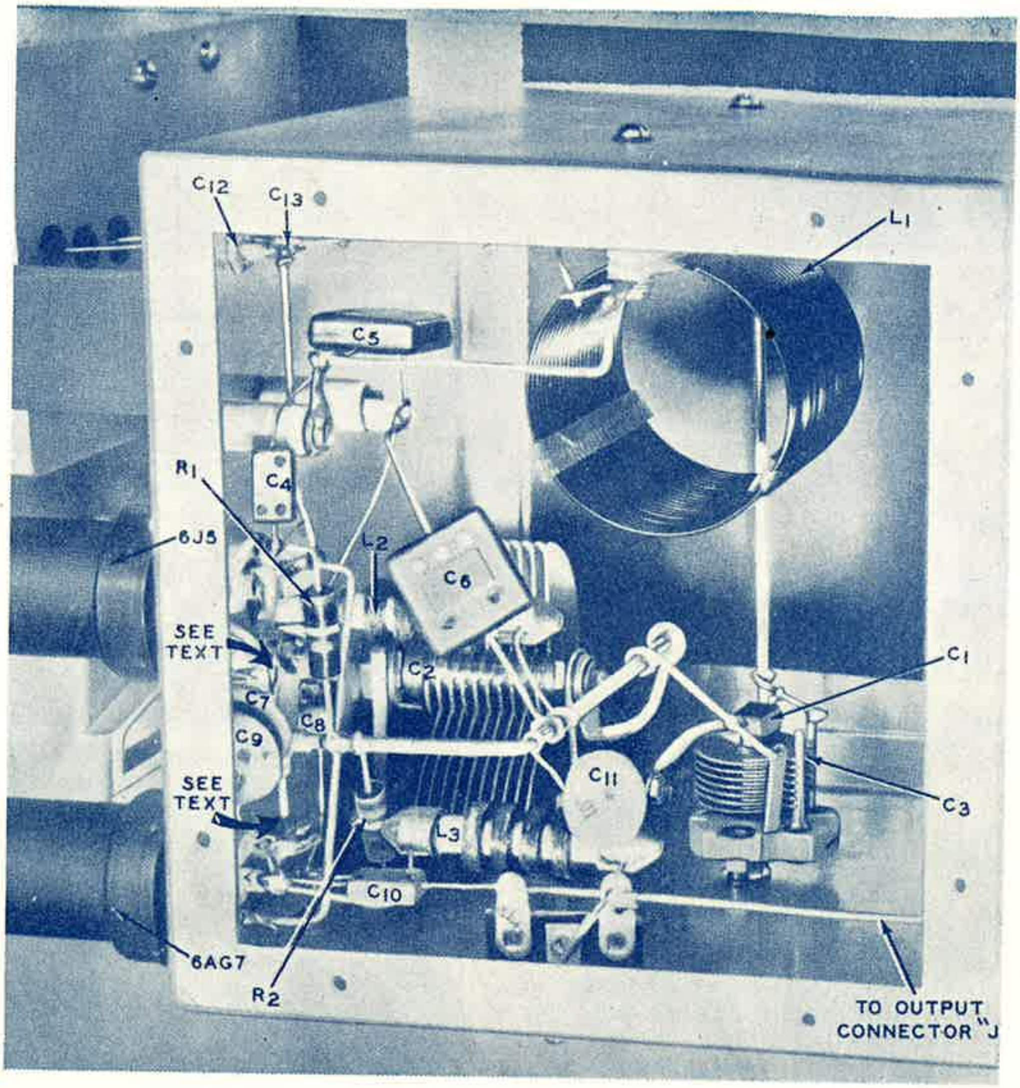


Fig. 3. Rear view of the oscillator box with the cover removed. The ground bus is bent and routed so that it functions as a common, convenient, vibrationless ground.

Vibration of leads in the frequency-determining circuit can raise havoc with the note; therefore, wherever possible, ceramic standoffs and lug terminal strips are used to strengthen the lead terminations. For the same reason, bus bar has been used for a common ground.

Heater and B + leads from the VFO to the power supply pass through feed-through capacitors. These capacitors are used to keep rf from feeding back to the power supply and also to prevent these connecting leads from radiating harmonics.

Line-voltage and stand-by switch connections are made through a connector on the rear apron of the power supply as shown in Fig. 4. This type of connector was used to conform with other connectors on the author's rack-mounted transmitter.

Wiring Procedure.

A length of No. 10 bus bar serves as a common ground; it is connected to ground *only* through the rotor shaft of the tuning capacitor. All oscillator-box ground connections are made to this bus. The other end of this bus is supported by the heater lug of each tube socket which is to be grounded (see arrows in Fig. 3). This routing of the ground bus is also clearly shown in Fig. 3.

The use of such a ground system eliminates ground loops which may be set up if the ground connections are made in several places on the chassis. The effect of one type of ground loop was demonstrated when an aluminium block was used (in place of the bakelite block previously mentioned) for mechanical support between oscillator box and power-supply chassis. The loop created by the addition of the aluminium block changed the calibration by approximately 20 Kc.

Connections to coil L_1, the band-set capacitor C_3, and to capacitors C_4-C_6 should be made as direct as possible and with bus bar. All other components should also be wired with short connections.

The forming and bending of the bus bar should be done before it is soldered. This procedure eliminates undue lever-action strain on lugs and terminals which would occur if bending was done after soldering one end of the bus.

Exercise reasonable care while mounting and soldering feed-through capacitors C_{12}-C_{14}. Too much pressure during the nut-tightening operation or too much heat when wires are soldered to either end of these capacitors will cause damage.

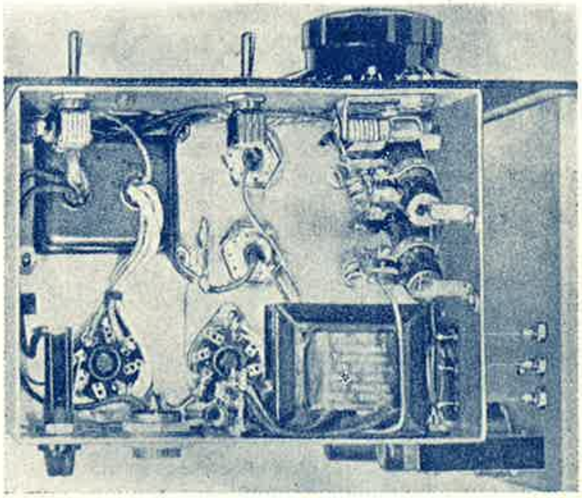


Fig. 4. Note the coiled flexible lead connecting the slider to one end of the bleeder thereby shorting out the unused resistance. Because the connection to the slider is terminated on the fixed end terminal, this arrangement prevents damage to the resistance wire by keeping the strain off the slider.

Adjustment and Calibration.

Insert a milliammeter at point "X" in the circuit (see Fig. 2) and connect a voltmeter from the junction of R_4 and R_5 to ground. Turn on the standby switch a half minute or so after the rectifier filaments have reached their operating temperature.

Alternately adjust resistors R_4 and R_5 until the voltmeter indicates approximately 280 volts and the milliammeter indicates approximately 10 ma. Use an insulated screwdriver to loosen and tighten the sliders on R_4 and R_5. (*Although it takes a little more time, for safety reasons it is advisable to turn the power switch off each time an adjustment is made.*) After these adjustments are made, remove the temporary meter connections. With these settings of resistors R_4 and R_5, the voltages on the oscillator and buffer tubes should be as follows:

6AG7 Plate	— 280 volts	(at 20 ma)
6AG7 Screen	— 150 volts	(at 15 ma)
6J5 Plate	— 150 volts	

A signal source, a fairly good wavemeter, or a heterodyne frequency meter will be required to calibrate the VFO; the writer used a heterodyne frequency meter. It is preferable to do the calibrating at normal room temperature; also, it is desirable to allow the oscillator to warm up for at least 15 minutes with the stand-by switch turned on. From a cold start, the oscillator drifts about + 1 Kc; however, at the end of 15 minutes the drift is negligible.

Loosen the set screws on the dial side of the flexible coupling and, with the dial set at the first division mark, rotate C_2 to a position about one-third out from the maximum-capacitance position; tighten the set screw on the coupling. With the rotor of capacitor C_3 set practically all the way out, the low-frequency end of the VFO tuning range (3,500 Kc) should fall near the first division mark on the dial. Several trial-and-error runs may be necessary to select the proper 180° portion of the tuning capacitor and the proper setting of C_3 to make the full 500 Kc of the 80-meter band cover the 500 dial divisions. If your station has more than one operator, it is a good idea to seal the final setting of C_3 with sealing wax immediately after the VFO is calibrated!

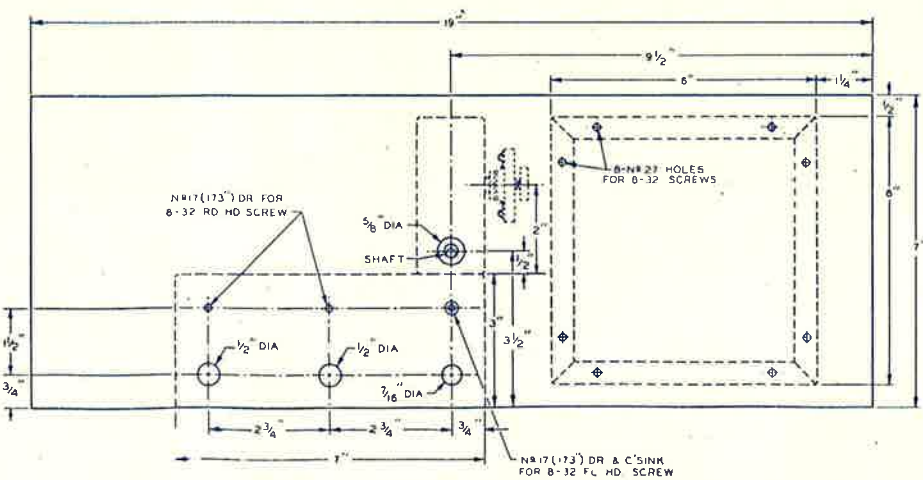


Fig. 5. Panel-layout drawing showing the location of the power-supply chassis, VFO box, and the dial gear box.

RF output at the output connector on the oscillator box was measured and found to be 45 volts rms with only a five-volt drop at the other end of the band. Connection to the transmitter should be made with unshielded wire of not more than two feet in length. The use of coaxial cable is not recommended because its capacitance would shunt the high-impedance output of the buffer.*

Performance.

The original calibration of this VFO was checked recently and found to be substantially as accurate as it was the day the curve was plotted. Time and again, schedules were kept on a pre-arranged frequency by returning to the same number on the VFO dial.

* This VFO was installed in the transmitter relay rack. If the VFO is to be located on the operating table several feet from the transmitter, coax may be used if a cathode follower is inserted between the 6AG7 buffer and the coax.

TWO EARS IN THREE DIMENSIONS

NORMAN C. PICKERING† and ERIC BAENDER, M.D.‡

Mr. Pickering: This discussion will be quite different from the kind we usually present; that is, a discussion on some technical point or on a new piece of apparatus.

Actually, we are reaching out into a different realm of audio, because we have come pretty close to the fence in certain aspects of the whole problem of listening. We have perfected systems, or at least we have come a lot closer at that elusive objective. We are getting nearer to what we thought we were looking for, and the nearer we get, the more we realize that that was not the goal at all. Therefore, we are now faced with the problem of "where do we go from here?"

It was realized long ago that the big advances in sound reproduction would be made in the problem of space. No one can listen to sound coming out of a little hole in a box and convince himself that it is the real thing. That has been said many times, but it is really the point that we are trying to bring out—the fact that we are trying to create this illusion in the mind of the listener. How we do it, of course, is a matter of technology and technique. Equipment development has come a long way, and we have to make use of every possible aspect to achieve our ends, but we also have to know what the end result must be. We have to know what *kind* of illusion we want to create in the mind of the listener.

We certainly learned that the first use of two-channel reproduction was about the time of the Paris Exposition of 1878, when someone hooked up two telephone receivers and two mouthpieces and got a startling improvement in reproduction. Of course we would, as we know. Most of us have heard two-channel reproduction on headphones, which does produce a startling concept of space in the mind of the listener. Not much work was done along these lines until the early 1930's when an extensive programme at Bell Telephone Laboratories, involving such men as Steinberg, Snow, and Fletcher, got under way. This resulted, in 1934, in an avalanche of papers on the subject of stereophonic sound. There was a great deal of very fine work in these papers, and it would be worth while to read some of them.

For a time after that, stereophonic reproduction was forgotten. But now it has again become a current issue, and it is important to know the good work that has been done in the past and to take advantage of it. That work, of course, included such striking things as the successful demonstration of three-channel stereophonic reproduction. During this demonstration, an orchestra playing in the Academy of Music in Philadelphia was reproduced on a stage in Washington with speakers placed in conformity with the microphones in the original auditorium. That, of course, was a great step forward in the handling of the space problem. It was only one phase of the problem, however, and the conditions represented a very special set of circumstances indeed. These are not the conditions which prevail in all listening environments, and we must be careful to differentiate between the conditions we encounter in our normal course of activities and those encountered in special demonstrations of this kind. Then in 1941 there was a series of papers by Fletcher on the Bell System recording techniques using four-channel film recordings, and there was Walt Disney's Fantasia, which involved a bag of tricks and special handling of stereosound. That was definitely a theatrical presentation, and the spatial distribution of the sound was used as one of the elements in the theatrics. As such, it was extremely effective.

The present situation leaves us in a rather strange position. We want to know what can be done to improve the space factor and enhance the illusion of reality. We want to know how far we can go, using modern techniques, the experience of the past, and our own ears, to preserve and present to the listener what exists, in substance, at the source of sound. This illusion is the thing we are all striving for so desperately.

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* This is a report of a discussion presented at the meeting of the Audio Engineering Society in New York on January 13, 1953.

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‡ Diplomate of the American Board of Radiology.

All of us have had the experience of building a sound system which, when completed, was far better than anything we had had before, only to discard it a few months later when we tired of it, or when we heard a system that sounded better. This continues until sometimes we feel that we are chasing a will-o'-the-wisp. Actually we have come now to a point where the next step will be a big one. Both Dr. Baender and I are convinced that audio engineers are on the tracks of something wonderful. However, there are a lot of "ifs" and "buts" to be considered, and we propose, without any implication of condemnation or criticism, to survey carefully the various systems which have been proposed to give an improvement in space illusion. Dr. Baender has done a superb job of examining all the relevant factors, at least all that we can think of at the present time. He is uniquely qualified to do this examination. His original training in Germany was in the field of medicine. His specialty, x-ray work, also required considerable use of electronic and photographic techniques, so he is also an excellent technician. He has developed special equipment and techniques in his medical work. Above all—and I think he would place this fact above anything else—he is a musician, and a good musician. He is an organist and has devoted many years to the study of baroque music, not only for organ, but for all kinds of instruments. I first met him many years ago when I played string quartets at his home, and I have been going back regularly ever since. He is constantly exposed to and interested in live music, and he has a superb record-reproducing system as well. I now want to present a man who has made an interesting evaluation of the problem of space and sound—Dr. Eric Baender.

Dr. Baender: The science of hearing is the natural concern of sound engineers. As the alpha and the omega, at the beginning and the end, it frames the field of audio engineering, as it were. But hearing is also the concern of such divergent sciences as physics, music, anatomy, psychology, physiology, otology and of practical medicine in general. None of these may claim priority—none can afford to neglect it entirely. All contribute to the ever-expanding field but can do so only with the hope of mutual open-mindedness toward new ideas and developments in correlated sciences. This, I take it, is my excuse for expressing my thoughts on the subject of tridimensionality as it affects sound reproduction.

The title chosen, "Two Ears in Three Dimensions", should stress at once the complexity of the subject, with its divergent extensions into psychophysiology in one direction and into the physical outer world in the other. We shall therefore have to throw more than a casual glance into ourselves and around ourselves, with much emphasis on the human element.

A block diagram will serve to illustrate and clarify the outline of the problem. Field 1 represents the concert hall or studio. We should agree at once that music will be our chief concern—instrumental and vocal music, from solo performance to large orchestra, to choir and organ, speech to be included as merely a special case of vocal utterance—in kind, everything from Beethoven to bebop, from a barcarole to a Bach chorale.

Field 2 represents the living room, and technically the last stop of the transmitted sound. Here we expect comfortable informality and full freedom of movement. Between fields 1 and 2, we know the transmission to be in the trustworthy hands of audio engineers. Thus, we have set our stage.

Field 1 is usually controllable both technically and acoustically. Field 2, however, has so far remained beyond the reach of the controlling engineer. Acoustical characteristics here are haphazard in every conceivable respect.

At the risk of injecting still more uncertainty into our discussion, we shall have to consider the listener—to be specific, the human mind, the ego. We show him as a wavy line, which one may take to represent the gyrations of the human brain, anatomically or otherwise. The Greeks represented Psyche as a maiden with the wings of a butterfly, which calls for another wavy line. Or one may think of a cloud. This, at any rate, is the final recipient of our endeavours—*His Majesty, the listener.*

It was one of the astonishing results of recent advances in disc recordings at their best that they were accepted by many music lovers who had stayed aloof from "canned" music but who now began to feel, to their ever-increasing gratification, that here at last was an approach to an idealized modus of listening, free from time limitations, free from formal demands imposed by social gatherings, and free from incidental noises. At last attention could be focused on sound and thus on the musical essence of the performance. The music lover went happily along with technical advances and gladly adopted into his vocabulary such terms as "tape", "LP", and "magnetic pickup", once he had identified them as the means to better reproduction of good music. He welcomed enthusiastically, in fact, every step that brought him closer to the coveted reality, although painfully aware at times of the expotential law stipulating that he would never quite make it. And now he reads of binaural reproduction, sterephonic recording, three-dimensional sound, two-channel transmission—an array of terms used indiscriminately and interchangeably. Are they really synonymous?

In science, understanding is not possible without precise terms. They are the key words in any discussion. We have to know what a word means, what a thing is. To throw the light on some points of special difficulty is desirable, of course, but not always sufficient. We would welcome explicit definitions to include all that belongs to the object under discussion and to exclude all that does not. Our comprehension will deepen in this search.

It needs to be emphasized that advertising slogans of the trade do not interest us here. The good old "high fidelity" and its offspring, "ffrr", "Orthophonic Sound", and "Living Presence", to mention a few, are harmless descriptive terms for good quality. We tolerate them with a benevolent smile. However, when precise scientific terms are being misused, whose meanings are unalterably fixed by derivation, by definition, and often by tradition, only confusion can result.

One such unfortunate misrepresentation is the ill-considered and careless use of the term "binaural" and of its counterpart, "monaural". These terms are derived from the Latin *auris,* meaning ear, monaural referring to one ear, binaural to two ears. So, when we speak of monaural listening, to the ordinary telephone for instance, we refer to the fact that one ear is stimulated. We designate precisely the number and kind of sensory apparatus employed. Advertisers, however, speaking of "monaural" tape recorders, usurp the term to express an entirely different meaning, namely, the absence of a third dimension allegedly present only with "binaural" tape recorders. We correctly speak of a doctor's binaural stethoscope, and thus simply refer to the fact that both ears are stimulated by a sound originating at one end piece. But advertisers continue to use the term "binaural" whenever they mean "stereophonic". An additional, somewhat curious twist is given to the word "binaural" in such terms as: "binaural broadcasting", "binaural disc", and "binaural tape". This absurd connotation is unfortunately rather suggestive to the unsuspecting layman. He is made to believe, although unintentionally, that all he needs is two radios, or two recorded bands on one disc, or two tracks on a tape—that is to say, two channels—in order to stimulate two ears. But then, what should he do with three channels, or five, as have been used in Fantasia and Cinerama? Obviously, he will still have to get along with binaural hearing, that is, with two ears, regardless of the number of channels.

Surely, the interested public, the musician, the audio trade, and the acoustical engineer are entitled to a frank discussion of the subject, not only of the semantics but of the related problems as well. The fact is that we listen to a standard conventional radio as we would listen to the live voice, with two ears, that is, binaurally. We listen to our conventional records, or, to be more exact, to the reproduction by conventional method, binaurally. In each case we have one amplifier and speaker system, but we listen with two ears, therefore binaurally. Whether I listen to a friend sitting across the table or to a loudspeaker in the same opposition I listen with both ears, naturally. That enables me to be aware of the direction from which the sound originates. Since the acoustical characteristics of any room are dependent upon its size and shape, whether it is crowded with overstuffed furniture, draperies, carpets, or almost empty, for instance, at the time of spring cleaning, my two ears will unfailingly, if subconsciously, perceive the original sound modified by the characteristics of the room in which I listen. This gives me my acoustical orientation. We may categorically state:

Normal hearing is always binaural.

This statement, by the way, takes into account the person who is stone deaf in one ear, for he is not normal. He listens monaurally, just like the person who in laboratory tests listens through one headphone, monaurally. These are obviously very special cases which do not interest us here. To sum up, the terms monaural and binaural do not refer to the number of *channels* but to the number of *ears,* and they do not indicate anything whatever about stereophonic sound. Unless we need a distinction between one-eared and two-eared hearing as required under special laboratory conditions, we might as well avoid these terms altogether. The prefix "stereo" serves very well as a general term traditionally covering the entire field of spatial perception. Rigid adherence to unmistakable terms will facilitate the not-so-complicated mathematics of listening with two ears, to perceive the three dimensions as suggested by one or more channels.

In the science of hearing, for very good reasons, we have contrasted the subjective response with the objective phenomenon that causes it. We have loudness versus intensity; we have pitch versus frequency. The physical stimulus is thus fully defined in terms of intensity and frequency, and, of course, duration. The psychological attributes of loudness and pitch are not sufficient to define the subjective response, a fundamental fact of utmost interest, investigation of other possible intangible sound qualities has led to the recognition of volume in the sense of voluminousness, or bigness. The validity of this additional concept is no longer challenged by science.

The complex phenomenon of auditory perspective also has no such counterpart in the physical world. It is the subjective response to a compound of many sounds which do exist individually and in a very real sense objectively and which are themselves complex in nature. Although these components are susceptible to analysis, we must nevertheless realize that there is no acoustical equivalent of the composite mental image which our mind forms out of many independent though related perceptions. *Auditory perspective has no physical existence.* It is entirely of the mind.

There is certainly no need here to discuss in detail the propagation of sound through air. We recall that sound waves spread in concentric spheres of ever-increasing diameter until they encounter a medium that differs in density from air. In closed rooms, any solid object will partly reflect and partly absorb sound. It will usually discriminate against certain frequencies. What we actually hear in fields 1 and 2 will always be a broad bundle of *essentially nondirectional* sound waves, the end result of random reflections, with a lavish profusion of related sounds varying in intensity, phase, and spectral content.

Well known also is the parallactic effect of the position of our ears and the resulting disparity in their stimulation. We know of differences in the time of arrival of individual wave fronts, and we may study phase differences when working with pure sounds. Of equal importance are differences in intensity at the two ears, and diffraction also plays its role. The net effect is chiefly one of phase difference for low frequencies and of intensity for high frequencies.

Thus we arrive at something optimistically called localization. As a matter of fact, information is received mainly as to the azimuth angle and virtually none as to the orientation in height and depth. Distance can be judged only by recognition of familiar sounds and by their known relative loudnesses. Such secondary cues dominate. We have, for instance, the concept of "presence", which is largely a phenomenon determined by the spectral content of the reproduction of a familiar sound. We know from experience that the high-frequency content of complex sounds increases with proximity to the source. Of particular importance are the cues that reach us through sensory organs *other* than the ear.

Spatial perception is of a very complex nature. The mind, eager to accept signals from all possible sources, takes its cues from a number of sensory organs. In the case of the three-dimensional, physical outer world, we are guided largely by visual stimuli. The sense of touch aids in recognition of near objects. Our perception of signals from all muscles and joints, together with signals from our semicircular canals of the inner ear supply the basic reference to the three-dimensional world. Auditory stimuli, our prime concern in this discussion, are not more than auxiliary in the perception of space. At times they may be strong and dominating, at other times they may be weak and subordinate, or they may be missing altogether, their absence not even being registered in the presence of strong stimuli which hold our interest in other directions. Psychologists can prove that the mind is not even capable of simultaneously registering a multitude of divergent perceptions with all their details. Thus, the concept of spatial perception is recognized to extend over many provinces, the auditory being by no means the largest. On its own, auditory perspective, or, more generally, stereosound, is a meaningless concept. It remains an empty frame, or rather it would suggest an empty shell if not co-ordinated with appropriate stimuli from other senses. If congruity is maintained, however, stereosound affords an entirely new and lifelike experience. Nobody, as Mr. Pickering has already mentioned, who remembers the exciting Fantasia can deny the extraordinary thrill of this dramatic presentation. The new Cinerama production is sure to kindle further interest in the problem involved.

Within this new field much ingenuity has been devoted to recording and transmitting systems. We are confronted with double-track tape, with simultaneous AM and FM broadcasting, with two-band discs, even with simultaneous lateral and vertical modulation on discs. Adding to these the possibilities of multiple sound tracks with stereo pictures on film and of identical methods applied to television, we may look forward to a healthy development of these multi-channel recording and transmitting techniques.

However, the receiving end of all these endeavours, the listener—the music lover in particular—seems all but forgotten. He has just settled down with contentment to enjoy LP, FM, and high fidelity. True, he still finds surprising variants in liveness, presence and balance, which are, of course, nothing but differences of skill in handling space problems. There is good depth if the recording is of the best. There is also a measure of appropriate spatial expansion, and even of auditory perspective, if his reproducing system "conforms" to field 2—that is, if all care has been taken to provide, by the use of multiple speakers of appropriately selected disparity, at pleasing loudness levels, the same lavish profusion of sound that prevailed in field 1. We cannot fry a chicken with a blowtorch, and fireplaces in our homes are not particularly known as sources of uniform temperature.

The music lover who possesses good conventional audio equipment which conforms to his particular environment is likely to be perplexed and bewildered by the "new developments" in audio. He cannot accept the common variety of comparison A–B tests, since they prove only the stunning superiority of the two-channel headphone transmission, virtually useless for home consumption; neither does he cherish any personal restriction of movement imposed by two-channel two loud-speaker tests, which offer too little beyond his well-balanced home system. He is keenly aware of the unquestionable dissimilarity between listening to music at home and listening while watching a motion picture screen which gives him the illusion of planned, orderly motion. In this case, the ability to recognize direction by ear, that is, auditory "localization" of sound sources within the pictures scene, certainly strengthens the illusion of life-likeness. But presentations of this type have in common moving sound sources, their visual counterparts being now audibly supported. Eye and ear in unison follow the sound sources, say from right to left, or from front to back.

No such auditory localization can have any place in music listening. The operatic performance as we have come to accept it on recordings (without simultaneous visualization of the scene) is but a compromise. Here alone localization of the sound source might be desirable, but it might again be questioned whether this illusion unsupported by visual observation can be at all convincing.

To be sure, the feeling of spaciousness contributes to the subconscious awareness of the three-dimensional enclosure needed to contain musicians and instruments as well as the audience. But it is one thing to be *aware* of space, and it is quite another to be constantly and annoyingly reminded of the fact that now this instrument is being played in the left foreground and then another one is sounding off from the right background. Instead of the orderly, continuous movement on a stage or on the screen, there would be a senseless, bizarre pattern indeed. A listener seated in the audience could visually notice such proceedings during an actual performance, although not always without detriment to his musical enjoyment. And, more important, he doesn't *have* to look—he even may close his eyes. In stereophonic reproduction, we are plainly a captive audience. Soloists, chamber players, or members of the orchestra just don't move around the stage during the performance, and they are invariably as tightly packed as circumstances permit, regardless of the available space, indoors or outdoors. How would we like a string quartet, say in Carnegie Hall, with the four players sounding out from the four corners of the hall? *Cohesion* of sound, not spatial separation, is the orchestra leader's goal, and no finer compliment can be paid to the concerted efforts of small or large musical groups than to state that "It sounds like ONE instrument."

This seems to be one of the most serious misconceptions about stereosound. The realm of music at its loftiest is in no way to be identified with three-dimensional space. Our musical scores demand changes in pitch, duration, colour, and loudness. The last thing asked for is localization. Physical space requirements dictate the arrangement of multiple instruments and their players. They concern the conductor and are of interest only to the naïve listener who is waiting for "sound effects".

Finally, there remains the question of how much of the original acoustical "wrapping" of the concert hall should be carried over into reproduction. The transfer from field 1 to field 2, as we remember, must consider the listener. In field 1 he is exposed to the *visual* impact of the room and its contents, in addition to the auditory stimuli. He is conditioned and primed as an interested member of the audience, seated with many others in neat arrangement in a more or less festive spirit. When we consider the psychological attitude of the listener both towards the performance and towards the physical characteristics of the concert hall, we may well admit that both contribute to but are in no way part of the substance of the music. In the concert hall, they are invariably congruous elements. Transferred to the home, however, they are distorted into incongruous nonessentials, subordinated to the main undertaking. Somehow they don't fit.

We may use again an analogy from the field of vision. Suppose that we were out in the country on a pleasant summer day, and we wished to take a color picture of our lady. She wears a white dress and is blond, and therefore we use the dark opening of a barn door as a contrasting background. But when we later see the picture we are quite disappointed. The dress now shows all sorts of discolorations, and the color of the hair is not identifiable. What has happened? On examination we find that we failed to take into account some incidental phenomena. The object of our attention, in visual terms white and blond, was modified by barely noticeable incidental color reflections, congruous out in the country, with the wide expanses of red barn, green grass, and blue sky which there dominated the color scheme. These retained color reflections became incongruously conspicuous and disturbing in the restricted frame of our picture which shows the lady only. On the other hand, sensations associated with life on the farm, smells from barn and stable, animal sounds, and the feel of warmth and wind, did contribute at the source, if subconsciously, to our experience of being in the country. They are not registered by the camera, and their absence is not noticed. Are we not wilfully and deliberately doing violence to our imaginative capacity when we insist on squeezing Carnegie Hall proportions into our living room?

Recognizing the wide variety of acoustical conditions at the source, and the relative inflexibility of our listening environment, acoustically and otherwise, we must tolerate some incongruity, depending on our attitude towards the program material. Sound effects and art music call for exactly opposite treatment, with many possible steps in between. We must strive for better *conformity* between loudspeakers and the living room, utilizing their inherent potentialities, and thus derive more listening pleasure through two ears in three dimensions.

Mr. Pickering: I should like now to pick up a couple of the technical points suggested by Dr. Baender's well-prepared discussion. He spoke, for example, of conformity, which I feel is an excellent term. All of us know people who have small radio sets that they love. They listen to their favourite musical programmes on them and are completely happy. They may lie in bed with a 4-in. speaker 8 in. away from their left ear, have it turned down to a very low level so that the amplifier distortion is reasonably low, and enjoy music much more than many of us who have big deluxe hundred-watt rigs. This, I call conformity. These people really are enjoying music. They are not stupid, and they are not to be looked down upon. Again, we have the fellow who has his old Rola speaker which he has had since 1930 or thereabouts, and which he refuses to part with. He has a pair of 45's driving it, and the cone suspension by now is as limp as a hound's ear. He, too, is very happy. He doesn't like these modern speakers or the things that he hears through them. In this particular setup this speaker conforms. He likes it, and he is happy, so let us leave him alone. We have all come across too many of these examples to be able to dismiss them easily and readily, and yet let us not make the opposite mistake of saying that we should *all* strive for an old limp Rola speaker or a midget portable radio.

There is much involved in this problem of conformity. If we do have a big room well suited for music reproduction, neither of the aforementioned examples is going to do a satisfactory job of filling the room with music.

That brings me to the next point. What *will* do a really satisfactory job? At the moment, we really don't know. People in the audio field have been wildly seeking the answer to that question for decades, and now we have the new experiment of two-channel radio broadcasts which give people an opportunity to try something different. In many cases the results have been disappointing, largely because of the very nature of sound and sound waves and the fact that we cannot compare two-channel headphone reproduction to two-channel loudspeaker reproduction. The two are only remotely similar. And when I hear people drawing conclusions about loudspeaker operation based on experiments made with headphones, I realize that we need more knowledge of this kind of transmission before we can approach the conformity we need for average-size rooms. Each loudspeaker sets up a field of its own which is reflected in turn from all the interior surfaces of the room in which it is being used. It doesn't take very long, in a room of any appreciable liveness, for the field to become scrambled, and the more reflection there is in the room, the less difference there will be at any point in the room between a two-channel two-speaker system and a one-channel two-speaker system. This can be readily demonstrated.

In a completely live room, one loudspeaker any place in the room would set up such a din that it would be difficult, by hearing alone, to locate exactly the source of sound. If there is very little loss at each reflection, each image will sound very much like the original source. This is analogous to a point source of light in a room. If the room is lined with mirrors there will be many lights in the room. If the room is completely covered with black absorbing material, it won't be hard to locate the original source of light. But even in a completely dead room, two loudspeakers supplied from signals which would do a good job of headphone reproduction (which, by the way, we stress over and over again is *true* sterephonic reproduction) cannot be made to produce in the ears separate signals corresponding to those which existed at the microphones in field 1.

An effect is produced, there is no doubt about it, and in some cases a very striking effect. If, for example, the microphones in field 1 are very widely spaced, much wider, say, than the loudspeakers are, you will get a separation effect if field 2 is reasonably dead—that is, if there are not too many reflections in field 2 to obscure the original sound. Then there will be an effect of separation which can be very startling and very exciting. In fact, in many cases the music can be torn apart right down the middle. This usually isn't desirable, but for unusual sound effects, such as the Fantasia production, it can produce a very telling theatrical effect. However, it does not help to convey a more satisfying illusion to the listener in the case of art music, as Dr. Baender pointed out. It is the presence of the additional loudspeaker, more often than not, regardless of the signal which is feeding it, which sets up a different pattern in field 2, tends to eliminate the blow-torch effect, and spreads the sound out a bit. This, as you know, is often disastrous on voice transmission, so it appears that the answer to the problem is not going to be a simple one. Adjustment will be required for different kinds of programme material and for congruity with the room in which the subject listener is located. For example, I will tell you a little about Dr. Baender's sound system, which I have found to be thoroughly satisfactory from the standpoint of musical enjoyment.

In the room where the listener is seated is a 15-in. speaker of high quality, mounted in a large cabinet. This is a wide-range speaker, capable of handling quite a lot of power but used far under its maximum power rating. Upstairs, up a stairwell and around a turn, there is a battery of speakers designed for the electric organ. This battery is capable of handling a great deal of power. For large music, such as choral groups, orchestra, or organ, the effect is overpowering and quite satisfying when the bulk of power is supplied by this distant speaker (which isn't so distant, by the way, that there is an appreciable time lag). By the time the sound reaches the living room through a large opening, almost the entire cross section of the room, it is thoroughly scrambled and well diffused. That, by itself, would give a rather unpleasant sort of sound, with excessive fusion; but the presence of the other speaker, in the path of the more distant one, gives a most astonishing effect of auditory perspective.

I am sure that you have all experimented with speaker configurations of various sorts. It so happens that in this particular listening room this setup "conforms". It works very well, and everyone who hears it is pleased. Even here, however, Dr. Baender uses a balance control right at his fingertips, which he sets for programme material. He doesn't ride it during the programme, but he sets it up once for each kind of programme. That is, for speech, naturally the nearby speaker would handle all the power. For a chorus or organ, he can change the balance so that more of the power goes to the distant speaker, and one has the wonderful sensation of being immersed in a flood of sound. Now there is a case where stereophonic quality is given to a single channel and yet done very well. As Dr. Baender has said, the speakers should be of appropriately selected disparity. After years of listening tests, it is our contention that if two identical speakers are located the same distance from the listener and are separated by any appreciable distance, the effect is sooner or later going to be schizoid, to say the least. There will always be some programme material which will appear to be torn down the centre. It is not possible to handle such things, for example, as a speaking voice. In that case it is necessary to shut one of the loudspeakers off in order to get any kind of naturalness, whereupon the image is shifted in the direction of the operating loudspeaker. This has been demonstrated many times. In the case of a completely dead room, where the listener is seated at a critical point in the room, about on the median plane between the speakers, some kind of effect is possible in which this splitting is avoided, but generally these ideal conditions are difficult to achieve in practice. By other means, however, varying the techniques of splitting channels and splitting loudspeakers, it is possible by conforming to the listener's taste, to his kind of music, and to his particular living-room conditions, to achieve artistic results far superior to the one-loudspeaker system which has been considered standard for a long time.

LOUDSPEAKER IMPEDANCE

By F. Langford-Smith.

An article on this subject by V. Salmon has recently been published (Ref. 4), and the following article was inspired by it and partly based on it, although the writer has adopted his own approach, and followed usages and symbols as in the Radiotron Designers' Handbook. It is intended to clarify the usage of terms in connection with loudspeaker impedance.

There are five impedances associated with the operation and testing of loudspeakers:

1. The loudspeaker (complex) impedance (Z_S).
2. The loudspeaker rating impedance (R_{SR}).
3. The loudspeaker measurement source impedance (R_{SG}).
4. The amplifier load resistance (R_L), also called amplifier load impedance.
5. The amplifier (internal) output resistance (R_O), also called amplifier (internal) output impedance.

The loudspeaker complex impedance is the actual loudspeaker impedance, usually measured on a large flat baffle, and may be shown by curves either in the magnitude-phase angle form (Ref. 1) or in the resistance-reactance form (Ref. 2), as a function of frequency.

The loudspeaker rating impedance is a single figure, such that when a pure resistance of this value is connected to an amplifier having a rated load resistance of the same value, then the combination will deliver rated performance. There is no standard method used by all loudspeaker manufacturers for determining the rating impedance. However, Salmon (Ref. 4) suggests two rule-of-thumb methods which may be used for estimating this value, for a wide range audio signal and moving-coil loudspeakers:

1. If the loudspeaker impedance characteristic is known, locate the minimum impedance in the range 200 to 800 c/s and add 10% (for horn loudspeakers, the rating impedance is the average value of the magnitude of the impedance taken near the centre of the pass band).

2. If the loudspeaker impedance characteristic is not known, measure the dc resistance of the voice coil and add 20% (or 40% for horn loudspeakers).

Most American loudspeakers for sound equipment have loudspeaker rating impedance values of 4, 8 or 16 ohms (Ref. 3).

The loudspeaker measurement source impedance is the value of a pure resistance, to be connected in series with the loudspeaker and a constant voltage source, when measuring the speaker performance. The value of the measurement source impedance should always be stated. The measurement source impedance is intended to be approxi-

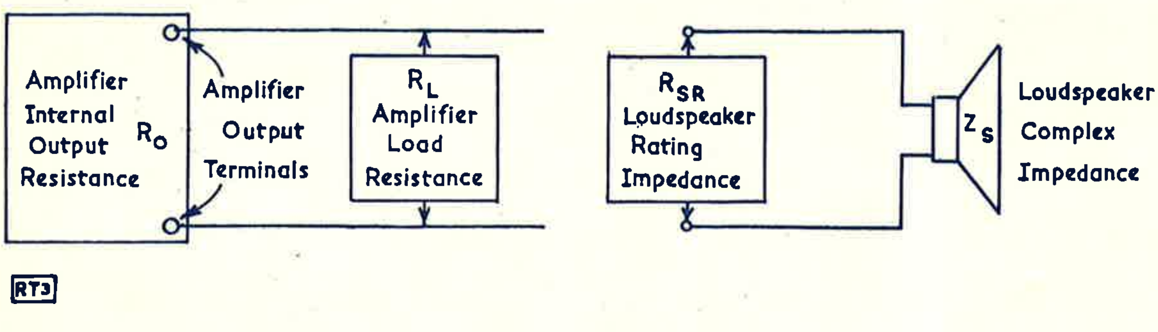

Fig. 1. Amplifier and loudspeaker as used in operation. The amplifier output terminals are on the secondary side of the output transformer, and all impedances are referred to the voice coil circuit.

mately the same as the amplifier (internal) output resistance. With high degrees of negative voltage feedback an amplifier would have a very low (internal) output resistance, and loudspeakers intended for use with such amplifiers are usually tested with zero measurement source impedance, that is with constant voltage applied to the voice coil terminals.

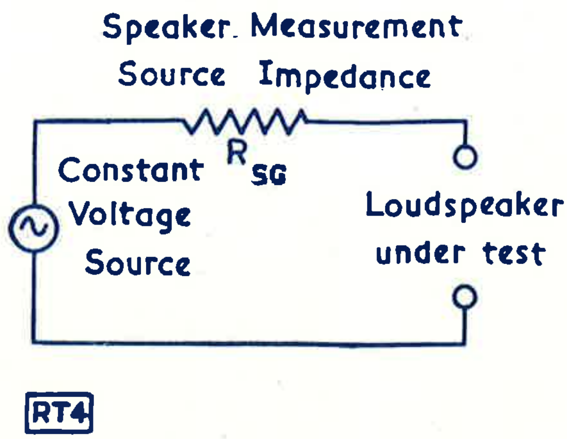

Fig. 2. Loudspeaker test circuit.

Loudspeakers intended for use with triode valves without feedback could be tested with a measurement source impedance of 40% of the loudspeaker rating impedance (e.g., Ref. 3). Finally, loudspeakers intended for use with pentode valves without feedback (although not covered by any of the published standards) could well be tested with a high value of measurement source impedance, or even with a constant current source.

Alternatively, the *source voltage regulation* should be stated. The voltage regulation of the source may be derived by firstly measuring the open-circuit voltage across the amplifier output terminals, using a reduced input voltage to ensure keeping inside the linear region. Then connect the rated load resistance across the output terminals, measuring the drop in voltage, which may be expressed in decibels to give the source voltage regulation. Some typical values of regulation are given below:

Constant voltage source	0 db
Negative voltage feedback amplifiers (extreme limit) . .	0.2 db
Triode valves without feedback	3.0 to 3.5 db
Beam power valves without feedback (lower limit)	15 db

The importance of the regulation is this: at extreme low and high frequencies the loudspeaker impedance is usually very large compared with the rating impedance and hence the loudspeaker approaches an open-circuit load condition. The regulation then represents the maximum increase in voltage across the loudspeaker (and hence the rise in output), expressed in decibels, to be expected as a consequence of the rise in impedance. Of course, the presence of reactive components in the source and load may somewhat alter this increase in output, but the regulation is seen to furnish a good basis for estimating the behaviour of a given loudspeaker with different output stages. It also points out the necessity for stating the source regulation in giving results of loudspeaker tests.

The amplifier load resistance is the published or recommended load resistance for the amplifier. The amplifier should be connected to a loudspeaker with a rating impedance equal to the recommended load resistance of the amplifier.

The amplifier (internal) output resistance is the "looking backwards" output resistance of the amplifier. Most negative feedback amplifiers have very low values of output resistance, thus providing the maximum possible amount of electro-magnetic damping.* However, loudspeakers in certain types of enclosures (Ref. 6) have a reduced bass response when operated by amplifiers having low values of output resistance. The optimum value of output resistance is a matter of much difference of opinion, some preferring the particular value to give a level frequency response, and others a very low value to give maximum damping — leaving the frequency compensation to be attended to elsewhere.

The power available to the loudspeaker is derived by replacing the loudspeaker in the test circuit by a resistor of value equal to the loudspeaker rating impedance. Then vary the applied voltage until the desired power is absorbed by the rating impedance. When the loudspeaker is reinserted into the test circuit, it will actually absorb a different value of power, but by keeping the source voltage constant the conditions of use will be simulated in an idealized fashion.

* The only known method for further increase in electro-magnetic damping is by the use of combined negative voltage feedback and positive current feedback to give a negative value of output resistance (Ref. 5), but the writer is not aware of any commercial usage.

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3. R.T.M.A. Standard SE-103, "Speakers for sound equipment".
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   Childs, U. J., "Dynamic negative feedback", Audio Eng. (Feb., 1952).
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6. e.g., enclosed cabinet, see R.D.H. 4th ed., pp. 844-845 and Fig. 20.12.

New RCA Releases

RADIOTRON 4J52 is a 3-centimeter "packaged" magnetron of the internal-resonant circuit type in which the permanent magnet is integral with the tube. Intended for service as a pulsed oscillator at a fixed frequency of 9375 ± 30 megacycles per second in applications such as radar, the 4J52 operates with high efficiency at pulse durations up to 5 microseconds, and has a maximum peak input power rating of 450 kilowatts when it is operated at a peak anode current of 15 amperes, corresponding to a peak anode voltage in the order of 15,000 volts, the 4J52 is capable of giving a peak output of approximately 80 kilowatts.

In addition to the integral magnet, the design of the 4J52 incorporates an axial cathode mount which has excellent structural rigidity and conserves space; and an output waveguide which can be coupled to a standard JAN RG-51/U waveguide by means of a modified JAN UG-52/U choke flange.

The input and output structures of the 4J52 are designed to prevent electrical breakdown at atmospheric pressure. However, the output waveguide and the mounting flange are made so that the 4J52 can be used in applications requiring a pressure seal

Radiotron–6BF5 is a beam power amplifier of the 7-pin miniature type used in the audio output stage of television and radio receivers. It has high sensitivity and is capable of delivering relatively large power output at low plate and screen voltage. Connected as a triode, the 6BF5 is used as a vertical deflection amplifier in television receivers.

Radiotron-6BY6 is a pentagrid amplifier of the 7-pin miniature type intended especially for use as a gated amplifier in TV receivers. In such service, it may be used as a combined sync separator and sync clipper.

The design of the 6BY6 includes separate base-pin terminals for grids No. 1 and No. 3. Each of these grids can be used independently as a control electrode, and has a sharp-cutoff characteristic. Such a characteristic is particularly suited for obtaining good sync clipping and noise cancellation with relatively low value of input signals. Furthermore, grid No. 3 is processed to minimize secondary emission and the resultant possibility of blocking.

An important operating feature of the 6BY6 is its favourable ratio of plate current to grids-No. 2-and-No. 4 current which permits achieving the desired output signal with relatively low power input to grids No. 2 and No. 4.

Radiotron–5751 is a 'premium' high-μ twin triode of the 9-pin miniature type. It is intended for use as a phase inverter and for use in numerous applications in industrial control devices where dependable performance under shock and vibration is a major consideration and where high voltage gain is an important design factor.

Utilized in the 5751 is a compact structure designed to resist shock and vibration, a pure-tungsten heater to give long life under conditions of frequent "on-off" switching, a mid-tapped heater to permit operation from either a 6.3-volt or a 12.6-volt supply, and separate terminals for each cathode to provide flexibility of circuit arrangement.

Each 5751 is manufactured under rigid controls and undergoes rigorous tests to ensure its 'premium' quality.

The 5751 has electrical characteristics somewhat similar to those of the miniature type 12AX7 but differs in having higher heater-current rating, lower amplification factor, and lower transconductance.

Radiotron–5819 is a head-on type of high vacuum multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear radiation, and in other applications involving low-level, large-area light sources.

The spectral response of the 5819 covers the range from about 3000 to 6200 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 4000 angstroms. The 5819, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation. Because of its spectral response, the 5819 is well suited for use with organic phosphors such as anthracene as well as with inorganic materials such as thallium-activated-sodium-iodide.

Design features of the 5819 include a semi-transparent cathode having a diameter of $1\frac{1}{2}$ inches on the inner glass surface of the face end of the bulb, and ten electrostatically focused multiplying stages. The relatively large cathode area permits very efficient collection of light from excited phosphor crystals, such as are employed in scintillation counters.

The 5819 is capable of multiplying feeble photoelectric current produced at the cathode by an average value of 500,000 times when operated with a supply voltage of 1000 volts. The output current of the 5819 is a linear function of the exciting illumination under normal operating conditions.

The frequency response of the 5819 is flat up to a frequency of about 50 megacycles per second above which the variation in electron transit time becomes the limiting factor.

In the scintillation type of nuclear radiation detector, the 5819 is particularly useful because of its large, essentially flat-cathode area which permits good optical coupling between the phosphor and the cathode. As a result, the scintillation pulses are larger in amplitude than the majority of the dark-current pulses and thus discrimination against the dark-current pulses is facilitated. The 5819 permits the design of a scintillation counter with high efficiency and a resolving time of only a small fraction of a microsecond.

Radiotron–6197 is a sharp-cut-off power pentode of the 9-pin miniature type having very high transconductance (11,000 micromhos). It is especially designed for frequency-divider and pulse amplifier circuits in electronic computers, and other "on-off" control applications requiring long periods of operation under cut-off conditions.

In such control service, the 6197 maintains its emission capabilities even after long periods of operation under cut-off conditions, and will supply a high minimum value of plate current during its "on" periods. In addition, consistency of cut-off bias is maintained because of the stable cut-off characteristic of the tube as well as its freedom from grid-No. 1 emission.

Featured in the design of the 6197 are the use of radiating fins on grid No. 2 to increase its dissipation capabilities, a getter shield to minimize inter-electrode leakage, and a pure-tungsten heater to give long life under conditions of frequent "on-off" switching.

Furthermore, the use of production controls correlated with typical electronic computer conditions, and rigorous tests for shorts and leakage, ensure long and dependable performance from the 6197.

Radiotron–6326 is a small camera tube of the vidicon type intended primarily for use in TV cameras for motion-picture film, transparencies, and opaques. Its small size and simplicity facilitate the design of the camera and associated equipment in comparison with iconoscope cameras.

Utilizing a photoconductive layer as its light-sensitive element, the 6326 has a sensitivity which permits televising motion-picture film with $\frac{1}{3}$ to $\frac{1}{2}$ of the light requirements of the iconoscope. For televising transparencies and opaques, the light requirement is only 1/20 of that needed for film pickup. The photoconductive layer has a spectral-response characteristic approaching that of the eye.

The 6326 gives excellent results with any TV film projector. When the light-application time is greater than 30 per cent of that for a single TV field the projector need not be synchronized with the field rate of the television synchronizing generator. This operating advantage is attributable to the manner in which the signal is formed within the vidicon.

This new vidicon has resolution capability of about 600 lines, employs magnetic focus and magnetic deflection, and operates with relatively low dc voltages. The electrode structure permits the use of circuitry to provide for dynamic focusing if desired.

Measuring only about 1 inch in diameter and $6\frac{1}{4}$ inches in length, the 6326 lends itself to use in light-weight, compact television cameras.

Components for use with the 6326 are the same as those available for the Radiotron–6198 Vidicon.

ERRATA

FEBRUARY ISSUE

Corrected.

Page 13. Fourth line from bottom of right-hand column: Read "200" for "300". ✓

Page 14. Seventh line from top of left-hand column: Read "power" for "voltage". ✓

STANDARD FREQUENCIES RANGES

The 7th Plenary Assembly of the International Radio Consultative Committee (C.C.I.R.) meeting in London during September and October, 1953, has recommended to the International Telecommunication Union (I.T.U.) the abolition of all adjectives and superlatives in describing frequency bands (Column 1 in Table 32 on page 1361 of the R.D.H.) and the substitution of a Band Number based on the formula: Band "N" extends from 0.3×10^N to 3×10^N c/s. Bands in the table become numbers 4 to 11 inclusive, while Band 12 has been added.

The recommended revised table is given below:

Band Number.	Frequency Range.	Metric Subdivision.
4	3 to 30 kc/s	Myriametric waves
5	30 to 300 kc/s	Kilometric waves
6	300 to 3,000 kc/s	Hectometric waves
7	3,000 to 30,000 kc/s	Decametric waves
8	30 to 300 Mc/s	Metric waves
9	300 to 3,000 Mc/s	Decimetric waves
10	3,000 to 30,000 Mc/s	Centimetric waves
11	30,000 to 300,000 Mc/s	Millimetric waves
12	300,000 to 3,000,000 Mc/s	Deci-millimetric waves

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